YK Refrigerant Relief Valve Vent Sizing

APPLICATION DATA	Supersedes: 160.73-AD1	Form 160.73-AD1

The ASHRAE-15 Safety Standard for Refrigeration Systems provides guidelines for sizing refrigerant relief valves and vent piping. Without attempting to provide a complete and thorough interpretation, this document provides the necessary data to properly determine piping requirements.

Relief Valve Sizing

YORK YK Mod F units are supplied with pressure relieving devices which are properly sized, selected, and installed on each unit. Owners, facility managers, or consulting engineers need relief valve rated discharge capacities [Cr] to adequately size relief vent piping from the chiller. ASHRAE 15-2004, Section 9.4, provides guidelines for selecting the type of pressure-relief protection (relief valves, rupture discs, or fusible plugs) and Section 9.7 provides the criteria for properly sizing the relief valve and vent piping from the chiller.

Section 9.7.5 defines the **minimum required discharge capacity [C]** of the relief device as:

$$C = f\,DL \qquad \text{[lbs. of air per minute (kg/s)]} \qquad \text{Eq. 1}$$

Where:

f = factor dependent upon type of refrigerant {= 1.6 for R-134a},
D = outside diameter of vessel in feet (m), and
L = length of vessel in feet (m)

Notes: 1) When combustible materials are used within 20 ft. (6.1 m) of a pressure vessel, multiply the value of f (or C as provided in tabular form) 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.

The rated discharge capacities [Cr] for relief valves on York YK modification level F equipment are provided in Table I.

Section 9.7.6 specifies that the rated discharge capacity of each relief device shall be determined in accordance with the ASME Boiler and Pressure Vessel Code (paragraph UG-131, Section VIII, Division I) and that pipe and fittings between the pressure-relief valve and the parts of the system it protects shall have at least the area of the pressure-relief valve inlet area. Section 9.7.2.3 requires vessels or systems with refrigerant capacity greater than 10 cubic feet be provided with one or more rupture member(s) or a dual relief valve assembly. A single relief valve is adequate for all vessels less than 10 cubic feet and low side vessels equipped with isolation valves. Additionally, every pressure vessel containing liquid refrigerant and that is capable of being isolated by stop valves requires over-pressure relief protection (Section 9.7.2).

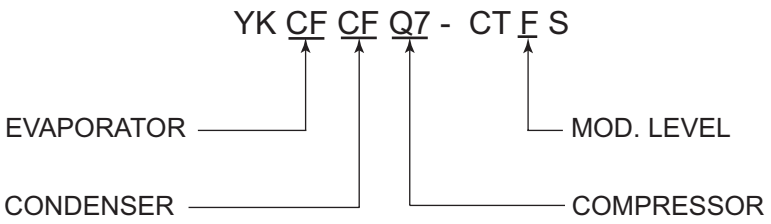
Table 1 – Refrigerant Relief Characteristics
YORK YK (Modification F) Chillers

Chiller Ordered:	Evaporator				Condenser		
	with isolation valves		w/o isolation valves		with or without isolation valves		
Shells	Single Relief Valves		Dual Relief Valves (2)		Shells	Dual Relief Valves (2)	
	Cr	Outlet Size	Cr	Outlet Size		Cr	Outlet Size
	#air/min	NPT	#air/min	NPT		#air/min	NPT
Machines with P & Q Compressors							
235 psig set pressure					**235 psig set pressure**		
A	91.8	1-1/4”	91.8	1-1/4”	A	55.9	1”
B	91.8	1-1/4”	91.8	1-1/4”	B	55.9	1”
C	91.8	1-1/4”	91.8	1-1/4”	C	91.8	1-1/4”
D	91.8	1-1/4”	91.8	1-1/4”	D	91.8	1-1/4”
E	91.8	1-1/4”	91.8	1-1/4”	E	91.8	1-1/4”
F	91.8	1-1/4”	91.8	1-1/4”	F	91.8	1-1/4”
G (1)	2 @ 55.9	1”	2 @ 55.9	1”	G	91.8	1-1/4”
H (1)	2 @ 55.9	1”	2 @ 55.9	1”	H	91.8	1-1/4”
Machines with H Compressors							
180 psig set pressure					**235 psig set pressure**		
E (1)	2 @ 43.5	1”	2 @ 43.5	1”	E	55.9	1”
F (1)	2 @ 43.5	1”	2 @ 43.5	1”	F	91.8	1-1/4”
G (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	G	91.8	1-1/4”
H (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”			
K (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	K	91.8	1-1/4”
L (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	L	91.8	1-1/4”
Machines with J Compressors							
180 psig set pressure					**235 psig set pressure**		
G (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	G	91.8	1-1/4”
H (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	H	91.8	1-1/4”
J (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	J	91.8	1-1/4”
T (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	T (1)	2 @ 55.9	1”
V (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	V (1)	2 @ 55.9	1”
W (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”	X (1)	1 @ 91.8	1-1/4”
X (1)	2 @ 71.4	1-1/4”	2 @ 71.4	1-1/4”		1 @ 55.9	1”
Y	173	1-1/2”	173	1-1/2”	Y (1)	2 @ 91.8	1-1/4”
Z	173	1-1/2”	173	1-1/2”	Z (1)	1 @ 91.8	1-1/4”
						1 @ 55.9	1”

Where: Cr = Rated capacity of York supplied relief valve(s).

Notes: (1) Evaporator shell sizes G & H (P compressors), E - X (H & J compressors), and condenser sizes T - Z have two valves in operation at all times. If the chiller is ordered with refrigerant isolation valves (optional), the chiller will be shipped with two single relief valves on the evaporator. If the chiller is ordered without refrigerant isolation valves (standard), the evaporator will be supplied with two dual valve assemblies (four evaporator relief valves total) with one valve of each dual assembly active at all times. In either case, two evaporator and two condenser relief valves must be considered when sizing the vent line(s).

(2) Dual relief valves consist of one three-way shut off valve and two single relief valves. The valve configuration will not allow both valves to be shut off at the same time, and valves are sized such that each relief valve has sufficient discharge capacity when used alone (line sizing should be based on the capacity of one valve for each dual relief assembly). This permits safe removal of either relief valve for repair or replacement, while maintaining vessel protection.



Vent Line Sizing

Piping. ASHRAE 15-2004, Section 9.7.8 outlines acceptable relief piping locations and sizing. Summarized, the relief piping should vent R-134a refrigerant at least 15 feet above ground level and at least 20 feet from any window, ventilation opening, or building exit. The discharge piping should prevent a discharged refrigerant from being sprayed directly on personnel and prevent foreign material or debris from entering the piping. Additionally, discharge piping for a fusible plug or rupture disc shall have provisions to prevent plugging the pipe in the event of a discharge by the plug or disc.

As indicated in YORK Installation Instructions (Form 160.73-N1), each vent line must contain a dirt trap in the vertical section to allow collection and removal for any stack condensation or debris. The piping MUST be arranged to avoid strain on the relief valves – *YORK recommends the use of a flexible connector*. The vent line should be sized in accordance with ANSI/ASHRAE 15, and local code, *but should never be smaller than relief valve outlet sizes provided in Table I.*

Common Header. Section 9.7.8.4 allows for multiple relief devices (on the same or multiple units) to be connected into a common line or header. The sizing of the common discharge header and vent piping for relief devices expected to operate simultaneously shall be based on the sum of their outlet areas, with due allowance for the pressure drop in all downstream sections and back-pressure resulting from the discharge of multiple relief devices.

Maximum Length. Section 9.7.8.5 and Appendix H define the maximum length of discharge piping downstream of the pressure-relief device as:

$$L = \frac{0.2146 d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d * \ln(P_0 / P_2)}{6 f} \qquad \text{[feet]} \qquad \text{Eq.(2)a}$$

$$\left[L = \frac{7.4381 \times 10^{-15} d^5 (P_0^2 - P_2^2)}{f C_r^2} - \frac{d * \ln(P_0 / P_2)}{500 f} \right] \qquad \text{[meters]} \qquad \text{Eq.(2)b}$$

Where:

L = equivalent length of discharge piping, ft (m);
C_r = rated capacity as stamped on the device in lb/min (kg/s);
f = Moody friction factor in fully turbulent flow (see Table III);
d = inside diameter of pipe or tube, in (mm);
ln = natural logarithm;
P_2 = absolute pressure at outlet of discharge piping, psi (kPa);
P_0 = allowed back pressure (absolute) at the outlet of pressure release device, psi (kPa)
= (0.15 x relief valve set pressure + atmospheric pressure)

For YK mod F equipment:
P_0 = 41.7 for 180 psig set pressure or
P_0 = 50.0 for 235 psig set pressure

The ASHRAE 15 User's Manual provides that, when the length of vent pipe exceeds approximately 220 diameters (L/d > 220), the first term in equation (2)a or (2)b may be used to solve for the diameter, d.

$$d = 1.36 * \left(\frac{fLC_r^2}{P_0^2 - P_2^2} \right)^{0.2} \quad \text{[inches]} \quad \text{Eq. (3)a}$$

$$\left[d = 2521 * \left(\frac{fLC_r^2}{P_0^2 - P_2^2} \right)^{0.2} \right] \quad \text{[millimeters]} \quad \text{Eq. (3)b}$$

An average friction factor f = 0.02 may be used when the pipe size is not known.

Table II lists the maximum lengths of vent piping for various YK relief valve capacities and pipe sizes vented to atmosphere.

Note: This document is to be used only as a guideline for estimating and is subject to changes made in standard ASHRAE 15 or overriding local code.

Table II -- Maximum Length [feet] of Discharge Piping.

Rated Relief Valve Capacity, Cr (lb. air / min.)	Relief Valve Pressure Setting, PSIG											
	180						235					
	Nominal pipe size, inches (calculations based on sch. 40 pipe)											
	1-1/4	1-1/2	2	2-1/2	3	4	1-1/4	1-1/2	2	2-1/2	3	4
43.5	30	79	324	847								
55.9							24	68	289	761		
71.4	4	20	108	300	976							
87.0		9	67	194	648							
91.8								15	93	265	876	
112								5	55	169	576	
143			13	57	220	994			25	93	340	
148									22	85	315	
173			3	31	141	666						
179									8	49	204	940
184									7	45	191	887
204									1	32	148	712
235										17	103	524
255										10	82	438
291										1	55	324
321											38	258
357											24	199

Table III - Steel Pipe Dimensions (Sch. 40)

	Nominal Pipe Size (in)								
	1	**1-1/4**	**1-1/2**	**2**	**2-1/2**	**3**	**4**	**5**	**6**
I. D. (in)	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	6.065
Friction Factor	0.0225	0.0209	0.0202	0.0190	0.0182	0.0173	0.0163	0.0155	0.0149

Example 1: ***Maximum length -- Single vent line per relief valve.***

(1) YKDGDFP6-CHF is to be installed in the equipment room. The relief valves will be vented to atmosphere, using standard schedule 40 pipe, at a distance 40 feet from the valves.

Solution:

From Table I: C_r = 91.8 lbs. of air / min for each relief valve
P_0 = (rated pressure x 0.15)+14.7 = (235) (0.15)+14.7 = 50.0 PSIA
P_2 = 14.7 PSIA
Valve outlet size = 1-1/4”

Using Table II, scan down the first column to find the Rated Discharge Capacity [C_r] of 91.8. Next, follow that row across to intersect a 235 PSIG set pressure column with a length that meets or exceeds the 40 feet requirement. The first intersection (for 1-1/2” diameter pipe) has a value of 15 feet, which does not meet the 40 feet minimum requirement. At the next intersection, we find that 2” diameter pipe is good for a maximum of 93 feet, which satisfies the job requirements.

Alternatively, since L/d > 220, equation (3) may be used, assuming f = 0.02. The required pipe diameter is given by:

$$d = 1.36 * \left(\frac{fLC^2}{P_0^2 - P_2^2} \right)^{0.2} = 1.36 * \left(\frac{(0.02)(40)(91.8)^2}{50.0^2 - 14.7^2} \right)^{0.2} = 1.689"$$

From Table III, we see that 2” diameter pipe is the smallest size having an inside diameter of 1.689” or more.

Example 2: ***Maximum length – Common header vent line.***

(1) YKWFVCJ4-DHE is to be installed in the equipment room. The relief valves will be vented to atmosphere, using standard schedule 40 pipe, at a distance 70 feet from the valves.

Solution:

From Table I:
W evaporator has two 1-1/4” valves, 71.4 lbs of air/min each valve, 180 psig set pressure.
V condenser has two (dual) 1” valves, 55.9 lbs of air/min each valve, 235 psig set pressure.

The minimum line size of a common header application is based on the **sum of the relief device discharge areas and the sum of the rated discharge *capacities*.**

First, sum the discharge areas of the relief valves using actual I.D. values from Table III:

$$\Sigma \pi r^2 = \Sigma 0.25\pi d^2 = 0.25\pi (\Sigma d^2)$$

$$\Sigma d^2 = (1.380^2 + 1.380^2 + 1.049^2 + 1.049^2) = 6.01$$

$$d_{(min)} = (6.01)^{1/2} = 2.45”$$

From Table III, we see that 2-1/2” pipe (2.469” I.D.) is the minimum size which meets or exceeds the sum of the relief valve discharge areas.

Next, sum the rated discharge capacities [C_r] to determine required flow capacity.

$$C_r(\text{sum}) = 2\ (71.8) + 2\ (55.9) = 255.4 \text{ lb. air / min}$$

NOTE: Evaporator relief valves are sized such that gas will be discharged fast enough to prevent vessel damage at the discharge pressure. Therefore, refrigerant will be discharged from the evaporator prior to system pressure reaching 235 psig (condenser relief valve set pressure) in a fire condition. It is conservative to use the cumulative rated discharge capacities at the *higher* pressure.

Using Table II, scan down the first column to find the Rated Discharge Capacity [C_r] of 255. Next, follow that row across to intersect a 235 PSIG set pressure column with a length that meets or exceeds the 70' feet requirement. The first intersection (for 2-1/2" diameter pipe) has a value of 10 feet, which does not meet the 70 feet minimum requirement. At the next intersection, we find that 3" diameter pipe is good for a maximum of 82 feet, which satisfies the job requirements.

Alternatively, since L/d > 220, equation (3) may be used, assuming f = 0.02:

$$d = 1.36 * \left(\frac{fLC^2}{P_0^2 - P_2^2} \right)^{0.2} = 1.36 * \left(\frac{(0.02)(70)(255.4)^2}{50.0^2 - 14.7^2} \right)^{0.2} = 2.844"$$

From Table III, we see that 3" diameter pipe is the smallest size having an inside diameter of 2.844" or more.

Other Methods:

Equation (2) can be used to calculate the maximum length of vent piping for any relief valve rating and pipe or tubing diameter. Table 3 in ASHRAE 15-2004 also lists flow capacities for various set pressures and line lengths.

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