Opteon™

Chemours™

Refrigerant Piping Handbook

Acknowledgments

We would like to acknowledge the work of Garth Denison for his decades of service to the HVACR industry and in helping to lay the foundation for this handbook.

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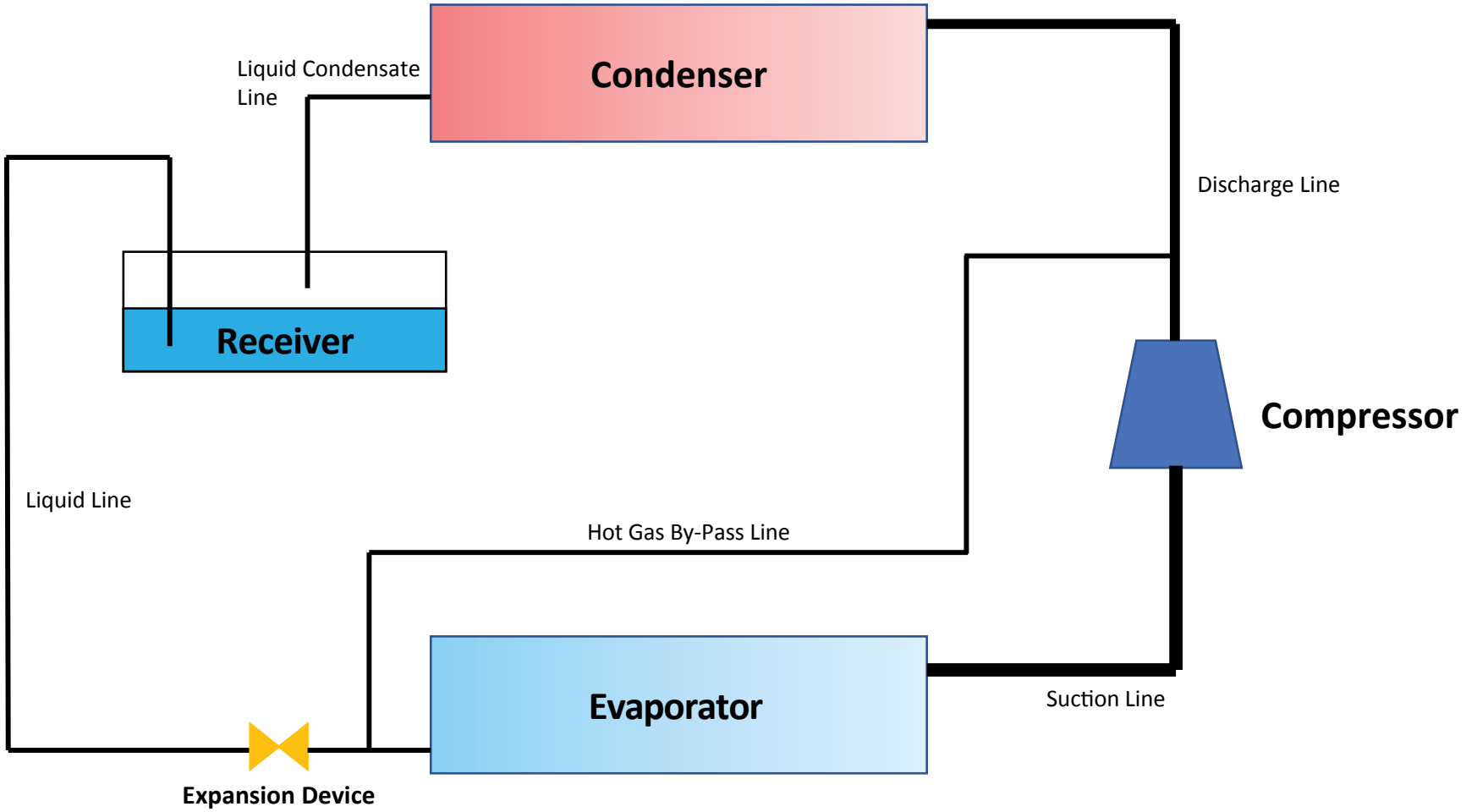
Refrigerant Line Identification



Design Goals

Common practice -> size the suction, discharge, and liquid lines for a 2 °F, 1 °F, and fixed velocity pressure drop at design capacity, respectively

Suction Line Must:

- Ensure proper oil return
- Prevent oil from draining to an idle evaporator
- Dampen line vibrations and noise from compressor
- Minimize line sweating from condensation
- Prevent unnecessary heat gain into the refrigerant

Discharge Line Must:

- Avoid oil trapping at minimum capacity
- Prevent backflow of oil or liquid refrigerant to the compressor during low capacity or shutdown
- Dampen line vibration and noise caused by gas pulsations and compressor vibration

Liquid Line Must Prevent:

- Formation of flash gas upstream of the metering device, unless piping is designed for it i.e., sewer venting
- Heat gain to the refrigerant

Target Velocity Ranges
Suction: 900 – 4000 ft/min; Discharge: 2000-3500 ft/min; Liquid: 100 ft/min or less

Design Goals

Other piping lines…

Hot Gas Defrost Line Must:

- Maintain Sufficient refrigerant flow rate
- Velocities determined at saturated conditions will be conservative in line size
- Be properly sized to handle calculated needed hot gas load -> based on twice the evaporator flow rate
- Prevent condensed liquid refrigerant from backflow to compressor

Refrigerant Condensate Line Must:

- Provide sewer-type flow -> free draining of liquid refrigerant in one direction, while refrigerant vapor flows adjacent in the other direction via the condensate line or separate equalization line

Considerations and Assumptions

- System design for MINIMUM pressure drop
  - Pressure drops result in…
    - Decrease in thermal capacity
    - Increase in power requirements
- Refrigerant being piped DOES NOT change state
- Lubricants are miscible with refrigerants
  - Minimize the accumulation of liquid refrigerant in compressor crankcase
  - Oil returns to compressor at same rate it leaves

Code Regulations

Design should conform to all necessary codes, laws, and regulations that apply at the site of the installation

Examples include…

- Mechanical Codes
- Fire Codes
- State, Local, Municipal codes
- ASHRAE 15
- UL Standards

General Design Principles

- Ensure proper feed to evaporators
- Find a balance between line size and pressure drop
- Protect compressor by…
  - Preventing excessive oil from being trapped in system
  - Minimizing oil loss from the compressor
  - Preventing liquid refrigerant or oil from entering the compressor while operating or while on the off cycle
  - Maintaining a clean and dry system

Capacity vs Line Pressure Drop

Vapor Lines

Effect of Gas Line Pressure Drops Compressor Capacity and Power

Line Loss °F	R-410A Vol Capacity (%)	R-410A Energy (HP/Ton %)	R-454B Vol Capacity (%)	R-454B Energy (HP/Ton %)
Suction Line				
0	100	100	100	100
2	96.4	104.0	96.4	104.0
4	92.9	108.1	92.9	108.1
Discharge Line				
0	100	100	100	100
2	98.8	104.0	98.8	104.0
4	97.7	108.2	97.7	108.2

Liquid Lines

Pressure drop not as critical as in vapor lines

Pressure drop should not cause…

- Vapor formation in line
- Insufficient liquid pressure at expansion device

Typical liquid line pressure drop no greater than 1 °F change in saturated refrigerant temperature

Equivalent Lengths

Nominal Pipe Size (in)	Globe	Angle	90° Std	90° LR	45° Std	Sudden Enlargement, d/D			Sudden Contraction, d/D		
						1/4	1/2	3/4	1/4	1/2	3/4
						→ d D →			→ D d →		
3/8	17	6	1.4	0.9	0.7	1.4	0.8	0.3	0.7	0.5	0.3
1/2	18	7	1.6	1.0	0.8	1.8	1.1	0.4	0.9	0.7	0.4
3/4	22	9	2.0	1.4	0.9	2.5	1.5	0.5	1.2	1.0	0.5
1	29	12	2.6	1.7	1.3	3.2	2.0	0.7	1.6	1.2	0.7
1 1/4	38	15	3.3	2.3	1.7	4.7	3.0	1.0	2.3	1.8	1.0
1 1/2	43	18	4.0	2.6	2.1	5.8	3.6	1.2	2.9	2.2	1.2
2	55	24	5.0	3.3	2.6	8.0	4.8	1.6	4.0	3.0	1.6
2 1/2	69	29	6.0	4.1	3.2	10.0	6.1	2.0	5.0	3.8	2.0
3	84	35	7.5	5.0	4.0	13.0	8.0	2.6	6.5	4.9	2.6
3 1/2	100	41	9.0	5.9	4.7	15.0	9.2	3.0	7.7	6.0	3.0

2022 ASHRAE Handbook: Refrigeration

Copper Tubing Specification

Nominal or standard size, inches	Type	Diameter		Flow Area (in²)	Weight of tube only (pounds/ linear ft.)
		OD (in)	ID (in)		
1/4	K L	0.375 0.375	0.305 0.315	0.073 0.078	0.145 0.126
3/8	K L	0.500 0.500	0.402 0.430	0.127 0.145	0.269 0.198
1/2	K L	0.625 0.625	0.527 0.545	0.218 0.233	0.344 0.285
5/8	K L	0.750 0.750	0.652 0.666	0.334 0.348	0.418 0.362
3/4	K L	0.875 0.875	0.745 0.785	0.436 0.484	0.641 0.455
1	K L	1.125 1.125	0.995 1.025	0.778 0.825	0.839 0.655
1 1/4	K L	1.375 1.375	1.245 1.265	1.22 1.26	1.040 0.884
1 1/2	K L	1.625 1.625	1.481 1.505	1.72 1.78	1.36 1.14
2	K L	2.125 2.125	1.959 1.985	3.01 3.10	2.06 1.75
2 1/2	K L	2.625 2.625	2.435 2.465	4.66 4.77	2.93 2.48
3	K L	3.125 3.125	2.907 2.945	6.64 6.81	4.00 3.33
3 1/2	K L	3.625 3.625	3.385 3.425	9.00 9.21	5.12 4.29
4	K L	4.125 4.125	3.557 3.905	11.7 12.0	6.51 5.38

Taken from the "Copper Tube Handbook" by the Copper Development Association
https://www.copper.org/publications/pub_list/pdf/copper_tube_handbook.pdf

Weight of Refrigerant in Copper Tubing

Tube O.D.		Flow Area (in^2)	ft³/ 100 ft	Opteon™ XL10 R-1234YF 68.17¹ L	Opteon™ XL10 R-1234YF 2.37² V	Opteon™ XL20 R-454C 65.08 L	Opteon™ XL20 R-454C 2.78 V	Opteon™ XL40 R-454A 63.73 L	Opteon™ XL40 R-454A 3.00 V	Opteon™ XL41 R-454B 61.65 L	Opteon™ XL41 R-454B 3.17 V	Opteon™ XP10 R-513A 70.81 L	Opteon™ XP10 R-513A 2.35 V	Opteon™ XP40 R-449A 68.49 L	Opteon™ XP40 R-449A 3.08 V	Opteon™ XP44 R-452A 70.26 L	Opteon™ XP44 R-452A 4.00 V
1/2	K	0.127	0.088	6.0	0.21	5.7	0.24	5.6	0.26	5.4	0.28	6.2	0.21	6.0	0.27	6.2	0.35
	L	0.145	0.101	6.9	0.24	6.6	0.28	6.4	0.30	6.2	0.32	7.1	0.24	6.9	0.31	7.1	0.40
5/8	K	0.218	0.151	10.3	0.36	9.9	0.42	9.6	0.45	9.3	0.48	10.7	0.36	10.4	0.47	10.6	0.61
	L	0.233	0.162	11.0	0.38	10.5	0.45	10.3	0.49	10.0	0.51	11.5	0.38	11.1	0.50	11.4	0.65
3/4	K	0.334	0.232	15.8	0.55	15.1	0.64	14.8	0.70	14.3	0.73	16.4	0.54	15.9	0.71	16.3	0.93
	L	0.348	0.242	16.5	0.57	15.7	0.67	15.4	0.73	14.9	0.77	17.1	0.57	16.6	0.74	17.0	0.97
7/8	K	0.436	0.303	20.6	0.72	19.7	0.84	19.3	0.91	18.7	0.96	21.4	0.71	20.7	0.93	21.3	1.21
	L	0.484	0.336	22.9	0.80	21.9	0.93	21.4	1.01	20.7	1.06	23.8	0.79	23.0	1.03	23.6	1.34
1 1/8	K	0.778	0.540	36.8	1.28	35.2	1.50	34.4	1.62	33.3	1.71	38.3	1.27	37.0	1.66	38.0	2.16
	L	0.825	0.573	39.1	1.36	37.3	1.59	36.5	1.72	35.3	1.81	40.6	1.35	39.2	1.76	40.3	2.29
1 3/8	K	1.217	0.845	57.6	2.00	55.0	2.35	53.9	2.54	52.1	2.68	59.8	1.99	57.9	2.60	59.4	3.38
	L	1.257	0.873	59.5	2.07	56.8	2.42	55.6	2.62	53.8	2.76	61.8	2.05	59.8	2.69	61.3	3.49
1 5/8	K	1.723	1.197	81.6	2.83	77.9	3.32	76.3	3.59	73.8	3.79	84.7	2.81	81.9	3.68	84.1	4.79
	L	1.779	1.235	84.2	2.92	80.4	3.43	78.7	3.71	76.2	3.91	87.5	2.90	84.6	3.80	86.8	4.94
2 1/8	K	3.014	2.093	142.7	4.96	136.2	5.81	133.4	6.29	129.0	6.63	148.2	4.92	143.3	6.44	147.1	8.37
	L	3.095	2.149	146.5	5.09	139.9	5.96	137.0	6.46	132.5	6.81	152.2	5.05	147.2	6.62	151.0	8.60
2 5/8	K	4.657	3.234	220.4	7.66	210.5	8.97	206.1	9.71	199.4	10.24	229.0	7.60	221.5	9.96	227.2	12.93
	L	4.772	3.314	225.9	7.85	215.7	9.20	211.2	9.95	204.3	10.49	234.6	7.78	227.0	10.20	232.8	13.25
3 1/8	K	6.637	4.609	314.2	10.91	299.9	12.79	293.7	13.84	284.1	14.59	326.3	10.83	315.7	14.19	323.8	18.43
	L	6.812	4.731	322.5	11.20	307.9	13.13	301.5	14.21	291.6	14.98	334.9	11.11	324.0	14.57	332.4	18.92
3 5/8	K	8.999	6.249	426.0	14.80	406.7	17.34	398.3	18.77	385.3	19.79	442.5	14.68	428.0	19.24	439.1	24.99
	L	9.213	6.398	436.1	15.15	416.4	17.75	407.7	19.21	394.4	20.26	453.0	15.03	438.2	19.70	449.5	25.59
4 1/8	K	11.684	8.114	553.1	19.21	528.0	22.52	517.1	24.37	500.2	25.69	574.5	19.06	555.7	24.98	570.1	32.45
	L	11.977	8.317	567.0	19.69	541.3	23.08	530.1	24.98	512.7	26.34	588.9	19.54	569.6	25.61	584.4	33.27

L = Saturated Liquid (lbs)
V = Saturated Vapor (lbs)
1 = Saturated Liquid Density (lbs/ft³)
2 = Saturated Vapor Density (lbs/ft³)
*All weights and densities are calculated at 77°F (25°C)
** The weights in the table are for the refrigerant only, not the refrigerant and tubing

Refrigerant Receivers

R-410A capacities at 80% Full at 90 °F
Density of R-410A at 90 F = 63.719 lbs/ft³

Vertical Receivers

(R-410A capacity in lbs)

Diameter		Length		Lbs
3.5	x	7.5	=	2
3.5	x	10	=	3
4	x	10	=	4
5	x	10	=	6
5	x	20	=	12
6	x	12	=	10
6	x	18	=	15
6	x	24	=	20
6	x	30	=	25

Horizontal Receivers

(R-410A capacity in lbs)

Diameter		Length		Lbs	Diameter		Length		Lbs	Diameter		Length		Lbs
5	x	28	=	16	9 3/4	x	22	=	48	14	x	72	=	327
										14	x	96	=	436
6	x	30	=	25	10 3/4	x	36	=	96					
6	x	36	=	30	10 3/4	x	48	=	129	16	x	60	=	356
					10 3/4	x	60	=	161	16	x	72	=	427
6 5/8	x	38	=	39	10 3/4	x	72	=	193	16	x	96	=	569
					10 3/4	x	96	=	257					
7 5/8	x	28	=	38						18	x	72	=	540
					12 3/4	x	48	=	181					
8 5/8	x	28	=	48	12 3/4	x	60	=	226	20	x	72	=	667
8 5/8	x	36	=	62	12 3/4	x	72	=	271	20	x	94	=	871
8 5/8	x	42	=	72	12 3/4	x	96	=	362	20	x	96	=	1890
8 5/8	x	48	=	83										
8 5/8	x	60	=	103										

For other Freon™ and Opteon™ storage capacities, multiple the rated capacity in the table above by the following conversion factors...

R-410A ... 1.0000	R-449A (XP40) ... 1.0423	R-454A (XL40) ... 0.9689
R-404A ... 0.9875	R-513A (XP10) ... 1.0836	R-454B (XL41) ... 0..9331
R-134a ... 1.1548	R-452A (XP44) ... 1.0659	R-454C (XL20) ... 0..9912
R-407C ... 1.0828	R-449C (XP20) ... 1.0484	R-1234yf (XL10) ... 1.0432

Example: An R-410A horizontal receiver measures 9 3/4" x 22", what would the revised capacity be with R-454B?
Answer: R-410A capacity for 9 3/4" x 22" is 48 lbs -> 48 lbs x 0.9331 = 44.8 lbs

Opteon™ XP PT Charts

Medium Temp Applications

Pressures in PSIG

°F	Incumbent Refrigerant Freon™ 134a R-134a	Replacement Refrigerant R-513A Opteon™ XP10	°C
-40	-7.3	-5.7	-40
-35	-6.1	-4.4	-37
-30	-4.8	-2.9	-34
-25	-3.4	-1.4	-32
-20	-1.8	0.4	-29
-15	0.0	2.3	-26
-10	1.9	4.4	-23
-5	4.1	6.7	-21
0	6.5	9.2	-18
5	9.1	12.0	-15
10	11.9	14.9	-12
15	15.0	18.1	-9
20	18.4	21.6	-7
25	22.1	25.4	-4
30	26.1	29.4	-1
35	30.4	33.8	2
40	35.0	38.4	4
45	40.1	43.4	7
50	45.4	48.8	10
55	51.2	54.5	13
60	57.4	60.6	16
65	64.0	67.0	18
70	71.1	73.9	21
75	78.7	81.3	24
80	86.7	89.0	27
85	95.2	97.2	29
90	104.3	105.9	32
95	113.9	115.1	35
100	124.2	124.9	38
105	135.0	135.1	41
110	146.4	145.9	43
115	158.4	157.3	46
120	171.2	169.2	49
125	184.6	181.8	52
130	198.7	195.0	54
135	213.6	208.9	57
140	229.2	223.4	60

Low & Medium Temp Applications

Pressures in PSIG (R400 series refrigerants contain bubble and dew point pressures)

°F	Incumbent Refrigerant R-404A Freon™ 404A		Replacement Refrigerants R-452A Opteon™ XP44		R-449A Opteon™ XP40		°C
	Liquid (Bubble)	Vapor (Dew)	Liquid (Bubble)	Vapor (Dew)	Liquid (Bubble)	Vapor (Dew)	
-40	4.9	4.3	5.7	2.4	4.5	0.0	-40
-35	7.5	6.8	8.3	4.7	7.1	2.1	-37
-30	10.3	9.6	11.3	7.3	9.9	4.4	-34
-25	13.4	12.7	14.6	10.1	13.0	7.0	-32
-20	16.8	16.0	18.1	13.2	16.4	9.9	-29
-15	20.5	19.7	22.0	16.7	20.1	13.0	-26
-10	24.6	23.6	26.2	20.4	24.2	16.4	-23
-5	28.9	27.9	30.8	24.4	28.6	20.2	-21
0	33.7	32.6	35.7	28.9	33.4	24.3	-18
5	38.8	37.7	41.1	33.7	38.5	28.7	-15
10	44.3	43.1	46.9	38.8	44.1	33.5	-12
15	50.2	49.0	53.1	44.4	50.1	38.8	-9
20	56.6	55.3	59.8	50.5	56.6	44.5	-7
25	63.4	62.1	66.9	57.0	63.5	50.6	-4
30	70.7	69.3	74.6	64.0	70.9	57.1	-1
35	78.6	77.1	82.8	71.4	78.9	64.2	2
40	86.9	85.4	91.5	79.4	87.4	71.8	4
45	95.8	94.2	100.9	88.0	96.4	80.0	7
50	105.3	103.6	110.8	97.1	106.1	88.7	10
55	115.3	113.6	121.3	106.9	116.3	98.0	13
60	126.0	124.2	132.4	117.3	127.2	107.9	16
65	137.3	135.5	144.3	128.3	138.8	118.5	18
70	149.3	147.4	156.8	140.0	151.0	129.7	21
75	162.0	160.1	170.0	152.4	163.9	141.7	24
80	175.4	173.4	183.9	165.6	177.6	154.3	27
85	189.5	187.5	198.6	179.5	192.0	167.8	29
90	204.5	202.4	214.1	194.3	207.2	182.0	32
95	220.2	218.1	230.4	209.9	223.2	197.1	35
100	236.8	234.6	247.6	226.4	240.1	213.1	38
105	254.2	252.0	265.6	243.7	257.8	229.9	41
110	272.5	270.4	284.5	262.1	276.4	247.7	43
115	291.8	289.6	304.3	281.4	295.9	266.5	46
120	312.0	309.9	325.1	301.8	316.3	286.3	49
125	333.3	331.2	346.8	323.3	337.8	307.2	52
130	355.6	353.5	369.6	345.9	360.2	329.2	54
135	379.1	377.0	393.4	369.8	383.7	352.4	57
140	403.7	401.7	418.3	395.0	408.3	376.8	60

Opteon™ XP PT Charts

Automotive AC

Pressures in PSIG

°F	Incumbent Refrigerant Freon™ 134a R-134a	Replacement Refrigerant Opteon™ XL10 R-1234yf	°C
-40	-7.3	-5.7	-40
-35	-6.1	-4.4	-37
-30	-4.8	-2.9	-34
-25	-3.4	-1.4	-32
-20	-1.8	0.4	-29
-15	0.0	2.3	-26
-10	1.9	4.4	-23
-5	4.1	6.7	-21
0	6.5	9.2	-18
5	9.1	12.0	-15
10	11.9	14.9	-12
15	15.0	18.1	-9
20	18.4	21.6	-7
25	22.1	25.4	-4
30	26.1	29.4	-1
35	30.4	33.8	2
40	35.0	38.4	4
45	40.1	43.4	7
50	45.4	48.8	10
55	51.2	54.5	13
60	57.4	60.6	16
65	64.0	67.0	18
70	71.1	73.9	21
75	78.7	81.3	24
80	86.7	89.0	27
85	95.2	97.2	29
90	104.3	105.9	32
95	113.9	115.1	35
100	124.2	124.9	38
105	135.0	135.1	41
110	146.4	145.9	43
115	158.4	157.3	46
120	171.2	169.2	49
125	184.6	181.8	52
130	198.7	195.0	54
135	213.6	208.9	57
140	229.2	223.4	60

New Low & Medium Temp Commercial Applications

Pressures in PSIG (R400 series refrigerants contain bubble and dew point pressures)

°F	Incumbent Refrigerant R-404A Freon™ 404A		Replacement Refrigerants Opteon™ XL20 R-454C		Opteon™ XL40 R-454A		°C
	Liquid (Bubble)	Vapor (Dew)	Liquid (Bubble)	Vapor (Dew)	Liquid (Bubble)	Vapor (Dew)	
-40	4.9	4.3	4.3	-1.5	6.5	1.6	-40
-35	7.5	6.8	6.8	0.4	9.3	3.9	-37
-30	10.3	9.6	9.5	2.4	12.3	6.4	-34
-25	13.4	12.7	12.4	4.7	15.7	9.1	-32
-20	16.8	16.0	15.7	7.2	19.3	12.1	-29
-15	20.5	19.7	19.2	10.0	23.3	15.5	-26
-10	24.6	23.6	23.1	13.0	27.6	19.1	-23
-5	28.9	27.9	27.3	16.3	32.3	23.0	-21
0	33.7	32.6	31.8	19.9	37.4	27.3	-18
5	38.8	37.7	36.7	23.8	42.9	32.0	-15
10	44.3	43.1	41.9	28.0	48.8	37.1	-12
15	50.2	49.0	47.6	32.6	55.2	42.6	-9
20	56.6	55.3	53.6	37.6	62.0	48.5	-7
25	63.4	62.1	60.1	42.9	69.4	54.9	-4
30	70.7	69.3	67.1	48.7	77.2	61.7	-1
35	78.6	77.1	74.5	54.9	85.6	69.1	2
40	86.9	85.4	82.4	61.5	94.6	76.9	4
45	95.8	94.2	90.8	68.6	104.1	85.4	7
50	105.3	103.6	99.7	76.3	114.2	94.4	10
55	115.3	113.6	109.2	84.4	125.0	104.0	13
60	126.0	124.2	119.3	93.1	136.4	114.2	16
65	137.3	135.5	129.9	102.3	148.4	125.1	18
70	149.3	147.4	141.2	112.2	161.2	136.7	21
75	162.0	160.1	153.0	122.6	174.7	149.0	24
80	175.4	173.4	165.6	133.7	188.9	162.1	27
85	189.5	187.5	178.8	145.5	203.9	175.9	29
90	204.5	202.4	192.6	158.0	219.7	190.6	32
95	220.2	218.1	207.2	171.2	236.4	206.0	35
100	236.8	234.6	222.5	185.1	253.8	222.4	38
105	254.2	252.0	238.6	199.9	272.2	239.7	41
110	272.5	270.4	255.5	215.5	291.4	258.0	43
115	291.8	289.6	273.1	232.0	311.6	277.2	46
120	312.0	309.9	291.6	249.3	332.7	297.5	49
125	333.3	331.2	310.8	267.7	354.9	319.0	52
130	355.6	353.5	331.0	287.0	378.0	341.5	54
135	379.1	377.0	352.0	307.3	402.1	365.3	57
140	403.7	401.7	373.9	328.8	427.4	390.4	60

New Residential/Commercial AC

Pressures in PSIG (R400 series refrigerants contain bubble and dew point pressures)

°F	Incumbent Refrigerant R-410A Freon™ 410A		Opteon™ XL41 R-454B		°C
	Liquid (Bubble)	Vapor (Dew)	Liquid (Bubble)	Vapor (Dew)	
-40	10.8	10.7	9.5	8.4	-40
-35	14.1	14.0	12.7	11.4	-37
-30	17.8	17.7	16.2	14.8	-34
-25	21.9	21.8	20.1	18.5	-32
-20	26.3	26.2	24.3	22.6	-29
-15	31.2	31.0	28.9	27.0	-26
-10	36.5	36.3	33.9	31.8	-23
-5	42.2	42.0	39.4	37.0	-21
0	48.4	48.2	45.3	42.7	-18
5	55.2	54.9	51.7	48.8	-15
10	62.4	62.2	58.5	55.4	-12
15	70.3	70.0	66.0	62.6	-9
20	78.7	78.4	73.9	70.3	-7
25	87.7	87.4	82.5	78.5	-4
30	97.4	97.0	91.7	87.4	-1
35	107.7	107.3	101.5	96.9	2
40	118.8	118.4	112.0	107.0	4
45	130.6	130.1	123.1	117.8	7
50	143.2	142.6	135.0	129.3	10
55	156.5	156.0	147.7	141.6	13
60	170.7	170.1	161.1	154.6	16
65	185.8	185.1	175.4	168.5	18
70	201.8	201.1	190.5	183.1	21
75	218.7	217.9	206.5	198.7	24
80	236.5	235.8	223.4	215.2	27
85	255.4	254.6	241.2	232.6	29
90	275.4	274.5	260.0	251.0	32
95	296.4	295.5	279.9	270.4	35
100	318.5	317.6	300.8	290.9	38
105	341.9	340.9	322.8	312.5	41
110	366.4	365.4	345.9	335.2	43
115	392.3	391.2	370.2	359.1	46
120	419.4	418.3	395.7	384.3	49
125	447.9	446.8	422.4	410.8	52
130	477.9	476.8	450.5	438.7	54
135	509.4	508.3	479.9	468.0	57
140	542.5	541.4	510.7	498.8	60

Section 2

Piping Losses

Piping Losses

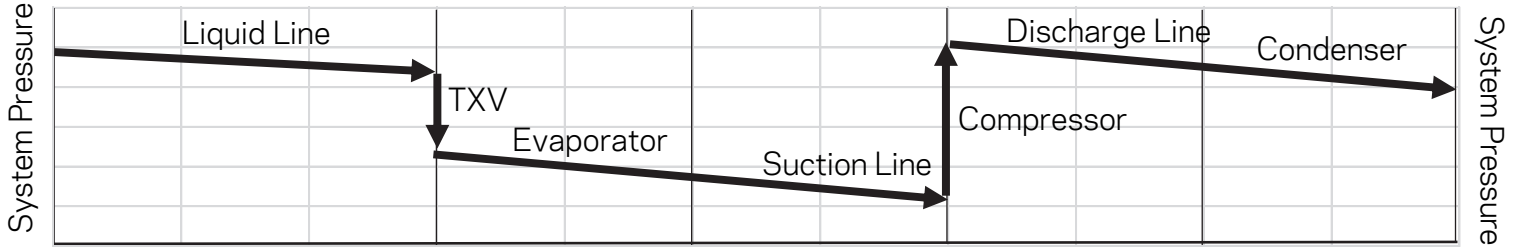
Pressure Drop Results in:

- Decrease in Thermal Capacity
- Increased Power Consumption
- Possible Flashing Before Expansion Device

Pressure drop occurs during fluid flow through pipes as a result of frictional forces between the fluid molecules itself and between the fluid and the piping walls

- Type of flow (turbulent, laminar, etc.)
- Physical properties of the fluid (viscosity, density, etc.)
- Pipe characteristics (diameter, pipe roughness, length, etc.)
- Velocity of flow

Pressure drop also increases with anything that disturbs the flow (valves, elbows, fittings, etc.)



Section 3 – Line Capacity Tables

Assumptions and Considerations

(a.) Pipe inside diameter is same as nominal pipe size (for 12 inch steel only)

1. Tons based on standard refrigeration cycle of 105 °F saturated liquid and the corresponding evaporator outlet temperature as a saturated vapor. Liquid tons based on 20 °F evaporator temperature
2. Suction Line Pressure drop assuming half of the pressure drop occurs upstream of the reference temperature
3. Discharge line pressure drop calculations assume saturated vapor temperature drop
4. Discharge pressure drop inlet conditions calculated assuming isentropic compressor efficiency of 0.7 and pressure corresponding to condenser saturated liquid outlet temperature
5. Liquid line pressure drop assuming reference temperature at inlet with temperature drop occurring downstream
6. Thermophysical properties and viscosity data based on calculations from NIST REFPROP program version 10
7. Capacities based on conditions outside of these tables can be provided upon request
8. Cells highlighted in gray indicate velocity from the given saturated temperature drop is outside the recommended gas line velocities per ASHRAE Refrigeration Handbook
9. ASHRAE recommended velocity limits for refrigerant piping take into consideration economics, pressure drop, noise (vapor sizing), potential hammering (liquid), and practical requirements for oil return to the compressor. These velocity limits are presented as guidelines used in conjunction with generally accepted and recommended suction and discharge pressure loss limitations to achieve an optimal design.
10. Because saturated evaporator temperatures are used, calculated refrigerant flow rates may be slightly higher than actuality as superheat is likely present. Per ASHRAE, flow rates may be reduced approximately 3% for each 10°F increase in superheat in the evaporator.
11. Tables don't consider any pressure differences due to elevation changes.
12. If pressure drop is more than 5% of the inlet pressure, it is suggested that the segment length (default of 100ft) be cut up with properties recalculated for each segment.

Opteon™ XP10 (R-513A)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R513A (Single- or High-Stage Applications)																	
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 2.24 psi						Liquid Lines			
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F									
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F		Δt = 5 °F
				Corresponding Δp, psi/		100 ft				Corresponding Δp, psi/		100 ft		Velocity =	Drop/ 100 ft		Drop/ 100 ft
		0.31	0.50	0.75	1.09	1.51	2.04	2.24	2.24	2.24	2.24	2.24	2.24	100 fpm	Δp = 2.24		Δp = 11.0
1/2		0.02	0.05	0.08	0.14	0.22	0.34	0.40	0.44	0.49	0.53	0.57	0.62	1.67	2.34		5.61
5/8		0.05	0.09	0.16	0.26	0.42	0.64	0.75	0.83	0.91	1.00	1.08	1.15	2.68	4.41		10.53
3/4		0.08	0.15	0.27	0.45	0.71	1.09	1.27	1.41	1.55	1.69	1.83	1.96	4.01	7.53		17.90
7/8		0.12	0.24	0.42	0.70	1.11	1.68	1.97	2.18	2.40	2.62	2.83	3.03	5.57	11.69		27.65
1 1/8		0.25	0.48	0.85	1.42	2.24	3.41	3.98	4.42	4.85	5.28	5.71	6.13	9.50	23.74		55.89
1 3/8		0.44	0.84	1.49	2.47	3.92	5.94	6.93	7.68	8.44	9.19	9.93	10.66	14.46	41.44		97.24
1 5/8		0.71	1.34	2.36	3.92	6.19	9.39	10.94	12.13	13.33	14.51	15.68	16.82	20.47	65.60		153.72
2 1/8		1.47	2.79	4.91	8.14	12.85	19.44	22.61	25.09	27.56	30.01	32.40	34.75	35.62	136.18		317.75
2 5/8		2.62	4.95	8.69	14.41	22.70	34.32	39.86	44.24	48.58	52.89	57.17	61.25	54.92	240.86		560.17
3 1/8		4.20	7.92	13.90	23.01	36.22	54.70	63.48	70.43	77.32	84.21	91.00	97.58	78.40	384.49		891.99
3 5/8		6.27	11.80	20.70	34.21	53.82	81.21	94.18	104.47	114.67	124.99	134.96	144.71	106.04	571.53		1323.22
4 1/8		8.87	16.67	29.22	48.28	75.88	114.42	132.61	146.91	161.44	175.94	189.94	203.75	137.84	806.15		1863.21
5 1/8		15.94	29.91	52.35	86.34	135.57	204.14	236.15	261.88	287.82	313.14	338.35	363.12	214.83	1441.15		3321.96
6 1/8		25.71	48.20	84.26	138.83	217.78	327.66	378.77	419.97	461.48	502.06	542.49	582.18	308.82	2316.49		5327.74
8 1/8		53.58	100.23	174.92	287.75	450.73	677.32	782.10	867.21	951.39	1036.01	1119.63	1201.87	539.43	4803.64		10999.93
Steel																	
IPS	SCH																
3/8	80	0.02	0.04	0.07	0.11	0.17	0.25	0.29	0.32	0.36	0.39	0.42	0.45	1.62	1.83		4.12
1/2	80	0.04	0.08	0.13	0.22	0.34	0.50	0.58	0.64	0.70	0.76	0.82	0.88	2.69	3.61		8.11
3/4	80	0.09	0.17	0.30	0.49	0.76	1.13	1.30	1.44	1.58	1.72	1.85	1.98	4.98	8.14		18.26
1	80	0.19	0.34	0.59	0.96	1.49	2.22	2.54	2.82	3.09	3.37	3.62	3.89	8.28	15.98		35.78
1 1/4	80	0.49	0.91	1.56	2.52	3.91	5.83	6.68	7.38	8.13	8.80	9.51	10.19	17.21	42.12		93.93
1 1/2	80	0.74	1.36	2.34	3.79	5.86	8.71	10.05	11.08	12.13	13.20	14.28	15.29	23.43	63.19		140.21
2	40	1.44	2.64	4.53	7.31	11.32	16.79	19.29	21.42	23.39	25.48	27.49	29.44	38.62	121.74		270.19
2 1/2	40	2.30	4.21	7.19	11.66	17.99	26.84	30.74	34.13	37.32	40.57	43.77	46.89	55.10	193.95		430.70
3	40	4.07	7.46	12.73	20.62	31.81	47.40	54.50	60.01	65.88	71.62	77.16	82.76	85.08	342.96		762.21
4	40	8.35	15.23	25.96	42.10	64.79	96.20	110.45	122.41	134.18	145.88	157.37	168.56	146.52	699.15		1553.36
5	40	15.04	27.57	46.91	75.96	117.29	174.14	199.59	220.75	241.98	263.07	283.79	303.97	230.25	1263.15		2800.21
6	40	24.39	44.38	75.86	122.80	188.82	280.81	322.21	356.37	392.09	424.65	458.11	490.69	332.50	2032.55		4520.67
8	40	50.06	90.96	155.42	250.22	386.35	574.25	659.37	729.27	799.38	868.97	937.44	1004.09	575.77	4157.75		9242.76
10	40	90.74	164.75	281.40	454.20	700.27	1039.35	1191.40	1317.61	1444.27	1570.06	1693.76	1814.18	907.55	7522.46		16700.61
12	ID*	145.30	263.61	449.96	725.44	1118.31	1659.86	1905.75	2107.72	2310.20	2511.40	2709.25	2901.85	1301.66	12049.08		26696.33
14	30	188.16	341.35	582.94	937.39	1445.20	2145.09	2464.64	2725.69	2987.68	3247.87	3503.73	3752.81	1586.97	15593.44		34494.29
16	30	270.34	492.40	840.59	1351.47	2083.48	3092.24	3549.35	3925.23	4302.29	4676.74	5044.96	5403.42	2102.21	22477.46		49722.10

Opteon™ XP40 (R-449A)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R449A (Single- or High-Stage Applications)																
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 3.74 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
		Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft						Velocity = 100 fpm	Drop/ 100 ft Δp = 3.61	Drop/ 100 ft Δp = 17.7
		0.50	0.80	1.19	1.71	2.35	3.15	3.74	3.74	3.74	3.74	3.74	3.74			
1/2		0.05	0.09	0.15	0.24	0.38	0.56	0.72	0.79	0.86	0.93	1.00	1.07	1.85	3.49	8.30
5/8		0.09	0.16	0.28	0.46	0.71	1.05	1.36	1.49	1.62	1.75	1.88	2.01	2.97	6.56	15.54
3/4		0.15	0.28	0.48	0.78	1.21	1.80	2.31	2.53	2.75	2.98	3.19	3.41	4.44	11.19	26.40
7/8		0.24	0.44	0.75	1.21	1.87	2.78	3.56	3.90	4.25	4.59	4.93	5.26	6.17	17.31	40.72
1 1/8		0.48	0.89	1.52	2.46	3.79	5.62	7.20	7.88	8.58	9.27	9.95	10.61	10.51	35.09	82.06
1 3/8		0.85	1.56	2.66	4.28	6.60	9.78	12.51	13.71	14.92	16.12	17.28	18.43	16.01	61.18	142.60
1 5/8		1.35	2.46	4.22	6.78	10.43	15.45	19.75	21.65	23.55	25.44	27.26	29.08	22.66	96.73	224.90
2 1/8		2.82	5.15	8.77	14.07	21.62	31.98	40.83	44.73	48.65	52.47	56.32	60.04	39.42	200.47	464.25
2 5/8		5.01	9.13	15.52	24.89	38.20	56.16	71.98	78.86	85.74	92.47	99.22	105.76	60.79	354.10	817.40
3 1/8		8.02	14.61	24.81	39.73	60.92	89.46	114.62	125.55	136.32	147.22	157.89	168.15	86.77	564.67	1300.93
3 5/8		11.96	21.76	36.74	59.06	90.49	132.78	170.06	186.21	202.17	218.31	234.11	249.30	117.37	838.66	1929.04
4 1/8		16.90	30.75	51.87	83.31	127.57	187.05	239.46	261.86	284.62	307.30	329.10	350.59	152.57	1182.10	2715.27
5 1/8		30.35	55.06	92.88	148.80	226.71	333.45	426.42	466.82	507.44	546.93	586.24	624.84	237.78	2108.58	4838.29
6 1/8		48.94	88.73	149.49	239.22	364.09	535.10	683.94	748.61	813.61	876.90	939.94	1001.78	341.82	3386.30	7756.13
8 1/8		101.88	184.25	310.20	495.65	753.28	1105.81	1412.23	1545.84	1677.32	1809.47	1939.93	2068.09	597.06	7005.68	16003.83
Steel																
IPS	SCH															
3/8	80	0.04	0.07	0.12	0.19	0.28	0.41	0.53	0.58	0.62	0.67	0.72	0.77	1.79	2.64	5.93
1/2	80	0.08	0.14	0.23	0.37	0.56	0.81	1.04	1.14	1.23	1.33	1.42	1.51	2.98	5.21	11.68
3/4	80	0.18	0.32	0.53	0.84	1.26	1.83	2.34	2.55	2.78	2.98	3.19	3.40	5.51	11.76	26.28
1	80	0.35	0.62	1.04	1.64	2.46	3.60	4.57	5.00	5.41	5.86	6.24	6.66	9.16	23.09	51.49
1 1/4	80	0.93	1.64	2.73	4.29	6.47	9.45	11.99	13.09	14.26	15.29	16.39	17.44	19.05	60.55	135.16
1 1/2	80	1.40	2.47	4.09	6.43	9.72	14.11	18.05	19.65	21.28	22.95	24.61	26.18	25.93	90.85	201.75
2	40	2.71	4.78	7.92	12.42	18.75	27.19	34.65	38.00	41.02	44.28	47.39	50.41	42.75	175.03	388.79
2 1/2	40	4.32	7.63	12.64	19.82	29.80	43.47	55.24	60.55	65.47	70.51	75.47	80.28	60.99	278.84	619.76
3	40	7.63	13.45	22.36	35.04	52.69	76.76	97.93	106.44	115.57	124.47	133.03	141.70	94.17	493.06	1096.79
4	40	15.58	27.47	45.37	71.53	107.34	155.78	198.45	217.12	235.40	253.52	271.32	288.61	162.17	1005.15	2235.23
5	40	28.22	49.72	81.99	129.08	194.30	282.00	358.61	391.55	424.51	457.19	489.26	520.45	254.85	1815.99	4029.39
6	40	45.75	80.45	132.60	208.67	312.80	454.73	578.93	632.09	687.83	738.00	789.81	840.15	368.03	2922.13	6505.07
8	40	93.44	164.88	271.68	425.20	640.04	929.91	1184.72	1293.50	1402.34	1510.19	1616.19	1719.18	637.29	5977.46	13299.98
10	40	169.37	297.13	491.89	771.82	1160.08	1683.06	2140.63	2337.04	2533.66	2728.64	2920.14	3106.21	1004.52	10814.79	24031.55
12	ID[a]	271.22	475.43	786.54	1232.75	1852.61	2687.87	3424.13	3738.45	4052.75	4364.60	4670.90	4968.49	1440.74	17322.56	38415.02
14	30	351.22	615.64	1019.00	1592.92	2394.14	3473.63	4428.31	4834.54	5241.24	5644.52	6040.63	6425.48	1756.53	22418.17	49636.00
16	30	507.15	888.07	1469.39	2296.56	3451.54	5007.38	6377.26	6962.18	7547.44	8127.79	8697.81	9251.63	2326.82	32315.10	71548.24

Opteon™ XP44 (R-452A)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R452A (Single- or High-Stage Applications)																
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 3.78 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
		Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft						Velocity = 100 fpm	Drop/ 100 ft Δp = 3.67	Drop/ 100 ft Δp = 18.0
		0.57	0.89	1.31	1.84	2.51	3.31	3.78	3.78	3.78	3.78	3.78	3.78			
1/2		0.04	0.08	0.13	0.22	0.34	0.50	0.59	0.66	0.74	0.81	0.87	0.94	1.40	2.65	6.29
5/8		0.08	0.15	0.25	0.41	0.63	0.94	1.11	1.24	1.38	1.51	1.64	1.76	2.24	4.98	11.78
3/4		0.13	0.25	0.43	0.69	1.08	1.60	1.89	2.11	2.34	2.56	2.78	2.99	3.35	8.48	20.01
7/8		0.21	0.39	0.66	1.07	1.66	2.48	2.91	3.26	3.61	3.95	4.29	4.61	4.65	13.12	30.82
1 1/8		0.43	0.78	1.34	2.18	3.37	5.00	5.88	6.58	7.28	7.97	8.66	9.31	7.93	26.59	62.21
1 3/8		0.75	1.37	2.35	3.79	5.86	8.70	10.23	11.44	12.65	13.85	15.04	16.18	12.08	46.36	108.11
1 5/8		1.19	2.17	3.71	6.00	9.26	13.74	16.13	18.04	19.96	21.85	23.73	25.52	17.10	73.30	170.51
2 1/8		2.48	4.52	7.71	12.44	19.15	28.39	33.32	37.25	41.19	45.09	48.99	52.67	29.74	151.98	351.98
2 5/8		4.41	8.01	13.65	21.97	33.80	50.06	58.62	65.53	72.45	79.30	86.29	92.77	45.87	268.10	619.94
3 1/8		7.05	12.81	21.78	35.07	53.86	79.70	93.29	104.28	115.27	126.16	136.90	147.77	65.47	427.57	986.33
3 5/8		10.51	19.07	32.38	52.10	79.95	118.23	138.32	154.59	170.88	187.00	202.76	217.96	88.55	635.08	1462.77
4 1/8		14.85	26.92	45.69	73.36	112.63	166.46	194.69	217.59	240.51	263.18	285.35	306.73	115.11	895.19	2058.70
5 1/8		26.65	48.22	81.72	131.05	200.99	296.76	346.96	387.71	428.50	468.85	508.30	546.35	179.41	1598.84	3667.56
6 1/8		42.94	77.61	131.28	210.49	322.56	475.90	556.25	621.52	686.84	751.46	814.64	875.58	257.90	2567.67	5848.91
8 1/8		89.21	161.09	272.32	435.57	666.62	982.39	1147.86	1282.35	1416.92	1550.07	1680.26	1805.82	450.49	5312.00	12065.05
Steel																
IPS	SCH															
3/8	80	0.03	0.06	0.10	0.16	0.25	0.37	0.43	0.48	0.53	0.57	0.62	0.67	1.35	2.00	4.47
1/2	80	0.07	0.12	0.20	0.32	0.49	0.72	0.84	0.94	1.04	1.13	1.22	1.31	2.25	3.94	8.81
3/4	80	0.15	0.28	0.46	0.73	1.11	1.62	1.89	2.11	2.33	2.54	2.76	2.96	4.16	8.89	19.82
1	80	0.30	0.54	0.91	1.44	2.18	3.18	3.71	4.12	4.57	4.99	5.41	5.80	6.91	17.41	38.83
1 1/4	80	0.80	1.43	2.39	3.78	5.70	8.36	9.68	10.80	11.97	13.09	14.14	15.19	14.38	45.66	101.94
1 1/2	80	1.21	2.15	3.58	5.66	8.55	12.55	14.56	16.20	17.96	19.55	21.22	22.80	19.57	68.51	152.93
2	40	2.34	4.15	6.91	10.92	16.50	24.19	27.96	31.33	34.44	37.72	40.86	43.90	32.25	132.00	294.71
2 1/2	40	3.73	6.62	11.02	17.34	26.36	38.47	44.56	49.92	54.96	60.07	65.08	69.90	46.02	210.29	467.46
3	40	6.61	11.72	19.50	30.67	46.60	67.94	79.00	88.19	97.01	106.04	115.29	123.38	71.06	371.84	827.26
4	40	13.50	23.90	39.70	62.60	94.46	138.57	160.10	179.00	197.59	215.98	233.97	251.30	122.36	758.04	1685.95
5	40	24.44	43.15	71.74	112.97	170.99	249.60	289.31	322.81	356.33	389.49	421.90	453.18	192.29	1369.47	3039.21
6	40	39.52	69.81	115.45	182.63	276.65	402.48	467.05	521.12	577.36	628.73	681.07	731.56	277.68	2214.74	4906.52
8	40	81.01	143.05	236.53	373.98	563.25	823.06	955.78	1066.41	1177.11	1286.58	1393.68	1496.98	480.84	4530.42	10031.66
10	40	146.76	258.71	428.24	675.48	1020.89	1489.68	1726.98	1926.75	2126.74	2324.61	2518.10	2704.73	757.92	8156.04	18126.06
12	ID[a]	234.91	413.95	684.76	1078.88	1630.34	2379.03	2762.45	3082.13	3401.85	3718.34	4027.82	4326.32	1087.06	13063.91	28974.94
14	30	304.12	533.34	887.09	1394.10	2106.90	3074.51	3572.58	3985.80	4399.46	4808.75	5208.96	5594.99	1325.32	16906.80	37438.49
16	30	438.12	769.35	1279.19	2009.91	3037.43	4432.03	5144.91	5739.91	6335.27	6924.32	7500.31	8055.86	1755.61	24370.62	53966.03

Opteon™ XL10 (R-1234YF)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R1234YF (Single- or High-Stage Applications)

Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 2.09 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
		Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft						Velocity =	Drop/ 100 ft	Drop/ 100 ft
		0.31	0.49	0.73	1.05	1.45	1.93	2.09	2.09	2.09	2.09	2.09	2.09	100 fpm	Δp = 2.09	Δp = 10.2
1/2		0.02	0.04	0.07	0.12	0.20	0.30	0.34	0.38	0.42	0.46	0.50	0.55	1.44	1.99	4.76
5/8		0.04	0.08	0.14	0.23	0.37	0.57	0.63	0.71	0.79	0.87	0.95	1.02	2.32	3.75	8.94
3/4		0.07	0.13	0.24	0.40	0.63	0.97	1.07	1.21	1.34	1.48	1.61	1.74	3.46	6.40	15.20
7/8		0.11	0.21	0.37	0.62	0.98	1.50	1.66	1.87	2.07	2.28	2.49	2.68	4.80	9.92	23.48
1 1/8		0.22	0.43	0.75	1.26	1.99	3.04	3.36	3.78	4.19	4.61	5.02	5.40	8.19	20.15	47.45
1 3/8		0.39	0.75	1.32	2.19	3.48	5.29	5.85	6.57	7.29	8.02	8.73	9.39	12.48	35.18	82.57
1 5/8		0.63	1.19	2.09	3.47	5.50	8.36	9.23	10.37	11.53	12.66	13.79	14.89	17.66	55.69	130.52
2 1/8		1.31	2.48	4.34	7.22	11.41	17.31	19.08	21.46	23.83	26.18	28.49	30.76	30.72	115.61	269.81
2 5/8		2.33	4.40	7.69	12.77	20.17	30.57	33.64	37.83	42.00	46.15	50.28	54.22	47.38	204.48	475.64
3 1/8		3.74	7.04	12.30	20.40	32.18	48.71	53.56	60.23	66.85	73.48	80.03	85.95	67.62	326.40	757.40
3 5/8		5.57	10.49	18.32	30.33	47.81	72.32	79.47	89.33	99.15	109.07	118.69	128.09	91.46	485.19	1123.56
4 1/8		7.88	14.82	25.87	42.80	67.41	101.89	111.90	125.62	139.58	153.54	167.04	179.46	118.90	684.37	1582.07
5 1/8		14.17	26.58	46.34	76.54	120.44	181.80	199.28	223.95	248.86	273.27	297.56	321.44	185.30	1223.43	2820.70
6 1/8		22.86	42.84	74.59	123.08	193.48	291.80	319.62	359.13	399.01	438.13	477.09	515.35	266.38	1966.53	4523.83
8 1/8		47.63	89.08	154.84	255.11	400.43	603.18	659.97	741.58	822.61	904.08	984.65	1063.90	465.30	4077.95	9340.13
Steel																
IPS	SCH															
3/8	80	0.02	0.03	0.06	0.10	0.15	0.23	0.25	0.28	0.31	0.34	0.37	0.40	1.40	1.56	3.50
1/2	80	0.04	0.07	0.12	0.19	0.30	0.45	0.49	0.55	0.61	0.67	0.72	0.78	2.32	3.06	6.89
3/4	80	0.08	0.15	0.27	0.43	0.67	1.01	1.10	1.23	1.37	1.50	1.63	1.76	4.29	6.91	15.51
1	80	0.16	0.30	0.52	0.85	1.32	1.98	2.15	2.41	2.67	2.94	3.18	3.44	7.14	13.57	30.38
1 1/4	80	0.44	0.80	1.38	2.24	3.47	5.19	5.63	6.31	7.03	7.68	8.36	9.02	14.85	35.75	79.75
1 1/2	80	0.66	1.20	2.07	3.36	5.21	7.76	8.48	9.47	10.49	11.52	12.55	13.54	20.21	53.65	119.05
2	40	1.27	2.33	4.01	6.48	10.06	14.95	16.28	18.32	20.22	22.23	24.17	26.06	33.31	103.35	229.42
2 1/2	40	2.04	3.72	6.37	10.34	15.98	23.90	25.94	29.19	32.27	35.41	38.50	41.50	47.53	164.65	365.71
3	40	3.60	6.60	11.27	18.28	28.26	42.21	45.99	51.32	56.96	62.50	67.86	73.26	73.39	291.15	647.20
4	40	7.38	13.47	22.98	37.32	57.56	85.67	93.20	104.68	116.02	127.30	138.40	149.21	126.38	593.53	1318.97
5	40	13.31	24.38	41.52	67.35	104.20	155.08	168.42	188.77	209.23	229.57	249.57	269.07	198.61	1072.32	2377.68
6	40	21.57	39.25	67.15	108.87	167.75	250.08	271.90	304.74	339.01	370.57	402.88	434.36	286.81	1725.49	3838.54
8	40	44.27	80.45	137.58	221.84	343.24	511.40	556.41	623.62	691.18	758.31	824.42	888.82	496.65	3529.63	7848.10
10	40	80.25	145.70	249.09	402.68	622.13	925.59	1005.36	1126.73	1248.77	1370.13	1489.57	1605.92	782.83	6386.03	14180.62
12	ID[a]	128.51	233.13	398.29	643.17	993.52	1478.18	1608.16	1802.38	1997.49	2191.59	2382.63	2568.73	1122.78	10228.80	22668.07
14	30	166.41	301.88	516.00	831.08	1283.93	1910.30	2079.77	2330.83	2583.27	2834.28	3081.33	3321.99	1368.87	13237.71	29289.39
16	30	239.11	435.47	744.07	1198.19	1851.00	2753.78	2995.10	3356.61	3719.93	4081.20	4436.76	4783.12	1813.31	19081.75	42219.44

Opteon™ XL20 (R-454C)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R454C (Single- or High-Stage Applications)																	
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 3.43 psi						Liquid Lines			
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F									
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F		Δt = 5 °F
				Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft				Velocity =	Drop/ 100 ft		Drop/ 100 ft
		0.45	0.70	1.05	1.50	2.06	2.75	3.43	3.43	3.43	3.43	3.43	3.43	100 fpm	Δp = 3.28		Δp = 16.1
1/2		0.04	0.07	0.12	0.20	0.31	0.47	0.62	0.69	0.76	0.82	0.89	0.95	1.63	3.00		7.15
5/8		0.07	0.13	0.23	0.38	0.58	0.87	1.17	1.29	1.42	1.54	1.66	1.78	2.63	5.65		13.39
3/4		0.12	0.23	0.39	0.64	1.00	1.49	1.99	2.20	2.41	2.62	2.83	3.03	3.92	9.64		22.75
7/8		0.19	0.35	0.61	0.99	1.54	2.30	3.07	3.40	3.72	4.04	4.36	4.67	5.45	14.91		35.10
1 1/8		0.39	0.72	1.24	2.01	3.12	4.66	6.21	6.86	7.52	8.17	8.81	9.43	9.29	30.22		70.83
1 3/8		0.69	1.27	2.17	3.52	5.44	8.11	10.80	11.93	13.07	14.20	15.31	16.40	14.15	52.70		123.09
1 5/8		1.10	2.01	3.44	5.57	8.60	12.79	17.05	18.82	20.61	22.41	24.16	25.87	20.02	83.33		193.92
2 1/8		2.30	4.19	7.15	11.54	17.83	26.47	35.25	38.89	42.59	46.24	49.83	53.35	34.83	172.71		400.35
2 5/8		4.08	7.43	12.66	20.41	31.50	46.72	62.14	68.57	75.00	81.49	87.79	93.99	53.72	305.09		705.14
3 1/8		6.54	11.88	20.22	32.59	50.23	74.39	98.93	109.16	119.38	129.62	139.74	149.53	76.68	486.55		1121.94
3 5/8		9.75	17.68	30.09	48.44	74.51	110.43	146.65	161.90	177.04	192.39	207.23	221.76	103.71	722.67		1663.23
4 1/8		13.78	24.97	42.47	68.33	105.04	155.59	206.49	227.88	249.24	270.82	291.66	312.03	134.81	1018.65		2340.68
5 1/8		24.74	44.77	76.02	122.16	187.62	277.60	368.11	405.86	444.37	482.01	519.55	556.49	210.10	1819.26		4164.76
6 1/8		39.90	72.11	122.17	196.35	301.33	445.58	590.34	650.85	712.48	772.81	833.01	892.19	302.03	2921.66		6675.59
8 1/8		83.06	149.85	253.45	406.73	623.08	921.06	1217.80	1343.97	1468.85	1594.68	1719.24	1841.86	527.57	6039.01		13771.30
Steel																	
IPS	SCH																
3/8	80	0.03	0.06	0.10	0.15	0.24	0.34	0.45	0.50	0.55	0.59	0.64	0.68	1.58	2.27		5.12
1/2	80	0.06	0.11	0.19	0.30	0.46	0.68	0.89	0.99	1.08	1.17	1.26	1.34	2.64	4.49		10.07
3/4	80	0.14	0.26	0.43	0.69	1.04	1.53	2.02	2.22	2.43	2.63	2.83	3.02	4.87	10.14		22.67
1	80	0.29	0.51	0.85	1.35	2.04	3.00	3.94	4.34	4.74	5.16	5.53	5.93	8.10	19.81		44.42
1 1/4	80	0.76	1.34	2.24	3.54	5.38	7.89	10.34	11.38	12.48	13.47	14.53	15.53	16.84	52.21		116.60
1 1/2	80	1.14	2.02	3.36	5.31	8.07	11.79	15.57	17.08	18.64	20.22	21.81	23.32	22.92	78.34		174.05
2	40	2.20	3.91	6.50	10.25	15.57	22.72	29.88	33.03	35.92	39.02	42.00	44.89	37.77	150.93		335.40
2 1/2	40	3.52	6.21	10.33	16.36	24.75	36.32	47.63	52.64	57.33	62.14	66.88	71.49	53.89	240.45		534.65
3	40	6.22	11.00	18.27	28.92	43.75	64.14	84.44	92.53	101.20	109.69	117.89	126.19	83.21	425.18		946.17
4	40	12.71	22.46	37.25	59.04	89.12	130.16	171.12	188.76	206.13	223.42	240.44	257.02	143.30	866.77		1928.28
5	40	23.01	40.65	67.33	106.55	161.32	235.63	309.22	340.40	371.73	402.90	433.58	463.49	225.19	1565.98		3476.06
6	40	37.31	65.78	108.88	172.24	259.71	379.95	499.20	549.52	602.31	650.37	699.93	748.21	325.20	2519.84		5611.76
8	40	76.20	134.14	223.08	350.96	531.42	776.99	1021.56	1124.53	1227.98	1330.86	1432.26	1531.05	563.12	5154.53		11473.56
10	40	138.12	242.95	403.89	637.07	963.20	1406.29	1845.83	2031.75	2218.64	2404.61	2587.81	2766.28	887.61	9325.90		20731.41
12	ID*	221.18	388.74	645.83	1017.52	1538.20	2245.86	2952.57	3250.10	3548.86	3846.31	4139.32	4424.77	1273.06	14937.72		33139.67
14	30	286.42	503.37	836.70	1314.81	1987.83	2902.41	3818.45	4203.02	4589.58	4974.24	5353.17	5722.31	1552.09	19331.81		42819.72
16	30	413.60	726.13	1206.52	1895.60	2865.77	4183.93	5498.99	6052.72	6609.04	7162.62	7707.94	8239.19	2056.01	27866.20		61722.86

Opteon™ XL40 (R-454A)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R454A (Single- or High-Stage Applications)

Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 3.88 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
		Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft						Velocity =	Drop/ 100 ft	Drop/ 100 ft
		0.55	0.86	1.27	1.80	2.46	3.26	3.88	3.88	3.88	3.88	3.88	3.88	100 fpm	Δp = 3.74	Δp = 18.3
1/2		0.05	0.10	0.16	0.26	0.40	0.60	0.76	0.84	0.91	0.98	1.05	1.13	1.80	3.62	8.60
5/8		0.10	0.18	0.31	0.50	0.76	1.12	1.43	1.57	1.71	1.84	1.98	2.11	2.89	6.81	16.07
3/4		0.17	0.31	0.53	0.84	1.29	1.90	2.44	2.67	2.90	3.13	3.37	3.59	4.32	11.60	27.29
7/8		0.27	0.49	0.82	1.31	2.00	2.93	3.76	4.12	4.48	4.83	5.18	5.54	6.00	17.94	42.09
1 1/8		0.55	0.99	1.66	2.65	4.04	5.93	7.60	8.32	9.04	9.75	10.46	11.19	10.23	36.35	84.92
1 3/8		0.97	1.73	2.91	4.63	7.05	10.33	13.23	14.46	15.72	16.96	18.17	19.46	15.58	63.36	147.40
1 5/8		1.54	2.75	4.61	7.33	11.13	16.30	20.88	22.83	24.79	26.76	28.67	30.69	22.05	100.16	232.49
2 1/8		3.21	5.73	9.58	15.20	23.05	33.72	43.15	47.17	51.23	55.23	59.44	63.30	38.36	207.21	479.44
2 5/8		5.70	10.15	16.96	26.87	40.70	59.44	76.07	83.15	90.21	97.32	104.73	111.52	59.15	365.94	844.44
3 1/8		9.13	16.23	27.09	42.81	64.84	94.72	121.12	132.38	143.59	154.80	165.87	177.42	84.43	583.47	1343.58
3 5/8		13.61	24.16	40.23	63.63	96.30	140.48	179.55	196.34	212.96	229.78	245.97	263.13	114.19	866.48	1991.81
4 1/8		19.23	34.12	56.78	89.74	135.73	197.93	252.81	276.37	299.80	323.44	346.19	370.23	148.44	1220.10	2803.09
5 1/8		34.52	61.14	101.61	160.39	242.20	353.15	450.68	492.22	534.51	575.66	616.68	656.98	231.35	2179.04	4987.52
6 1/8		55.65	98.44	163.55	257.55	388.99	566.83	722.76	789.34	857.01	922.97	988.75	1053.32	332.57	3499.46	7994.36
8 1/8		115.78	204.45	338.72	533.51	804.34	1171.71	1490.97	1629.93	1766.80	1904.53	2040.66	2174.49	580.92	7233.30	16491.85
Steel																
IPS	SCH															
3/8	80	0.04	0.08	0.13	0.20	0.30	0.44	0.56	0.61	0.66	0.71	0.76	0.81	1.74	2.72	6.10
1/2	80	0.09	0.16	0.26	0.40	0.60	0.86	1.09	1.20	1.29	1.40	1.49	1.59	2.90	5.36	12.00
3/4	80	0.20	0.35	0.58	0.90	1.35	1.94	2.47	2.69	2.93	3.14	3.35	3.57	5.36	12.09	27.01
1	80	0.40	0.69	1.13	1.76	2.64	3.80	4.82	5.27	5.70	6.17	6.57	7.00	8.92	23.73	52.92
1 1/4	80	1.05	1.83	2.97	4.64	6.90	9.99	12.66	13.81	15.02	16.09	17.25	18.34	18.54	62.22	138.93
1 1/2	80	1.58	2.73	4.47	6.97	10.36	14.92	19.06	20.71	22.42	24.15	25.89	27.53	25.23	93.36	207.38
2	40	3.06	5.29	8.64	13.38	20.00	28.76	36.59	40.06	43.21	46.60	49.85	53.00	41.59	179.87	399.64
2 1/2	40	4.87	8.45	13.78	21.35	31.94	45.97	58.32	63.84	68.96	74.21	79.38	84.40	59.34	286.56	637.06
3	40	8.64	14.97	24.39	37.75	56.20	81.18	103.38	112.22	121.73	131.00	139.93	148.98	91.63	506.71	1127.41
4	40	17.65	30.40	49.73	77.06	114.47	164.75	209.51	228.92	247.94	266.83	285.40	303.44	157.79	1032.98	2297.64
5	40	31.81	55.03	89.42	139.06	207.21	298.24	378.59	412.83	447.13	481.18	514.64	547.20	247.96	1866.27	4141.89
6	40	51.57	89.05	144.60	224.80	333.58	480.93	611.18	666.45	724.49	776.74	830.78	883.33	358.08	3003.04	6686.69
8	40	105.83	182.50	296.27	460.35	682.57	983.48	1250.71	1363.80	1477.07	1589.45	1700.03	1807.55	620.06	6142.95	13671.31
10	40	190.89	330.53	536.41	831.45	1237.16	1780.01	2259.87	2464.05	2668.68	2871.84	3071.61	3265.86	977.36	11114.22	24702.49
12	ID[a]	305.67	526.21	857.73	1327.99	1975.71	2842.70	3614.87	3941.63	4268.72	4593.67	4913.18	5223.87	1401.79	17802.16	39487.53
14	30	395.83	681.39	1111.22	1715.98	2553.22	3673.73	4674.98	5097.30	5520.55	5940.76	6353.96	6755.74	1709.04	23038.85	51021.79
16	30	571.59	982.92	1602.38	2473.98	3680.88	5295.83	6732.49	7340.57	7949.65	8554.36	9148.97	9727.15	2263.92	33209.79	73545.80

Opteon™ XL41 (R-454B)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R454B (Single- or High-Stage Applications)

Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 4.52 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
				Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft				Velocity =	Drop/ 100 ft	Drop/ 100 ft
		0.76	1.16	1.69	2.36	3.19	4.19	4.52	4.52	4.52	4.52	4.52	4.52	100 fpm	Δp = 4.49	Δp = 22.0
1/2		0.10	0.17	0.28	0.43	0.64	0.92	1.07	1.15	1.24	1.33	1.41	1.50	2.31	5.26	12.45
5/8		0.19	0.33	0.53	0.82	1.21	1.73	2.00	2.16	2.32	2.49	2.65	2.80	3.71	9.89	23.28
3/4		0.32	0.56	0.90	1.39	2.06	2.94	3.40	3.67	3.94	4.22	4.48	4.76	5.55	16.83	39.51
7/8		0.50	0.87	1.40	2.15	3.18	4.54	5.25	5.67	6.08	6.52	6.92	7.35	7.71	26.02	60.91
1 1/8		1.03	1.76	2.84	4.36	6.44	9.17	10.62	11.44	12.28	13.17	13.98	14.85	13.14	52.68	122.63
1 3/8		1.80	3.08	4.97	7.61	11.21	15.96	18.47	19.90	21.36	22.90	24.30	25.81	20.01	91.77	212.87
1 5/8		2.86	4.88	7.86	12.04	17.71	25.18	29.16	31.42	33.85	36.13	38.34	40.71	28.33	145.02	335.62
2 1/8		5.97	10.16	16.30	24.95	36.66	52.00	60.28	64.91	69.94	74.56	79.09	83.96	49.28	300.08	692.00
2 5/8		10.59	18.00	28.84	44.09	64.70	91.66	106.26	114.43	123.16	131.38	139.35	147.93	76.00	529.68	1217.66
3 1/8		16.94	28.77	46.05	70.29	103.08	146.00	169.18	182.18	196.03	208.98	221.79	235.35	108.47	843.08	1937.40
3 5/8		25.24	42.81	68.44	104.42	152.83	216.54	250.79	270.20	290.73	310.20	328.91	349.03	146.71	1251.69	2872.13
4 1/8		35.67	60.44	96.55	147.21	215.35	304.80	353.12	380.32	409.28	436.65	462.92	491.10	190.72	1762.85	4041.97
5 1/8		63.97	108.10	172.69	262.99	384.23	543.82	629.51	680.74	729.71	777.15	824.62	871.47	297.24	3146.99	7191.86
6 1/8		103.07	173.99	277.71	422.32	616.37	872.88	1009.55	1091.65	1169.97	1246.01	1322.14	1397.20	427.29	5048.31	11527.63
8 1/8		214.27	361.12	575.23	873.13	1274.52	1804.34	2092.97	2254.20	2412.01	2571.13	2728.75	2884.41	746.36	10434.73	23780.75
Steel																
IPS	SCH															
3/8	80	0.08	0.14	0.22	0.33	0.48	0.67	0.78	0.84	0.90	0.96	1.01	1.07	2.24	3.91	8.75
1/2	80	0.16	0.27	0.43	0.65	0.94	1.32	1.54	1.66	1.77	1.89	1.99	2.10	3.73	7.73	17.22
3/4	80	0.37	0.62	0.98	1.46	2.12	2.97	3.47	3.72	3.99	4.24	4.49	4.74	6.89	17.44	38.76
1	80	0.73	1.22	1.91	2.87	4.16	5.83	6.77	7.28	7.78	8.32	8.78	9.29	11.45	34.07	75.93
1 1/4	80	1.93	3.19	5.03	7.55	10.89	15.31	17.78	19.09	20.50	21.72	23.06	24.32	23.82	89.31	199.33
1 1/2	80	2.90	4.81	7.56	11.33	16.34	22.87	26.75	28.65	30.60	32.60	34.62	36.51	32.42	134.01	299.04
2	40	5.59	9.30	14.54	21.87	31.53	44.06	51.36	55.41	58.99	62.91	66.65	70.31	53.44	258.19	573.39
2 1/2	40	8.95	14.79	23.21	34.90	50.36	70.44	81.86	88.28	94.14	100.19	106.15	111.96	76.24	411.32	914.02
3	40	15.87	26.19	41.06	61.40	89.04	124.39	145.12	155.20	166.18	176.85	187.11	197.62	117.72	727.31	1617.54
4	40	32.27	53.48	83.73	125.35	180.47	252.43	294.10	316.59	338.48	360.22	381.63	402.51	202.72	1482.70	3296.52
5	40	58.45	96.32	151.32	226.19	326.69	456.97	531.45	570.94	610.41	649.60	688.17	725.85	318.58	2678.78	5942.54
6	40	94.28	155.85	243.49	365.66	525.93	736.88	857.94	921.70	989.06	1048.60	1110.91	1171.72	460.06	4332.17	9593.67
8	40	193.51	319.42	498.88	748.82	1076.15	1506.89	1755.70	1886.14	2016.47	2145.77	2273.26	2397.67	796.65	8861.80	19614.80
10	40	350.78	578.51	903.24	1352.44	1950.53	2727.35	3172.32	3407.79	3643.24	3877.01	4107.33	4332.09	1255.71	15952.97	35441.70
12	ID[a]	561.70	925.65	1444.29	2160.13	3114.93	4355.61	5074.40	5451.29	5827.59	6201.48	6569.85	6929.34	1801.00	25552.61	56654.42
14	30	727.39	1198.63	1871.13	2791.24	4025.45	5628.92	6562.54	7049.57	7536.56	8020.07	8496.45	8961.33	2195.76	33069.18	73203.11
16	30	1045.11	1720.38	2698.17	4024.22	5803.33	8114.31	9450.79	10152.03	10852.73	11548.44	12233.91	12902.85	2908.65	47668.20	105519.26

Freon™ 404A (R-404A)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R404A (Single- or High-Stage Applications)

Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 3.57 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
		Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft						Velocity = 100 fpm	Drop/ 100 ft Δp = 3.56	Drop/ 100 ft Δp = 17.4
		0.63	0.96	1.40	1.94	2.62	3.42	3.57	3.57	3.57	3.57	3.57	3.57			
1/2		0.05	0.09	0.15	0.23	0.36	0.53	0.57	0.64	0.71	0.78	0.84	0.90	1.32	2.58	6.12
5/8		0.09	0.16	0.27	0.44	0.68	1.00	1.07	1.20	1.33	1.45	1.57	1.69	2.12	4.85	11.46
3/4		0.15	0.28	0.47	0.75	1.15	1.69	1.82	2.04	2.25	2.46	2.67	2.87	3.16	8.27	19.44
7/8		0.24	0.43	0.72	1.16	1.77	2.62	2.81	3.14	3.47	3.80	4.12	4.43	4.40	12.78	29.97
1 1/8		0.48	0.87	1.47	2.35	3.59	5.29	5.67	6.34	7.01	7.67	8.32	8.95	7.49	25.89	60.35
1 3/8		0.85	1.52	2.57	4.10	6.26	9.20	9.85	11.01	12.18	13.33	14.45	15.55	11.42	45.11	104.76
1 5/8		1.34	2.41	4.07	6.48	9.88	14.52	15.54	17.37	19.21	21.03	22.79	24.53	16.16	71.28	165.17
2 1/8		2.80	5.02	8.43	13.43	20.46	29.98	32.08	35.86	39.65	43.39	47.02	50.59	28.11	147.69	340.55
2 5/8		4.97	8.90	14.92	23.73	36.10	52.84	56.51	63.17	69.82	76.41	82.79	89.12	43.34	260.68	599.25
3 1/8		7.95	14.22	23.82	37.84	57.52	84.17	89.93	100.51	111.09	121.53	131.55	141.79	61.87	414.92	953.45
3 5/8		11.85	21.16	35.40	56.21	85.28	124.83	133.32	149.01	164.69	180.03	195.03	210.28	83.68	616.02	1413.46
4 1/8		16.74	29.88	49.94	79.25	120.16	175.71	187.64	209.69	231.50	253.15	274.45	295.88	108.78	867.59	1989.17
5 1/8		30.02	53.43	89.31	141.58	214.40	313.49	334.29	373.59	412.53	451.04	488.41	525.04	169.53	1548.80	3539.32
6 1/8		48.37	86.00	143.63	227.35	343.93	500.66	535.82	598.16	660.81	722.40	783.08	841.78	243.71	2484.53	5673.08
8 1/8		100.55	178.50	297.51	470.04	711.18	1034.93	1104.44	1233.67	1362.32	1490.66	1616.20	1737.79	425.69	5135.47	11703.20
Steel																
IPS	SCH															
3/8	80	0.04	0.07	0.11	0.18	0.27	0.39	0.41	0.46	0.51	0.55	0.60	0.64	1.28	1.93	4.33
1/2	80	0.08	0.14	0.22	0.35	0.52	0.76	0.81	0.90	1.00	1.09	1.18	1.26	2.13	3.82	8.52
3/4	80	0.17	0.30	0.50	0.79	1.18	1.71	1.82	2.04	2.24	2.44	2.66	2.84	3.93	8.62	19.17
1	80	0.34	0.60	0.99	1.54	2.31	3.34	3.57	3.97	4.40	4.80	5.20	5.57	6.53	16.85	37.55
1 1/4	80	0.90	1.58	2.59	4.04	6.07	8.78	9.32	10.40	11.52	12.59	13.59	14.58	13.58	44.18	98.59
1 1/2	80	1.36	2.36	3.89	6.07	9.07	13.12	14.03	15.60	17.29	18.81	20.40	21.89	18.49	66.28	147.90
2	40	2.63	4.58	7.48	11.71	17.50	25.40	26.93	30.17	33.15	36.29	39.28	42.15	30.48	127.70	283.59
2 1/2	40	4.18	7.27	11.94	18.69	27.96	40.40	42.93	48.07	52.91	57.80	62.56	67.11	43.49	203.44	452.06
3	40	7.41	12.88	21.13	32.89	49.44	71.34	76.10	84.94	93.39	102.02	110.82	118.46	67.14	359.73	800.01
4	40	15.07	26.30	43.09	67.14	100.20	144.79	154.23	172.39	190.22	207.79	224.90	241.28	115.62	733.35	1630.40
5	40	27.29	47.37	77.87	121.16	181.38	262.11	278.70	310.90	343.04	374.73	405.55	435.11	181.71	1324.94	2939.09
6	40	44.25	76.65	125.93	195.86	293.47	422.66	449.92	501.89	555.83	604.90	654.68	702.39	262.40	2142.72	4744.87
8	40	90.36	157.09	256.72	401.10	597.48	864.32	920.72	1027.06	1133.21	1237.81	1339.66	1437.30	454.38	4383.10	9701.16
10	40	163.79	284.51	464.81	724.42	1082.94	1564.35	1663.62	1855.65	2047.42	2236.49	2420.51	2596.90	716.20	7890.43	17528.89
12	ID[a]	262.28	455.24	743.23	1157.05	1729.42	2498.28	2661.11	2968.40	3274.97	3577.39	3871.71	4153.83	1027.22	12638.47	28020.35
14	30	339.64	589.49	962.88	1495.10	2234.94	3228.62	3441.52	3838.72	4235.37	4626.46	5007.08	5371.92	1252.37	16356.21	36205.06
16	30	488.00	846.09	1388.48	2155.53	3222.03	4654.18	4956.17	5528.10	6098.98	6661.84	7209.62	7734.68	1658.98	23576.97	52188.10

Freon™ 410A (R-410A)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R410A (Single- or High-Stage Applications)																
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 4.77 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
				Corresponding Δp, psi/		100 ft				Corresponding Δp, psi/		100 ft		Velocity =	Drop/ 100 ft	Drop/ 100 ft
		0.84	1.28	1.85	2.58	3.48	4.56	4.77	4.77	4.77	4.77	4.77	4.77	100 fpm	Δp = 4.76	Δp = 23.3
1/2		0.10	0.17	0.27	0.42	0.62	0.90	1.01	1.10	1.18	1.27	1.35	1.43	2.00	4.56	10.77
5/8		0.18	0.31	0.51	0.79	1.17	1.68	1.89	2.06	2.22	2.37	2.53	2.68	3.21	8.56	20.14
3/4		0.31	0.53	0.87	1.35	2.00	2.86	3.22	3.50	3.76	4.05	4.30	4.56	4.79	14.57	34.12
7/8		0.48	0.83	1.35	2.08	3.08	4.41	4.97	5.40	5.81	6.24	6.64	7.02	6.66	22.52	52.59
1 1/8		0.98	1.68	2.73	4.21	6.24	8.92	10.05	10.89	11.72	12.59	13.39	14.18	11.35	45.58	106.08
1 3/8		1.71	2.94	4.77	7.35	10.87	15.52	17.49	18.93	20.36	21.88	23.27	24.64	17.29	79.38	184.11
1 5/8		2.72	4.67	7.56	11.63	17.17	24.50	27.59	29.85	32.11	34.51	36.70	38.88	24.47	125.41	289.75
2 1/8		5.66	9.71	15.67	24.10	35.55	50.59	56.96	61.63	66.28	71.21	75.70	80.17	42.57	259.59	597.33
2 5/8		10.05	17.20	27.72	42.58	62.42	89.17	100.35	108.55	116.71	125.42	133.31	141.25	65.65	458.05	1050.94
3 1/8		16.08	27.50	44.26	67.89	99.45	141.33	159.68	172.72	185.70	199.49	211.82	224.71	93.70	729.50	1671.44
3 5/8		23.96	40.92	65.78	100.85	148.19	209.60	236.72	256.05	275.29	295.51	314.03	331.61	126.73	1082.75	2475.49
4 1/8		33.86	57.77	92.80	141.46	207.76	295.04	333.17	360.33	388.89	415.54	441.90	466.59	164.75	1525.03	3483.77
5 1/8		60.73	103.32	165.98	252.71	370.69	526.40	593.57	641.97	693.00	740.35	786.41	832.10	256.76	2721.13	6198.66
6 1/8		97.84	166.29	265.59	405.82	594.65	844.91	951.41	1032.99	1110.08	1185.77	1260.88	1334.08	369.10	4365.63	9935.66
8 1/8		202.39	345.14	550.13	839.02	1229.62	1737.78	1961.08	2130.48	2288.54	2446.83	2602.32	2754.10	644.72	9020.49	20496.61
Steel																
IPS	SCH															
3/8	80	0.08	0.13	0.21	0.32	0.46	0.65	0.73	0.79	0.85	0.91	0.97	1.02	1.93	3.39	7.54
1/2	80	0.15	0.26	0.41	0.62	0.90	1.28	1.45	1.56	1.68	1.79	1.89	2.00	3.22	6.66	14.84
3/4	80	0.35	0.59	0.93	1.41	2.04	2.87	3.25	3.52	3.77	4.01	4.28	4.50	5.95	15.03	33.41
1	80	0.69	1.15	1.83	2.76	3.99	5.61	6.37	6.85	7.38	7.88	8.37	8.82	9.89	29.36	65.44
1 1/4	80	1.82	3.04	4.79	7.22	10.50	14.74	16.63	17.96	19.35	20.67	21.88	23.11	20.57	76.99	171.80
1 1/2	80	2.73	4.55	7.19	10.84	15.76	22.13	25.04	26.94	29.04	30.87	32.85	34.69	28.00	115.52	257.73
2	40	5.28	8.80	13.91	20.91	30.26	42.65	48.06	52.10	55.69	59.57	63.25	66.79	46.16	222.56	496.67
2 1/2	40	8.41	14.06	22.09	33.37	48.34	67.84	76.61	83.02	88.88	94.87	100.72	106.36	65.86	354.56	787.75
3	40	14.92	24.78	39.07	59.00	85.48	119.80	135.81	146.68	156.88	167.46	178.44	187.74	101.69	626.95	1394.09
4	40	30.48	50.60	79.68	119.84	173.24	244.34	275.22	297.72	319.55	341.08	362.12	382.39	175.11	1278.09	2841.13
5	40	54.93	91.59	143.99	216.26	313.60	440.11	497.34	536.90	576.26	615.10	653.00	689.58	275.19	2309.11	5121.62
6	40	89.06	147.47	232.86	349.61	507.40	709.69	802.88	866.74	933.72	992.90	1054.13	1113.18	397.40	3734.34	8268.36
8	40	181.87	302.23	474.71	715.96	1033.03	1451.30	1643.02	1773.68	1903.66	2031.80	2157.06	2277.87	688.15	7638.90	16905.14
10	40	329.67	547.37	859.48	1293.09	1872.38	2626.74	2968.71	3204.61	3439.42	3671.08	3897.39	4115.64	1084.69	13751.50	30545.65
12	ID[a]	527.90	875.84	1374.33	2065.33	2990.12	4194.93	4748.72	5126.27	5501.57	5872.09	6234.04	6583.12	1555.73	22026.42	48827.97
14	30	683.62	1134.12	1780.49	2668.75	3864.16	5421.27	6141.34	6629.26	7114.93	7594.09	8062.16	8513.59	1896.72	28505.71	63090.56
16	30	982.23	1627.79	2567.47	3847.62	5570.81	7814.97	8844.22	9546.73	10245.57	10935.05	11608.58	12258.17	2512.53	41090.11	90942.44

Freon™ 134a (R-134a)

Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R134a (Single- or High-Stage Applications)

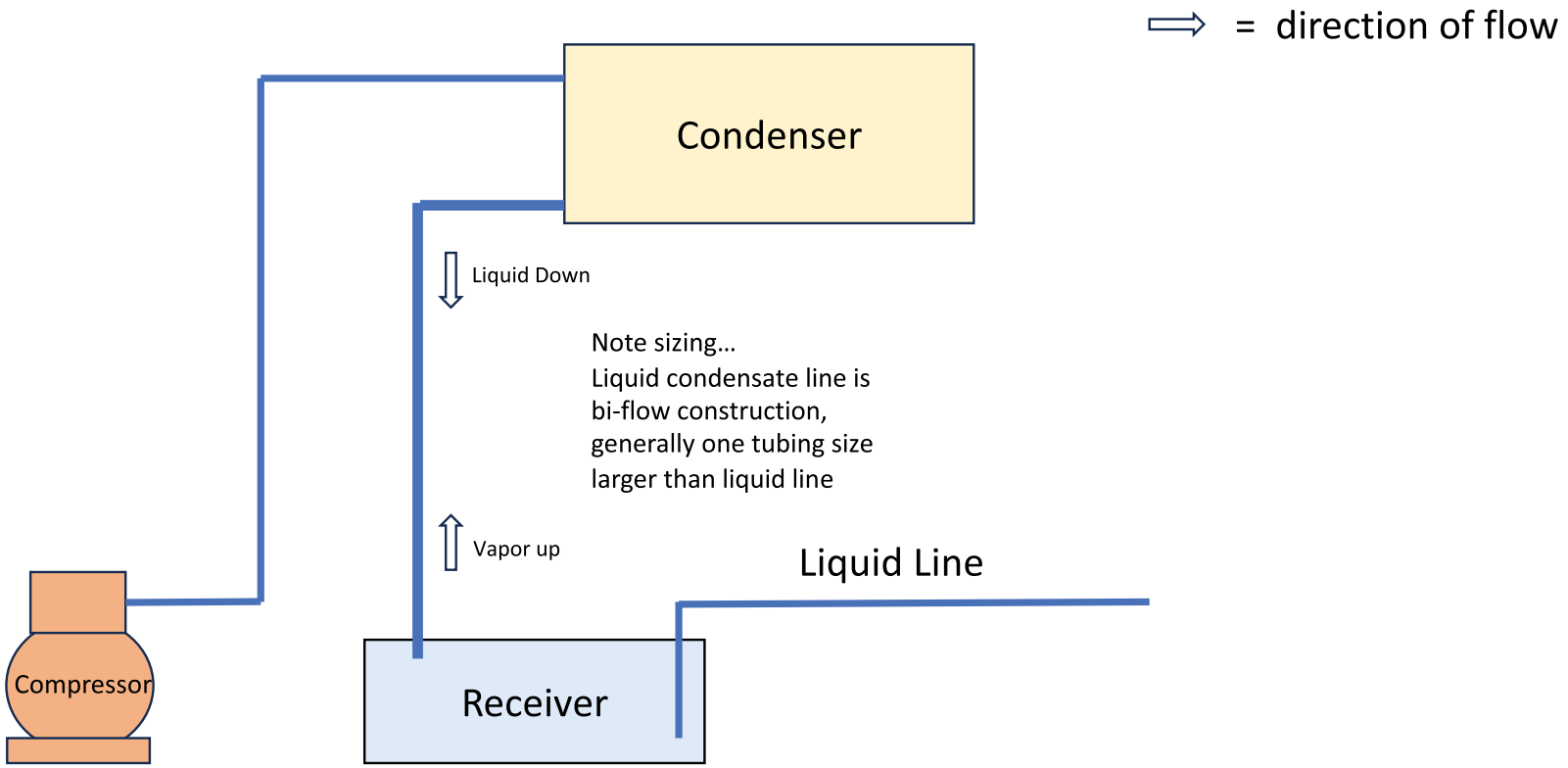
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 2.21 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
				Corresponding Δp, psi/		100 ft				Corresponding Δp, psi/		100 ft		Velocity =	Drop/ 100 ft	Drop/ 100 ft
		0.26	0.43	0.67	1.00	1.41	1.93	2.21	2.21	2.21	2.21	2.21	2.21	100 fpm	Δp = 2.21	Δp = 10.8
1/2		0.02	0.05	0.08	0.14	0.23	0.35	0.45	0.49	0.53	0.57	0.61	0.66	2.13	2.83	6.77
5/8		0.04	0.09	0.16	0.27	0.43	0.67	0.84	0.92	1.00	1.08	1.15	1.23	3.42	5.33	12.72
3/4		0.08	0.15	0.27	0.46	0.74	1.13	1.43	1.56	1.70	1.83	1.96	2.09	5.11	9.10	21.64
7/8		0.12	0.23	0.42	0.71	1.14	1.75	2.20	2.41	2.62	2.83	3.03	3.24	7.10	14.11	33.45
1 1/8		0.25	0.48	0.86	1.45	2.32	3.56	4.46	4.88	5.30	5.73	6.14	6.54	12.10	28.67	67.67
1 3/8		0.44	0.84	1.51	2.54	4.06	6.20	7.77	8.50	9.23	9.97	10.68	11.39	18.43	50.08	117.97
1 5/8		0.69	1.34	2.40	4.03	6.42	9.81	12.28	13.43	14.58	15.74	16.87	17.98	26.09	79.32	186.29
2 1/8		1.45	2.79	4.99	8.37	13.32	20.31	25.41	27.78	30.16	32.55	34.88	37.17	45.39	164.79	385.37
2 5/8		2.59	4.97	8.85	14.82	23.58	35.87	44.84	49.01	53.27	57.40	61.51	65.54	69.99	291.63	679.78
3 1/8		4.16	7.96	14.17	23.69	37.63	57.18	71.45	78.18	84.84	91.42	97.94	104.36	99.90	465.72	1082.90
3 5/8		6.20	11.86	21.10	35.24	55.95	84.91	106.16	116.00	125.88	135.63	145.30	154.90	135.12	692.54	1606.87
4 1/8		8.78	16.77	29.80	49.72	78.88	119.66	149.54	163.38	177.19	190.99	204.61	218.11	175.65	977.15	2263.30
5 1/8		15.80	30.15	53.42	89.11	141.00	213.68	266.78	291.42	316.05	341.01	365.20	388.95	273.74	1748.05	4036.90
6 1/8		25.52	48.63	86.02	143.35	226.60	343.13	428.05	467.93	507.55	546.89	585.78	623.83	393.52	2814.21	6476.96
8 1/8		53.23	101.23	178.72	297.29	469.28	710.10	885.10	966.54	1048.12	1129.44	1209.66	1288.17	687.37	5832.46	13395.14
Steel																
IPS	SCH															
3/8	80	0.02	0.04	0.07	0.11	0.18	0.27	0.33	0.36	0.39	0.42	0.45	0.48	2.06	2.23	5.04
1/2	80	0.04	0.08	0.14	0.23	0.35	0.53	0.66	0.72	0.77	0.84	0.89	0.95	3.43	4.41	9.92
3/4	80	0.09	0.18	0.31	0.51	0.80	1.19	1.48	1.61	1.75	1.88	2.01	2.13	6.34	9.95	22.33
1	80	0.19	0.35	0.61	1.00	1.56	2.34	2.90	3.15	3.43	3.68	3.94	4.18	10.55	19.55	43.75
1 1/4	80	0.50	0.93	1.61	2.63	4.10	6.15	7.58	8.26	8.98	9.66	10.31	10.96	21.94	51.26	114.85
1 1/2	80	0.75	1.39	2.42	3.95	6.15	9.18	11.40	12.39	13.47	14.43	15.47	16.45	29.86	76.92	171.45
2	40	1.45	2.69	4.67	7.63	11.88	17.69	21.89	23.96	25.83	27.85	29.79	31.68	49.21	148.93	330.39
2 1/2	40	2.31	4.31	7.46	12.17	18.88	28.29	34.89	38.17	41.22	44.35	47.44	50.45	70.22	237.26	526.64
3	40	4.11	7.63	13.19	21.52	33.38	49.95	61.86	67.44	72.76	78.29	84.04	89.05	108.42	419.53	931.99
4	40	8.42	15.58	26.91	43.71	67.99	101.88	125.35	136.89	148.21	159.46	170.55	181.37	186.70	855.26	1899.38
5	40	15.24	28.19	48.62	79.28	123.07	183.51	226.52	246.87	267.28	287.57	307.55	327.07	293.40	1537.52	3423.97
6	40	24.68	45.63	78.63	128.16	198.14	295.91	365.68	398.52	433.07	464.20	496.47	527.98	423.70	2486.51	5527.66
8	40	50.68	93.51	161.10	261.15	405.41	605.13	748.33	815.53	882.94	949.90	1015.93	1080.39	733.69	5086.35	11301.62
10	40	91.90	169.36	291.68	474.01	734.81	1095.23	1352.14	1473.46	1595.24	1716.30	1835.58	1952.04	1156.46	9202.09	20420.74
12	ID[a]	147.18	270.99	466.40	757.09	1173.47	1749.09	2162.87	2357.03	2551.69	2745.31	2936.09	3122.35	1658.67	14739.41	32643.05
14	30	190.61	350.91	601.24	978.28	1516.48	2260.42	2797.16	3048.10	3299.98	3550.38	3797.09	4037.97	2022.22	19075.16	42178.05
16	30	275.15	506.16	866.99	1410.42	2186.25	3258.48	4028.22	4389.54	4752.01	5112.35	5467.37	5814.01	2678.77	27496.25	60797.91

Freon™ 22 (R-22)

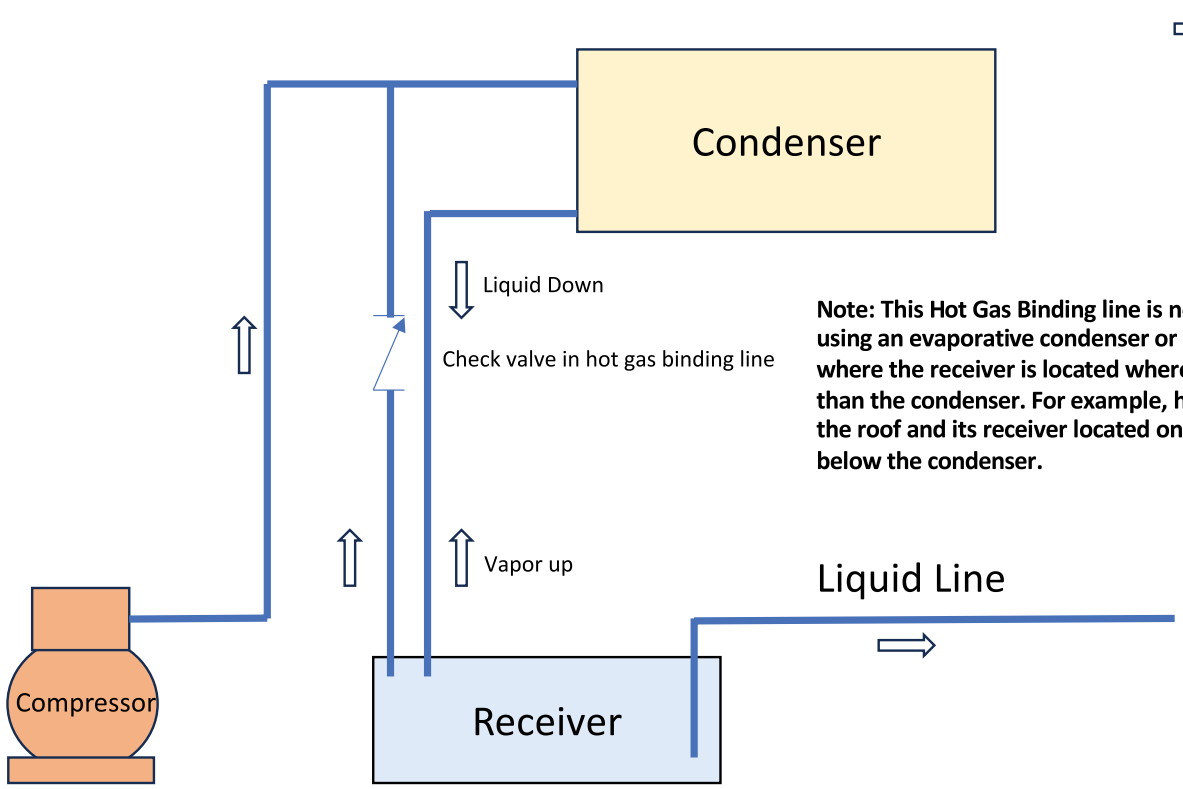
Suction, Discharge, and Liquid Line Capacities in Tons for Refrigerant R22 (Single- or High-Stage Applications)																
Line Size		Suction Lines, Δt = 2 °F						Discharge Lines, Δt = 1 °F, Δp = 3.03 psi						Liquid Lines		
		Saturated Suction Temperature, °F						Saturated Suction Temperature, °F								
Type L Copper, OD		-60	-40	-20	0	20	40	-60	-40	-20	0	20	40		Δt = 1 °F	Δt = 5 °F
				Corresponding Δp, psi/ 100 ft						Corresponding Δp, psi/ 100 ft				Velocity = 100 fpm	Drop/ 100 ft Δp = 3.03	Drop/ 100 ft Δp = 14.8
		0.51	0.79	1.16	1.63	2.21	2.91	3.03	3.03	3.03	3.03	3.03	3.03			
1/2		0.06	0.10	0.17	0.27	0.40	0.58	0.65	0.71	0.76	0.81	0.87	0.92	2.32	3.73	8.89
5/8		0.11	0.20	0.32	0.51	0.76	1.09	1.23	1.33	1.43	1.52	1.63	1.72	3.73	7.02	16.68
3/4		0.19	0.34	0.55	0.86	1.29	1.86	2.09	2.27	2.43	2.59	2.77	2.93	5.57	11.98	28.36
7/8		0.30	0.52	0.86	1.34	2.00	2.88	3.23	3.50	3.76	4.01	4.28	4.54	7.73	18.55	43.79
1 1/8		0.61	1.07	1.75	2.72	4.05	5.81	6.53	7.08	7.60	8.12	8.63	9.18	13.18	37.65	88.49
1 3/8		1.07	1.87	3.05	4.74	7.06	10.12	11.38	12.33	13.23	14.13	15.02	15.97	20.08	65.62	153.97
1 5/8		1.70	2.96	4.84	7.50	11.16	15.98	17.97	19.48	20.89	22.32	23.71	25.21	28.42	103.85	243.01
2 1/8		3.56	6.17	10.06	15.58	23.13	33.08	37.38	40.30	43.22	46.15	49.02	52.11	49.44	215.52	502.22
2 5/8		6.32	10.94	17.82	27.54	40.86	58.37	65.96	71.10	76.33	81.39	86.44	91.89	76.24	381.09	884.19
3 1/8		10.12	17.49	28.46	43.96	65.15	92.99	105.11	113.40	121.57	129.63	137.64	146.33	108.82	608.20	1407.82
3 5/8		15.08	26.05	42.34	65.34	96.64	138.01	155.41	168.28	180.37	192.32	204.20	216.11	147.18	903.91	2088.23
4 1/8		21.33	36.80	59.76	92.16	136.20	194.40	218.91	237.00	253.90	270.81	287.56	304.28	191.33	1274.80	2940.24
5 1/8		38.29	65.96	106.84	164.78	243.24	346.84	392.47	422.75	452.89	483.52	513.24	542.62	298.19	2278.75	5241.58
6 1/8		61.75	106.23	171.87	264.83	390.60	556.55	629.73	678.79	727.28	775.46	823.25	870.29	428.65	3662.97	8405.92
8 1/8		128.52	220.70	356.50	548.47	808.00	1149.06	1295.66	1402.09	1501.89	1601.47	1700.04	1797.12	748.75	7585.30	17332.00
Steel																
IPS	SCH															
3/8	80	0.05	0.08	0.14	0.21	0.30	0.43	0.49	0.53	0.56	0.60	0.64	0.67	2.25	2.87	6.49
1/2	80	0.10	0.17	0.27	0.41	0.60	0.85	0.96	1.04	1.11	1.19	1.25	1.32	3.74	5.67	12.77
3/4	80	0.22	0.38	0.61	0.93	1.35	1.91	2.18	2.33	2.51	2.66	2.83	2.98	6.91	12.80	28.75
1	80	0.44	0.75	1.20	1.82	2.65	3.75	4.27	4.57	4.91	5.22	5.54	5.84	11.49	25.14	56.32
1 1/4	80	1.17	1.97	3.15	4.77	6.97	9.86	11.15	11.98	12.86	13.70	14.48	15.29	23.89	65.92	147.86
1 1/2	80	1.76	2.97	4.73	7.16	10.46	14.73	16.78	17.97	19.30	20.47	21.74	22.95	32.52	98.91	220.72
2	40	3.40	5.73	9.14	13.82	20.18	28.38	32.20	34.75	37.01	39.49	41.86	44.20	53.61	191.51	425.35
2 1/2	40	5.44	9.15	14.59	22.05	32.08	45.37	51.33	55.37	59.07	62.89	66.67	70.38	76.49	305.09	678.00
3	40	9.62	16.18	25.68	38.99	56.71	80.12	91.00	97.84	104.27	111.01	118.11	124.23	118.10	539.48	1199.86
4	40	19.67	33.05	52.37	79.59	115.52	163.41	184.41	198.57	212.37	226.11	239.69	253.03	203.37	1099.78	2445.30
5	40	35.59	59.81	94.64	143.61	209.10	294.34	333.24	358.11	382.99	407.75	432.22	456.29	319.60	1977.11	4408.07
6	40	57.52	96.80	153.05	232.15	336.65	474.63	537.97	578.11	620.56	658.21	697.73	736.57	461.53	3197.42	7116.40
8	40	117.91	197.39	313.57	473.06	688.82	970.60	1100.91	1183.02	1265.20	1346.90	1427.77	1507.24	799.20	6540.57	14549.89
10	40	213.78	357.51	567.73	858.66	1248.49	1756.71	1989.20	2137.43	2285.88	2433.60	2579.70	2723.27	1259.72	11833.02	26289.98
12	ID[a]	342.38	572.03	907.81	1371.46	1993.79	2805.49	3181.90	3419.15	3656.41	3892.67	4126.35	4355.96	1806.76	18953.50	42025.18
14	30	443.42	740.72	1176.16	1772.15	2576.59	3625.64	4115.04	4421.63	4728.67	5034.20	5336.39	5633.33	2202.77	24528.87	54300.69
16	30	640.09	1068.46	1687.51	2554.96	3714.57	5226.50	5926.12	6367.55	6809.34	7248.96	7683.79	8111.07	2917.95	35357.61	78272.20

Section 4 – Piping Procedures

Liquid Condensate Piping

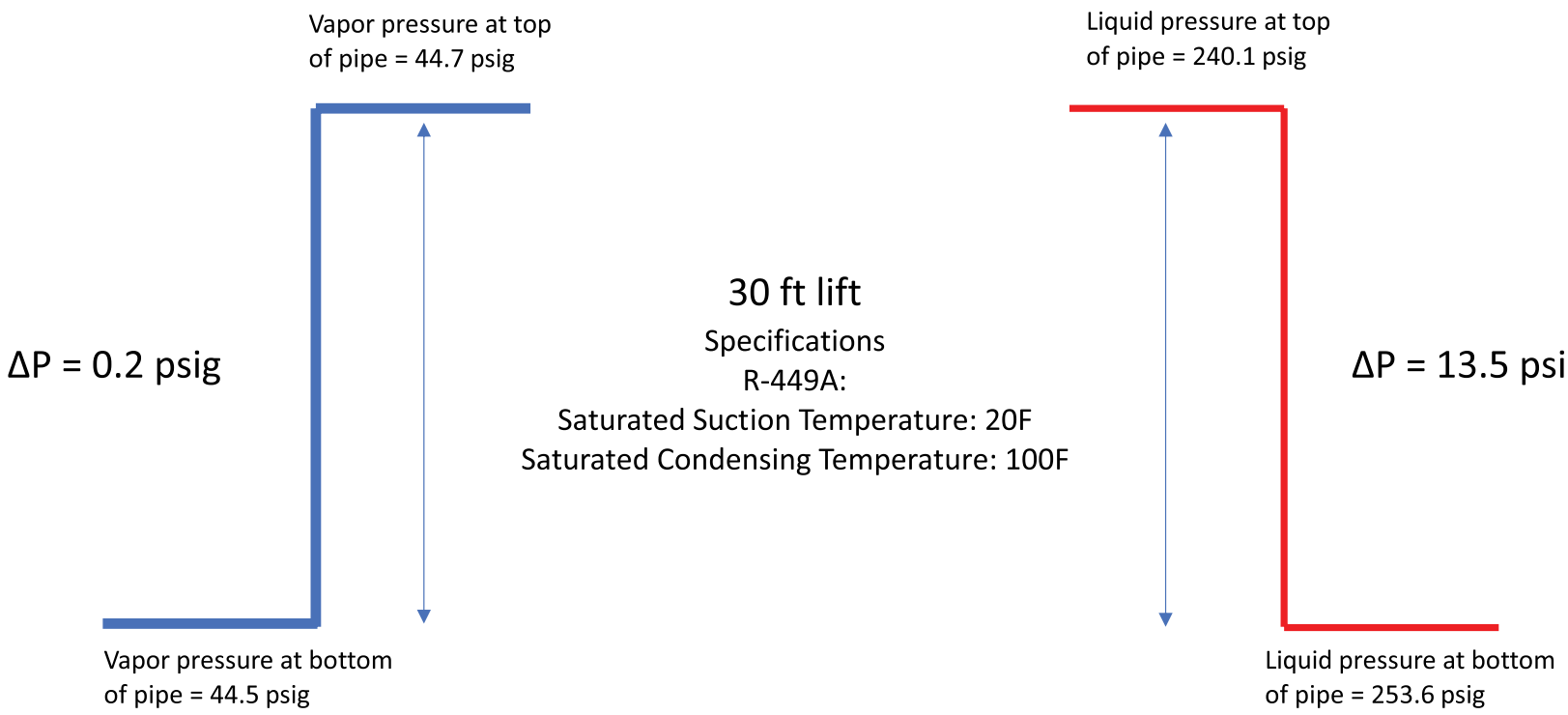


Hot Gas Binding Line



Note: This Hot Gas Binding line is needed on installations using an evaporative condenser or on air cooled condensers where the receiver is located where it can become warmer than the condenser. For example, having the condenser on the roof and its receiver located on an inside mezzanine below the condenser.

Effects of Height on Pressure



The height effect is usually of negligible importance in vapor lines where the weight of the fluid is low enough so that it has minimal impact on the total pressure of a column of vapor. In liquid line, however, the fluid is much denser. The weight of the liquid produces a significant change in the pressure from the top to the bottom of the column of fluid. Where the flow proceeds from a higher level to a lower level, the weight of the liquid column adds to the refrigerant pressure at the end of the line, therefore increases the ΔP across the expansion device. However, where the flow proceeds from a lower level to a higher level, pressure is lost, there by resulting in the flashing of liquid refrigerant in the liquid line

Pipe Hanger Spacing

Maximum Spacing Between Pipe Supports for Copper Tubing

Nominal Diameter (OD)	Max Span (ft)
5/8	5
7/8	6
1 1/8	7
1 3/8	8
1 5/8	9
2 1/8	10
2 5/8	11
3 1/8	12
3 5/8	13
4 1/8	14

Section 5 – Oil Traps

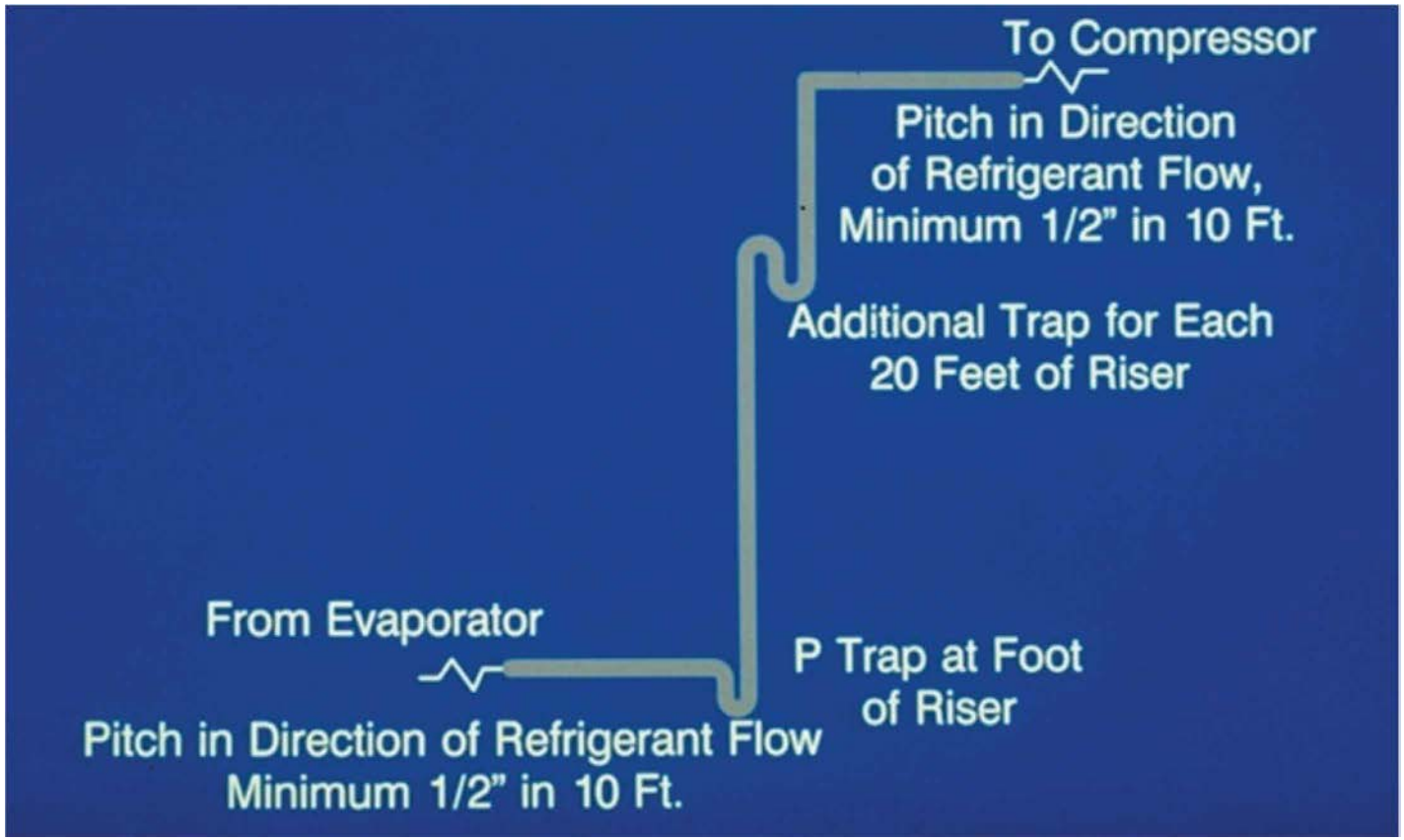
Why Do We Need Oil Traps?

Oil Traps serve 3 main purposes…

1. Assist in oil return to compressor
   a. Compressors require proper lubrication to function, especially during part-load operation
2. Prevent oil accumulation in the evaporator
   a. Excess oil in evaporator will reduce capacity
3. Prevent liquid refrigerant or oil from entering compressor during off cycle

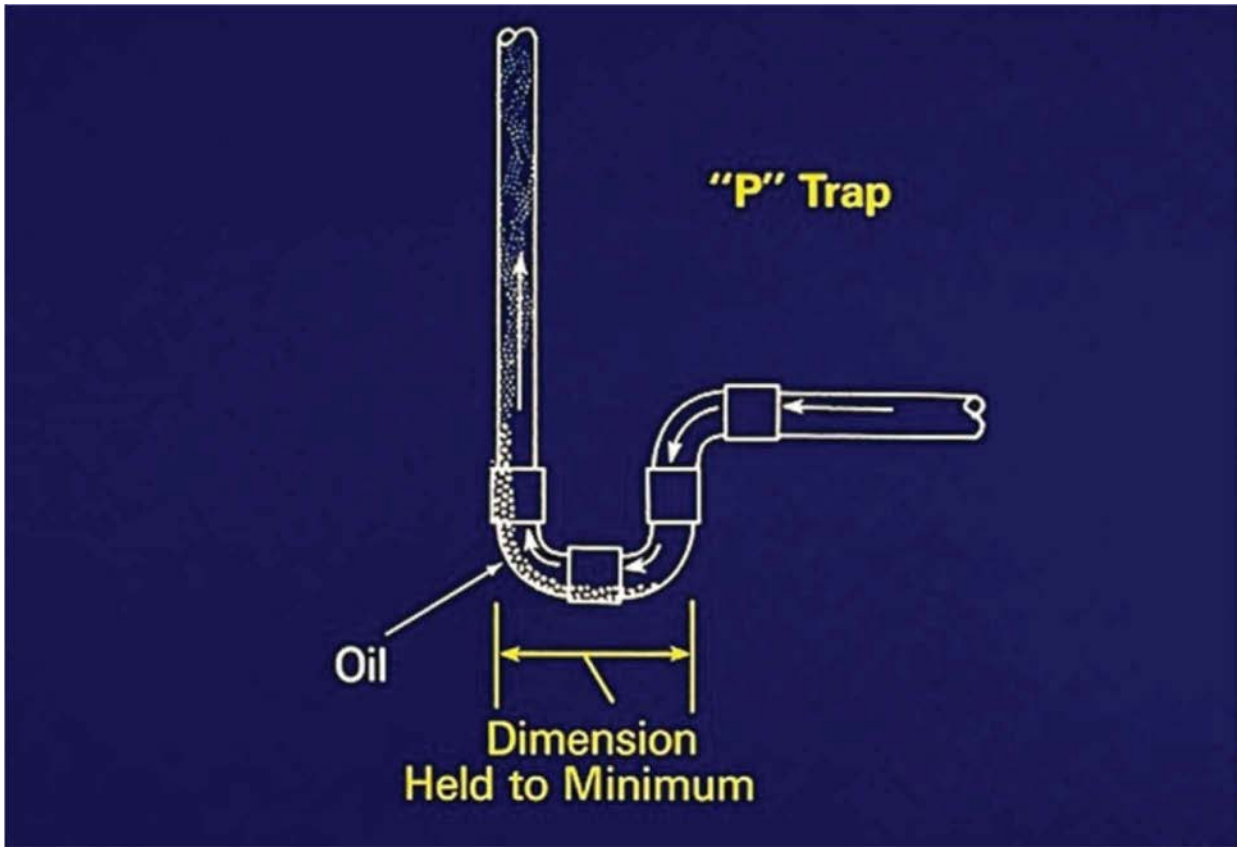
How Do They Work?

- At the suction riser, refrigerant and oil are flowing upward
- The oil will tend to fall back to the bottom of the riser due to gravity
- Installing "P" or "U" traps every 10-15 feet can help temporarily store the oil along the way and prevent the oil from returning to the evaporator
- Always follow manufacturers guidelines for installation



How Do We Size Them?

- Never go beyond 4x the size of the refrigerant line
- Must install oil trap whenever compressor is above evaporator



Discharge Line Oil Traps

- Installed where high discharge risers are present
- Prevents oil draining back to compressor head during off cycle
- Oil present in the compressor head can lead to damage on start ups
- Customary to reduce riser by one pipe size to maintain velocities or use dual risers for changing capacities

Section 6 – Expansion / Contraction

All refrigeration piping materials are subject to changes in temperature and will expand and contract with temperature change. Installation techniques must allow for expansion and contraction changes, this will prevent stresses which may buckle and rupture the copper tube or joints.

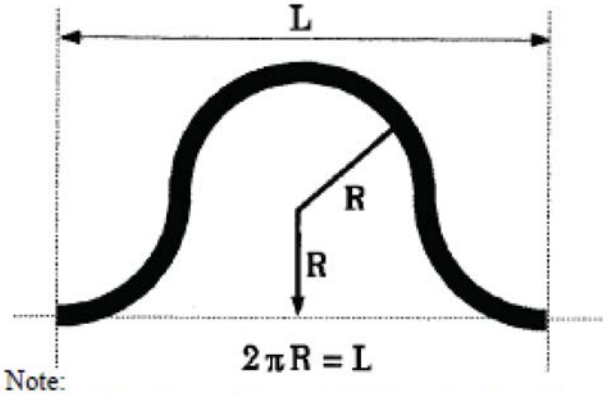
The average coefficient of expansion of copper is 0.0000104 inch/per inch/per degree F. Copper tubing will expand about 1 1/4 inches per 100 feet per 100°F change in temperature. For example, a copper line 75 feet long is used to carry hot discharge refrigerant vapor at 225° F to the systems condenser. The change in temperature could be 155°F, that is 225 - 70 (room ambient). The expected expansion on this application could very well be 75 x 12 x 0.0000104 x 155 = 1.451 or 1.5 inches.

There are two common methods of taking care of expansion and contraction in copper lines used in the refrigeration industry. These are the use of “expansion loops” or “pipe offsets”. See figures 1 and 2 for specifics on these two methods.

In the installation of expansion loops, the expansion member should be “cold sprung” approximately one-half the estimated travel expected. In this manner the bend is subject to only about one-half of the stress when the line is at the highest temperature, then it would be if the loop were installed in its natural position.

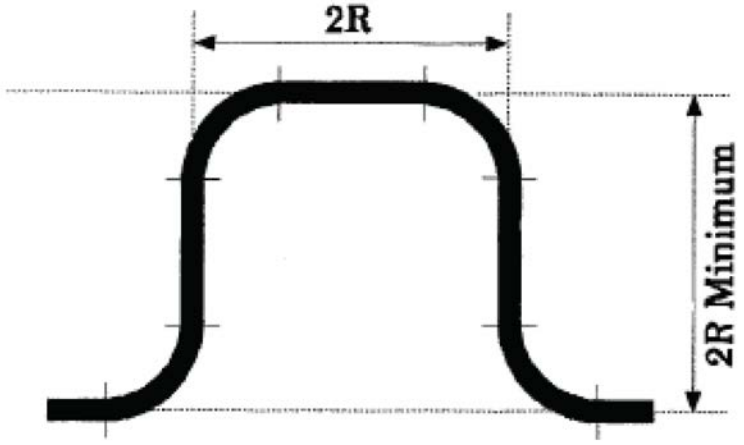
Care must be taken during the installation of the lines to maintain perfect alignment, if not, there will be a tendency for the lines to bow, and possibly buckle or rupture, particularly on the smaller sizes.

Section 6 – Expansion / Contraction



Note:
1. All radii are referenced to the centre line of pipe.
2. "L" length of pipe is referenced to the total length measured along the centre line of the bent pipe.

Figure 1: Expansion Loop (U-Bend)



Offset with four (4) 90° LR elbows

Figure 2: Offset and Return

Section 6 – Expansion / Contraction

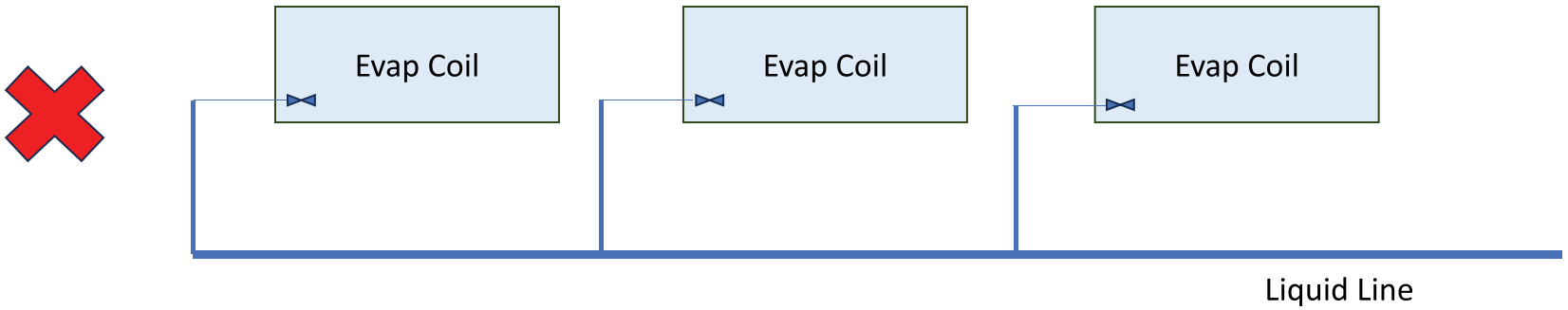
It is often possible to provide for expansion by offsetting the pipe line rather than to continue in a straight line. This method can be used only where there is plenty of space available. A single offset using two 90° elbows should have a minimum length of not less than three times the radius required in an expansion loop. The legs of the offset should not be spaced less than two times the radius from each other, see figure 2. This method is just as effective as expansion loops and can be made on the job, see table 1 for fabrication details. Offsetting by means of long radius allows the installer to vary the length to suit the job. Due to the amount of labor involved in the fabrication of expansion loops they are considered more expensive than offsets made up on the job.

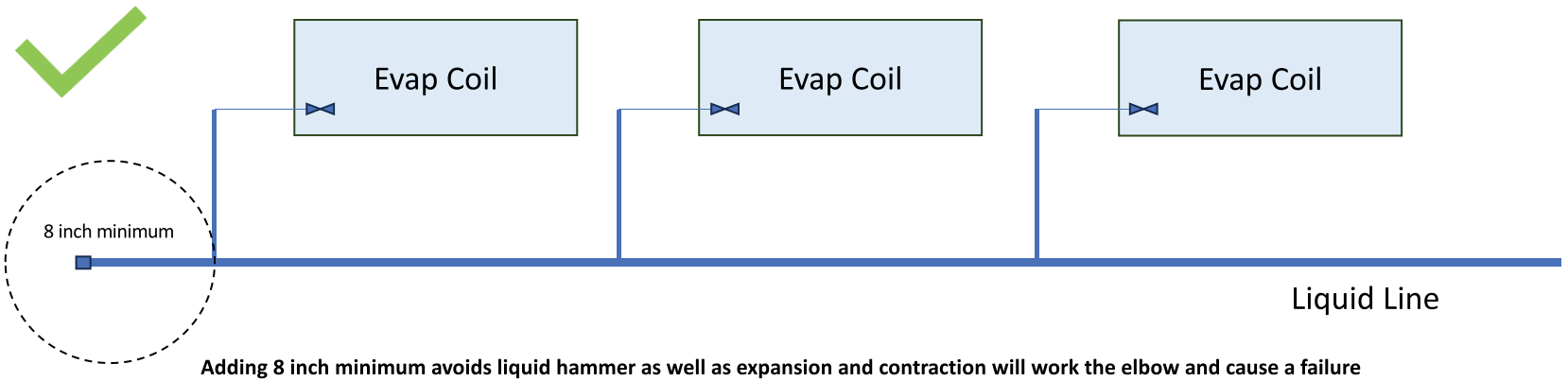
So far we have referred only to main lines in general; these are usually thought of as horizontal. Vertical lines or risers must also be considered in the same manner. Risers should have adequate support at or near the bottom. Where branch lines to fixtures are taken off they should be sufficiently
long to take care of any movement in the main.

Rigid fixtures should never be directly connected to risers. One or two turns or elbows in the line will take care of the short branches. Copper tubing may not break as readily, but if continually subjected to strain and bending it will ultimately fail. Designers and contractors must always keep the matter of expansion and contraction in mind.

Section 7 - Best Practices

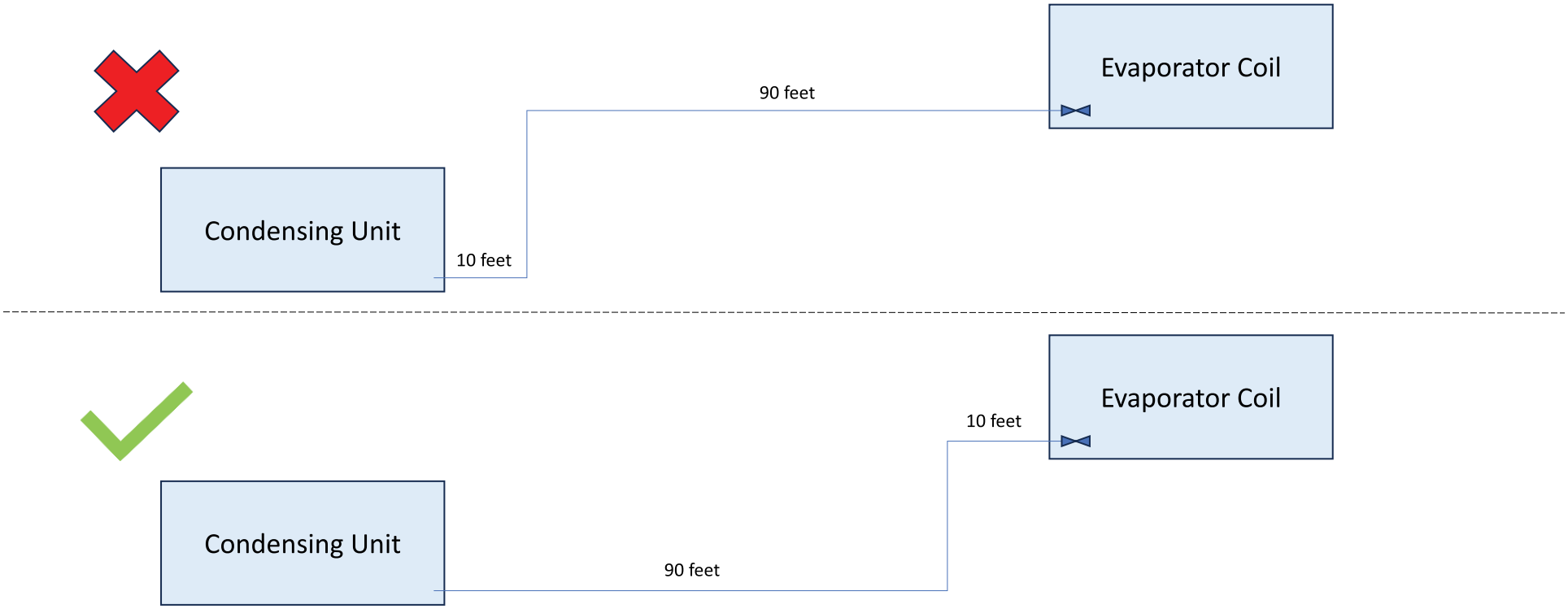
Liquid Line Piping for Multi-case





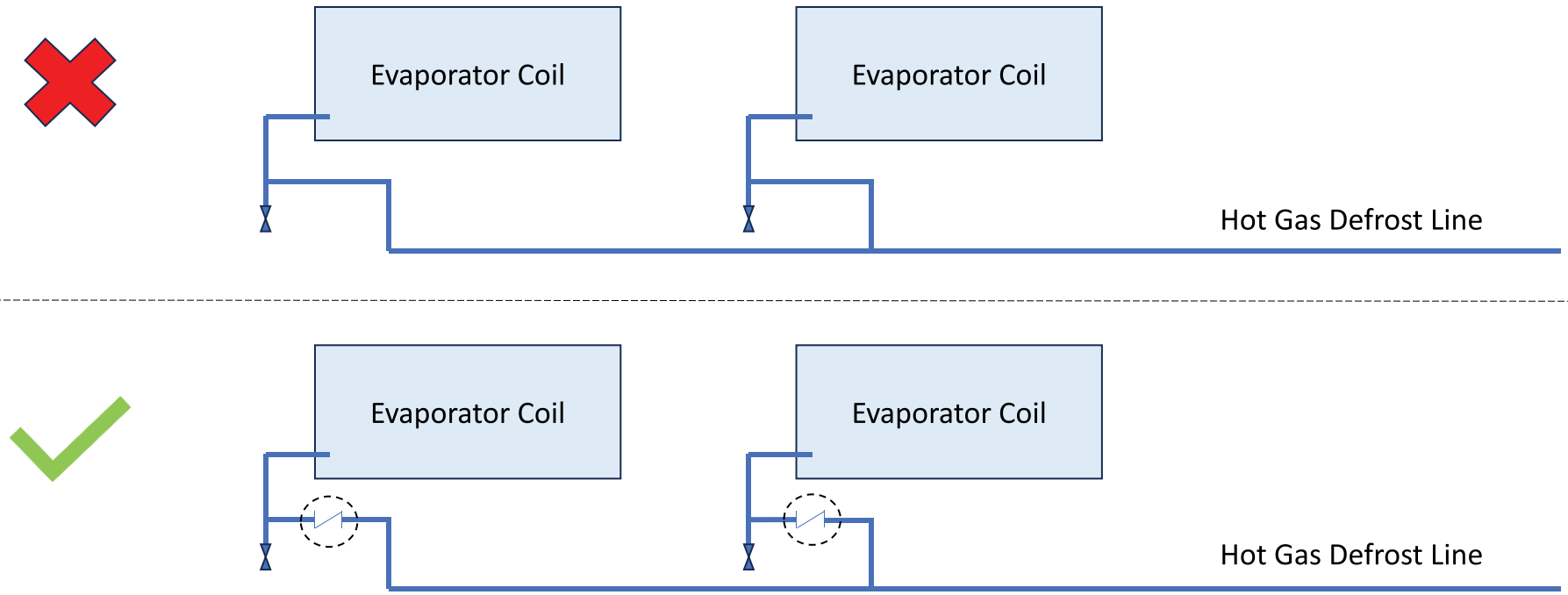
Adding 8 inch minimum avoids liquid hammer as well as expansion and contraction will work the elbow and cause a failure

Split A/C System, 100 Feet Apart, Evaporator Above Condensing Unit



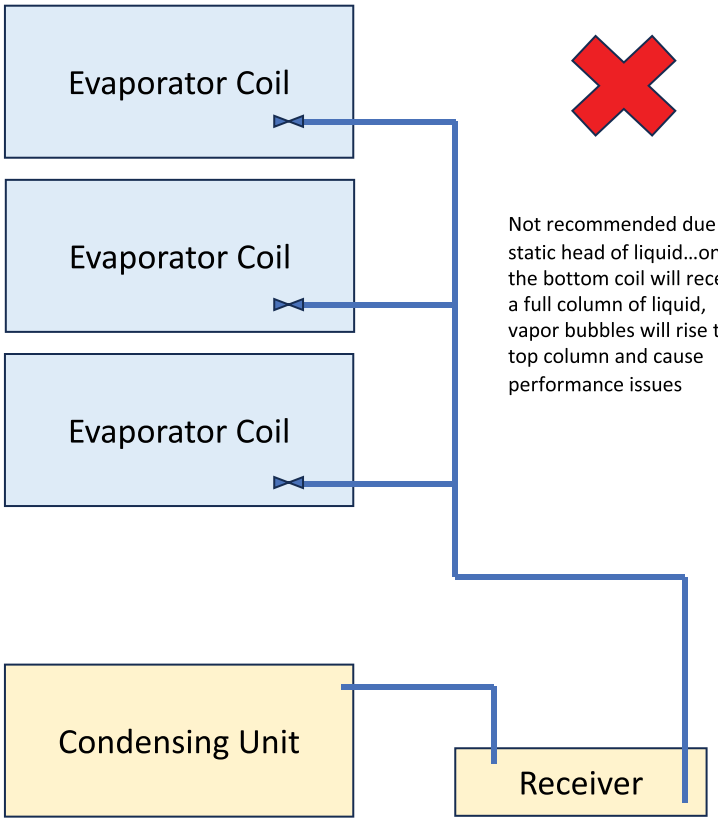
Recommended because only 10ft of liquid refrigerant will drain on off cycle into condensing unit, less chance to slug compressor on start up

Same Circuit Multi Evaporators with Hot Gas Defrost

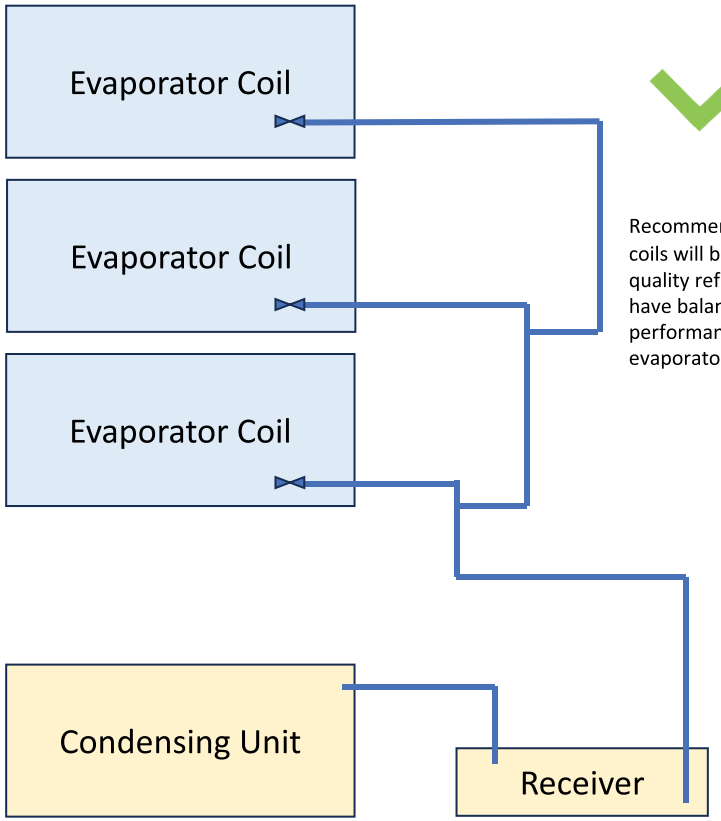


Check valves prevent liquid refrigerant from entering other evaporator when Hot Gas Defrost is not in use

Liquid line Feed to Stacked Evaporator Coils



Not recommended due to static head of liquid…only the bottom coil will receive a full column of liquid, vapor bubbles will rise to top column and cause performance issues



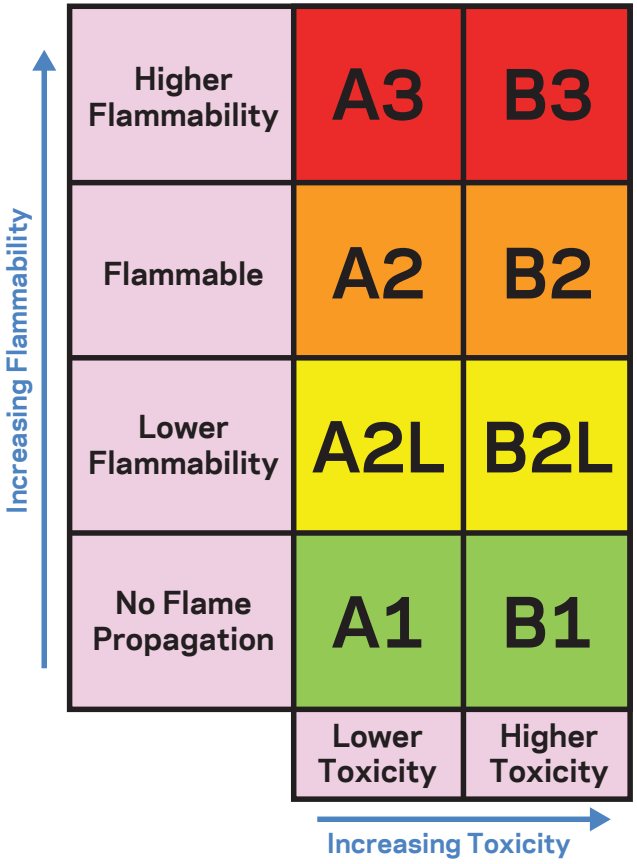
Recommended because all coils will be fed equal quality refrigerant and have balanced performance across evaporators

Section 8 - A2L Knowledge

What is an A2L?

A2L refrigerants:

- Are lower toxicity and lower flammability.
- Have lower GWP than commonly used HFC refrigerants (ex. R-404A)
- Have lower flammability than A2 or A3 refrigerants
- Are for NEW systems only!
  - Not allowed in retrofits



Class 3 Requirements
1. Exhibit flame propagation @ 60°C & 101.3 kPa
2. LFL ≤ 0.10 kg/m³ or HOC ≥ 19,000 kJ/kg

Class 2 Requirements
1. Exhibit flame propagation @ 60°C & 101.3 kPa
2. LFL > 0.10 kg/m³
3. HOC < 19,000 kJ/kg

Class 2L Requirements
1. Exhibit flame propagation @ 60°C & 101.3 kPa
2. LFL > 0.10 kg/m³
3. HOC < 19,000 kJ/kg
4. $S_u \leq 10$ cm/s

Class 1 Requirements
1. No flame propagation @ 60°C & 101.3 kPa

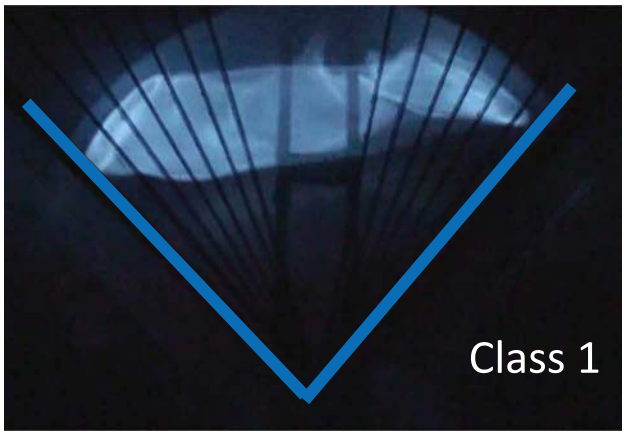
Flammability Characteristics

There are two key industry tests to determine whether a refrigerant is an A1, A2L, or an A2/A3

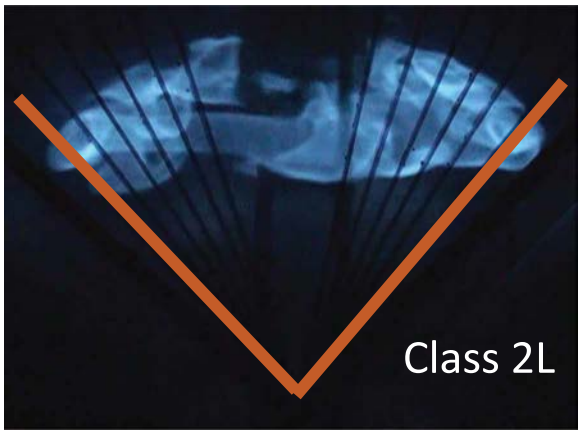
1. ASTM E681 determines flammable vs non-flammable
   a. Based on flame breaching a 90° angle
2. ISO 817 Burning Velocity determines if flammable refrigerant is an A2L or A2/A3
   a. A flame speed ⩽ 10 cm/s is considered an A2L "lower flammability"
   b. A flame speed > 10 cm/s is considered an A2/A3 (further testing required to determine A2 vs A3)

ASTM E681 Test

Class 1 (ex. R-410A)



Class 2L (ex. R-454B)



Best Practices

ACTION	A1s	A2Ls
Safely remove refrigerant following local & national regulations	Required	Required
Purge circuit with inert gas (e.g. oxygen-free nitrogen)	Best Practice	Required
Evacuate circuit	Best Practice	Required
Open circuit by cutting or brazing	Required	Required
Make repairs, purging with nitrogen while brazing	Required	Required
Leak and Pressure Test	Best Practice	Required
Evacuate the system	Required	Required
Charge the system	Required	Required

Resources

Refrigerant Engineering and Technical Data

What are A2L's?

CRE Download

For more information on the Opteon™ family of refrigerants, or other refrigerant products, visit freon.com or call (800) 235-7882.

O-RPH (3/24)