BSR/ASHRAE Addendum a to
ANSI/ASHRAE Standard 15-2019

First Public Review Draft

Proposed Addendum a to Standard 15-2019, Safety Standard for Refrigeration Systems

First Public Review (October 2019) (Draft shows Proposed Changes to Current Standard)

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FOREWORD

This addendum provides capacity factors for over pressure protection of pressure vessels and pressure equipment for a number of new refrigerants and expands the coverage of capacity factors for existing refrigerants based on the design pressure for the portion of the system being pressure-protected. Because the capacity factors are now dependent on the equipment's design pressure, there will be cases where the revised capacity factors will be larger than individual values for grouped refrigerants provided in previous editions to this standard. Such cases will not necessarily dictate a larger relief valve for a given piece of equipment since many pressure vessels will have a relief device that has a modestly larger capacity compared to the calculated minimum required relief capacity for the pressure vessel. In addition, this addendum introduces a method for calculating pressure relief capacity factors for refrigerants not included in the standard or for design pressures for current refrigerants that are outside of the ranges of pressures listed in the pressure relief capacity factor tables.

[Note to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]

Addendum a to 15-2019

~~9.7.5 The minimum required discharge capacity of the *pressure relief device* or *fusible plug* for each *pressure vessel shall* be determined by the following formula.~~

$$C = fDL$$

~~where~~

~~C = minimum required discharge capacity of the *pressure relief device* expressed as mass flow of air, lb/min (kg/s)~~

~~D = outside diameter of vessel, ft (m)~~

~~L = length of vessel, ft (m)~~

~~f = factor dependent upon type of *refrigerant* (see Table 9-1)~~

~~***Informative Notes:***~~

~~1. When combustible materials are used within 20 ft (6.1 m) of a *pressure vessel*, multiply the value of f by 2.5.~~

~~2. The formula is based on fire conditions. Other heat sources *shall* be calculated separately.~~

~~When one *pressure relief device* or *fusible plug* is used to protect more than one *pressure vessel*, the required capacity *shall* be the sum of the capacities required for each *pressure vessel*.~~

~~**Table 9-1 *Pressure Relief Devices* Capacity Factor**~~

Refrigerant	Value of f
When Used on the *Lowside* of a Limited-Charge *Cascade System*	
R-23, R-170, R-744, R-1150, R-508A, R-508B	1.0 (0.082)
R-13, R-13B1, R-503	2.0 (0.163)
R-14	2.5 (0.203)
Other Applications	
R-718	0.2 (0.016)
R-11, R-32, R-113, R-123, R-142b, R-152a, R-290, R-600, R-600a, R-764	1.0 (0.082)
R-12, R-22, R-114, R-124, R-134a, R-401A, R-401B, R-401C, R-405A, R-406A, R-407C, R-407D, R-407E, R-409A, R-409B, R-411A, R-411B, R-411C, R-412A, R-414A, R-414B, R-500, R-1270	1.6 (0.131)
R-143a, R-402B, R-403A, R-407A, R-408A, R-413A	2.0 (0.163)
R-115, R-402A, R-403B, R-404A, R-407B, R- 410A, R-410B, R-502, R-507A, R-509A	2.5 (0.203)

9.7.5 The minimum required discharge capacity, C, of the *pressure relief device* or *fusible plug* for each *pressure vessel* shall be determined using the methods in this section.

The minimum required discharge capacity, C, shall be the largest value determined by consideration of potential thermal exposure from both external heat sources in accordance with Section 9.7.5.1 and internal heat sources in accordance with Section 9.7.5.2, with each case calculated using Equation 9.7.5-1. The calculated value of the minimum required relief device discharge capacity shall be rounded up to not less than two (2) significant figures.

When one *pressure relief device* or *fusible plug* is used to protect more than one *pressure vessel*, the required capacity shall be the sum of the capacities required for each *pressure vessel*.

The *pressure relief device* set pressure shall be in accordance with Section 9.5 and the relieving pressure for calculations in this section shall be 1.1 times the relief device set pressure. When the relieving pressure exceeds 90% of the refrigerant's *critical pressure*, an engineering analysis shall determine the value of the pressure relief capacity factor, f.

$$C = f \cdot A \qquad [9.7.5\text{-}1]$$

where

			IP	SI
C	=	minimum required discharge capacity of the relief device expressed as mass flow of air,	lb/min	(kg/s)
f	=	pressure relief capacity factor which is dependent upon type of refrigerant and vessel design pressure or protected equipment	lb/[ft²·min]	(kg/[m²·s])
A	=	area of the pressure vessel or protected equipment (per 9.7.5.1 or 9.7.5.2),	ft²	(m²)

Tables 9-1 through 9-6 provide values of pressure relief device capacity factors, f, for specific refrigerants and *pressure vessel* design pressures calculated in accordance with this section. The tables are arranged according to the *refrigerant designation* and the *design pressure* of the *pressure vessel* or protected equipment. Linear interpolation shall be used for determining capacity factors for intermediate *design pressure* values between tabulated values. Capacity factor values from Tables 9-1 through 9-6 shall not be extrapolated. Capacity factor values for other refrigerants or *design pressures* outside the range of the tables shall be calculated per the method in this section.

The area, A, shall be calculated in accordance with Section 9.7.5.1 and Section 9.7.5.2. The capacity factor, f, shall be calculated using Equation 9.7.5-2 when the relieving pressure of the vessel does not exceed 90% of the refrigerant *critical pressure*.

$$f = \frac{H}{h_{fg}} \cdot r_w \qquad [9.7.5\text{-}2]$$

where

			IP	SI
H	=	the heat flux from a thermal energy source originating from an external source or internal source in accordance with 9.7.5.1 and 9.7.5.2, respectively,	Btu/[ft²·min]	(kW/m²)
h_{fg}	=	the refrigerant's latent heat of vaporization at evaluated at the relieving pressure (1.1 times the component *design pressure*),	Btu/lb	(kJ/kg)
r_w	=	a dimensionless refrigerant to air mass flow rate conversion factor	-	-

The refrigerant to air mass flow rate conversion factor, r_w, shall be calculated using Equations 9.7.5-3 and 9.7.5-4.

$$r_w = \frac{C_a}{C_r}\sqrt{\frac{T_r}{T_a}}\sqrt{\frac{M_a}{M_r}} \qquad [9.7.5\text{-}3]$$

$$C_r = 520\sqrt{k\left(\frac{2}{k+1}\right)^{k+1/k-1}} \qquad [9.7.5\text{-}4]$$

where

			IP	SI
C_a	=	356, a dimensionless constant for air	-	-
T_r	=	the absolute dew point temperature of refrigerant evaluated at a relieving pressure of 1.1 times the relief device set pressure,	°R	(K)

T_a	=	the absolute temperature of standard air, 520 °R (289 K)	°R	(K)
M_r	=	the relative molar mass of the refrigerant in accordance with ASHRAE Standard 34 [1]	-	-
M_a	=	the relative molar mass of air, 28.97	-	-
k	=	the ratio of specific heats (c_p/c_v) for saturated refrigerant vapor evaluated at a relieving pressure of 1.1 times the relief device set pressure	-	-

9.7.5.1 External heat sources. The area, A, shall be the largest refrigerant containing, projected external surface area of the *pressure vessel* when viewed from any orientation. See Figure 9-1 for examples. The value of heat flux, H, shall be not less than 150 Btu/[min·ft²] (28.4 kW/m²). Where combustible materials are within 20 ft (6.1 m) of a pressure vessel, the value of heat flux, H, shall be not less than 375 Btu/[min·ft²] (71.0 kW/m²). Where a heat source, other than an external fire, has potential to generate a larger heat flux, H, during operating conditions and standby conditions as defined in Sections 9.2.1 and 9.2.1.2, or during other abnormal conditions, the pressure relief device shall be sized based on the other heat source.

9.7.5.2 Internal heat sources. The area, A, shall be the applicable refrigerant containing area for the *pressure vessel* or pressure-protected equipment that corresponds to the greatest internal heat flux, H, expected during operating conditions or standby conditions as defined in Sections 9.2.1 and 9.2.1.2.

Table 9-1 (I-P) Relief device refrigerant capacity factors, f, lb/[ft²·min]

	Design Pressure (psi, gauge)							
Refrigerant	50	100	150	200	300	400	500	600
R12	1.24	1.38	1.51	1.64	1.91	2.3	-	-
R22	0.98	1.09	1.18	1.26	1.43	1.62	1.88	-
R23	0.95	1.05	1.13	1.21	1.38	1.56	1.84	-
R32	0.73	0.80	0.86	0.91	1.02	1.13	1.26	1.45
R115	1.48	1.69	1.89	2.2	2.7	-	-	-
R134a	1.05	1.18	1.29	1.40	1.65	1.97	-	-
R143a	1.05	1.18	1.30	1.42	1.69	2.1	-	-
R152a	0.84	0.94	1.02	1.10	1.27	1.47	1.79	-
R170	0.70	0.77	0.83	0.89	1.01	1.14	1.33	-
R290	0.78	0.87	0.95	1.03	1.20	1.41	-	-
R401A	1.01	1.12	1.22	1.31	1.51	1.75	2.2	-
R401B	1.00	1.11	1.21	1.30	1.49	1.72	2.1	-
R401C	1.04	1.16	1.27	1.37	1.60	1.88	2.5	-
R402A	1.11	1.25	1.36	1.48	1.73	2.1	-	-
R402B	1.06	1.18	1.28	1.39	1.60	1.86	2.3	-
R403A	1.05	1.18	1.28	1.38	1.60	1.86	2.4	-
R403B	1.16	1.30	1.42	1.55	1.82	2.2	-	-
R404A	1.12	1.26	1.38	1.51	1.80	2.3	-	-
R405A	1.10	1.22	1.34	1.45	1.70	2.1	-	-
R406A	0.98	1.09	1.19	1.28	1.47	1.70	2.1	-
R407A	0.98	1.09	1.19	1.28	1.48	1.72	2.2	-
R407B	1.08	1.21	1.33	1.44	1.69	2.1	-	-
R407C	0.95	1.05	1.15	1.23	1.41	1.63	1.99	-
R407D	0.97	1.08	1.18	1.27	1.46	1.71	2.2	-

Refrigerant	*Design Pressure* (psi, gauge) 50	100	150	200	300	400	500	600
R407E	0.93	1.03	1.12	1.20	1.38	1.58	1.90	-
R407F	0.93	1.03	1.12	1.20	1.37	1.58	1.89	-
R407G	1.03	1.15	1.26	1.37	1.60	1.90	-	-
R407H	0.91	1.00	1.09	1.16	1.33	1.51	1.79	-
R408A	1.03	1.15	1.25	1.36	1.57	1.84	-	-
R409A	1.02	1.13	1.23	1.32	1.52	1.75	2.2	-
R409B	1.02	1.13	1.23	1.32	1.51	1.74	2.1	-
R410A	0.90	0.99	1.07	1.15	1.31	1.48	1.74	-
R410B	0.92	1.02	1.10	1.18	1.35	1.54	1.82	-
R411A	0.95	1.05	1.14	1.22	1.39	1.58	1.84	-
R411B	0.97	1.07	1.16	1.24	1.41	1.60	1.86	-
R412A	1.00	1.10	1.20	1.28	1.47	1.68	1.99	-
R413A	1.07	1.20	1.32	1.44	1.71	2.1	-	-
R414A	1.03	1.14	1.25	1.34	1.55	1.81	2.3	-
R414B	1.05	1.17	1.27	1.37	1.58	1.85	2.3	-
R415A	0.94	1.04	1.13	1.21	1.38	1.57	1.83	-
R415B	0.87	0.96	1.05	1.13	1.29	1.49	1.79	-
R416A	1.11	1.25	1.37	1.49	1.77	2.2	-	-
R417A	1.10	1.24	1.36	1.49	1.77	2.2	-	-
R417B	1.17	1.32	1.45	1.59	1.90	2.4	-	-
R417C	1.06	1.19	1.31	1.43	1.69	2.1	-	-
R418A	0.97	1.08	1.17	1.25	1.42	1.61	1.87	-
R419A	1.11	1.24	1.37	1.49	1.76	2.2	-	-
R419B	1.07	1.20	1.32	1.43	1.68	2.1	-	-
R420A	1.05	1.18	1.29	1.40	1.64	1.97	-	-
R421A	1.12	1.26	1.39	1.51	1.80	2.3	-	-
R421B	1.19	1.34	1.48	1.61	1.93	2.5	-	-
R422A	1.19	1.34	1.48	1.62	1.95	2.5	-	-
R422B	1.11	1.26	1.38	1.51	1.80	2.3	-	-
R422C	1.16	1.31	1.45	1.59	1.91	2.5	-	-
R422D	1.14	1.28	1.41	1.54	1.85	2.3	-	-
R422E	1.12	1.26	1.39	1.52	1.81	2.3	-	-
R423A	1.19	1.35	1.50	1.65	1.99	2.6	-	-
R424A	1.11	1.24	1.37	1.49	1.78	2.2	-	-
R425A	0.97	1.07	1.17	1.26	1.45	1.69	2.1	-
R426A	1.05	1.18	1.30	1.41	1.66	2.00	-	-
R427A	0.99	1.10	1.20	1.29	1.50	1.75	2.3	-
R428A	1.18	1.33	1.47	1.61	1.93	2.5	-	-
R429A	0.77	0.86	0.93	1.00	1.15	1.33	1.60	-
R430A	0.87	0.98	1.07	1.16	1.36	1.62	-	-
R431A	0.81	0.91	0.99	1.07	1.25	1.48	-	-
R432A	0.74	0.82	0.89	0.96	1.10	1.27	1.51	-
R433A	0.77	0.86	0.94	1.01	1.18	1.38	1.75	-
R433B	0.78	0.87	0.95	1.03	1.19	1.41	-	-
R433C	0.77	0.86	0.94	1.02	1.18	1.38	1.76	-

	Design Pressure (psi, gauge)							
Refrigerant	50	100	150	200	300	400	500	600
R434A	1.14	1.29	1.42	1.55	1.86	2.4	-	-
R435A	0.74	0.82	0.88	0.95	1.08	1.22	1.40	1.77
R436A	0.79	0.88	0.96	1.05	1.23	1.48	-	-
R436B	0.79	0.88	0.97	1.05	1.24	1.49	-	-
R437A	1.06	1.19	1.31	1.43	1.68	2.1	-	-
R438A	1.04	1.17	1.28	1.38	1.62	1.93	-	-
R439A	0.90	0.99	1.08	1.15	1.31	1.50	1.77	-
R440A	0.84	0.94	1.02	1.10	1.27	1.47	1.80	-
R441A	0.73	0.82	0.89	0.96	1.12	1.33	1.71	-
R442A	0.93	1.03	1.12	1.20	1.38	1.58	1.90	-
R443A	0.76	0.85	0.92	1.00	1.15	1.34	1.67	-
R444A	1.00	1.11	1.22	1.32	1.54	1.83	2.4	-
R444B	0.87	0.96	1.04	1.11	1.26	1.43	1.66	2.1
R445A	0.95	1.06	1.16	1.26	1.46	1.73	2.3	-
R446A	0.81	0.89	0.96	1.02	1.15	1.29	1.46	1.73
R447A	0.82	0.90	0.97	1.03	1.16	1.29	1.47	1.74
R447B	0.82	0.90	0.97	1.03	1.16	1.30	1.48	1.76
R448A	0.97	1.08	1.18	1.27	1.46	1.70	2.1	-
R449A	0.98	1.09	1.19	1.28	1.48	1.73	2.2	-
R449B	0.97	1.08	1.18	1.27	1.46	1.70	2.2	-
R449C	1.00	1.11	1.21	1.31	1.52	1.79	2.4	-
R450A	1.10	1.24	1.36	1.49	1.77	2.2	-	-
R451A	1.19	1.35	1.50	1.65	2.1	-	-	-
R451B	1.19	1.35	1.50	1.65	2.1	-	-	-
R452A	1.11	1.24	1.36	1.48	1.74	2.2	-	-
R452B	0.83	0.92	0.99	1.06	1.20	1.35	1.55	1.96
R452C	1.10	1.23	1.35	1.46	1.72	2.1	-	-
R453A	0.97	1.07	1.17	1.26	1.45	1.69	2.1	-
R454A	0.96	1.07	1.16	1.25	1.44	1.68	2.1	-
R454B	0.83	0.91	0.99	1.05	1.19	1.34	1.54	1.92
R454C	1.02	1.14	1.24	1.35	1.57	1.88	-	-
R455A	0.98	1.09	1.19	1.28	1.48	1.74	2.2	-
R456A	1.04	1.16	1.27	1.38	1.62	1.94	-	-
R457A	1.00	1.11	1.22	1.32	1.53	1.83	-	-
R458A	0.96	1.07	1.17	1.26	1.45	1.68	2.1	-
R459A	0.83	0.91	0.99	1.05	1.19	1.33	1.53	1.90
R459B	1.02	1.14	1.24	1.34	1.57	1.87	2.6	-
R460A	1.05	1.17	1.28	1.38	1.61	1.91	2.6	-
R460B	0.95	1.05	1.14	1.22	1.40	1.61	1.93	-
R500	1.11	1.24	1.35	1.47	1.71	2.1	-	-
R501	1.04	1.15	1.25	1.34	1.53	1.75	2.1	-
R502	1.20	1.34	1.47	1.60	1.87	2.3	-	-
R503	1.14	1.27	1.38	1.49	1.72	2.00	-	-
R504	0.99	1.10	1.20	1.29	1.48	1.72	2.2	-
R507A	1.13	1.27	1.40	1.53	1.83	2.3	-	-

Refrigerant	*Design Pressure* (psi, gauge) 50	100	150	200	300	400	500	600
R508A	1.25	1.41	1.55	1.69	2.1	2.6	-	-
R508B	1.21	1.36	1.49	1.62	1.91	2.4	-	-
R509A	1.29	1.46	1.62	1.77	2.2	2.8	-	-
R510A	0.73	0.81	0.88	0.94	1.07	1.22	1.41	-
R511A	0.77	0.87	0.95	1.02	1.19	1.40	-	-
R512A	0.85	0.95	1.03	1.11	1.28	1.49	1.82	-
R513A	1.14	1.29	1.42	1.56	1.87	2.4	-	-
R513B	1.14	1.29	1.43	1.57	1.88	2.4	-	-
R515A	1.16	1.32	1.46	1.60	1.94	2.5	-	-
R1150	0.69	0.76	0.81	0.87	0.98	1.10	1.27	-
R1234yf	1.21	1.37	1.53	1.69	2.1	-	-	-
R1234ze(E)	1.14	1.29	1.42	1.56	1.87	2.4	-	-
R1270	0.75	0.84	0.91	0.98	1.13	1.31	1.58	-

Table 9-2 (SI) Relief device refrigerant capacity factors, f, kg/[m²·s]

Refrigerant	*Design Pressure* (kPa, gauge) 350	700	1000	1500	2000	2500	3000	4000
R12	0.101	0.113	0.122	0.137	0.153	0.173	0.199	-
R22	0.080	0.089	0.095	0.105	0.115	0.126	0.138	-
R23	0.078	0.086	0.092	0.101	0.111	0.121	0.134	-
R32	0.060	0.066	0.070	0.076	0.082	0.088	0.095	0.114
R115	0.121	0.138	0.152	0.178	0.22	-	-	-
R134a	0.086	0.096	0.104	0.118	0.132	0.149	0.174	-
R143a	0.086	0.097	0.105	0.119	0.135	0.155	-	-
R152a	0.069	0.077	0.083	0.092	0.102	0.113	0.127	-
R170	0.057	0.063	0.067	0.074	0.081	0.089	0.098	-
R290	0.063	0.071	0.077	0.086	0.096	0.108	0.123	-
R401A	0.082	0.092	0.099	0.110	0.121	0.134	0.151	-
R401B	0.082	0.091	0.098	0.108	0.120	0.132	0.148	-
R401C	0.085	0.095	0.103	0.115	0.128	0.143	0.164	-
R402A	0.091	0.102	0.110	0.124	0.138	0.156	0.180	-
R402B	0.086	0.096	0.104	0.116	0.128	0.143	0.161	-
R403A	0.086	0.096	0.103	0.116	0.128	0.143	0.161	-
R403B	0.094	0.106	0.115	0.130	0.146	0.166	0.196	-
R404A	0.091	0.103	0.112	0.127	0.144	0.167	-	-
R405A	0.090	0.100	0.108	0.122	0.136	0.153	0.178	-
R406A	0.080	0.089	0.096	0.107	0.118	0.130	0.146	-
R407A	0.080	0.089	0.096	0.107	0.119	0.132	0.149	-
R407B	0.089	0.099	0.107	0.121	0.135	0.153	0.178	-
R407C	0.078	0.086	0.093	0.103	0.114	0.126	0.141	-
R407D	0.079	0.088	0.095	0.106	0.118	0.131	0.148	-
R407E	0.076	0.084	0.091	0.100	0.111	0.122	0.136	-
R407F	0.076	0.084	0.091	0.100	0.110	0.122	0.136	-
R407G	0.084	0.094	0.102	0.115	0.128	0.145	0.168	-
R407H	0.074	0.082	0.088	0.097	0.107	0.117	0.130	-

	Design Pressure (kPa, gauge)							
Refrigerant	350	700	1000	1500	2000	2500	3000	4000
R408A	0.084	0.094	0.101	0.113	0.126	0.141	0.161	-
R409A	0.083	0.093	0.099	0.110	0.122	0.135	0.151	-
R409B	0.083	0.092	0.099	0.110	0.121	0.134	0.150	-
R410A	0.073	0.081	0.087	0.096	0.105	0.115	0.127	-
R410B	0.075	0.083	0.089	0.099	0.108	0.119	0.132	-
R411A	0.078	0.086	0.092	0.102	0.112	0.123	0.135	-
R411B	0.079	0.087	0.094	0.103	0.113	0.124	0.137	-
R412A	0.081	0.090	0.097	0.107	0.118	0.130	0.144	-
R413A	0.087	0.098	0.107	0.121	0.137	0.157	0.189	-
R414A	0.084	0.093	0.101	0.112	0.125	0.139	0.157	-
R414B	0.086	0.095	0.103	0.114	0.127	0.141	0.160	-
R415A	0.077	0.085	0.091	0.101	0.111	0.121	0.134	-
R415B	0.071	0.079	0.085	0.094	0.104	0.115	0.128	-
R416A	0.091	0.102	0.111	0.125	0.142	0.162	0.195	-
R417A	0.090	0.101	0.110	0.125	0.141	0.162	0.197	-
R417B	0.095	0.108	0.117	0.134	0.152	0.176	-	-
R417C	0.087	0.098	0.106	0.120	0.135	0.154	0.182	-
R418A	0.079	0.088	0.094	0.104	0.114	0.125	0.138	-
R419A	0.091	0.102	0.110	0.125	0.141	0.160	0.191	-
R419B	0.087	0.098	0.106	0.120	0.135	0.153	0.180	-
R420A	0.086	0.096	0.104	0.117	0.132	0.149	0.174	-
R421A	0.091	0.103	0.112	0.127	0.144	0.165	0.200	-
R421B	0.097	0.109	0.119	0.136	0.154	0.179	-	-
R422A	0.097	0.110	0.120	0.136	0.156	0.181	-	-
R422B	0.091	0.103	0.112	0.127	0.144	0.166	0.21	-
R422C	0.095	0.107	0.117	0.134	0.152	0.177	-	-
R422D	0.093	0.105	0.114	0.130	0.148	0.171	0.22	-
R422E	0.091	0.103	0.112	0.128	0.145	0.167	0.21	-
R423A	0.098	0.111	0.121	0.139	0.159	0.188	-	-
R424A	0.090	0.102	0.111	0.125	0.142	0.163	0.199	-
R425A	0.079	0.088	0.095	0.105	0.117	0.130	0.147	-
R426A	0.086	0.096	0.105	0.118	0.133	0.151	0.178	-
R427A	0.080	0.090	0.097	0.108	0.120	0.134	0.153	-
R428A	0.096	0.108	0.118	0.135	0.154	0.179	-	-
R429A	0.063	0.070	0.075	0.084	0.093	0.103	0.115	-
R430A	0.071	0.080	0.086	0.097	0.109	0.123	0.143	-
R431A	0.066	0.074	0.080	0.090	0.100	0.113	0.130	-
R432A	0.060	0.067	0.072	0.080	0.089	0.098	0.109	-
R433A	0.063	0.070	0.076	0.085	0.094	0.105	0.120	-
R433B	0.063	0.071	0.076	0.086	0.096	0.107	0.123	-
R433C	0.063	0.070	0.076	0.085	0.095	0.106	0.120	-
R434A	0.093	0.105	0.115	0.130	0.148	0.172	-	-
R435A	0.060	0.067	0.071	0.079	0.087	0.095	0.104	0.135
R436A	0.064	0.072	0.078	0.088	0.098	0.112	0.130	-
R436B	0.064	0.072	0.078	0.088	0.099	0.112	0.132	-

Refrigerant	*Design Pressure* (kPa, gauge)							
	350	700	1000	1500	2000	2500	3000	4000
R437A	0.087	0.098	0.106	0.120	0.135	0.154	0.182	-
R438A	0.085	0.095	0.103	0.116	0.130	0.146	0.170	-
R439A	0.073	0.081	0.087	0.096	0.106	0.116	0.128	-
R440A	0.069	0.077	0.083	0.092	0.102	0.113	0.127	-
R441A	0.060	0.067	0.072	0.080	0.090	0.101	0.116	-
R442A	0.076	0.084	0.091	0.100	0.111	0.122	0.136	-
R443A	0.062	0.069	0.075	0.083	0.092	0.103	0.117	-
R444A	0.081	0.091	0.098	0.111	0.124	0.139	0.160	-
R444B	0.071	0.079	0.084	0.093	0.101	0.111	0.122	0.160
R445A	0.077	0.087	0.094	0.105	0.117	0.132	0.152	-
R446A	0.066	0.073	0.078	0.085	0.093	0.100	0.109	0.135
R447A	0.067	0.073	0.078	0.086	0.093	0.101	0.110	0.136
R447B	0.067	0.074	0.079	0.086	0.094	0.101	0.110	0.137
R448A	0.079	0.088	0.095	0.106	0.117	0.130	0.147	-
R449A	0.080	0.089	0.096	0.107	0.119	0.132	0.150	-
R449B	0.080	0.089	0.095	0.106	0.118	0.131	0.148	-
R449C	0.082	0.091	0.098	0.110	0.122	0.136	0.156	-
R450A	0.090	0.101	0.110	0.125	0.141	0.162	0.198	-
R451A	0.097	0.111	0.121	0.139	0.161	0.192	-	-
R451B	0.097	0.110	0.121	0.139	0.161	0.191	-	-
R452A	0.090	0.101	0.110	0.124	0.139	0.159	0.189	-
R452B	0.068	0.075	0.080	0.088	0.096	0.105	0.115	0.150
R452C	0.090	0.101	0.109	0.123	0.138	0.156	0.185	-
R453A	0.079	0.088	0.094	0.105	0.116	0.129	0.146	-
R454A	0.078	0.087	0.094	0.104	0.116	0.129	0.146	-
R454B	0.068	0.075	0.080	0.088	0.096	0.104	0.114	0.147
R454C	0.083	0.093	0.101	0.113	0.126	0.142	0.166	-
R455A	0.080	0.089	0.096	0.107	0.119	0.133	0.152	-
R456A	0.085	0.095	0.103	0.116	0.130	0.147	0.172	-
R457A	0.081	0.091	0.098	0.110	0.123	0.139	0.161	-
R458A	0.079	0.088	0.094	0.105	0.116	0.129	0.146	-
R459A	0.068	0.075	0.080	0.088	0.095	0.104	0.114	0.146
R459B	0.083	0.093	0.100	0.112	0.126	0.142	0.165	-
R460A	0.086	0.096	0.103	0.116	0.129	0.145	0.168	-
R460B	0.077	0.086	0.092	0.102	0.113	0.124	0.139	-
R500	0.090	0.101	0.109	0.123	0.137	0.154	0.177	-
R501	0.085	0.094	0.101	0.112	0.123	0.135	0.150	-
R502	0.098	0.110	0.119	0.134	0.150	0.169	0.198	-
R503	0.093	0.104	0.112	0.124	0.138	0.153	0.174	-
R504	0.081	0.090	0.097	0.108	0.119	0.132	0.149	-
R507A	0.092	0.104	0.113	0.129	0.146	0.169	-	-
R508A	0.102	0.115	0.125	0.142	0.161	0.187	-	-
R508B	0.099	0.111	0.120	0.136	0.153	0.176	-	-
R509A	0.105	0.119	0.130	0.149	0.171	0.21	-	-
R510A	0.060	0.066	0.071	0.079	0.086	0.095	0.104	0.138

Refrigerant	*Design Pressure* (kPa, gauge) 350	700	1000	1500	2000	2500	3000	4000
R511A	0.063	0.071	0.076	0.086	0.096	0.107	0.122	-
R512A	0.069	0.077	0.083	0.093	0.103	0.114	0.129	-
R513A	0.093	0.105	0.115	0.131	0.149	0.174	-	-
R513B	0.093	0.106	0.115	0.132	0.150	0.175	-	-
R515A	0.095	0.108	0.118	0.135	0.155	0.181	-	-
R1150	0.056	0.062	0.066	0.072	0.079	0.085	0.094	0.125
R1234yf	0.099	0.112	0.123	0.142	0.165	0.198	-	-
R1234ze(E)	0.093	0.105	0.115	0.131	0.150	0.174	-	-
R1270	0.061	0.068	0.074	0.082	0.091	0.101	0.113	-

Table 9-3 (I-P) Relief device refrigerant capacity factors, f, lb/[ft²·min]

Refrigerant	*Design Pressure* (psi, gauge) 15	50	100	150
R11	1.05	1.18	1.32	1.44
R113	1.21	1.38	1.57	1.75
R114	1.25	1.42	1.62	1.81
R123	1.09	1.24	1.40	1.55
R124	1.10	1.25	1.41	1.56
R142b	0.94	1.07	1.20	1.31
R245fa	0.99	1.12	1.27	1.41
R600	0.74	0.84	0.94	1.04
R600a	0.76	0.87	0.98	1.09
R718	0.24	0.26	0.28	0.29
R764	0.64	0.70	0.76	0.81
R1224yd(Z)	1.09	1.25	1.43	1.59
R1233zd(E)	1.02	1.16	1.31	1.45
R1336mzz(Z)	1.12	1.29	1.49	1.68

Table 9-4 (SI) Relief device refrigerant capacity factors, f, kg/[m²·s]

	Design Pressure (kPa, gauge)			
Refrigerant	100	350	700	1000
R11	0.086	0.096	0.107	0.116
R113	0.098	0.112	0.128	0.141
R114	0.101	0.116	0.133	0.146
R123	0.089	0.101	0.115	0.125
R124	0.089	0.102	0.115	0.126
R142b	0.077	0.087	0.098	0.106
R245fa	0.080	0.092	0.104	0.114
R600	0.060	0.068	0.077	0.084
R600a	0.062	0.071	0.080	0.088
R718	0.0195	0.021	0.023	0.023
R764	0.052	0.057	0.062	0.066
R1224yd(Z)	0.089	0.102	0.117	0.128
R1233zd(E)	0.083	0.094	0.107	0.117
R1336mzz(Z)	0.091	0.105	0.121	0.135

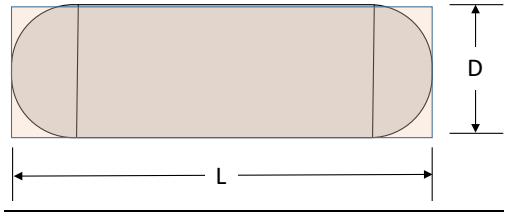
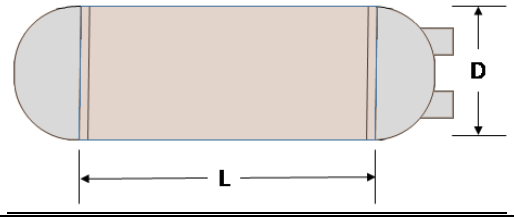
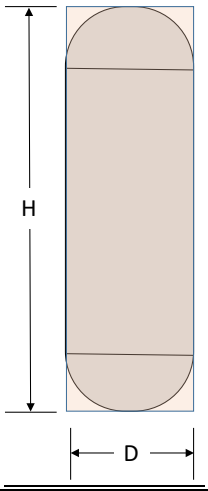
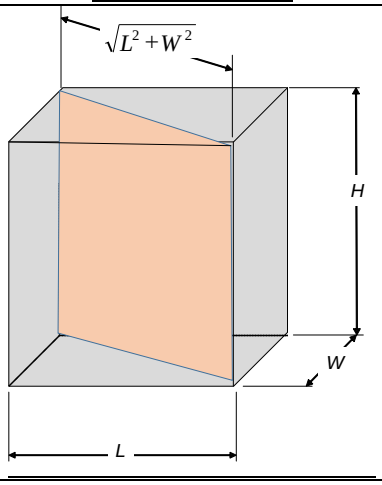
Table 9-5 (I-P) Relief device refrigerant capacity factors, f, lb/[ft²·min]

	Design Pressure (psi, gauge)							
Refrigerant	100	300	400	500	600	700	800	850
R744	0.75	0.93	1.01	1.09	1.18	1.30	1.48	1.63

Table 9-6 (SI) Relief device refrigerant capacity factors, f, kg/[m²·s]

	Design Pressure (kPa, gauge)											
Refrigerant	700	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	5900
R744	0.061	0.065	0.070	0.075	0.080	0.084	0.089	0.095	0.101	0.109	0.120	0.134

Figure 9-1, External Projected Area Examples for Common Pressure Equipment

Component	Example	Area
Pressure vessel, horizontal, without waterboxes		$A = D \cdot L$
Pressure vessel, horizontal, with waterboxes		$A = D \cdot L$
Pressure vessel, vertical		$A = D \cdot H$
Plate heat exchanger		$A = \sqrt{L^2 + W^2} \cdot H$

Informative Table ~~9-2~~ 9-7 Atmospheric Pressure at Nominal Installation Elevation (P_a)