

Table 12A. Recommended Line Sizes for R-502 *#

SYSTEM CAPACITY BTU/H	SUCTION LINE SIZE																				
	SUCTION TEMPERATURE																				
	+20°F						+10°F						-10°F						-20°F		
	Equivalent Lengths						Equivalent Lengths						Equivalent Lengths						Equivalent		
25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	
1,000	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	1/2	3/8	3/8	3/8	1/2	1/2	1/2	3/8	3/8	1/2	
3,000	3/8	1/2	1/2	1/2	5/8	1/2	1/2	5/8	5/8	5/8	5/8	1/2	1/2	5/8	5/8	7/8	7/8	1/2	5/8	5/8	
4,000	1/2	1/2	5/8	5/8	5/8	1/2	1/2	5/8	5/8	5/8	7/8	1/2	5/8	5/8	7/8	7/8	7/8	5/8	7/8	7/8	
6,000	1/2	5/8	5/8	7/8	7/8	1/2	5/8	5/8	7/8	7/8	7/8	5/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	
9,000	5/8	5/8	7/8	7/8	7/8	5/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	1 1/8	7/8	7/8	7/8	
12,000	5/8	7/8	7/8	7/8	7/8	5/8	7/8	7/8	7/8	7/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	
15,000	5/8	7/8	7/8	7/8	1 1/8	7/8	7/8	7/8	7/8	1 1/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	
18,000	7/8	7/8	7/8	7/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 1/8	1 1/8	1 1/8	
24,000	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 3/8	1 3/8	
30,000	7/8	1 1/8	1 1/8	1 1/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 5/8	
36,000	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8	
42,000	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 3/8	1 3/8	1 5/8	
48,000	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	
54,000	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	1 5/8	
60,000	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8	
66,000	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1 5/8	1 5/8	2 1/8	
72,000	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1 5/8	1 5/8	2 1/8	
78,000	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	1 5/8	2 1/8	
84,000	1 1/8	1 3/8	1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	
90,000	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	1 5/8	2 1/8	2 1/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	
120,000	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 1/8	
150,000	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	
180,000	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	2 1/8	2 5/8	2 5/8	
210,000	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	2 5/8	
240,000	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 1/8	2 5/8	2 5/8	2 5/8	
300,000	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	2 5/8	3 1/8	3 1/8	3 1/8	
360,000	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	2 5/8	3 1/8	3 1/8	3 1/8	
480,000	2 1/8	2 5/8	2 5/8	3 1/8	3 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	2 5/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	3 1/8	3 1/8	3 5/8	
600,000	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	2 5/8	3 1/8	3 1/8	3 1/8	3 5/8	3 5/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	5 1/8	3 1/8	3 5/8	3 5/8	

* Sizes that are highlighted indicate maximum suction line sizes that should be used for risers. Riser size should not exceed horizontal size. Properly placed suction traps must also be used for adequate oil return.
 All sizes shown are for O.D. Type L copper tubing.
 # Suction line sizes selected at pressure drop equivalent to 2'F. reduce estimate of system capacity accordingly.
 If system load drops below 40% of design, consideration to installing double suction risers should be made.

Table 12B. Recommended Line Sizes for R-502 (continued) *#

SUCTION LINE SIZE														LIQUID LINE SIZE						SYSTEM CAPACITY BTU/H	
SUCTION TEMPERATURE														Receiver to Expansion Valve Equivalent Lengths							
-20°F Lengths			-30°F Equivalent Lengths						-40°F Equivalent Lengths												
100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'		200'
1/2	1/2	1/2	3/8	1/2	1/2	1/2	5/8	5/8	1/2	1/2	1/2	1/2	5/8	7/8	3/8	3/8	3/8	3/8	3/8	3/8	1,000
7/8	7/8	7/8	5/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	3/8	3/8	3/8	3/8	3/8	3/8	3,000
7/8	7/8	1 1/8	5/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	7/8	1 1/8	3/8	3/8	3/8	3/8	3/8	1/2	4,000
7/8	1 1/8	1 1/8	5/8	7/8	7/8	7/8	1 1/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	3/8	3/8	3/8	3/8	3/8	1/2	6,000
1 1/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	3/8	3/8	3/8	3/8	3/8	1/2	9,000
1 1/8	1 1/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	3/8	3/8	3/8	1/2	1/2	1/2	12,000
1 1/8	1 1/8	1 3/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	3/8	3/8	1/2	1/2	1/2	1/2	15,000
1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	3/8	1/2	1/2	1/2	1/2	5/8	18,000
1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	1/2	1/2	1/2	1/2	5/8	5/8	24,000
1 5/8	1 5/8	1 5/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1/2	1/2	5/8	5/8	5/8	5/8	30,000
1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1/2	1/2	5/8	5/8	5/8	7/8	36,000
1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1/2	5/8	5/8	5/8	7/8	7/8	42,000
2 1/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	1/2	5/8	5/8	7/8	7/8	7/8	48,000
2 1/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	1/2	5/8	5/8	7/8	7/8	7/8	54,000
2 1/8	2 1/8	2 1/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	5/8	5/8	7/8	7/8	7/8	7/8	60,000
2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	5/8	5/8	7/8	7/8	7/8	7/8	66,000
2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	5/8	7/8	7/8	7/8	7/8	7/8	72,000
2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	5/8	7/8	7/8	7/8	7/8	7/8	78,000
2 1/8	2 1/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	5/8	7/8	7/8	7/8	7/8	7/8	84,000
2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	5/8	7/8	7/8	7/8	7/8	1 1/8	90,000
2 5/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 1/8	7/8	7/8	7/8	7/8	1 1/8	1 1/8	120,000
2 5/8	2 5/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 1/8	3 5/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	150,000
2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	3 1/8	3 1/8	3 1/8	3 5/8	2 5/8	3 1/8	3 1/8	3 1/8	3 5/8	3 5/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	180,000
3 1/8	3 1/8	3 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	4 1/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	210,000
3 1/8	3 5/8	3 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	3 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	4 1/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	240,000
3 5/8	3 5/8	3 5/8	2 5/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	5 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	300,000
3 5/8	4 1/8	4 1/8	3 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	5 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	360,000
3 5/8	4 1/8	4 1/8	3 1/8	3 5/8	4 1/8	4 1/8	4 1/8	5 1/8	3 5/8	4 1/8	4 1/8	5 1/8	5 1/8	6 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	480,000
4 1/8	4 1/8	5 1/8	3 5/8	4 1/8	4 1/8	5 1/8	5 1/8	5 1/8	3 5/8	4 1/8	5 1/8	5 1/8	5 1/8	6 1/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	600,000

* Sizes that are highlighted indicate maximum suction line sizes that should be used for risers. Riser size should not exceed horizontal size. Properly placed suction traps must also be used for adequate oil return.
 All sizes shown are for O.D. Type L copper tubing.
 # Suction line sizes selected at pressure drop equivalent to 2°F. reduce estimate of system capacity accordingly.
 If system load drops below 40% of design, consideration to installing double suction risers should be made.

Table 13A. Recommended Line Sizes for R-404A and R507 *#

SYSTEM CAPACITY BTU/H	SUCTION LINE SIZE																				
	SUCTION TEMPERATURE																				
	+20°F						+10°F						-10°F						-20°F		
	Equivalent Lengths						Equivalent Lengths						Equivalent Lengths						Equivalent		
	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'
1,000	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	1/2	3/8	3/8	3/8	1/2	1/2	1/2	3/8	3/8	1/2
3,000	3/8	3/8	1/2	1/2	1/2	5/8	3/8	1/2	1/2	1/2	5/8	5/8	1/2	1/2	5/8	5/8	5/8	7/8	1/2	1/2	5/8
4,000	3/8	1/2	1/2	1/2	5/8	5/8	1/2	1/2	1/2	5/8	5/8	7/8	1/2	5/8	5/8	5/8	7/8	7/8	1/2	5/8	5/8
6,000	1/2	1/2	5/8	5/8	7/8	7/8	1/2	1/2	5/8	5/8	7/8	7/8	1/2	5/8	5/8	7/8	7/8	7/8	5/8	5/8	7/8
9,000	5/8	5/8	7/8	7/8	7/8	7/8	5/8	5/8	7/8	7/8	7/8	7/8	5/8	7/8	7/8	7/8	7/8	1 1/8	5/8	7/8	7/8
12,000	5/8	7/8	7/8	7/8	7/8	7/8	5/8	7/8	7/8	7/8	7/8	1 1/8	7/8	7/8	7/8	7/8	1 1/8	1 1/8	7/8	7/8	7/8
15,000	5/8	7/8	7/8	7/8	7/8	1 1/8	7/8	7/8	7/8	7/8	1 1/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	7/8	1 1/8
18,000	7/8	7/8	7/8	7/8	1 1/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	7/8	1 1/8	1 1/8
24,000	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	1 1/8	1 1/8	1 1/8	1 1/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8
30,000	7/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8
36,000	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 1/8	1 3/8
42,000	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8
48,000	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8
54,000	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 3/8	1 3/8	1 5/8
60,000	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8
66,000	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8
72,000	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	1 5/8	1 3/8	1 5/8	1 5/8
78,000	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	1 5/8	1 5/8	1 5/8
84,000	1 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8
90,000	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 5/8	1 5/8	1 5/8	2 1/8
120,000	1 3/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1 3/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	1 5/8	2 1/8	2 1/8
150,000	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8
180,000	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	2 1/8	2 1/8	2 5/8
210,000	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	2 5/8
240,000	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	2 5/8
300,000	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	2 5/8	2 5/8	2 5/8
360,000	2 1/8	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	2 5/8	2 5/8	3 1/8
480,000	2 1/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	2 5/8	2 5/8	2 5/8	2 5/8	3 5/8	3 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	4 1/8	2 5/8	3 1/8	3 1/8
600,000	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	3 1/8	3 1/8	3 1/8	3 5/8	4 1/8	4 1/8	3 1/8	3 1/8	3 1/8

* Sizes that are highlighted indicate maximum suction line sizes that should be used for risers. Riser size should not exceed horizontal size. Properly placed suction traps must also be used for adequate oil return.

All sizes shown are for O.D. Type L copper tubing.

Suction line sizes selected at pressure drop equivalent to 2°F. reduce estimate of system capacity accordingly.

If system load drops below 40% of design, consideration to installing double suction risers should be made.

Table 13B. Recommended Line Sizes for R-404A and R507 (continued) *#

SUCTION LINE SIZE															LIQUID LINE SIZE						SYSTEM CAPACITY BTU/H
SUCTION TEMPERATURE															Receiver to Expansion Valve Equivalent Lengths						
-20°F Lengths			-30°F Equivalent Lengths						-40°F Equivalent Lengths												
100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	25'	50'	75'	100'	150'	200'	
1/2	1/2	1/2	3/8	3/8	1/2	1/2	1/2	5/8	3/8	1/2	1/2	1/2	5/8	5/8	3/8	3/8	3/8	3/8	3/8	3/8	1,000
5/8	7/8	7/8	1/2	1/2	5/8	5/8	7/8	7/8	1/2	1/2	5/8	5/8	7/8	7/8	3/8	3/8	3/8	3/8	3/8	3/8	3,000
7/8	7/8	7/8	5/8	5/8	5/8	7/8	7/8	7/8	1/2	5/8	5/8	7/8	7/8	7/8	3/8	3/8	3/8	3/8	3/8	3/8	4,000
7/8	7/8	7/8	5/8	5/8	7/8	7/8	7/8	7/8	5/8	5/8	7/8	7/8	7/8	1 1/8	3/8	3/8	3/8	3/8	3/8	3/8	6,000
7/8	1 1/8	1 1/8	5/8	7/8	7/8	7/8	1 1/8	1 1/8	5/8	7/8	7/8	7/8	1 1/8	1 1/8	3/8	3/8	3/8	3/8	3/8	3/8	9,000
1 1/8	1 1/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	3/8	3/8	3/8	3/8	3/8	1/2	12,000
1 1/8	1 1/8	1 3/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	3/8	3/8	3/8	3/8	1/2	1/2	15,000
1 1/8	1 3/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	3/8	3/8	3/8	1/2	1/2	1/2	18,000
1 3/8	1 3/8	1 5/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	3/8	3/8	1/2	1/2	1/2	1/2	24,000
1 3/8	1 3/8	1 5/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	3/8	1/2	1/2	1/2	1/2	1/2	30,000
1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1/2	1/2	1/2	1/2	1/2	5/8	36,000
1 5/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1/2	1/2	1/2	1/2	5/8	5/8	42,000
1 5/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	1/2	1/2	1/2	5/8	5/8	5/8	48,000
1 5/8	1 5/8	1 5/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 3/8	1 5/8	1 5/8	2 1/8	1/2	1/2	1/2	5/8	5/8	5/8	54,000
1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	2 1/8	1/2	1/2	5/8	5/8	5/8	5/8	60,000
1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	1/2	1/2	5/8	5/8	5/8	5/8	66,000
1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	1 3/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	1/2	5/8	5/8	5/8	5/8	5/8	72,000
1 5/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	5/8	5/8	5/8	5/8	5/8	7/8	78,000
2 1/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	1 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	5/8	5/8	5/8	5/8	7/8	7/8	84,000
2 1/8	2 1/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 1/8	2 5/8	1 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	5/8	5/8	5/8	7/8	7/8	7/8	90,000
2 1/8	2 5/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	1 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	5/8	5/8	7/8	7/8	7/8	7/8	120,000
2 5/8	2 5/8	2 5/8	2 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	2 5/8	5/8	7/8	7/8	7/8	7/8	1 1/8	150,000
2 5/8	2 5/8	3 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	2 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	7/8	7/8	7/8	7/8	1 1/8	1 1/8	180,000
2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	2 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	210,000
2 5/8	3 1/8	3 1/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	2 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	240,000
3 1/8	3 5/8	3 5/8	2 5/8	2 5/8	3 1/8	3 1/8	3 5/8	4 1/8	2 5/8	2 5/8	3 1/8	3 5/8	3 5/8	4 1/8	7/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	300,000
3 5/8	3 5/8	4 1/8	2 5/8	3 1/8	3 1/8	3 5/8	3 5/8	4 1/8	2 5/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	360,000
3 5/8	3 5/8	4 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	4 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	4 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	480,000
3 5/8	3 5/8	4 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	5 1/8	3 1/8	3 5/8	3 5/8	4 1/8	4 1/8	5 1/8	1 1/8	1 3/8	1 3/8	1 5/8	1 5/8	1 5/8	600,000

* Sizes that are highlighted indicate maximum suction line sizes that should be used for risers. Riser size should not exceed horizontal size. Properly placed suction traps must also be used for adequate oil return.
 All sizes shown are for O.D. Type L copper tubing.
 # Suction line sizes selected at pressure drop equivalent to 2'F. reduce estimate of system capacity accordingly.
 If system load drops below 40% of design, consideration to installing double suction risers should be made.

Refrigerant Piping

The system as supplied by *Heatcraft*, was thoroughly cleaned and dehydrated at the factory. Foreign matter may enter the system by way of the evaporator to condensing unit piping. Therefore, care must be used during installation of the piping to prevent entrance of foreign matter.

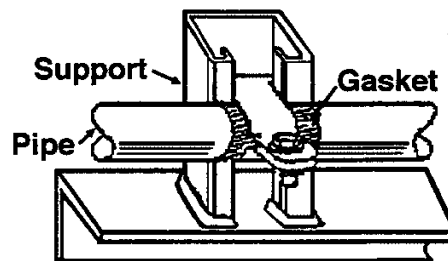
Install all refrigeration system components in accordance with applicable local and national codes and in conformance with good practice required for the proper operation of the system.

The refrigerant pipe size should be selected from the tables on pages 13-21. The interconnecting pipe size is not necessarily the same size as the stub-out on the condensing unit or the evaporator.

The following procedures should be followed:

- (a) Do not leave dehydrated compressors or filter-driers on condensing units open to the atmosphere any longer than is absolutely necessary.
- (b) Use only refrigeration grade copper tubing, properly sealed against contamination.
- (c) Suction lines should slope 1/4" per 10 feet towards the compressor.
- (d) Suitable P-type oil traps should be located at the base of each suction riser of four (4) feet or more to enhance oil return to the compressor.
- (e) For desired method of superheat measurement, a pressure tap should be installed in each evaporator suction line in the proximity of the expansion valve bulb.
- (f) **When brazing refrigerant lines, an inert gas should be passed through the line at low pressure to prevent scaling and oxidation inside the tubing. Dry nitrogen is preferred.**
- (g) Use only a suitable silver solder alloy on suction and liquid lines.
- (h) Limit the soldering paste or flux to the minimum required to prevent contamination of the solder joint internally. Flux only the male portion of the connection, never the female. After brazing, remove excess flux.
- (i) See Table 9 on page 13 for discharge and liquid drain line sizes for remote condenser connections.
- (j) If isolation valves are installed at the evaporator, full port ball valves should be used.

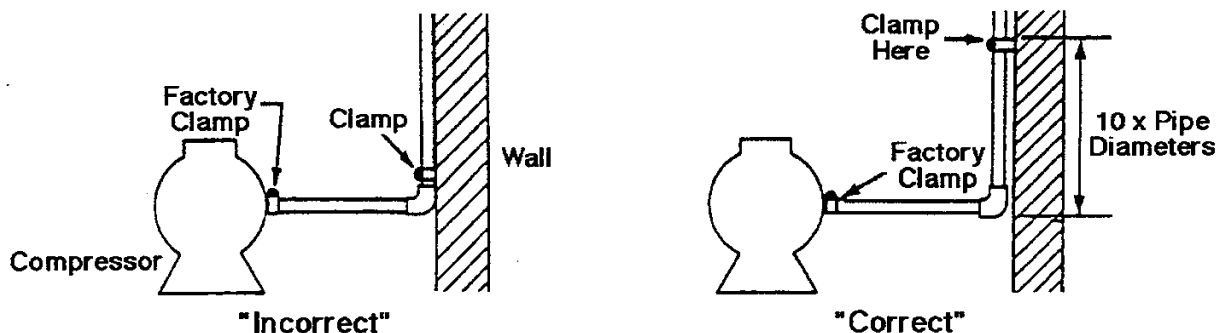
Figure 14. Example of Pipe Support



Refrigerant Pipe Support

1. Normally, any straight run of tubing must be supported in at least two locations near each end of the run. Long runs require additional supports. The refrigerant lines should be supported and fastened properly. As a guide, 3/8 to 7/8 should be supported every 5 feet; 1-1/8 and 1-3/8 every 7 feet; and 1-5/8 and 2-1/8 every 9 to 10 feet.
2. When changing directions in a run of tubing, no corner should be left unsupported. Supports should be placed a maximum of 2 feet in each direction from the corner.
3. Piping attached to a vibrating object (such as a compressor or compressor base) must be supported in such a manner that will not restrict the movement of the vibrating object. Rigid mounting will fatigue the copper tubing.
4. Do not use short radius ells. Short radius elbows have points of excessive stress concentration and are subject to breakage at these points.
5. Thoroughly inspect all piping after the equipment is in operation and add supports wherever line vibration is significantly greater than most of the other piping. Extra supports are relatively inexpensive as compared to refrigerant loss.

Figure 15. Condensing Unit/Compressor to Wall Support.



Suction Lines

NOTE: If the suction line must rise to a point higher than the suction connection on the evaporator, a suction line trap at the outlet of the evaporator must be provided.

Horizontal suction lines should slope away from the evaporator toward the compressor at the rate of 1/4 inch per 10 feet for good oil return. When multiple evaporators are connected in series using a common suction line, the branch suction lines must enter the top of the common suction line.

For dual or multiple evaporator systems, the branch lines to each evaporator should be sized for the evaporator capacity. The main common line should be sized for the total system capacity.

Suction lines that are outside of refrigerated space must be insulated. See **Leak Testing** section, item 2 on page 24 for more information.

Suction Line Risers

NOTE: To provide proper oil return, a suction trap must be provided at the base of all suction risers of four (4) feet or more.

Prefabricated wrought copper traps are available, or a trap can be made by using two street ells and one regular ell. The suction trap must be the same size as the suction line. For long vertical risers, additional traps may be necessary. Generally, one trap is recommended for each length of pipe (approximately 20 feet) to insure proper oil movement. See Figure 16 below for methods of constructing proper suction line P-traps.

Figure 16. Suction P-Traps.

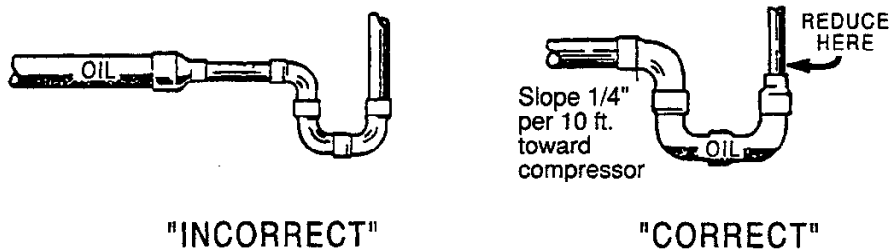
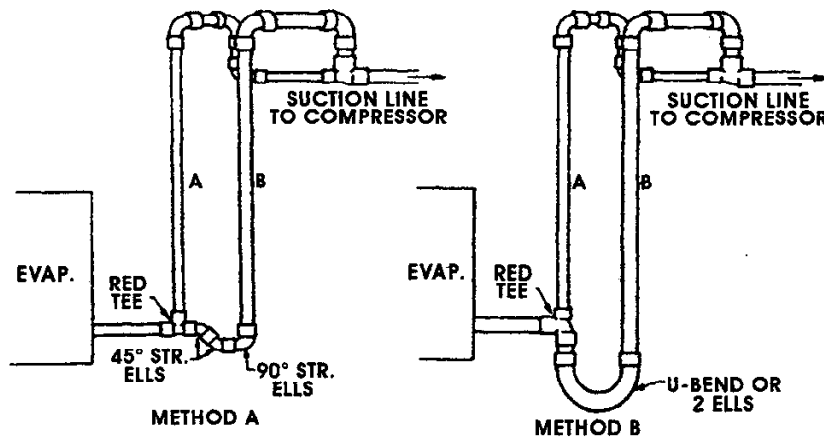


Figure 17. Double Suction Riser Construction



Liquid Lines

Liquid lines should be sized for a minimum pressure drop to prevent "flashing". Flashing in the liquid lines would create additional pressure drop and poor expansion valve operation. If a system requires long liquid lines from the receiver to the evaporator or if the liquid has to rise vertically upward any distance, the losses should be calculated to determine whether or not a heat exchanger is required. The use of a suction to liquid heat exchanger may be used to subcool the liquid to prevent flashing. This method of subcooling will normally provide no more than 20°F subcooling on high pressure

systems. The amount of subcooling will depend on the design and size of the heat exchanger and on the operating suction and discharge pressures. An additional benefit from the use of the suction to liquid type heat exchanger is that it can help raise the superheat in the suction line to prevent liquid return to the compressor via the suction line. Generally, heat exchangers are not recommended on R-22 low temperature systems. However, they have proved necessary on short, well insulated suction line runs to provide superheat at the compressor.

City / Tower Connections

In the refrigeration industry "City" and "Tower" are designations of temperature and flow conditions, not applications. The term "City" refers to operating conditions where incoming water is 75°F, and condensing temperature is 105°F. "Tower" refers to a higher temperature relationship which is normally 85°F, incoming water and 105°F condensing temperature.

Water circuits in some condenser models provide a center, or Tower, outlet connection to allow divided inlet water flow. This extra water port reduces water velocity, water pressure drop, and condenser wear in applications such as cooling towers where higher inlet temperatures and water flows occur.

Evacuation and Leak Detection

Due to the smaller molecule size of HFC's, they will tend to leak more readily than CFC. Consequently, it is of the utmost importance that proper system evacuation and leak detection procedures be employed.

Copeland recommends a minimum evacuation to 500 microns. In addition, a vacuum decay test is strongly recommended to assure there is not a large pressure differential between the system and vacuum pump. Good evacuation processes include frequent vacuum pump oil changes and large diameter, short hose connections to both high and low sides of the system preferably using bronze braided hose.

Leak detection can be carried out in the conventional manner. If HCFC or CFC tracer gas is used, care must be taken to completely remove all traces of the gas prior to introducing HFC's.

Electronic leak detectors are now available that will sense HFC's. This is considered preferable since it removes the possibility of chlorine remaining in the system after leak testing with HCFC's and/or CFC's. There is a view that even small quantities of chlorine may act as a catalyst encouraging copper plating and/or corrosion and should therefore be avoided.

Leak Testing

1. After all lines are connected, the entire system must be leak tested. The complete system should be pressurized to not more than 150 psig with refrigerant and dry nitrogen (or dry CO₂). The use of an electronic type leak detector is highly recommended because of its greater sensitivity to small leaks. As a further check it is recommended that this pressure be held for a minimum of 12 hours and then rechecked. For a satisfactory installation, the system must be leak tight.
2. After the final leak test, refrigerant lines exposed to high ambient conditions should be insulated to reduce heat pick-up and prevent the formation of flash gas in the liquid lines. Suction lines should be insulated with 3/4" wall Armstrong "Armaflex" or equal. Liquid lines should be insulated with 1/2 inch wall insulation or better. The insulation located in outdoor environments should be protected from UV exposure to prevent deterioration of insulating value.

Evacuation

CAUTION: Do not use the refrigeration compressor to evacuate the system. Do not start the compressor while it is in a vacuum.

A good, deep vacuum pump should be connected to both the low and high side evacuation valves with copper tube or high vacuum hoses (1/4" ID minimum). If the compressor has service valves, they should remain closed. A deep vacuum gauge capable of registering pressure in microns should be attached to the system for pressure readings.

A shut off valve between the gauge connection and vacuum pump should be provided to allow the system pressure to be checked after evacuation. Do not turn off vacuum pump when connected to an evacuated system before closing shut off valve.

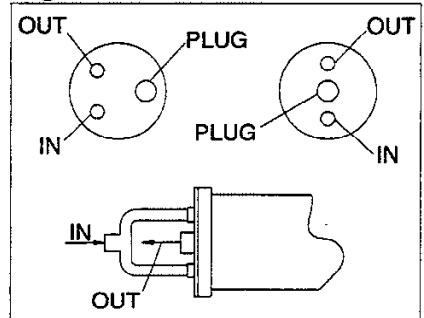
Water Connections for City

For City water (open system) high pressure applications, the Tower connections is plugged.

Water Connections for Tower

For Tower usage and low pressure applications, both normal water connections will be used as inlets and the tower connection as an outlet.

Figure 18. Tower Connections



WARNING: HFC-134a has been shown to be combustible at pressure as low as 5.5 psig (at 350°F) when mixed with air at concentrations more than 60% air by volume. At lower temperature, higher pressures are required to support combustion. Therefore, air should never be mixed with HFC-134a for leak detection.

Within the last several years, manufacturers have developed fluorescent dye leak detection systems for use with refrigerants. These dyes mix with the lubricant and, when exposed to an ultraviolet light "fluoresce," indicates the location of leaks. Copeland has tested and approved the Rigid "System Safe" dye and found it to be compatible with the compressor materials in systems using mineral oil and HCFC-22. Testing has not been conducted by Copeland with HFC and POE; however, the suppliers of these dyes claim to have appropriate materials for the new refrigerants. If you intend on using this technique in a Copeland system, please consult Heatcraft Application Engineering for the status regarding approval of the dyes.

The vacuum pump should be operated until a pressure of 1,500 microns absolute pressure is reached — at which time the vacuum should be broken with the refrigerant to be used in the system through a drier until the system pressure rises above "0" psig.

NOTE: EPA regulations are constantly being updated to ensure your procedure follow correct regulations.

Repeat this operation a second time.

Open the compressor service valves and evacuate the entire system to 500 microns absolute pressure. Raise the pressure to 2 psig with the refrigerant and remove the vacuum pump.

Refrigerant Charging Instructions

1. Install a liquid line drier in the refrigerant supply line between the service gauge and the liquid service port of the receiver. This extra drier will insure that all refrigerant supplied to the system is clean and dry.
2. When initially charging a system that is in a vacuum, liquid refrigerant can be added directly into the receiver tank.
3. Check serial data tag attached to the unit for refrigerant capacity. System refrigerant capacity is 90% of receiver capacity. Do not add more refrigerant than the data tag indicates. Weigh the refrigerant drum before charging so an accurate record can be kept of the weight of refrigerant put in the system.
4. Start the system and finish charging until the sight glass indicates a full charge and the proper amount has been weighed in. If the refrigerant must be added to the system

through the suction side of the compressor, charge in vapor form only. Liquid charging must be done in the high side only or with liquid metering devices to protect the compressor.

Low Head Pressure Systems

If you are charging the system by using a clear sight glass as an indication of proper charge the following must be considered.

Check the condensing temperature. It must be above 105°F. If not, it will be necessary to reduce the amount of air going through the condenser from fans still running. Simply reduce the effective condenser face area to raise the discharge pressure above the equivalent 105°F condensing temperature and then proceed to charge to clear the sightglass. Adjust evaporator superheat at this time. Return to full condenser face area and allow the system to balance.

Field Wiring

WARNING: All wiring must be done in accordance with applicable codes and local ordinances.

The field wiring should enter the areas as provided on the unit. The wiring diagram for each unit is located on the inside of the electrical panel door. All field wiring should be done in a professional manner and in accordance with all governing codes. Before operating unit, double check all wiring connections, including the factory terminals. Factory connections can vibrate loose during shipment.

1. The nameplate on the unit is marked with the electrical characteristic for wiring the unit.
2. Consult the wiring diagram in the unit cooler and in the condensing unit for proper connections.

3. Wire type should be of copper conductor only and of the proper size to handle the connected load.
4. The unit must be grounded.
5. For multiple evaporator systems, the defrost termination controls should be wired in series. Follow the wiring diagrams for multiple evaporator systems carefully. This will assure complete defrost of all evaporators in the system.
6. If a remote defrost Timer is to be used, the Timer should be located outside the refrigerated space.
7. Air cooled condensers - due to multiple low amp motors, we recommend time delay fuse protection instead of circuit breakers.

Check-Out and Start-Up

After the installation has been completed, the following points should be covered before the system is placed in operation:

- (a) Check all electrical and refrigerant connections. Be sure they are all tight.
- (b) Observe compressor oil level before start-up. The oil level should be at or slightly above the 1/4 level of the sight glass. Refer to Table 16 on page 31 for proper compressor oil.
- (c) Remove upper mounting nuts on the compressor feet. Remove the shipping spacers. Install the neoprene washers onto the compressor feet. Replace the upper mounting nuts and washers, allowing 1/16" space between the mounting nut and the neoprene spacer.
- (d) Check high and low pressure controls, pressure regulating valves, oil pressure safety controls, and all other safety controls, and adjust if necessary.
- (e) Check the room thermostat for normal operation and adjust.
- (f) Wiring diagrams, instruction bulletins, etc. attached to the condensing units should be read and filed for future reference.
- (g) All fan motors on air cooled condensers, evaporators, etc. should be checked for proper rotation. Fan motor mounts should be carefully checked for tightness and proper alignment.
- (h) Electric and hot gas evaporator fan motors should be temporarily wired for continuous operation until the room temperature has stabilized.

- (i) Observe system pressures during charging and initial operation. Do not add oil while the system is short of refrigerant unless oil level is dangerously low.
- (j) Continue charging until system has sufficient refrigerant for proper operation. Do not overcharge. Remember that bubbles in a sight glass may be caused by a restriction as well as a shortage of refrigerant.
- (k) Do not leave unit unattended until the system has reached normal operating conditions and the oil charge has been properly adjusted to maintain the oil level at the center of the sight glass.

CAUTION: Extreme care must be taken in starting compressors for the first time after system charging. At this time all, of the oil and most of the refrigerant might be in the compressor, creating a condition which could cause compressor damage due to slugging. Activating the crankcase heater for 24 hours prior to start-up is recommended. If no crankcase heater is present, then directing a 500 watt heat lamp or other safe heat source on the lower shell of the compressor for approximately thirty minutes will be beneficial in eliminating this condition which might never reoccur.

WARNING: Scroll compressor is directional dependant. If noisy, change phase of input wiring.

Operational Check-Out

After the system has been charged and has operated for at least two hours at normal operating conditions without any indication of malfunction, it should be allowed to operate overnight on automatic controls. Then a thorough recheck of the entire system operation should be made as follows:

- (a) Check compressor discharge and suction pressures. If not within system design limits, determine why and take corrective action.
- (b) Check liquid line sight glass and expansion valve operation. If there are indications that more refrigerant is required, leak test all connections and system components and repair any leaks before adding refrigerant.
- (c) Observe oil level in compressor crankcase sight glass. Add oil as necessary to bring level to bottom 1/4 of the sight glass.
- (d) Thermostatic expansion valves must be checked for proper superheat settings. Feeler bulbs must be in positive contact with the suction line and should be insulated. Valves with high superheat causes low refrigeration capacity. Low superheat promotes liquid slugging and compressor bearing washout.
- (e) Using suitable instruments, carefully check line voltage and amperage at the compressor terminals.
- (f) The maximum approved settings for high pressure controls on Heatcraft air cooled condensing equipment is 400 psig. On air cooled systems, check as follows: Disconnect the fan motors or block the condenser inlet air. Watch high pressure gauge for cutout point. Recheck all safety and operating controls for proper operation and adjust if necessary.
- (g) Check defrost controls for initiation and termination settings, and length of defrost period. Set fail safe at length of defrost + 25%.
Example: 20 minute defrost + 5 minutes
= 25 minute fail safe
- (h) Check winter head pressure controls for pressure setting.
- (i) Check crankcase heater operation if used.
- (j) Install instruction card and control system diagram for use of building manager or owner.

System Balancing - Compressor Superheat

IMPORTANT: In order to obtain the maximum capacity from a system, and to ensure trouble-free operation, it is necessary to balance each and every system.

This is extremely important with any refrigeration system.

The critical value which must be checked is suction superheat.

Suction superheat should be checked **at the compressor** as follows:

1. Measure the suction pressure at the suction service valve of the compressor and determine the saturation temperature corresponding to this pressure from a "Temperature-Pressure" chart.
2. Measure the suction temperature of the suction line about one foot back from the compressor using an accurate thermometer.
3. Subtract the saturated temperature from the actual suction line temperature. The difference is superheat.

Phase Loss Monitor

The combination phase sequence and loss monitor relay protects the system against phase loss (single phasing), phase reversal (improper sequence) and low voltage (brownout). When phase sequence is correct and full line voltage is present on all three phases, the relay is energized as the red indicator light glows.

NOTE: If compressor fails to operate and the red indicator light on the phase monitor does not glow, then the supplied electrical current is not in phase with the monitor. This problem is easily corrected by the following steps:

Too low a suction superheat can result in liquid being returned to the compressor. This will cause dilution of the oil and eventual failure of the bearings and rings or in the extreme case, valve failure.

Too high a suction superheat will result in excessive discharge temperatures which cause a break down of the oil and results in piston ring wear, piston and cylinder wall damage.

It should also be remembered that the system capacity decreases as the suction superheat increases. For maximum system capacity, suction superheat should be kept as low as is practical. Copeland mandates a **minimum** superheat of 20°F **at the compressor**. *Heatcraft* recommends that the superheat **at the compressor** be between 30°F and 45°F.

If adjustments to the suction superheat need to be made, the expansion valve at the evaporator should be adjusted. See instructions on page 27.

1. Turn power off at disconnect switch.
2. Remove orange relay monitor from the socket.
3. Swap any two of the three power input wires (terminals 3, 4 and 5).
4. Replace orange relay monitor into the socket.
5. Turn power on. Red indicator light should glow and compressor should start.

Evaporator Superheat

Check Your Superheat. After the box temperature has reached or is close to reaching the desired temperature, the evaporator superheat should be checked and adjustments made if necessary. Generally, systems with a design TD of 10°F should have a superheat value of 6' to 10°F for maximum efficiency. For systems operating at higher TD's, the superheat can be adjusted to 12' to 15' °F as required.

NOTE: Minimum compressor suction superheat of 20°F may override these recommendations on some systems with short line runs.

To properly determine the superheat of the evaporator, the following procedure is the method Heatcraft recommends:

WARNING: If the condensing unit has no flooded condenser head pressure control, the condensing unit must have the discharge pressure above the equivalent 105°F condensing pressure. See refrigerant charging instructions on page 25.

1. Measure the temperature of the suction line at the point the bulb is clamped.
2. Obtain the suction pressure that exists in the suction line at the bulb location by either of the following methods:
 - a. A gauge in the external equalized line will indicate the pressure directly and accurately.

Defrost

Many types of control arrangements can be used. In some applications, it may not be necessary to have scheduled defrost periods. The normal "off cycle" of the compressor may be adequate to keep the evaporator coil clear of frost. In other applications, a defrost timer may be necessary to help assure a clear coil. In a medium temperature environment, "air defrost" is initiated by the timer, but the evaporator fans continue to operate to facilitate the melting of frost on the fin surface. Other types of defrost schemes

Defrost Thermostat

Adjustable (F25-209 Series)

The defrost duration is determined by the setting of the defrost termination thermostat. Initially, the thermostat should be set at mid-range. This will terminate the defrost at about a 60°F bulb temperature which will be satisfactory for most applications. A somewhat longer or shorter defrost can be obtained by adjusting the control clockwise for a shorter defrost and counterclockwise for a longer defrost. The fan delay temperature setting of the thermostat is factory set at 25°F. It can be adjusted upward by turning the adjusting screw next to the duration adjustment with a small screwdriver. Each complete clockwise rotation of this screw raises the setting approximately 3°F. This screw should not be adjusted more than four turns. Making this adjustment also raises the defrost termination temperature setting of the thermostat by a similar amount. For example, with the duration setting at mid-range, the termination temperature would be approximately 60°F. Turning the adjusting screw one turn would raise the fan delay temperature to about 28°F as well as changing the termination temperature from 60°F to 63°F. On medium temperature applications it may be necessary to raise the setting to assure that the thermostat will reset after a defrost.

Note: Defrost controls are positioned as determined by engineering test. Job conditions may require the sensing device to be relocated for optimal defrosting.

- b. A gauge directly in the suction line near the evaporator or directly in the suction header of the evaporator will yield the same reading as 2a above.
3. Convert the pressure obtained in 2a or 2b above to saturated evaporator temperature by using a temperature-pressure chart.
4. Subtract the saturated temperature from the actual suction line temperature. The difference is Superheat.

Alternative Superheat Method

The most accurate method of measuring superheat is found by following the previous procedure, Temperature/Pressure method. However, that method may not always be practical. An alternative method which will yield fairly accurate results is the temperature / temperature method:

1. Measure the temperature of the suction line at the point the bulb is clamped (outlet).
2. Measure the temperature of one of the distributor tubes close to the evaporator coil (inlet).
3. Subtract the inlet temperature from the outlet temperature. The difference is Superheat.

This method will yield fairly accurate results as long as the pressure drop through the evaporator coil is low.

require that the fans on the evaporator shut off during the defrost period.

For most applications, two to four defrost cycles per day should be adequate. The defrost requirements will vary on each installation so the defrost settings should be determined by observing the system operation.

Bimetal Disc

A bimetal disc type thermostat is wired to the control circuit to terminate the defrost cycle when the coil temperature reaches approximately 50°F. The bimetal disc thermostat provides a fan delay to allow moisture on the coil to freeze after defrost termination.

NOTE: On systems where the suction temperature is above approximately 25°F, the fans may not start for an extended period of time.

This can be corrected by jumping the fan switch contacts. This will allow the fans to start immediately after defrost termination. This will disable the fan delay.

If moisture blow-off is encountered without the fan delay, a higher temperature defrost thermostat can be ordered. This thermostat terminates defrost at 60°F and prevents the fans from running when the coil temperature is above 40°F. Refer to the replacement parts list for the correct number to order.

Sequence of Operation

Refrigeration Cycle

1. Power is supplied to the timer at terminals "1" and "N".
2. The fan delay and the defrost termination thermostat is closed in the fan delay position and open in the defrost termination position. The unit cooler fans run continuously.
3. The defrost heaters are off.
4. The room thermostat closes when the temperature rises above the desired setting.
5. The liquid line solenoid is energized and opens, which allows liquid refrigerant to flow through the unit cooler.
6. The low pressure control closes when the suction pressure rises above the cutin setting of the control.
7. On systems with oil pumps, the oil safety control is closed. If the net oil pressure is less than 9 PSIG for more than 120 seconds, the oil safety opens, thus breaking the circuit to the compressor contactor holding coil. The compressor will not operate. This control is reset manually and must be reset before the compressor can be restarted.
8. The compressor contactor closes. The compressor and condenser fan start simultaneously.
9. The room temperature gradually decreases to the desired temperature.
10. Once the desired temperature is reached, the thermostat opens and the liquid line solenoid closes, stopping refrigerant flow through the evaporator.
11. Suction pressure decreases and the compressor contactor opens when the pressure drops below the cutout setting on the low pressure control. The compressor and condenser fan stop running.
12. This cycle is repeated as many times as necessary to satisfy the room thermostat.

13. Frost starts to form on the evaporator coil and continues to form until the defrost cycle is initiated.

Defrost Cycle

1. The defrost cycle starts automatically by the timer at predetermined times. Typical settings are two to four defrost cycles per day for freezers. For heavier frost loads additional settings may be required.
2. Switch "2" to "4" opens in the time clock which breaks the circuit to the room thermostat, liquid line solenoid, and evaporator fan motors, allowing the compressor to pump down and shut off. Simultaneously switch "1" to "3" closes in the timer allowing current to flow to one side of the defrost heater contactor. When the compressor shuts off, an auxiliary contact will send power to the contactor holding coil; thus, energizing the defrost heaters.
3. The heaters raise the temperature of the coil to 32°F causing the frost to melt off the coil.
4. When the coil warms to 45°F to 55°F, the defrost termination thermostat closes, which allows current to the switching solenoid in the timer allowing the refrigeration cycle to begin again.
5. The evaporator heaters are off. If the termination thermostat fails to close, the fail-safe set on the timer will terminate defrost.
6. The low pressure control closes and the compressor will start.
7. When the coil temperature reaches 23°F to 30°F, the fan delay closes. This allows the current to flow to the fan motors. The fan motors start running.
8. The system will now operate in the refrigeration cycle until another defrost period is initiated by the timer.

NOTES:

1. Lockout relays or normally closed switch of auxiliary contact on the compressor contactor may be wired to defrost contactor. Its purpose is to prevent energizing of the defrost heaters until the compressor has pumped down and stopped, thus keeping power demand to a minimum.
2. If the control voltage is to remain energized for any period of time with the compressor disabled, remove the defrost clock pins to prevent the defrost heaters from energizing.
3. A Preventative Maintenance schedule should be set up as soon as possible after start-up to maintain equipment integrity.

Head Pressure Control*

Several types of head pressure control systems are available on condensing units:

- A. Dual Valve System. (See section on operation and adjustment.)
- B. Single Valve system. No adjustments are necessary. (See section on operation.)
- C. Ambient Fan Cycle Control. (See section on operation and adjustment.)
- D. No Control.

* If applicable, refer to supplemental installation manual

A. Dual Valve System

This is an energy efficient low ambient control. The system employs an ORI (open on rise of inlet pressure) valve and an ORD (open on rise of differential pressure) valve. The high pressure discharge gas is introduced above the liquid in the receiver tank. The receiver discharge is regulated by the ORI valve.

The discharge pressure of the ORI valve must be adjusted to regulate the unit for proper operating conditions. Adjust the ORI valve shown on the following diagram to maintain a discharge pressure of 160 to 180 PSIG.