SPORLAN DIVISION
PARKER HANNIFIN CORPORATION

SUBJECT: TEV/DISTRUBUTOR CAPACITIES AND SELECTION PROCEDURES FOR REFRIGERANTS 13B1, 23, AND 508B

LIMITED: M & W

Note: R-13 and R-503 are no longer in use due to regulatory restrictions. The data for these refrigerants contained herein is for informational purposes. These are no longer directly supported with EGP charges by Sporlan Division. Page 2 discusses the options for charges for these refrigerants.

Low to extremely low temperature refrigeration systems are distinguished from medium temperature refrigeration systems by their ability to maintain evaporator temperatures well below zero. Low temperature applications (0°F to -40°F) generally include the freezing of foods, while extremely low temperature applications (-40°F to -250°F) include more specialized applications such as environmental testing, cryogenic processes, medical research and storage, certain chemical processes, and cold treating of metals.

Every given temperature range has a corresponding refrigerant that allows that system to operate at maximum efficiency. Temperatures in the range of 0°F to -50°F are usually attained with a single stage unit using R-22, R-404A, or a lower-GWP replacement such as R-448A or R-449A. Maintaining temperatures in the range of -50° to -150°F typically warrant the use of a two stage cascade system using a single stage refrigerant in the first stage (R-22, R-404A, R-448 or R-449A), and R-13, R-23, R-503, or R-508B in the second stage. Ethane (R-170) may also be used in the second stage of a cascade, provided it can be applied with the proper safety precautions, since it is an A3 highly flammable refrigerant. A three-stage cascade system is necessary if an application requires evaporator temperatures below -150°F. For example, R-404A in the first stage, R-508B in the second stage, and the R-14 in the third stage.

Applications of standard Sporlan products at temperatures of -50°F or lower require a degree of caution, because extremely low temperature systems have inherent characteristics that may adversely affect certain metals. Most metals are compatible with extremely low temperatures. For examples: copper, brass, stainless steel, aluminum, silver solder, and most soft solders are capable of resisting temperatures down as low as -320°F, the metal that presents potential problems is low carbon steel. As the temperature is lowered, low carbon steel goes through a transition from a ductile material to a brittle material that could have potential for cracking or failure.

Sporlan Catch-Alls and Suction Filters are constructed solely of low carbon steel. See•Alls are comprised mostly of low carbon steel, and thermostatic expansion valves have certain parts that are made from low carbon steel. TEV diaphragm cases and springs fall under this category.

Test were run in Sporlan's lab on low carbon steel products. The results showed no obvious loss of impact strength or other deterioration. Sporlan believes these products will perform satisfactorily on most applications at temperatures as low as -120°F, although an ASME code specifies -50°F as the minimum temperature at which low carbon steel can be used.

Sporlan has had extensive experience over many years in applying TEVs at temperatures down as low as -150°F. The special charges involved in each application of extremely low temperatures require an accurate selection of a TEV. When a system requires rapid pull down the system capacity should be 70% of the valve's capacity. When a system that requires accurate control, the system capacity should be between 90% and 100% of the valve's capacity. For these reasons it is suggested that the customer thoroughly evaluate all products on applications below -50°F, and that the customer make the decision concerning their suitability.

The two body types available for use with these refrigerants are the S and P which cover the nominal capacity range of 0-3 tons (0-10.5 kW) and 5-12 tons (17.6 kW–42 kW) respectively. Traditionally, other bodies have been available, but market self-selection has indicated these are the best choices. So Sporlan is meeting this market's needs with these products. Contact Sporlan Technical Support for applications requiring body types other than these.

Thermostatic charge specifications exist for the No. 83 and 33 elements to meet these needs. Traditionally charges containing R-13 were used with R-13, R-503, and R-508B systems. However, this refrigerant is no longer available for purchase and the EGP charges are

obsolete. The WGP charges will remain available and are identical to equivalent GGP charges. The WGP15 charge will have similar MOP to the EGP15.

The GGP charges developed for R-23 have similar SH characteristics since R-23 has very similar PT characteristics to these refrigerants in the evaporating temperature range of -60°F (-51°C) to -120°F (-84°C). The MOP point is similar, but the GGP has a flatter SH curve and lower tendency to flood which makes it a better choice. Please see Figure 1 for a comparison of SH characteristics for the EGP and GGP charges. The GGP 35 has a similar MOP at about -100°F (73°C) as the EGP35. The EGP55 and EGP60 charges will not be duplicated in the WGP offering due to low usage.

Using a modified spring is also required for using the WGP charges for R-508B just as was required when using the EGP charges. The proper spring for the S valve using the No. 83 element is part number 0694-080 (Saleable item number 183169). Similarly, use spring part number 0559-000 for the No. 33 element for the P valve.

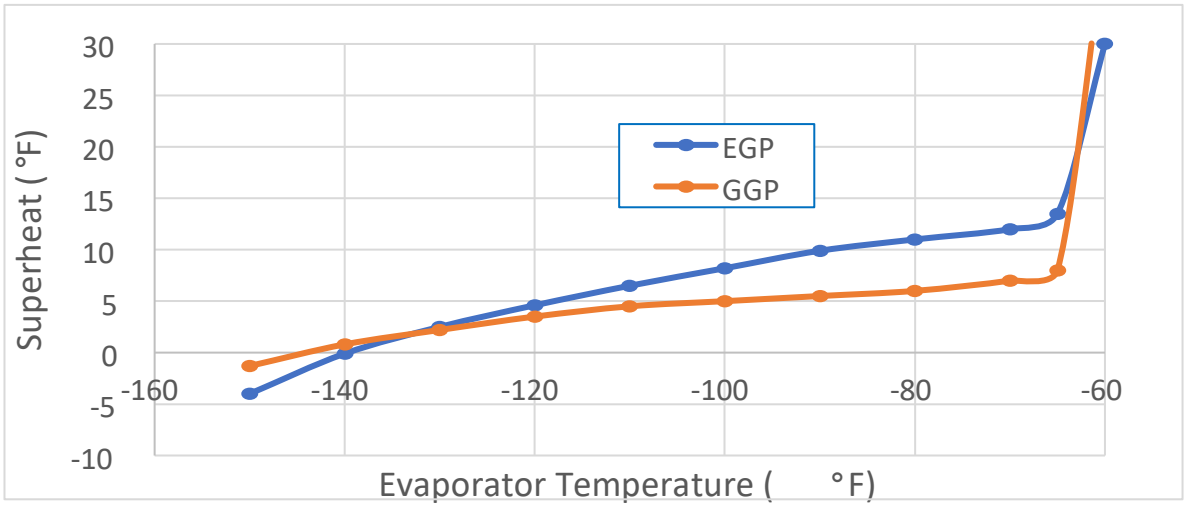

Figure 1, EGP and GGP Comparison

TABLE 1: AVAILABLE THERMOSTATIC CHARGES AND FACTORY AIR TEST MOP

Thermostatic Element No. KT-83 (C&S Valves)

R-13	R-23(G)	R-503 CFC & R-508B (W)HFC Using Element with Spring No. 0559-100 (0.100" dia.)	MOP Setting
GGP	GGP	WGP	85
GGP35	GGP35	WGP35	35

Thermostatic Element No. KT-83 (C&S Valves)

R-13	R-23(G)	R-503 CFC & R-508B (W)HFC Using Element with Spring No. 0694-080 (0.080" dia.)	MOP Setting
GGP	GGP	WGP	85
GGP35	GGP35	WGP35	35
-	-	WGP15	15

For example, R170, ethane, may also be used in the second stage of a cascade, so long as it can applied with the proper safety precautions, being an A3 highly flammable refrigerant. CAPACITY DATA AND SELECTION PROCEDURES

The following tables provide thermostatic expansion valve and refrigerant distributor capacities for R-13, R-23 ("G"), R-503, R508B ("W"). All valves will be supplied with an external equalizer only. In these low temperature systems, the external equalizer is required because any pressure drop through the evaporator can prevent an internal equalized expansion valve from controlling superheat. For system capacities greater than the P valve capacities, these will be considered on a special order basis, contact Parker Hannifin – Sporlan Division.

Capacity tables for R-13 B1 have been added to the last page of this bulletin as a supplement. This refrigerant is a CFC and will most commonly be found in older systems.

Supply the following design conditions to Sporlan for Selection Consideration:

1. Evaporator Load
2. Evaporator temperature
3. Condenser Temperature
4. Liquid Temperature
5. Size of Distributor Circuits
6. Number of Distributor Circuits
7. Connection Type on Expansion Valve

Generally, valve capacities are not provided for evaporator temperatures which fall in to the vacuum range. Valve and distributor capacities are based on 0°F liquid at the valve inlet. Liquid correction factors are shown for other entering liquid temperatures. Pressure correction factors are given for expansion valve selection with other than standard pressure drop.

PRESSURE-TEMPERATURE TABLES

Pressure-Pounds Per Square Inch Gauge Vacuum-Inches of Mercury-*Italic Figures**

TEMPERATURE		REFRIGERANT			
°F	**°C**	**R-13**	**R-23**	**R-**	**R-508B**
-140	-95.6	*16.78**	*17.12**	*11.1**	*11.5**
-130	-90	*11.43**	*11.48**	*3.49**	*3.85**
-120	-84.4	*4.51**	*3.95**	3.13	2.98
-110	-78.9	2.11	2.86	9.28	9.16
-100	-73.3	7.53	9.01	16.9	16.9
-90	-67.8	14.19	16.7	26.3	26.3
-80	-62.2	22.28	26.3	37.7	37.8
-70	-56.7	31.98	37.9	51.3	51.5
-60	-51.1	43.49	52.0	67.4	67.7
-50	-45.6	57.01	68.7	86.1	86.8
-40	-40	72.73	88.3	108	109
-30	-34.4	90.90	111	133	135
-20	-28.9	111.7	138	161	164
-10	-23.3	135.4	168	194	197
0	-17.8	162.1	203	231	235
10	-12.2	192.1	242	272	277
20	-6.7	225.7	287	318	326
30	-1.1	262.2	337	369	378
40	4.4	34.9	393	426	438
45	7.2	327.5	424	457.5	470
50	10.0	351.2	456	489	503
55	12.8	376.1	491	524.5	539
60	15.6	402.3	528	560	—
65	18.3	429.8	567	—	—
70	21.1	458.7	609	—	—

TABLE 3: TEV Capacities – Tons of Refrigerant (Sporlan Code)

VALVE TYPE	NOMINAL CAPACITY	REFRIGERANT							
		13				23(G)			
		EVAPORATOR TEMPERATURE (°F)							
		-60°	-80°	-100°	-120°	-60°	-80°	-100°	-120°
S	1/8	0.27	0.21	0.17	0.14	0.43	0.35	0.29	0.19
S	1/4	0.53	0.42	0.34	0.27	0.86	0.69	0.58	0.39
S	1/2	0.72	0.57	0.47	0.33	1.17	0.94	0.79	0.53
S	1	1.41	1.11	0.91	0.56	2.30	1.85	1.55	1.03
S	1 1/2	1.71	1.35	1.11	1.12	2.78	2.24	1.88	1.25
S	2	2.49	1.96	1.61	1.79	4.05	3.26	2.74	1.82
S	2 1/2	3.14	2.47	2.03	2.23	5.11	4.11	3.45	2.29
S	3	4.33	3.41	2.80	2.79	7.05	5.67	4.76	3.16
P	5	6.32	5.16	4.34	2.90	10.30	8.58	7.39	5.04
P	8	8.14	6.64	5.59	3.73	13.30	11.10	9.51	6.49
P	12	12.3	10.1	8.47	5.65	20.1	16.7	14.40	9.83

VALVE TYPE	NOMINAL CAPACITY	REFRIGERANT							
		503				508B(W)			
		EVAPORATOR TEMPERATURE (°F)							
		-60°	-80°	-100°	-120°	-60°	-80°	-100°	-120°
S	1/8	0.33	0.29	0.23	0.16	0.28	0.24	0.19	0.13
S	1/4	0.66	0.57	0.46	0.32	0.56	0.48	0.38	0.26
S	1/2	0.89	0.78	0.62	0.44	0.75	0.65	0.51	0.35
S	1	1.74	1.52	1.22	0.85	1.48	1.27	1.00	0.69
S	1 1/2	2.11	1.84	1.47	1.03	1.79	1.54	1.22	0.84
S	2	3.08	2.68	2.15	1.50	2.61	2.24	1.77	1.22
S	2 1/2	3.88	3.38	2.71	1.90	3.29	2.83	2.23	1.54
S	3	5.35	4.66	3.73	2.62	4.53	3.90	3.08	2.12
P	5	7.81	7.05	5.80	4.18	6.62	5.90	4.78	3.39
P	8	10.1	9.08	7.46	5.38	8.52	7.59	6.15	4.37
P	12	15.2	13.8	11.3	8.15	12.9	11.5	9.32	6.61

TABLE 4: TEV LIQUID CORRECTION FACTORS

REFRIGERANT	LIQUID TEMPERATURE ENTERING TEV (°F)					
	-40°	-30°	-20°	-10°	0°	10°
	CORRECT FACTOR, CF LIQUID					
13	1.32	1.24	1.16	1.08	1.00	0.92
23	1.26	1.20	1.13	1.07	1.00	0.93
503	1.33	1.25	1.17	1.08	1.00	0.91
508B	1.44	1.33	1.22	1.11	1.00	0.88

TABLE 5: PRESSURE CORRECTION FACTORS FOR R-13

EVAPORATOR TEMPERATURE (OF)	PRESSURE DROP ACROSS TEV (PSI)							
	50	75	100	125	150	175	200	225
	CORRECTION FACTOR, CF PRESSURE DROP							
-60° & -80°	0.71	0.87	1.00	1.12	1.22	1.32	1.41	1.50
-100° & -120°	0.63	0.77	0.89	1.00	1.10	1.18	1.26	1.34

TABLE 6: PRESSURE CORRECTION FACTORS FOR R-23

EVAPORATOR TEMPERATURE (OF)	PRESSURE DROP ACROSS TEV (PSI)							
	75	100	125	150	175	200	225	250
	CORRECTION FACTOR, CF PRESSURE DROP							
-60° & -80°	0.77	0.89	1.00	1.10	1.18	1.26	1.34	1.41
-100°	0.71	0.82	0.91	1.00	1.08	1.15	1.22	1.29
-120°	0.65	0.76	0.85	0.93	1.00	1.07	1.13	1.20

TABLE 7: PRESSURE CORRECTION FACTORS FOR R-503 & R-508B

EVAPORATOR TEMPERATURE (OF)	PRESSURE DROP ACROSS TEV (PSI)							
	75	100	125	150	175	200	225	250
	CORRECTION FACTOR, CF PRESSURE DROP							
-60°	0.77	0.89	1.00	1.10	1.18	1.26	1.34	1.41
-80°	0.71	0.82	0.91	1.00	1.08	1.15	1.22	1.29
-100°	0.65	0.76	0.85	0.93	1.00	1.07	1.13	1.20
-120°	0.61	0.71	0.79	0.87	0.94	1.00	1.06	1.12

TABLE 8: DISTRIBUTOR TUBE CAPACITIES

Tons of Refrigerant Based on 0°F Liquid Temperature, 30" Tube Lengths, 10 psi Δp

TUBE SIZE OD INCHES	REFRIGERANT															
	R-13				R-23				R-503				R-508B			
	EVAPORATOR TEMPERATURE (°F)															
	-60	-80	-100	-120	-60	-80	-100	-120	-60	-80	-100	-120	-60	-80	-100	-120
3/16	0.23	0.17	0.12	0.03	0.36	0.26	0.20	0.07	0.28	0.20	0.15	0.11	0.23	0.16	0.12	0.09
1/4	0.66	0.48	0.36	0.09	1.05	0.77	0.57	0.19	0.80	0.58	0.43	0.33	0.65	0.47	0.35	0.26
5/16	1.33	0.97	0.73	0.19	2.13	1.56	1.16	0.39	1.61	1.18	0.88	0.66	1.31	0.96	0.71	0.53
3/8	2.39	1.75	1.31	0.35	3.85	2.81	2.10	0.71	2.89	2.13	1.58	1.20	2.34	1.72	1.28	0.96

TABLE 9: NOZZLE CAPACITIES

Tons of Refrigerant Based on 0°F Liquid Temperature Entering TEV, and 25 psi Δp

NOZZLE NUMBER	REFRIGERANT															
	R-13				R-23				R-503				R-508B			
	EVAPORATOR TEMPERATURE °F															
	-60	-80	-100	-120	-60	-80	-100	-120	-60	-80	-100	-120	-60	-80	-100	-120
1/9	0.08	0.06	0.05	0.04	0.13	0.10	0.08	0.67	0.09	0.07	0.06	0.05	0.08	0.06	0.05	0.04
1/6	0.13	0.10	0.08	0.07	0.19	0.15	0.12	0.10	0.14	0.11	0.09	0.07	0.12	0.09	0.07	0.06
1/4	0.20	0.16	0.13	0.10	0.31	0.24	0.20	0.17	0.23	0.17	0.14	0.11	0.19	0.14	0.11	0.09
1/3	0.27	0.21	0.16	0.14	0.41	0.32	0.26	0.22	0.30	0.23	0.18	0.15	0.25	0.19	0.15	0.12
1/2	0.37	0.28	0.23	0.19	0.56	0.44	0.35	0.30	0.41	0.32	0.25	0.21	0.34	0.26	0.20	0.16
3/4	0.56	0.43	0.34	0.28	0.85	0.66	0.53	0.45	0.62	0.48	0.38	0.31	0.51	0.39	0.31	0.25
1	0.75	0.57	0.46	0.38	1.14	0.88	0.71	0.60	0.83	0.64	0.51	0.42	0.69	0.52	0.41	0.33
1 ½	1.09	0.83	0.67	0.55	1.66	1.28	1.04	0.88	1.21	0.93	0.74	0.61	1.00	0.76	0.60	0.48
2	1.49	1.14	0.91	0.76	2.27	1.76	1.43	1.21	1.66	1.28	1.01	0.83	1.37	1.04	0.82	0.66
2 ½	1.86	1.43	1.14	0.95	2.83	2.20	1.78	1.51	2.07	1.59	1.26	1.04	1.71	1.30	1.02	0.83
3	2.23	1.71	1.37	1.14	3.40	2.64	2.14	1.81	2.48	1.91	1.52	1.25	2.05	1.56	1.22	0.99
4	2.99	2.29	1.83	1.52	4.55	3.53	2.86	2.42	3.32	2.55	2.03	1.67	2.74	2.08	1.64	1.33
5	3.69	2.82	2.26	1.88	5.61	4.35	3.52	2.98	4.10	3.15	2.50	2.06	3.38	2.57	2.02	1.64
6	4.42	3.39	2.71	2.25	6.73	5.22	4.23	3.58	4.91	3.78	3.00	2.47	4.06	3.08	2.42	1.97
8	5.33	4.08	3.26	2.71	8.11	6.28	5.09	4.31	5.92	4.55	3.61	2.97	4.89	3.71	2.92	2.37
10	5.97	4.57	3.66	3.04	9.09	7.04	5.71	4.83	6.64	5.10	4.05	3.33	5.48	4.16	3.27	2.65
12	7.37	5.65	4.51	3.75	11.2	8.70	7.05	5.96	8.20	6.30	5.00	4.11	6.77	5.14	4.04	3.28
15	9.14	7.00	5.60	4.66	13.9	10.8	8.74	7.39	10.1	7.81	6.20	5.10	8.39	6.37	5.01	4.07
17	10.2	7.83	6.26	5.21	15.6	12.1	9.77	8.27	11.3	8.73	6.94	5.71	9.38	7.13	5.60	4.55
20	12.3	9.44	7.55	6.27	18.8	14.5	11.8	9.96	13.7	10.5	8.36	6.88	11.3	8.59	6.75	5.48
25	15.5	11.9	9.49	7.89	23.6	18.3	14.8	12.5	17.2	13.2	10.5	8.65	14.2	10.8	8.49	6.89
30	17.7	13.6	10.8	9.02	27.0	20.9	16.9	14.3	19.7	15.1	12.0	9.88	16.2	12.3	9.70	7.87
35	21.3	16.3	13.0	10.8	32.4	25.1	20.4	17.2	23.7	18.2	14.5	11.9	19.5	14.9	11.7	9.47
40	23.9	18.3	14.6	12.2	36.4	28.2	22.8	19.3	26.6	20.4	16.2	13.3	21.9	16.7	13.1	10.6
50	31.0	23.7	19.0	15.8	47.2	36.6	29.6	25.1	34.4	26.5	21.0	17.3	28.4	21.6	17.0	13.8

TABLE 10: TUBE AND NOZZLE CORRECTION FACTORS

REFRIGERANT	REFRIGERANT LIQUID TEMPERATURE °F					
	10	0	-10	-20	-30	-40
R-13	0.87	1.00	1.15	1.33	1.56	1.88
R-23	0.89	1.00	1.13	1.29	1.48	1.75
R-503	0.87	1.00	1.14	1.31	1.52	1.78
R-508B	0.85	1.00	1.17	1.37	1.61	1.92

R-23 SELECTION EXAMPLE

R-23, actual load = 0.75 tons t_{cond} = 10°F t_{liq} = -10°F t_{evp} = -80°F
Liquid Line & Accessories Loss = 3psi

Tube Selection 3 circuits; 30" tubes

Actual load per Tube	= 0.75 ÷ 3	= 0.25 tons/tube
Choice 3/16"	= 0.26 tons/tube (from TABLE 8)	
Liquid Correction Factor	= 1.13 (from TABLE 10)	
Corrected Tube Capacity	= 0.26 X 1.13	= 0.294
% Loading	= 0.25 ÷ 0.294	= 0.85 = 85%
D Pressure	= 7 psi (using R-22 data in TABLE C, Bulletin 20-10)	

Nozzle Selection

Actual Nozzle Load	= 0.75 tons	
Choice: #3/4 Nozzle (from TABLE 9)	= 0.66 tons (from TABLE 9)	
Liquid Correction Factor	= 1.13 (from TABLE 10)	
Corrected Nozzle Capacity	= 0.66 X 1.13	= 0.75 tons
% Loading	= 0.75 ÷ 0.75	=1.00 = 100%
D Pressure	= 25 psi (using R-22 data in TABLE C, Bulletin 20-10)	

Expansion Valve Selection

Available Pressure Drop Across TEV:

Condensing Pressure (psig)	242
Liquid Line & Accessories Loss (psi)	-3
Evaporator Pressure (psig)	-26
Distributor & Tubes (psi)	-32
Δp (psi)	181

Liquid Correction Factor	= 1.07 (form TABLE 4)	
Pressure Drop Correction Factor	= 1.12 (form TABLE 6)	
S - 1/4	= 0.69 tons @ -80°F Evaporating Temperature (form TABLE 3)	
Corrected Valve Capacity	= 0.69 X 1.07 X 1.12 =	0.82 tons
% Loading	= 0.75 ÷ 0.82 = 0.91 =	91%

Selection can be: SGE-1/4-GP, 1/2" X 5/8"ODF with 1620-3-3/16-LNWR and nozzle kit J-3/4
Or SGE-1/4-GP, 3/8" X 1/2"ODF with D260-3-3/16-LNWR and nozzle kit L-3/4

R-13B1 ("T") TEV CAPACITIES –TONS OF REFRIGERANT (EXTERNALLY EQUALIZED ONLY)

VALVE TYPE	NOMINAL CAPACITY	EVAPORATOR TEMPERATURE -°F											
		-40				-60				-80			
		PRESSURE DROP ACROSS VALVE - PSI											
		40	60	80	100	40	60	80	100	40	60	80	100
S	**1/4**	0.24	0.30	0.35	0.39	0.18	0.22	0.25	0.28	0.11	0.13	0.15	0.17
S	**1/2**	0.34	0.42	0.48	0.54	0.24	0.29	0.33	0.37	0.13	0.16	0.18	0.21
S	**1**	0.68	0.84	0.97	1.08	0.49	0.60	0.69	0.77	0.28	0.34	0.39	0.44
S	**1 1/2**	0.81	0.99	1.14	1.28	0.55	0.67	0.77	0.86	3.00	0.36	0.42	0.46
S	**2**	1.18	1.44	1.66	1.86	0.86	1.05	1.21	1.36	0.53	0.65	0.75	0.84
S	**2 1/2**	1.48	1.81	2.09	2.34	1.07	1.31	1.51	1.69	0.70	0.86	0.99	1.10
S	**3**	2.02	2.48	2.86	3.20	1.44	1.77	2.04	2.28	0.91	1.12	1.29	1.44
P	**5**	2.87	3.52	4.06	4.5	2.11	2.59	2.99	3.34	1.34	1.64	1.89	2.12
P	**8**	4.10	5.02	5.80	6.48	3.00	3.68	4.25	4.75	1.93	2.36	2.72	3.05
P	**12**	6.53	8.00	9.24	10.3	4.96	6.07	7.01	7.84	3.31	4.05	4.68	5.23

REFRIGERANT LIQUID CORRECTION FACTORS

LIQUID TEMP.	10	0	-10	-20	-30	-40
R13B1	0.95	1.00	1.05	1.10	1.16	1.21

TABLE 3: R-13B1 DISTRIBUTOR TUBE CAPACITIES

Tons of refrigerant based on 0°F liquid temperature, 30" tube lengths, 10 psi Δp

TUBE SIZE OD INCHES	EVAPORATOR TEMPERATURE °F		
	-40	-60	-80
3/16	0.20	0.20	0.13
1/4	0.49	0.57	0.33
5/16	0.88	1.16	0.62
3/8	1.43	2.06	1.04

R-13B1 NOZZLE CAPACITIES TONS OF REFRIGERANT BASED ON 0°F LIQUID TEMPERATURE ENTERING TEV, AND 25 PSI Δp

NOZZLE NUMBER	EVAPORATOR TEMPERATURE °F		
	-40	-60	-80
1/9	0.10	0.07	0.05
1/6	0.15	0.10	0.08
1/4	0.25	0.17	0.13
1/3	0.32	0.22	0.17
1/2	0.45	0.30	0.23
3/4	0.67	0.46	0.35
1	0.90	0.61	0.47
1 1/2	1.31	0.89	0.68
2	1.80	1.22	0.93
2 1/2	2.24	1.52	1.16
3	2.69	1.82	1.39
4	3.61	2.44	1.87

NOZZLE NUMBER	EVAPORATOR TEMPERATURE °F		
	-40	-60	-80
5	4.45	3.00	2.30
6	5.33	3.60	2.76
8	6.42	4.34	3.32
10	7.20	4.86	3.73
12	8.89	6.00	4.60
15	11.0	7.45	5.71
17	12.3	8.33	6.38
20	14.9	10.0	7.69
25	18.7	12.6	9.67
30	21.4	14.4	11.1
35	25.7	17.3	13.3
40	28.8	19.5	14.9
50	37.4	25.2	19.3