Bristol
Compressors, Inc.®

Number: **129**

Application Bulletin

"G" SERIES "MULTIPLES" APPLICATION BULLETIN

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Subject: G Series "Multiples" Application Bulletin

This Bulletin pertains to the parallel connection of "multiple" Bristol G series compressors, including user advantages and commercial air conditioning application information. The use of multiple compressors can increase the G series capacity range to 73.5 tons at ARI (60 Hz) condition, i.e., three 24-ton compressors in parallel.

The Bristol Multiples are more economical and yield higher efficiency (when modulated) than a single compressor of comparable size. Modulation of a multiple compressor assembly will reduce operating cost and meet cooling requirements of a building when the outdoor temperature is less than the design temperature. This is accomplished by operating each compressor only as needed which, in turn, reduces compressor on/off cycles and substantially increases the efficiency.

While compressor modulation will increase SEER, it can also cause some problems if the system is not designed and tested for the application. Bristol Bulletin 121 (Compressor Application Guidelines) will assist in designing the system for the most reliable operation.

Modulating compressors require testing with one, two or three compressors operating (depending upon the number of compressors). A check valve is required in the discharge line of each compressor. These check valves are supplied with each compressor and are identified on the "Multiple" compressor bill of material. Engineering lab and field tests have proven that in a modulating system where only one compressor is running, the high pressure discharge gas from the first compressor condenses into liquid in the discharge muffler and cylinder head of the off compressors when discharge line check valves are not used. Over a period of time the liquid leaks past the discharge valves, filling the cylinders full of liquid refrigerant. Consequently, each time the second or third compressor starts, it slugs, which can shorten the life of the compressor. The addition of a check valve in the discharge line of each compressor prevents this damaging accumulation of liquid.

1.0 Assembly

The G series compressors will not be assembled into Multiple assemblies by Bristol. The compressors will be shipped individually, to be assembled into multiple units by the customer. They may be assembled into units in groups of two or three, but no more than three.

2.0 Check Valves

All G series Multiple compressors will be shipped with a magnetic check valve (Bristol part number 250562) that must be installed by the customer, therefore making the compressors suitable for modulation. Flow directional arrows are stamped on valve body.

2.1.0 Special brazing attention is required when installing the check valve in the discharge line.

2.1.1 The temperature of the check valve body must not exceed 232°C (450°F) maximum. Exceeding this temperature can damage the internal components of the check valve.

2.1.2 Keeping the temperature below 232°C, (450°F) can be accomplished by using either a wet rag, a water jacket, or venturi-type cooling device around the check valve body while brazing in place.

2.1.3 A thermocouple or other temperature measurement device should be used to monitor the check valve to insure the maximum temperature is not exceeded.

3.0 Sweat and Rotalock Fittings (Interconnects)

G series Multiple compressors will be shipped with all necessary fittings for the suction, discharge, check valve, pressure interconnect, and oil interconnect. All of these interconnects must be utilized to prevent compressor damage. (Refer to Attachments I and II.) Bristol does not supply any interconnect tubing/female fittings.

4.0 Crankcase Heaters

Crankcase heaters must be used on each compressor. Refer to the individual compressor specification summary sheet for crankcase heater size and part numbers. These heaters must be energized at all times and at least 24 hours before initial start-up. Each application should be evaluated for worst case high and low ambients to assure adequate refrigerant drive out capability.

5.0 Accumulators

All systems must be evaluated to determine the need for suction accumulator(s).

5.1.0 The evaluation should include a check during the transition from full load (lowest suction pressure and superheat with all compressors running) to only the first compressor running. The rapid increase in suction pressure could cause liquid refrigerant to flood the compressor.

5.1.1 A sight glass should be installed at least 152.4 mm (6.0 in.) from each compressor suction inlet to determine if the phenomenon described in 5.1.0 exists. If so, an accumulator is required. (If only one sight glass is used, it must be between compressor group and evaporator.)

6.0 Motor Protection

Each compressor is equipped with pilot duty motor protection. The protection should be wired in a way that would take all compressors off the line until the faulty compressor is isolated or replaced. By wiring the motor protection in this manner, cross contamination would be at a minimum.

7.0 Pressure Controls

Manual reset high and low pressure limit controls are required on commercial applications. To prevent nuisance trips, count logic may be employed to allow three faults prior to a safety switch lockout.

8.0 Starting Characteristics

The G series products are available only in three-phase models. Starting, therefore, should never be a problem. However, on units that modulate the compressors, we recommend running start tests on the second and third compressors while one compressor and while two compressors are operating. Tests should be run at worst case conditions (lowest voltage, highest load and highest pressure differential) the unit is designed to operate.

9.0 Filter and Screen Requirements

These elements are necessary to prevent cross contamination between compressors if one fails or generates debris.

9.1.0 Suction line filter: Install a replaceable core type filter in the system suction manifold as illustrated in Attachments I and II.

9.1.1 Oil screen: Install a 100 mesh screen in the oil interconnect lines (Bristol part number 250569). The screens must be cleaned or replaced after a failure has occurred.

10.0 Time Delay on Modulating Units

Delay on break time delay (five minute minimum) should be used on all compressors to prevent short cycling which can be caused by a close temperature differential on the stages of the thermostat or other defective controls. The electronic motor protection module has a 4 ± 1 minute time delay on removal of module power, which may be used for this requirement.

11.0 Refrigerant Metering Device for Modulation

A non-bleed TXV must be used on all modulating systems. Bristol strongly recommends using the non-bleed balanced port TXV for better control.

12.0 Lubricant Circulation and Return to the Compressors on Split Systems

The lubricant circulation and return to the compressor is very much dependent on the system design and application. In the case of multiple compressors, the tube sizing of the system is selected to meet the total capacity output of the multiple compressors. Due to a reduction in the refrigerant gas velocity, it is critical to assure oil circulation and return to the compressor(s) when the first compressor is operating alone.

12.1.0 The oil return is most critical for upward flow (condensing unit/compressor above evaporator) through the vapor suction line between the indoor coil and the compressor. The system design engineer needs to do the following:

Step 1: Specify the highest ambient temperature and the lowest evaporator temperature at which the lead compressor (single compressor operation) could operate alone.

Step 2: Determine the mass flow of the lead compressor at the condition in Step 1 using the performance tables of the lead compressor.

Step 3: Compare the mass flow from Step 2 with the minimum refrigeration capacity (in tons) for oil entrainment through the selected suction line size as from Attachment II.

Step 4: If the capacity of the lead compressor, as calculated from Step 2, is equal or close to the minimum capacity derived from the attached table, the designer should run actual oil return tests to assure there is adequate oil circulation and return at the worst case conditions of suction and discharge pressures and temperature conditions with allowance made for control tolerance. Oil level must always be visible in sight glass.

13.0 Compressor Mounting

Compressors must be mounted on a surface that is of sufficient rigidity to prevent relative motion. Heavy rails, channels, or a plate are suggested with the compressor hard-mounted to this chassis, and the chassis mounted on grommets to the system.

13.1.0 Compressors must be mounted horizontally level and within 3.2 mm (.125 in.) vertically of each other.

13.1.1 Compressors should be mounted no less than 533.4 mm (21.00 in.) apart when measured to the compressor centerline to avoid component interference.

14.0 Tubing Lengths

The maximum distance between compressors is normally based on unit design needs and should be minimized to prevent over stressing or sagging of tubing that could prevent oil level equalization. Tube lengths and supports should be designed to avoid harmonic vibration during transportation and operation.

15.0 Tube Diameters

The suction or discharge manifold lines (see Attachment 1) may be any size equal to or greater than the minimum tube sizes for their respective connect lines as outlined below.

15.1.0 Each compressor should have its suction line connected to the suction manifold through equal length tubes at least 41.3 mm (1.625 in.) outer diameter.

15.1.1 Each compressor should have its discharge line connected to the discharge manifold through equal length tubes at least 28.6 mm (1.125 in.) outer diameter.

15.1.2 The pressure interconnect must be at least 28.6 mm (1.125 in.) outer diameter tubing connected between each compressor.

15.1.3 The oil interconnect must be at least 28.6 mm (1.125 in.) outer diameter tubing connected between each compressor and must be level to allow the oil level to equalize.

15.1.4 Before removal of the rubber plugs or caps on the oil interconnect and installation of the tubing, the compressor oil should be drained to a level below the sight glass to prevent spillage.

15.1.5 After installation of the oil interconnect tubing, the compressors should be recharged to the recommended oil level, taking the extra volume of the tubing into consideration.

15.1.6 Care should be taken when brazing sweat connections to assure that no foreign material, i.e., carbon production metals, are introduced into the compressors.

16.0 Tube Bends

All bends in the interconnect tubing should have sufficient radii to allow adequate flexibility and prevent over stressing of the tubing. It is suggested that the bend radius of the tubing centerline be no less than 1.5 times the diameter of the tubing.

17.0 Tube Wall Thickness

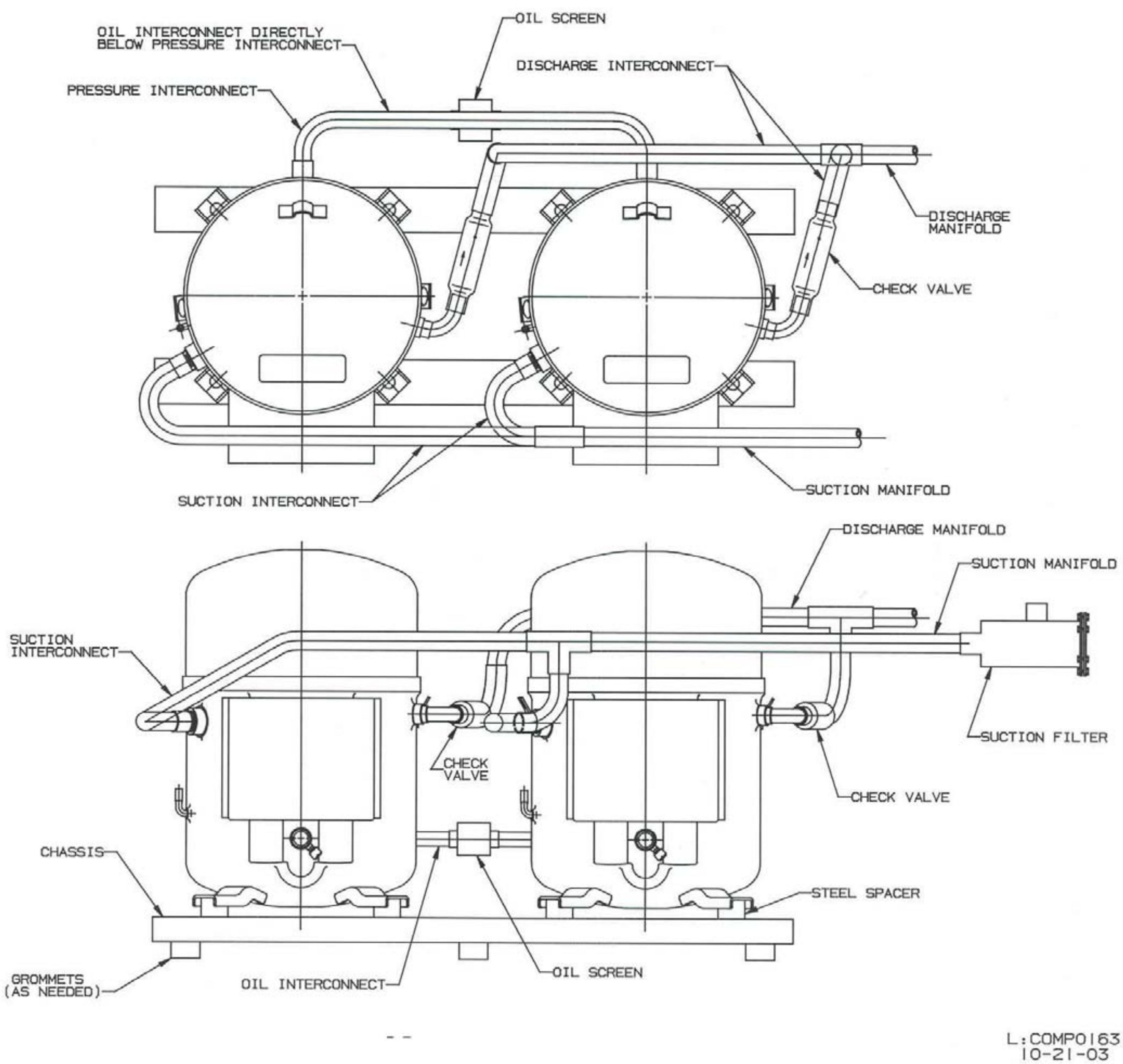
All tubes should have minimum wall thickness in accordance with ASTM B280. For 41.3 mm (1.625 in.) OD tubing, the minimum wall thickness should be 1.5 mm (.060 in.) and for 28.6 mm (1.125 in.) OD tubing, the minimum wall thickness should be 1.3 mm (.050 in.).

18.0 Remote Air-Cooled Condenser

Refer to Application Bulletin 127.

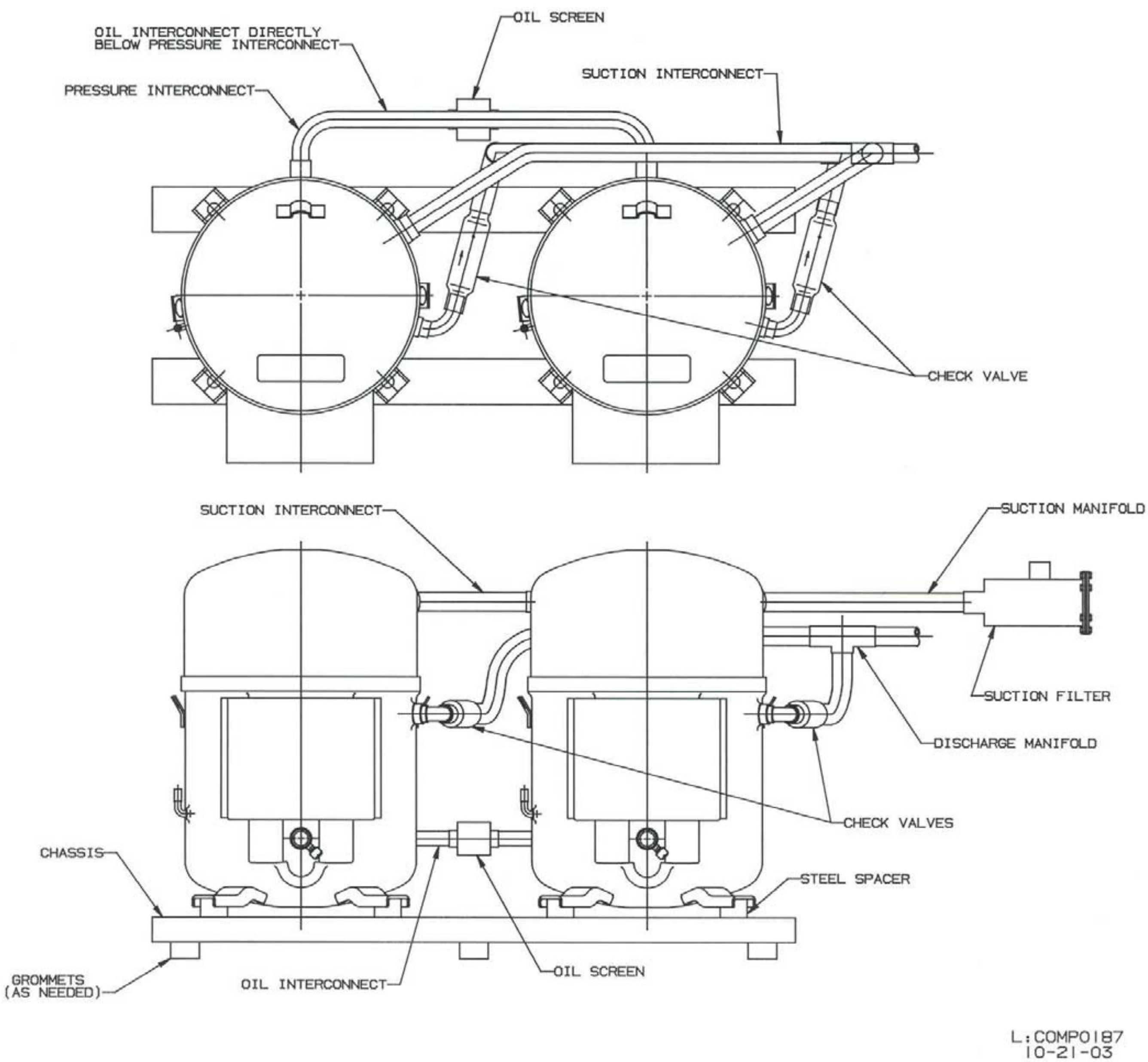
ATTACHMENT I

(NG and BG)



ATTACHMENT II

(25G)



ATTACHMENT III

Because most compressors have multiple capacity reduction features, gas velocities required to return oil up through vertical suction risers under all load conditions are difficult to maintain. When the suction riser is sized to permit oil return at the minimum operating capacity of the system, the pressure drop in this portion of the line may be too great when operating at full load. If a correctly sized suction riser imposes too great a pressure drop at full load, a double-suction riser should be used.

Oil Return Up Suction Risers—Multistage Systems. The movement of oil in the suction lines of multistage systems requires the same design approach as that for single-stage systems.

When refrigerants other than those listed in Tables 13 and 14 are used, follow the recommendations listed in Table 15. For oil to flow up along a pipe wall, a certain minimum drag of the gas flow is required. This can be represented by the friction gradient. Table 15 shows values for minimum friction gradients.

Table 13 Minimum Refrigeration Capacity in Kilowatts for Oil Entrainment up Suction Risers (Copper Tubing, ASTM B88M, Type B, Metric Size)

Refrigerant	Saturated Temp., °C	Suction Gas Temp., °C	Tubing Diameter, Nominal OD, mm											
			12	15	18	22	28	35	42	54	67	79	105	130
134a	−10.0	−5.0	0.274	0.502	0.844	1.437	2.732	4.848	7.826	15.006	25.957	39.340	81.164	140.509
		5.0	0.245	0.450	0.756	1.287	2.447	4.342	7.010	13.440	23.248	35.235	72.695	125.847
		15.0	0.238	0.436	0.732	1.247	2.370	4.206	6.790	13.019	22.519	34.129	70.414	121.898
134a	−5.0	0.0	0.296	0.543	0.913	1.555	2.956	5.244	8.467	16.234	28.081	42.559	87.806	152.006
		10.0	0.273	0.500	0.840	1.431	2.720	4.827	7.792	14.941	25.843	39.168	80.809	139.894
		20.0	0.264	0.484	0.813	1.386	2.634	4.674	7.546	14.468	25.026	37.929	78.254	135.471
134a	5.0	10.0	0.357	0.655	1.100	1.874	3.562	6.321	10.204	19.565	33.843	51.292	105.823	183.197
		20.0	0.335	0.615	1.033	1.761	3.347	5.938	9.586	18.380	31.792	48.184	99.412	172.098
		30.0	0.317	0.582	0.978	1.667	3.168	5.621	9.075	17.401	30.099	45.617	94.115	162.929
134a	10.0	15.0	0.393	0.721	1.211	2.063	3.921	6.957	11.232	21.535	37.250	56.456	116.479	201.643
		25.0	0.370	0.679	1.141	1.944	3.695	6.555	10.583	20.291	35.098	53.195	109.749	189.993
		35.0	0.358	0.657	1.104	1.881	3.576	6.345	10.243	19.640	33.971	51.486	106.224	183.891
22	−40	−35	0.182	0.334	0.561	0.956	1.817	3.223	5.203	9.977	14.258	26.155	53.963	93.419
		−25	0.173	0.317	0.532	0.907	1.723	3.057	4.936	9.464	16.371	24.811	51.189	88.617
		−15	0.168	0.307	0.516	0.880	1.672	2.967	4.791	9.185	15.888	24.080	49.681	86.006
22	−20	−15	0.287	0.527	0.885	1.508	2.867	5.087	8.213	15.748	27.239	41.283	85.173	147.449
		−5	0.273	0.501	0.841	1.433	2.724	4.834	7.804	14.963	25.882	39.226	80.929	140.102
		5	0.264	0.485	0.815	1.388	2.638	4.680	7.555	14.487	25.058	37.977	78.353	135.642
22	−5	0	0.389	0.713	1.198	2.041	3.879	6.883	11.112	21.306	36.854	55.856	115.240	199.499
		10	0.369	0.676	1.136	1.935	3.678	6.526	10.535	20.200	34.940	52.954	109.254	189.136
		20	0.354	0.650	1.092	1.861	3.537	6.275	10.131	19.425	33.600	50.924	105.065	181.884
22	5	10	0.470	0.862	1.449	2.468	4.692	8.325	13.441	25.771	44.577	67.560	139.387	241.302
		20	0.440	0.807	1.356	2.311	4.393	7.794	12.582	24.126	41.731	63.246	130.488	225.896
		30	0.422	0.774	1.301	2.217	4.213	7.476	12.069	23.141	40.027	60.665	125.161	216.675
502	−40	−35	0.129	0.236	0.397	0.676	1.284	2.279	3.679	7.054	12.201	18.492	38.152	66.048
		−25	0.125	0.229	0.385	0.657	1.248	2.215	3.575	6.855	11.858	17.972	37.079	64.190
		−15	0.121	0.223	0.374	0.638	1.212	2.151	3.472	6.658	11.516	17.453	36.009	62.337
502	−20	−15	0.210	0.385	0.647	1.102	2.096	3.718	6.003	11.510	19.909	30.173	62.253	107.769
		−5	0.204	0.374	0.628	1.070	2.033	3.607	5.823	11.166	19.314	29.272	60.392	104.549
		5	0.198	0.363	0.611	1.041	1.978	3.510	5.666	10.865	18.793	28.482	58.763	101.728
502	−5	0	0.288	0.528	0.887	1.510	2.871	5.094	8.224	15.770	27.277	41.341	84.292	147.655
		10	0.279	0.511	0.859	1.464	2.783	4.937	7.970	15.282	26.434	40.063	82.656	143.091
		20	0.271	0.496	0.834	1.421	2.701	4.793	7.737	14.835	25.661	38.891	80.239	138.907
502	5	10	0.347	0.637	1.071	1.824	3.467	6.151	9.931	19.041	32.936	49.917	102.986	178.286
		20	0.336	0.617	1.036	1.765	3.356	5.954	9.613	18.431	31.881	48.318	99.688	172.577
		30	0.326	0.598	1.005	1.713	3.256	5.777	9.326	17.882	30.932	46.880	96.721	167.439

Notes:
1. Refrigeration capacity in kilowatts is based on saturated evaporator as shown in table and condensing temperature of 40°C. For other liquid line temperatures, use correction factors in the table below.
2. The tables have been computed using an ISO 32 mineral oil for R-22 and R-502. R-134a has been computed using an ISO 32 ester-based oil.

Refrigerant	Liquid Temperature, °C		
	20	30	50
134a	1.20	1.10	0.89
22	1.17	1.08	0.91
502	1.26	1.12	0.86