Carrier

Application Data
Application Detail
5F,H

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5F,H-2XA ~~4/1/68~~
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Codes C and MB (510534)

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Table 1 - Physical Data - R-12, R-500, R-22, R-502 Compressors

COMPRESSOR MODEL			5F20	5F30	5F40	5F60	5H40	5H46	5H60	5H80	5H120
Nominal Horsepower		R-12	5	7-1/2	10	15	25	40	40	50	75
		R-500	7-1/2	10	15	20	30	50	50	60	100
		R-22	10	15	20	25	40	60	60	75	125
		R-502	10	15	20	25	40	60	60	75	125
Number of Cylinders			2	3	4	6	4	4	6	8	12
Bore (in.)			2-1/2	2-1/2	2-1/2	2-1/2	3-1/4	3-1/4	3-1/4	3-1/4	3-1/4
Stroke (in.)			2	2	2	2	2-3/4	3-7/16	2-3/4	2-3/4	2-3/4
Displacement Cfm at 1750 rpm			19.0	29.8	39.8	59.6	92.4	115.5	138.4	184.7	276.8
Ratings in Tons ARI Standard 516-60* and 514-62*		R-12	5.18	7.76	10.5	15.7	24.7	30.6	37.0	49.4	74.0
		R-500	6.11	9.16	12.2	18.3	29.2	36.2	43.9	58.6	88.0
		R-22	8.46	12.7	16.8	25.3	39.6	49.1	59.4	79.2	119.0
		R-502	8.85	13.2	17.7	26.5	40.5	50.2	60.9	81.2	122.0
Maximum Speed (rpm)	Single Stage	R-12, R-500	1750	1750	1750	1750	1750	1750	1750	1750	1750
		R-22, R-502	1750	1750	1750	1750	1750	1750	1750	1750	1750
	Booster	R-12	1750	1750	1750	1750	1750	1750	1750	1750	1750
		R-22	1750	1750	1750	1750	1750	1750	1750	1750	1750
Minimum Speed (rpm)	For Lubrication		400	400	400	400	400	400	400	400	400
	For Unloader Action		600	700	800	900	800	800	900	1100	900
Net Oil Pressure (psig)†			45	45	45	45	45	45	45	45	45
Oil Charge (pt)			5	5-1/2	12	13	18	18	21	41	81
Normal Oil Level in Sight Glass			C.L.	C.L.	3/8" Above C.L.	3/8" Above C.L.	C.L.	C.L.	C.L.	C.L.	C.L.
Minimum Oil Pressure for Unloader Action (psig)			22	28	35	35	35	35	35	35	35
Suction Line ODF (in.)			1-1/8	1-5/8	1-5/8	2-1/8	2-5/8	2-5/8	3-1/8	3-5/8	4-1/8
Discharge Line ODF (in.)			7/8	1-3/8	1-3/8	1-5/8	2-1/8	2-1/8	2-5/8	3-1/8	3-5/8
Bare Compressor Weight (lb)			175	215	355	400	610	610	795	1115	1580

*Standard 514-62 for 20 hp and smaller; 516-60 for 25 hp and larger. Group IV (40F Sat. Suct, 105F Sat. Disch, 15F Superheat, 0F Subcooling)

†Net oil pressure = oil pressure gage reading – suction pressure.

Table 2 - Physical Data - R-12, R-500, R22, R-502 Duplex Compressors

DUPLEX COMPRESSOR MODEL		5H40-60	5H60-60	5H60-80	5H80-80	5H80-120	5H120-120
Nominal Horsepower	R-12	60	75	100	100	125	150
	R-500	75	100	100	125	150	175
	R-22	100	125	150	150	200	250
	R-502	100	125	150	150	200	250
Number of Cylinders		10	12	14	16	20	24
Bore (in.)		3-1/4	3-1/4	3-1/4	3-1/4	3-1/4	3-1/4
Stroke (in.)		2-3/4	2-3/4	2-3/4	2-3/4	2-3/4	2-3/4
Displacement Cfm at 1750 rpm		230.8	276.8	323.1	369.4	461.5	553.6
Ratings in Tons ARI Standard 516-60* and 514-62*	R-12	61.7	74.0	86.4	98.8	123.4	148.0
	R-500	73.1	87.8	102.5	117.2	146.6	176.0
	R-22	99.0	118.8	138.6	158.4	198.2	238.0
	R-502	101.4	121.8	142.1	162.4	203.2	244.0
Oil Charge (pt)		39	42	62	82	122	162
Duplex Unit Net Weight (lb)		2210	2410	2713	3225	3840	4305

*Standard 514-62 for 20 hp and smaller; 516-60 for 25 hp and larger. Group IV (40F Sat. Suct, 105F Sat. Disch, 15F Superheat, 0F Subcooling)

Table 3 - Physical Data - R-12, R-500, R-22, R-502 Condensers

CONDENSER SIZE			5F20	5F30	5F40	5F60	09RH027	09RH043	09RH054	09RH070	09RH084	09RH097	09RH127
Nominal Tonnage – (Note 1)			7 5	11 2	16 4	26 6	33 0	48 3	67 0	83 2	98 0	137 0	155.8
Condenser Type			← Shell and Coil →		← Shell and Tube →								
Shell	OD (in.)		8-3/8	8-3/8	8-5/8	8-5/8	10-3/4	12-3/4	12-3/4	12-3/4	14	14	18
	Thickness (in)		.125	.125	277	277	.219	250	.250	250	.3125	.3125	.375
Overall Condenser Length (in)			28-5/8	39-5/8	63	74	77-1/8	79-1/4	95-1/4	95-1/4	99-3/8	123-1/8	100-1/2
Distance Between Tube Sheets (in.)			26-3/4	37-3/4	54	65	67-5/8	67-1/2	83-1/2	83-1/2	83-5/32	106-7/8	83
Tube Sheet Thickness (in.)			–	–	1-1/4	1-1/4	1-1/4	1-5/16	1-5/16	1-5/16	1-1/2	1-1/2	1-9/16
Coil Length (in.)			295-1/4	387-5/8	–	–	–	–	–	–	–	–	–
Tube Length (in.)			–	–	56-5/8	67-5/8	70-5/32	70-5/32	86-5/32	86-5/32	86-5/32	109-7/8	86-5/32
Tube Size (Finned) (in)			3/4	7/8	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4
Number of Coils			2	2	–	–	–	–	–	–	–	–	–
Number of Tubes			–	–	32	40	61	89	89	110	133	133	212
Number of Circuits			1 or 2	1 or 2	–	–	–	–	–	–	–	–	–
Number of Passes			–	–	4 or 8	4 or 8	3 or 6	3 or 6	3 or 6	3 or 6	3 or 6	3 or 6	3 or 6
Water Side Circuit Length – (ft)	Single Circuit		49 2	64 6	–	–	–	–	–	–	–	–	–
	Double Circuit		24 6	32 3	–	–	–	–	–	–	–	–	–
	4 or 3 Pass		–	–	18	21 6	17	16 9	20 9	20 9	20 8	26 7	20 8
	8 or 6 Pass		–	–	36	43 3	34	33 8	41 8	41 8	41 6	53 4	41 6
Water Side Surface (sq ft)			8 6	13 4	20 5	30 7	48 8	70 8	87 7	108 4	130 3	165.2	207 7
Refrigerant Side Surface (sq ft)			43 6	65 8	66 4	99 5	158 0	229 0	284 0	352 0	422 5	536 3	672 4
Max Working Pressure	Refrig (psig)		← 385 →										
	Water (psig)		← 150 →				← 250 →						
Shell Volume	Gross (cu ft)		.67	99	1 59	1 92	3 29	4 6	5 7	5 7	6.8	8 7	11 2
	Net (cu ft)		.47	64	1 22	1 37	2 38	3 3	4.1	3 7	4.4	5.6	7 4
Maximum Refrigerant Storage Capacity (lb) (Note 2)	R-12		40 4	50 7	79.4	89 6	154	212	263	238	282	358	475
	R-22		37 2	46 4	72 8	82 0	139	193	239	216	257	327	432
	R-500		36 0	44 9	70 6	79 5	135	187	232	210	248	316	418
	R-502		38 2	47 9	75 0	84 6	145	199	248	223	265	337	447
Minimum Refrigerant Operating Charge (lb)	R-12		2 0	3 0	14.0	16 0	37	41	51	51	78	100	126
	R-22		1 8	2 7	12 7	14 5	33	37	46	46	71	91	114
	R-500		1 8	2 7	12 4	14 2	32 4	36	44 5	44 5	69	88 5	111
	R-502		1 9	2 9	13 1	15 0	34 4	38 2	47 3	47 3	73	94	118
Net Weight (lb)			70	97	225	320	455	640	750	810	1055	1270	1500
Water Connections (in.)	Single Circuit	Inlet	1/2 FPT	3/4 FPT	–	–	–	–	–	–	–	–	–
		Outlet	1/2 FPT	3/4 FPT	–	–	–	–	–	–	–	–	–
	Double Circuit	Inlet	(2) 1/2 FPT	(2) 3/4 FPT	–	–	–	–	–	–	–	–	–
		Outlet	(2) 1 MPT	(2) 1 MPT	–	–	–	–	–	–	–	–	–
	4 or 3 Pass	Inlet	–	–	(2) 1-1/4 FPT	(2) 1-1/4 FPT	(2) 2 FPT	(2) 2 FPT	(2) 2 FPT	(2) 2 FPT	(2) 2-1/2 IPS	(2) 2-1/2 IPS	(2) 3 IPS
		Outlet	–	–	1-1/2 FPT	1-1/2 FPT	2-1/2 FPT	3 FPT	3 FPT	3 FPT	4 IPS	4 IPS	5 IPS
	8 or 6 Pass	Inlet	–	–	1-1/4 FPT	1-1/4 FPT	2 FPT	2 FPT	2 FPT	2 FPT	2-1/2 IPS	2-1/2 IPS	3 IPS
		Outlet	–	–	1-1/4 FPT	1-1/4 FPT	2 FPT	2 FPT	2 FPT	2 FPT	2-1/2 IPS	2-1/2 IPS	3 IPS
Refrigerant Connections (in.)	Gas Inlet (ODF)		1-1/8	1-3/8	1-3/8	1-5/8	2-1/8	2-5/8	3-1/8	3-1/8	3-1/8	3-5/8	3-5/8
	Conn Type		← F-Solder →		← 4-Bolt Flat Pad →		← T & G Pad →						
	Liquid Outlet (ODF)		1/2	1/2	7/8	1-1/8	1-3/8	1-3/8	1-5/8	1-5/8	2-1/8	2-1/8	2-1/8
	Conn Type		← 2-Bolt Valve →				← 4-Bolt Valve →						
Frangible Disc (Male Flare) (in)			3/8	3/8	–	–	–	–	–	–	–	–	–
Relief Valve (Male Flare) (in)			–	–	1/2	1/2	5/8	5/8	5/8	5/8	3/4 FPT	3/4 FPT	(2) 3/4 FPT
Water Drain and Vent Plug Size (in)			–	–	1/4	1/4	3/8	3/8	3/8	3/8	3/8	3/8	3/8
Water Reg Conn (Male Flare) (in)			← 1/4 →										

NOTES:

1 Based on R-22 at 105 F condensing, 85 F ent water temp, 10 F rise per ARI Standard 450-61 (Group IV). The 09RH097 is rated at 10 6 F rise in order to stay within the recommended water velocity range

2 90 F liquid, 80% filled, per ARI Standard 450-61

3. Purge and liquid test cocks furnished on all condensers

4 5F40 and larger condensers have cleanable and renewable tubes.

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REFRIGERANT 12, 22, 500, AND 502 COMPRESSORS

Operating Requirements - Satisfactory operation of a reciprocating compressor is largely dependent upon the recognition of these three fundamental requirements:

1. Prevention of excess discharge temperature
2. Adequate compressor lubrication
3. A clean and dry system

Discharge Temperature - The temperature at the discharge valves within the cylinders is the controlling factor. Some cooling of the discharge gas occurs before reaching the discharge stop valve, thus when water-cooled heads are used this cooling is greater than it is without water cooling. To prevent the occurrence of excessive temperature at the discharge valves within the compressor, the following temperatures when measured immediately following the discharge stop valve must never be exceeded.

For nonwater-cooled heads - 275 F max

For water-cooled heads - 250 F max

The approximate discharge gas temperature can be found by use of the following equation:

$$T_2 = T_1 \left(\frac{P_2}{P_1} \right)^{\frac{N-1}{N}}$$

Where:

T_2 = Discharge temperature, F absolute
T_1 = Suction temperature, F absolute (including superheat)
P_2 = Discharge pressure, psia
P_1 = Suction pressure, psia
N = Compression exponent of the gas (Table 4)

Table 4 - Compression Exponent "N"

COMPRESSION RATIO = Discharge psia / Suction psia	WITHOUT WATER-COOLED HEADS				WITH WATER-COOLED HEADS
	R-12	R-22	R-500	R-502	R-22
2	1.216	1.325	1.258	1.234	1.240
3	1.191	1.258	1.216	1.216	1.218
4	1.177	1.240	1.203	1.206	1.205
5	1.172	1.234	1.196	1.197	1.199
6	1.166	1.232	1.191	1.190	1.196
8	1.160	1.228	1.186	1.178	1.192
10	1.155	1.225	1.182	1.169	1.187
12	1.150	1.224	1.179	1.161	1.182

The value of the compression exponent (N) depends upon several factors such as - properties of the gas compressed, degree of cooling in the compressor jacket, leakages, etc.

In order to simplify discharge temperature calculations, the preceding formula may be stated in the following form:

$$T_2 = [(460 + T_1) \times C] - 460$$

Where:

T_2 = Discharge temperature, F actual
T_1 = Suction gas temperature, F actual (including superheat)

$$C = \left(\frac{P_2}{P_1} \right)^{\frac{N-1}{N}}$$

Values for C at various compression ratios are:

Table 5 - "C" Factors

COMPRESSION RATIO = Discharge psia / Suction psia	WITHOUT WATER-COOLED HEADS				WITH WATER-COOLED HEADS
	R-12	R-22	R-500	R-502	R-22
2	1.14	1.17	1.16	1.13	1.15
3	1.19	1.25	1.22	1.22	1.22
4	1.23	1.31	1.26	1.27	1.27
5	1.26	1.36	1.30	1.30	1.31
6	1.29	1.40	1.33	1.33	1.34
8	1.33	1.47	1.39	1.37	1.40
10	1.36	1.53	1.43	1.40	1.44
12	1.38	1.57	1.46	1.41	1.47

Example:

Refrigerant 12

Compression Ratio $\frac{P_2}{P_1} = 8$

Factor C = 1.33

Suction Temperature, T_1 = 0 F Saturated, Superheated to 65 F

Solution:

$$\begin{aligned} T_2 &= [(460 + 65) \times 1.33] - 460 \\ &= 698 - 460 \\ &= 238 \text{ F} \end{aligned}$$

Although exponents are shown for high compression ratios, these are for information purposes only. The rating tables define the allowable selection and operation limits.

High Compression Ratio - Avoid compressor operation at compression ratios exceeding those covered in the rating tables. For operating conditions outside the limits shown in the tables, use two-stage compression. Care must be taken to prevent the compressor from pulling down to levels outside the rating tables.

Suction Gas Superheat - Excessive suction gas superheat will result in abnormally high discharge temperatures which must be avoided. When using Refrigerants 12, 500, and 502 the actual suction gas temperature must not exceed the values listed in Table 6.

Table 6 - Actual Suction Gas Temperature Limits (F) Refrigerants 12, 500, and 502*

SAT SUCT† GAS TEMP		-60	-50	-40	-30	-20	-10	0 and Above
Actual Suction Gas Temp	R-12 R-500	–	–	35	45	55	65	65
	R-502	25	35	45	55	65	75	75

*With Refrigerant 22 the suction gas superheat should never exceed 25 F for continuous operation.

†For most saturated suction temperatures -10 F or below, coolers are required. See rating pages for specific information.

Keeping Liquid Refrigerant Out of Compressor - Liquid refrigerant, or even excessive amounts of entrained liquid particles, in the suction gas must be kept out of the compressor by proper system design and compressor control. Under running conditions, the presence of unevaporated liquid refrigerant in the compressor tends to break down the oil film on the cylinder walls resulting in increased wear and loss of machine capacity.

During compressor operation, proper adjustment of the expansion valve will prevent excessive amounts of liquid from entering the compressor.

During compressor shutdown, gravity, thermal action and refrigerant absorption will result in a refrigerant and oil mixture in the compressor crankcase. Gravity flow can be prevented by the use of recommended loops, but thermal action and the absorption of refrigerant by the lubricating oil cannot be prevented by piping design.

For the above reason, the compressor must be controlled during idle times by one of the following methods.

MINIMUM PROTECTION - The standard recommended control method (see Fig. 1) is to close, by action of the control thermostat, the liquid line solenoid valve and simultaneously energize the crankcase heaters. With the crankcase heaters energized the crankcase temperature is always held above the shutdown temperature in the evaporator coil and there will be no refrigerant migration to the crankcase.

With this type control a control relay is required and the crankcase heaters have to be energized whenever the compressor is not operating.

The control relay coil is located in parallel with the liquid line solenoid and a normally open control relay contact added in series with the compressor starter and other auxiliary safety devices.

When the thermostat calls for cooling, solenoid valve opens and control relay is energized. This closes the relay contact and, if other safety devices are in their normal position, compressor will start. Simultaneously the normally closed compressor auxiliary contact will open, removing the crankcase heaters from the circuit.

When the thermostat is satisfied, the solenoid will close and the control relay is de-energized. This opens the relay contacts and the compressor stops. This action causes compressor auxiliary contacts to close energizing the crankcase heaters.

Specifications are sometimes written to call for a degree of protection greater than that afforded by standard method. If this is the case, either single pumpout or automatic pumpdown control may be required.

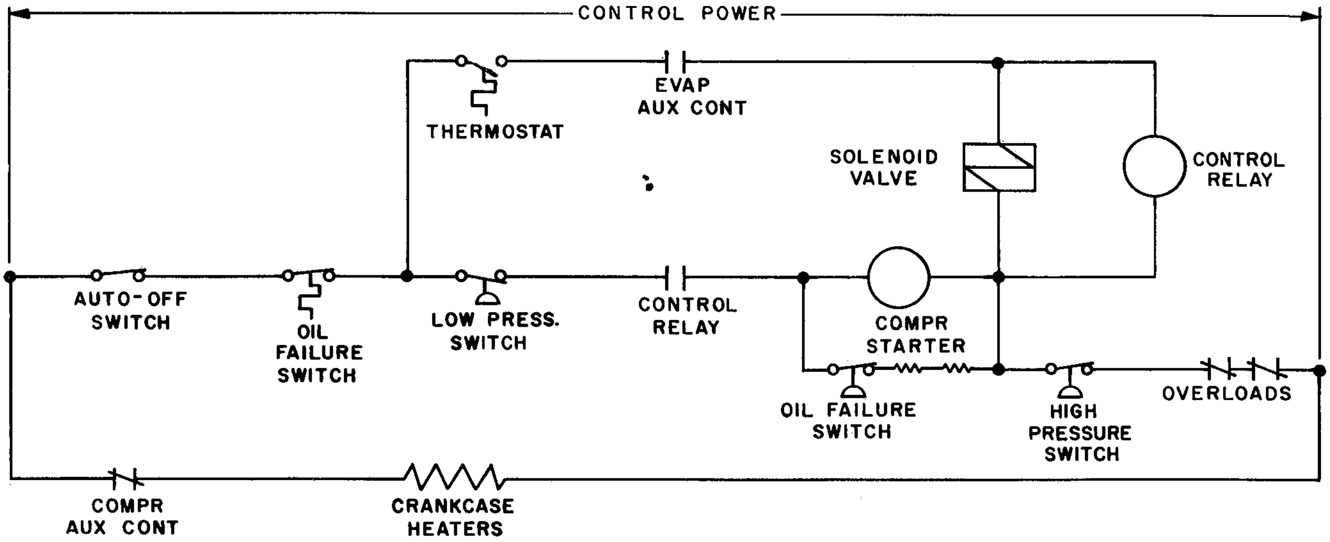

Fig. 1 - Minimum Protection

AUTOMATIC PUMPDOWN CONTROL (Fig. 2) - Pumpdown control is the most effective means of compressor control in keeping liquid refrigerant out of the crankcase on system shutdown.

In the basic pumpdown control sequence the thermostat controls the liquid line solenoid valve to stop or start the flow of refrigerant to the evaporator as required.

The pumpdown control system permits compressor cycling if a system malfunction allows the low side pressure to rise. Although this cycling is sometimes considered objectionable by the customer, it does promptly point out the need for maintenance attention and provides positive protection against liquid refrigerant accumulating in the compressor crankcase.

Pumpdown control should not be used with dry expansion coolers as it may cause frost pinching or freeze-up.

SINGLE PUMPOUT CONTROL - Pumpout control is not as positive as pumpdown control in keeping liquid refrigerant out of the crankcase. However, it is usually satisfactory when used with crankcase heaters if pumpdown is not acceptable.

Single pumpout control is similar to pumpdown control, except in the following ways: a pumpout relay is added, a normally open compressor auxiliary contact is necessary, and energizing of crankcase heaters is definitely required at the end of each operating cycle.

With single pumpout control, when the thermostat is satisfied, the compressor pumps down once and stops. It starts again only when the thermostat calls for cooling. In pumpdown control, the compressor cycles solely on the low pressure switch, regardless of the demands of the thermostat.

Pumpout control should not be used with dry expansion coolers as it may cause frost pinching or freeze-up.

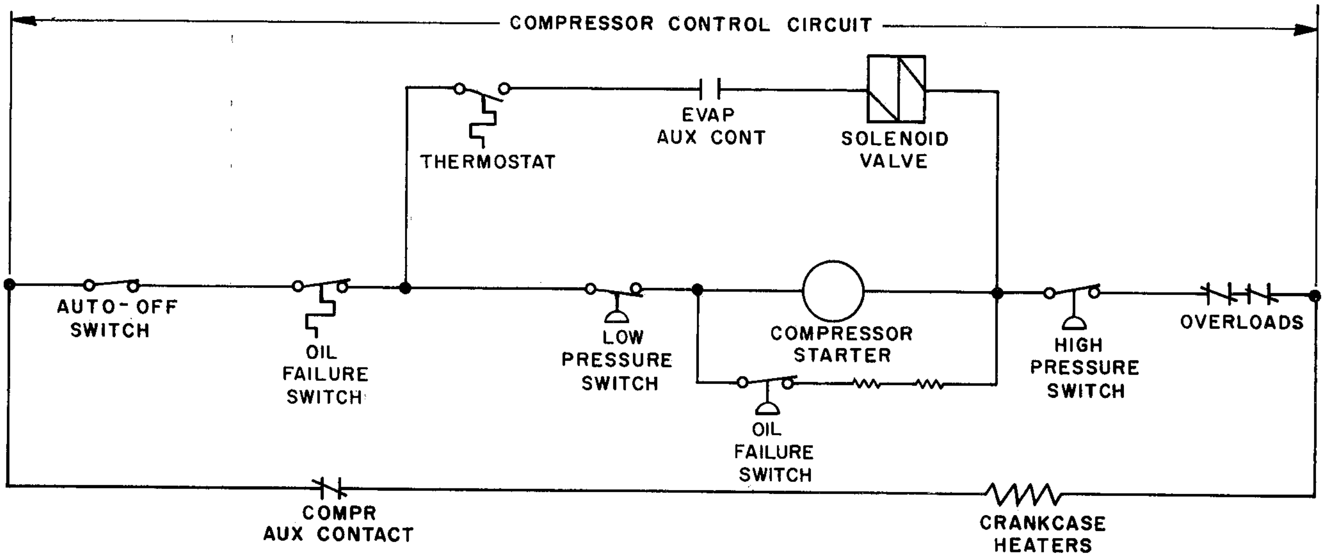

Fig. 2 - Automatic Pumpdown Control

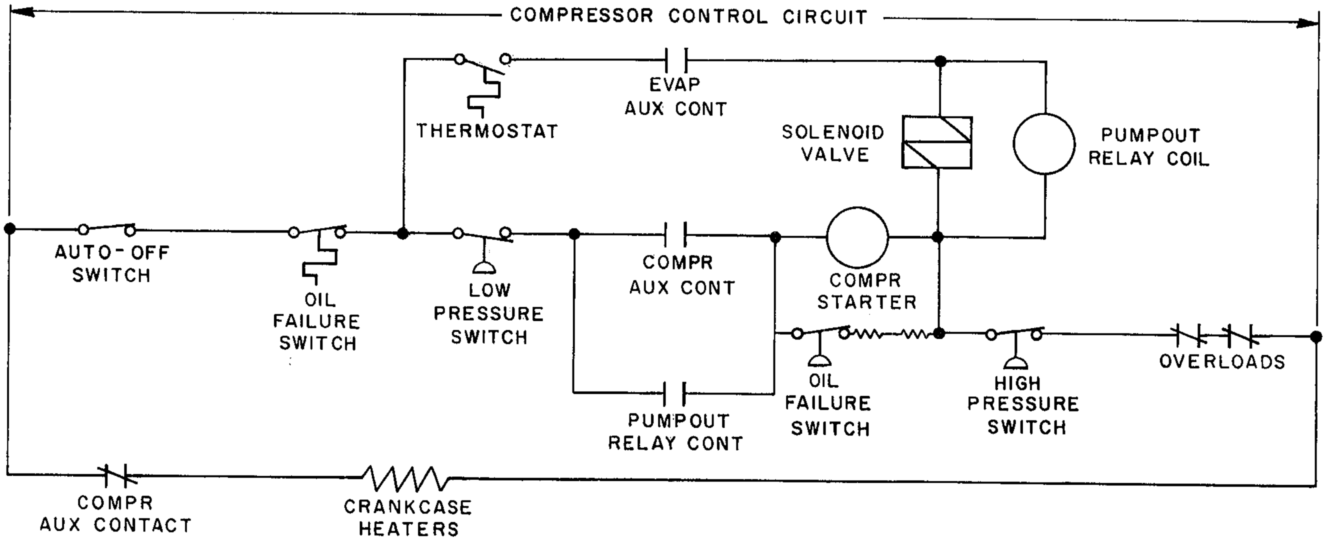

Fig. 3 - Single Pumpout Control

MANUAL PUMPDOWN - The compressor may be controlled manually without the use of pumpdown, or single pumpout control, and without crankcase heaters, provided the system is at all times under the control of a qualified operator. The operator will pump down the system by use of the manual valves and will keep liquid, suction and discharge valves closed when the machine is not operating. This method of manual operation may be used for any system, but is particularly applicable to flooded systems. With flooded systems crankcase heaters are used for short "OFF" cycle periods; manual pumpdown is needed during extended compressor shutdown.

Compressor Features and Accessories

WATER-COOLED HEADS AND OIL COOLERS - Water-cooled heads are available as accessories on all 5F,H compressors. Water cooling in cylinder heads is not necessary for any R-12, R-500 or R-502 application within the range of the ratings shown in this publication. Water-cooled heads are required, however, and must be used for most R-22 applications where the compression ratio is greater than 5.

In many cases when the operating conditions are such that the suction gas becomes superheated and the compression ratio is high, it is required that an oil cooler be used on the compressor. This will insure cooler oil temperatures thereby increasing the life expectancy of the shaft seal. Oil cooler packages and modified bearing heads are available from the factory and are easily installed on all 5 Series compressors (except 5F20 and 30). The oil coolers are field mounted. The special bearing head is available for field installation or can be factory mounted on special order. Refer to 5F,H Application Ratings (5F,H-3XR) to find when oil coolers are required.

Water flow thru compressor heads and oil cooler must be shut off when the compressor is not running to prevent the refrigerant vapors from condensing at the compressor during these OFF cycles. For this purpose a solenoid valve is recommended in the water supply line to the compressor heads.

The values listed in Table 7 assume a water temperature rise of 30 F. The oil cooler and water-cooled heads must be piped in series with the oil cooler first. Leaving water temperature should be between 100 F and 120 F, with 120 F being the maximum allowable temperature. The maximum working pressure for the water-cooled heads is 125 psi.

Table 7 - Minimum Gpm Required for Water-Cooled Heads and/or Oil Cooler (Based on 30 F Rise)

COMPRESSOR	GPM
5F	2-3
5H (4, 6 and 8 Cylinders)	6
5H (12 Cylinders)	8

SAFETY RELIEF VALVES - All 5H compressors are equipped with built-in safety relief valves which are factory set to relieve from the discharge to the suction side of the compressor at a pressure differential of 350 psi.

Safety relief valves which relieve at a 400 psi pressure differential are factory-installed on the 5F60 compressor but are not available with the smaller 5F compressors.

SUCTION STRAINERS - Each 5F,H compressor is equipped with one or two suction strainers located in the suction manifold. On new installations, felt filters should be used in the suction strainers to trap out foreign material left after installation. After about 50 hours these felt filters must be removed. See the 5F,H Installation Manual for further details.

OIL SAFETY SWITCH - An oil safety switch is provided with all compressors except the 5F20 and 5F30. This switch is optional equipment on the 5F20 and 5F30 compressors. This switch will shut off the compressor before high oil temperatures or lack of oil causes loss of oil pressure which can result in compressor failure. As a safety feature, this switch must be reset manually after cutout.

OIL SEPARATORS - Oil separators in the hot gas discharge line are not recommended for general use with Freon refrigerants. However, there are certain systems where the protection afforded by a separator is desirable, notably those systems employing flooded evaporators. For a more complete discussion see Carrier's System Design Manual.

CRANKCASE OIL HEATERS - Crankcase oil heaters are available for all 5F,H compressors. These heaters keep the crankcase warm during off cycles and thus minimize refrigerant absorption in the oil. Refer to the 5F,H Installation Manual for installation and wiring instructions.

INTERCONNECTION OF COMPRESSORS - All 5F,H compressors except 5F20 and 5F30 are furnished with removable handhole cover plates on each crankcase. When field interconnection is desired, these removable handhole cover plates can be removed and replaced by special cover plates with tapped openings. These tapped cover plates have connections for both oil and gas equalizing lines. For interconnection of the 5F20 and 5F30 compressors it is necessary to drill and tap the crankcase as shown in the 5F,H Installation Instruction Manual.

Because the 5F,H duplex units will usually be interconnected, these machines are equipped with tapped cover plates and interconnected at the factory.

VIBRATION ISOLATORS - A standard vibration isolation package is available for each 5F,H compressor. This consists of a standard rubber in shear and compression type mounting which gives an average static deflection of approximately 1/8 inch and provides reasonably good vibration isolation at 1750 rpm.

Isolation packages are recommended for use on all compressor and condensing units. They are valuable not only on upper floors in reducing vibration transfer to structure, but also when installed on cement floors they prevent misalignment of the drive shaft due to pull down on an uneven floor.

When compressors are run at slower speeds or when superior isolation is desired, isolators are available on the market which give approximately 3/8 inch deflection. Table 8 indicates the estimated weight distribution, using a nominal horsepower motor, on each leg of the condenser or compressor unit. For duplex units the weight is approximately the same on each leg.

MUFFLERS - Four standard mufflers cover the entire range of all 5F,H compressors. It is recommended that these mufflers be installed whenever compressors are used with remotely located water-cooled or evaporative condensers.

Mufflers are not usually necessary with the smaller 5F compressors and their use is recommended only when the application is critical with respect to quietness of operation.

Each piping package available to convert 5H compressor units to condensing units includes a standard muffler of the appropriate size.

Pressure drop thru these mufflers is about 1/2 psi at 40 F suction and 105 F discharge with the following loadings; 5 tons with 5F20 muffler, 15 tons with 5F40 muffler, 35 tons with the 5H40 muffler, and 100 tons with the 5H120 muffler.

CAPACITY CONTROL - A cylinder unloading type of capacity control package is available for 5F20 and 5F30 compressor. It is standard equipment on the 5F40 and larger compressors.

The cylinder unloading mechanism is powered by the compressor force feed lubricating system. This feature assures unloading of all controlled cylinders at starting regardless of the position of the capacity control valve, since the suction valves will be held in the open position until the lubricating oil pressure reaches its normal operating level.

The compressors as furnished from the factory will have the capacity control arranged for capacity reduction in response to suction pressure. An external adjusting stem is provided to set the control point and maintain the desired suction pressure. The control point is adjustable from 0 to 50 psig suction pressure. The differential over the complete range at any temperature level is 7 psig with Refrigerant 12 and Refrigerant 500. An 11-lb spring (for use on 5F40 and larger units) is furnished with the compressor which, when used, results in an adjustable control point from 0 to 85 psig with an 11 psig range. It should be inserted in the capacity control valve whenever R-22 or R-502 is used.

With this arrangement the suction pressure will not drop below the control set point minus the differential within the range of capacity steps since the compressor will unload to balance its capacity with the evaporator load.

The power elements and valve lifting mechanisms are identical on all 5F,H compressors. However, when using capacity control, various methods are used to activate the power elements.

See Table 10 for the unloading steps and power requirements at each step.

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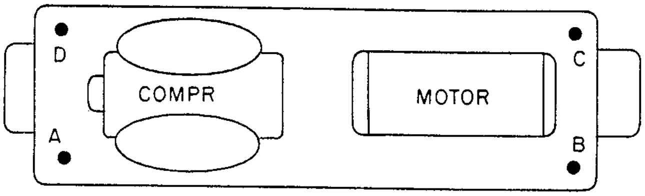
Table 8 - Estimated Operating Weight Distribution



BELT DRIVE COMPRESSOR UNITS

MODEL	1955 NEMA FRAME SIZE	A	B	C	D
5F20	213, 215 254U, 256U	90	100	100	140
5F30	215, 254U 256U, 284U	120	110	125	160
	256U, 284U	135	140	150	200
5F40	254U, 256U 284U, 286U	200	155	175	255
5F60	256U, 284U 286U, 324U	250	205	215	310
	286U, 324U	300	270	275	330
5H40	286U, 324U, 326U 364U, 365U	395	300	310	425
5H60	326U, 364U, 365U	470	385	405	560
	404U, 405U	495	515	550	765
5H80	364U, 365U, 404U 405U, 444U	575	555	560	795
5H120	404U, 405U, 444U	990	720	735	1110

DIRECT DRIVE COMPRESSOR UNITS

MODEL	1955 NEMA FRAME SIZE	A	B	C	D
5F40	254U, 256U 284U, 286U	210	145	145	210
5F60	256U, 284U, 286U 324U, 326U	245	185	185	245
	286U, 324U, 326U	290	255	255	290
5H40	286U, 324U, 326U 364US, 365US	380	275	275	380
5H46	286U, 324U, 326U 364US, 365US 404US*, 405US*	380	275	275	380
5H60	326U, 364US, 365US 404US, 405US	480	360	360	480
	404US, 405US	575	480	480	575
5H80	364US, 365US 404US, 405US, 444US*	690	605	605	690
5H120	404US, 405US 444US, 445US	890	690	690	890

*Requires 1-inch blocks under compressor to match motor shaft height.

BELT DRIVE CONDENSING UNITS

COMPR	CONDENSER	A	B	C	D
5F20	5F20	115	110	120	160
	5F30	125	120	130	170
5F30	5F20	140	135	150	185
	5F30	150	140	155	190
	5F40	235	245	270	300
5F40	5F30	250	210	230	310
	5F40	295	250	275	355
	5F60	315	275	295	375
5F60	5F40	350	300	310	380
	5F60	390	340	350	421
	09RH027	470	445	450	505
5H40	5F60	510	420	425	540
	09RH027	570	475	480	600
	09RH043	650	600	605	680
5H60	09RH027	640	560	580	745
	09RH043	700	615	635	790
	09RH054	690	750	885	960
	09RH054*	785	805	840	1055
	09RH070	795	815	850	1065
	09RH084	885	905	940	1155
5H80	09RH043	1005	800	805	1040
	09RH054	1045	845	850	1085
	09RH070	1055	855	860	1095
	09RH084	1145	940	945	1180
	09RH097	1115	1015	1020	1255
5H120	09RH054	1280	1000	1015	1390
	09RH070	1295	1015	1030	1405
	09RH084	1370	1090	1105	1480
	09RH097	1435	1155	1170	1550

*With 60- and 75-hp motors.

DIRECT DRIVE CONDENSING UNITS

COMPR	CONDENSER	A	B	C	D
5F40	5F40	305	240	240	305
	5F60	325	265	265	325
5F60	5F60	360	305	305	360
	09RH027	470	430	430	470
5H40	09RH027	555	450	450	555
	09RH043	580	505	505	580
5H46	09RH043	580	505	505	580
	09RH054	610	535	535	610
	09RH070	625	550	550	625
5H60	09RH043	710	590	590	710
	09RH054	755	635	635	755
	09RH070	765	645	645	765
	09RH084	960	865	865	960
5H80	09RH054	985	900	900	985
	09RH070	995	910	910	995
	09RH084	1080	995	995	1080
	09RH097	1150	1065	1065	1150
5H120	09RH070	1280	1080	1080	1280
	09RH084	1340	1140	1140	1340
	09RH097	1385	1185	1185	1385
	09RH127	1535	1335	1335	1535

5F20 And 5F30 (Fig. 4)

Major Elements of Control Systems:

1. *Capacity Control Valve:* The function of this valve is to raise or lower the oil pressure from the oil pump in response to the refrigerant suction pressure.
2. *Power Element:* The function of this element is to supply the power necessary to operate the valve lifting mechanism.
3. *Valve Lifting Mechanism:* This consists of a sleeve and push pin assembly around each controlled cylinder, designed to hold the suction valve open, or to permit the valve to remain in a normal operating position depending on its actuation by the power element.

Principle of Operation of the System - An increase in suction gas pressure, which requires increased compressor capacity, causes the needle valve to close. Therefore, the lubrication oil pressure in the power element increases. The increased oil pressure in the power element moves the power piston upward and the suction valve discs are allowed to seat.

Table 9 indicates the control oil pressure at which the controlled cylinders start to and completely unload.

The different points of control pressure on the 5F30 are obtained by using springs with different loading rates in the power element.

Table 9 - Initial and Final Unloading Oil Pressures - 5F20, 5F30

COMPR	CONTROLLED CYLINDER	START TO UNLOAD OIL PRESS.	COMPLETELY UNLOADED OIL PRESS.
5F20	1	19.8	13.0
5F30	1	30.0	20.2
	2	19.8	13.0

5F40 Thru 5H80 (Fig. 5)

Major Elements of Capacity Control System:

1. *Capacity Control Valve:* The function of this valve is to raise or lower control oil pressure to the hydraulic relay piston in response to the refrigerant suction pressure. An increase in suction pressure increases the control oil pressure in the hydraulic relay.
2. *Hydraulic Relay:* The function of this relay is to feed the lubrication oil from the oil pump at full pressure in sequence to one or more power elements. This hydraulic relay is activated by the control oil pressure from the capacity control valve.
3. *Power Element:* This element supplies the power to operate the valve lifting mechanism.
4. *Valve Lifting Mechanism:* This consists of a sleeve and push pin assembly around each controlled cylinder, designed to hold the suction valve open, or to permit the valve to remain in a normal operating position depending on its actuation by the power element.

Principle of Operation of the System - A decrease in suction gas pressure, which necessitates a decrease in compressor capacity, causes the range spring to open the capacity control modulating valve. This allows the control oil to relieve from the hydraulic relay and thus reduces the control oil pressure in the relay. With reduced control oil pressure the spring in the hydraulic relay moves the piston and thus the lubrication oil from the oil pump is prevented from flowing to the particular deactivated power element. This relieves the oil pressure from the power element allowing the spring in the power element to move the lifting fork and unload the cylinder. An increase in suction pressure reverses the action and loads the cylinders.

5H120 Capacity Control (Fig. 6) - The 5H120 capacity control system is similar to that used on the 5F40 to 5H80 compressors. Unloaded starting and capacity reduction is obtained by holding open the suction valves of a number of the cylinders. For capacity control purposes, a suction pressure activated capacity control valve pilots a hydraulic relay which loads or unloads the cylinders in pairs.

Major Difference from the 5F40 thru 5H80 Capacity Control:

1. The hydraulic relay design provides a wider pressure differential between cylinder cut-in and cutout points. This hydraulic relay is a small, easily removed cartridge rather than an integral part of the pump end cover.
2. The surge chamber on the 5H120 is an integral part of the bearing head casting.

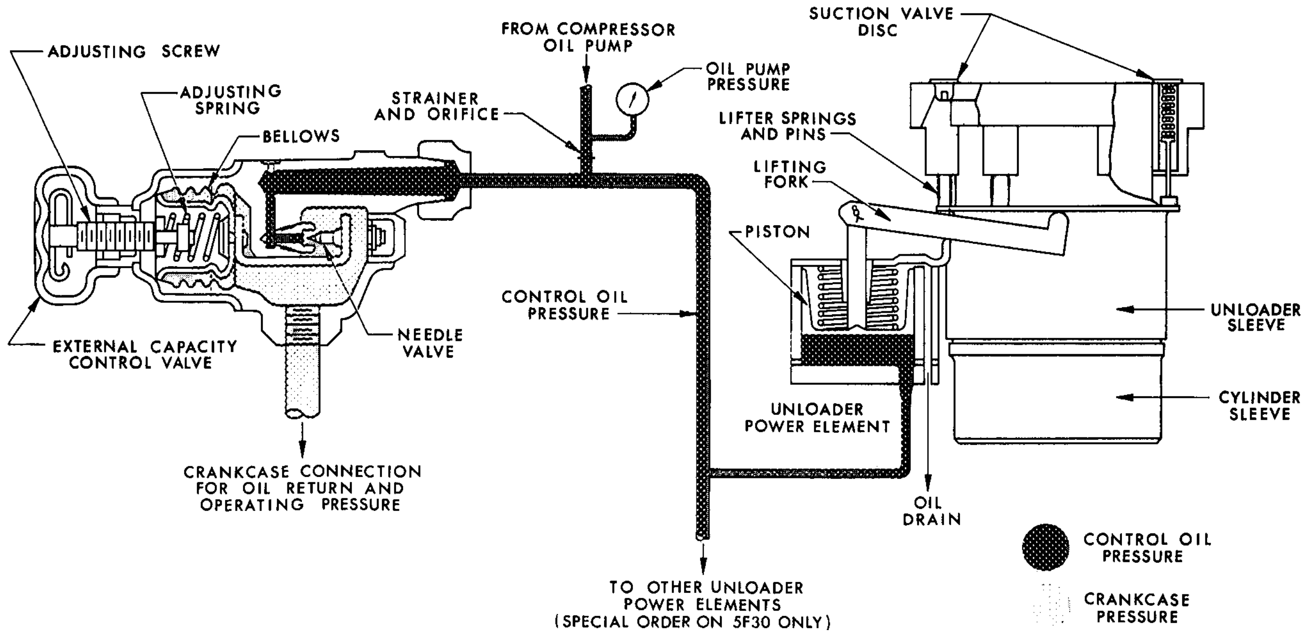


Fig. 4 - Capacity Control - 5F20, 5F30

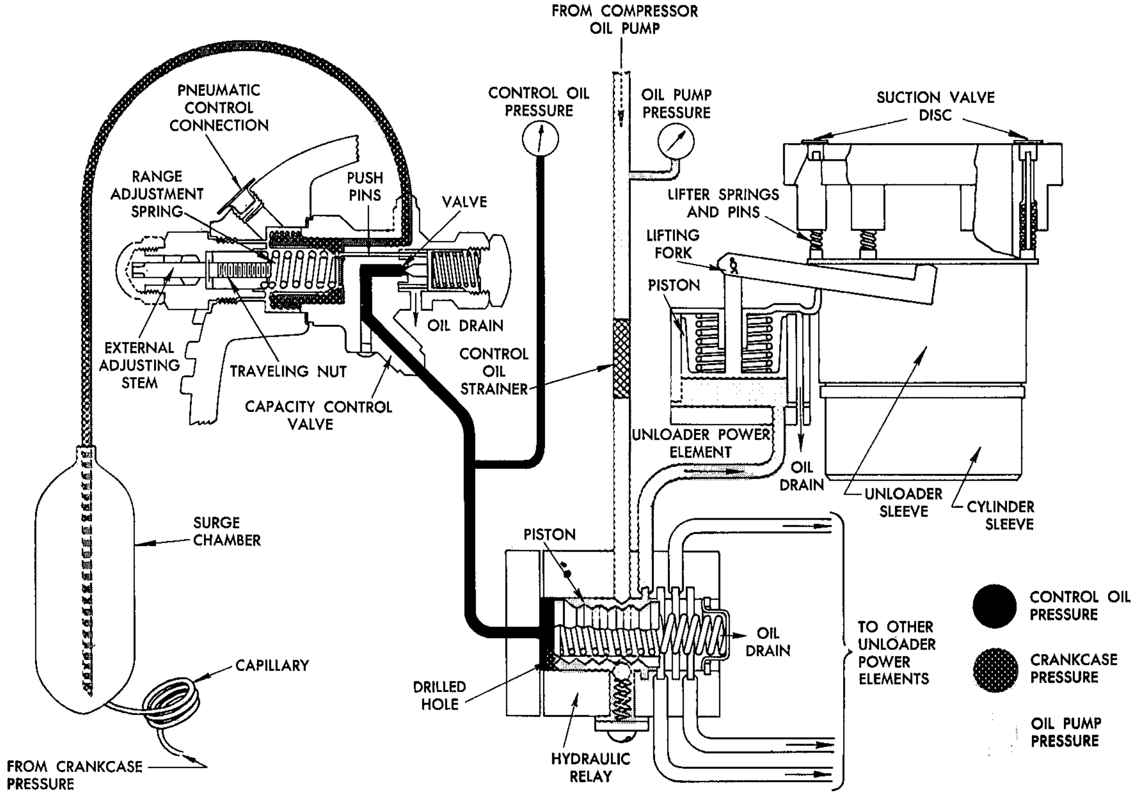


Fig. 5 - Capacity Control - Except 5F20, 5F30, 5H120

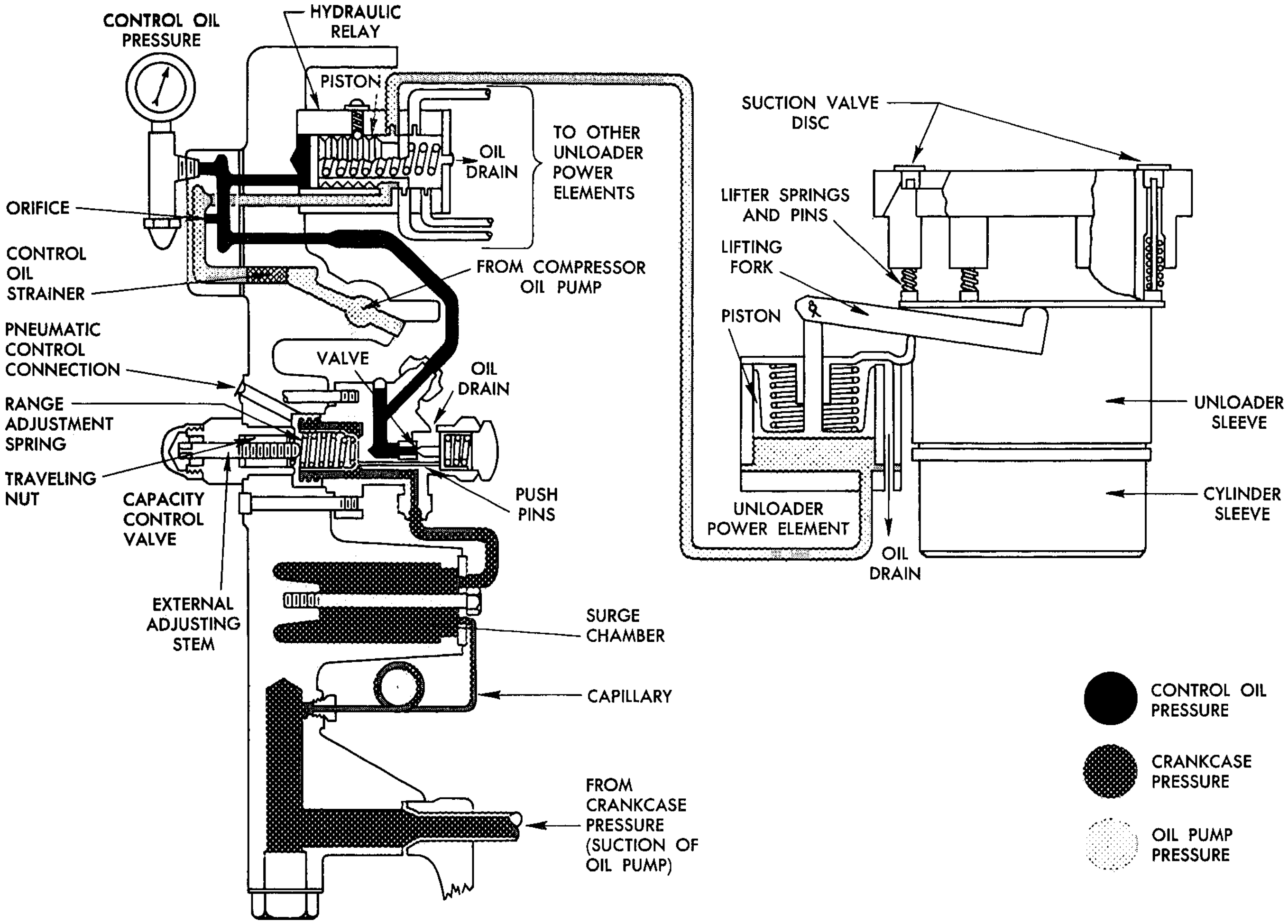


Fig. 6 - Capacity Control - 5H120

Table 10 - Capacity Control Steps and Bhp Requirements

MACHINE SIZE	NUMBER OF CONTROLLED CYLINDERS	CAPACITY STEPS IN PERCENT									
		100	87-1/2	83-1/3	75	66-2/3	62-1/2	50	37-1/2	33-1/2	25
		Percent Full Load Bhp									
		100	90	86	80	74	71	60	50	45	38
		Number of Active Cylinders									
5F20	1 of 2	2	–	–	–	–	–	1	–	–	–
5F30*	2 of 3	3	–	–	–	2	–	–	–	1	–
5F40, 5H40, 46	3 of 4	4	–	–	3	–	–	2	–	–	1
5F60, 5H60	4 of 6	6	–	5	–	4	–	3	–	2	–
5H80	6 of 8	8	7	–	–	–	5	–	3	–	2
5H120	8 of 12	12	–	10	–	8	–	6	–	4	–

*Standard unloading compressor package has only one-step reduction (66-2/3%). Two-step reduction available on request

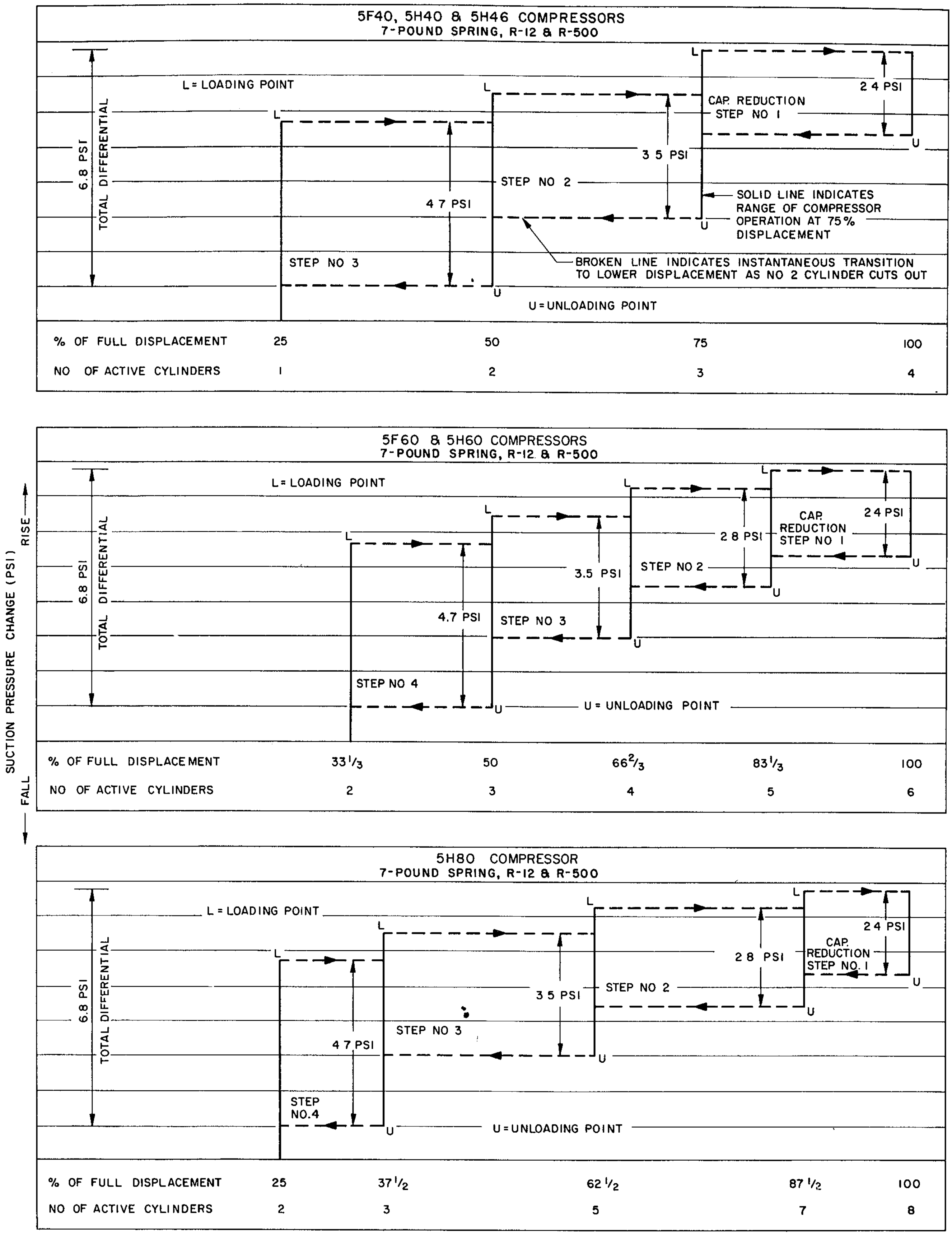


Fig. 7 - Operating Sequence of Capacity Reduction Steps with 5F,H Type Compressors (Using the Standard 7-Pound Range Adjustment Spring)

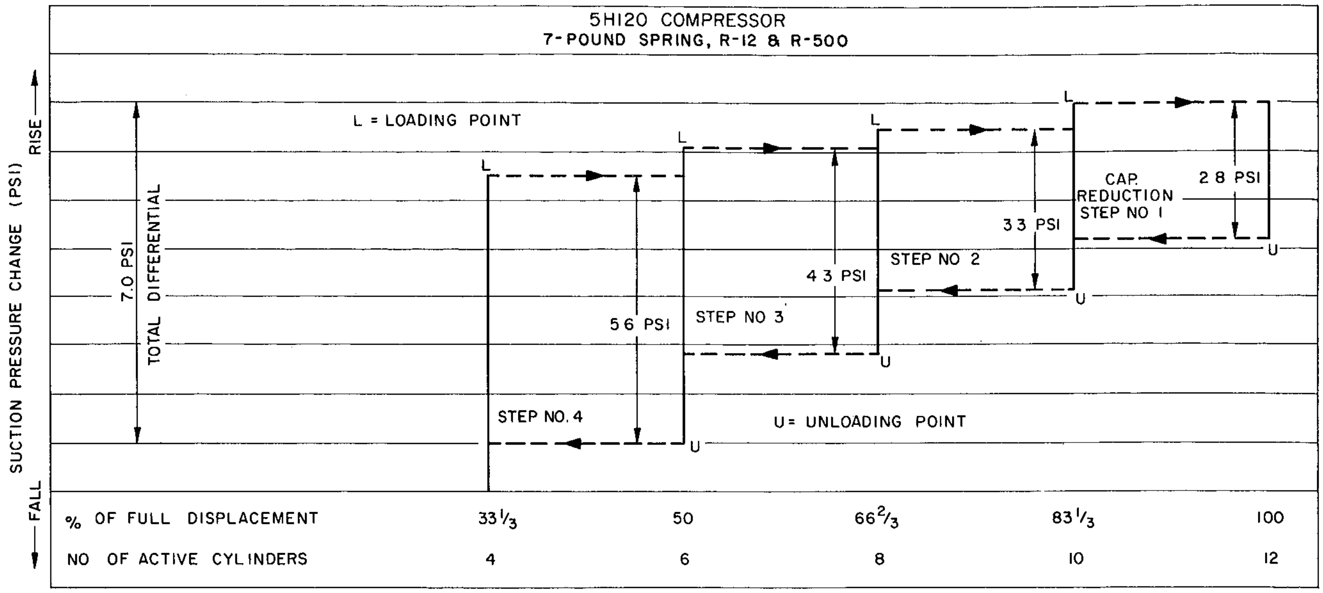


Fig. 8 - Operating Sequence of Capacity Reduction Steps with 5F,H Type Compressors (Contd) (Using the Standard 7-Pound Range Adjustment Spring)

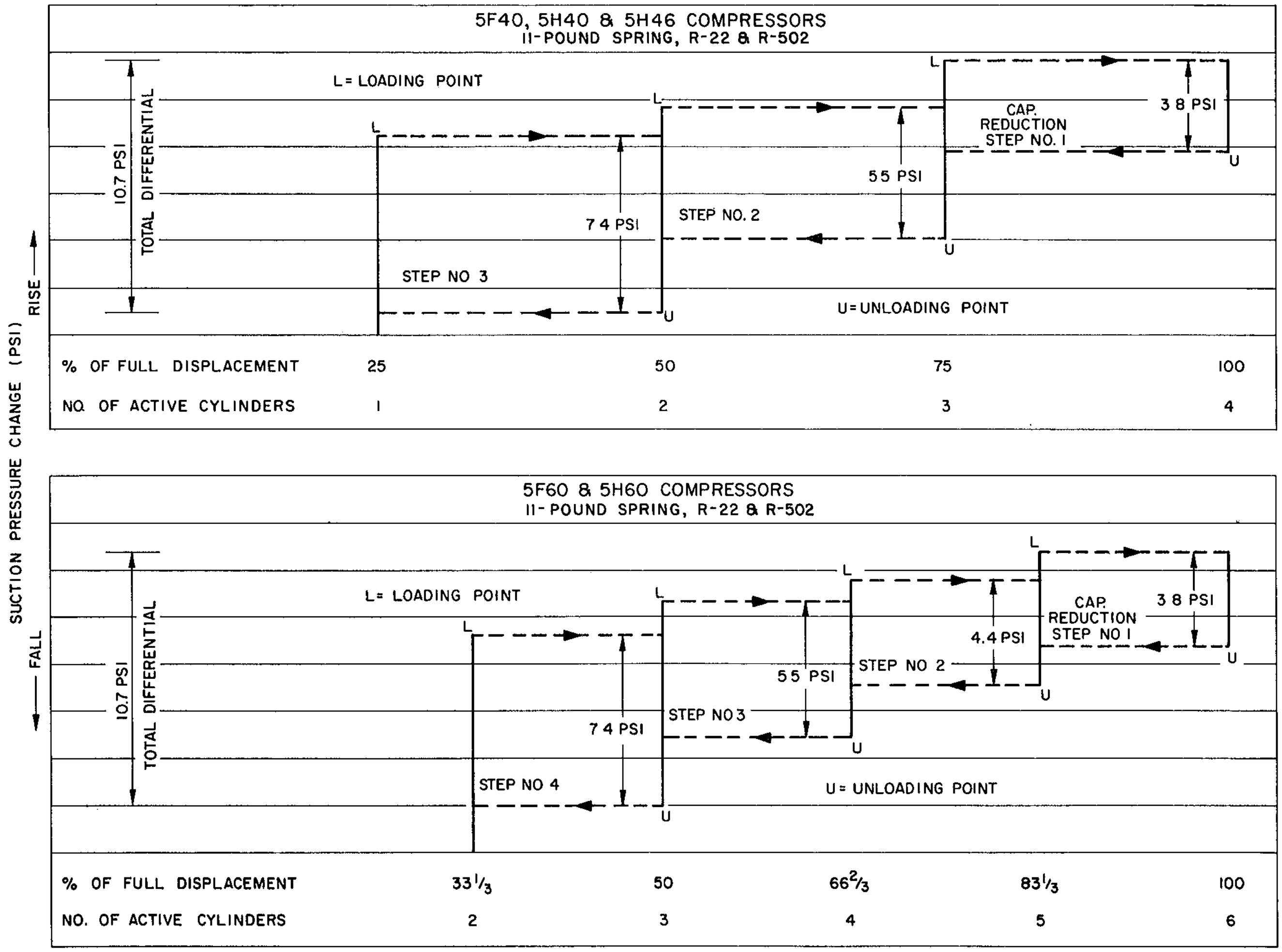


Fig. 9 - Operating Sequence of Capacity Reduction Steps with 5F,H Type Compressors (Using the Standard 11-Pound Range Adjustment Spring)

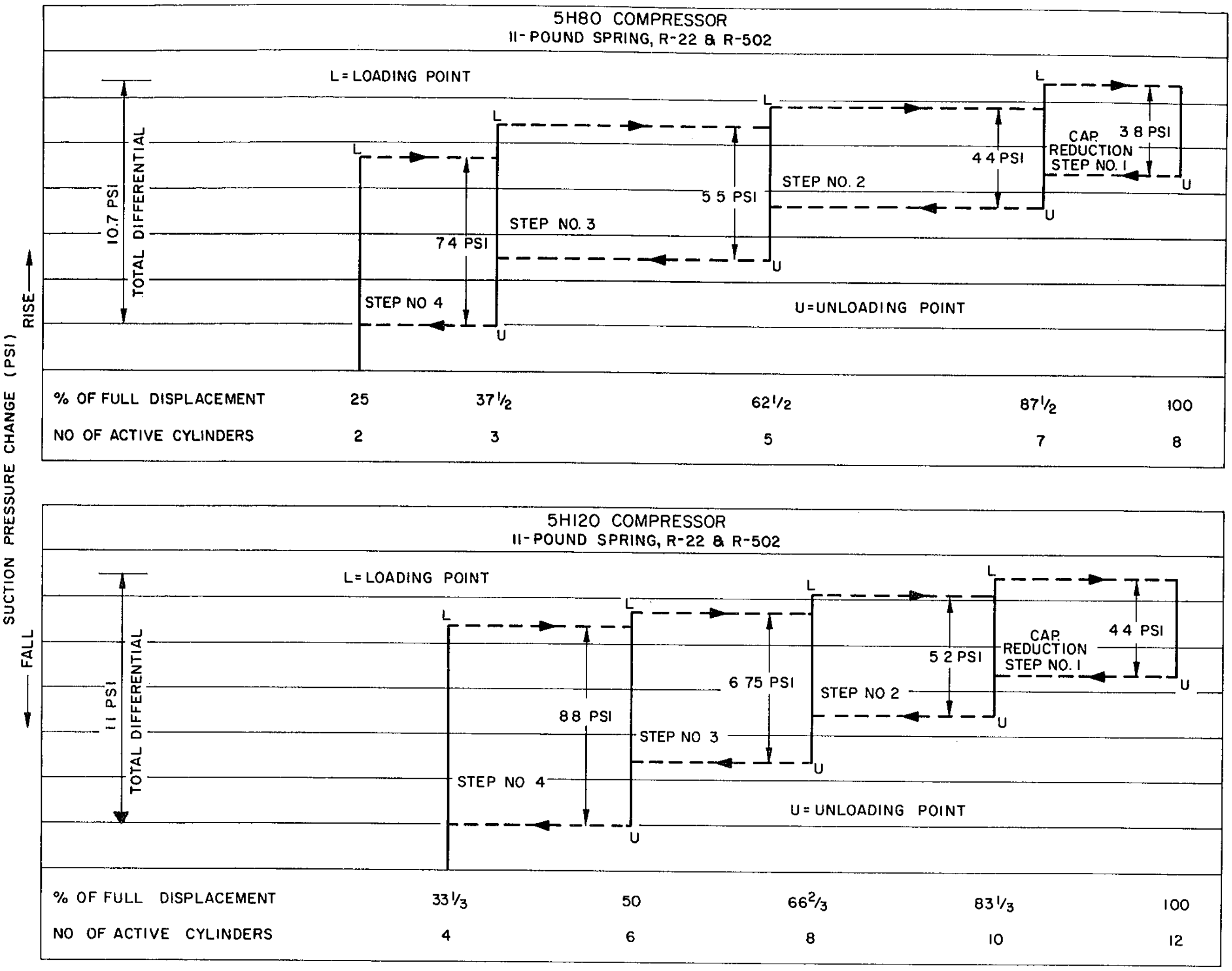


Fig. 10 - Operating Sequence of Capacity Reduction Steps with 5F,H Type Compressors (Contd) (Using the Standard 11-Pound Range Adjustment Spring)

Electrical Compensation of Compressor Capacity Control - Electrically actuated capacity control is available for all 5F,H compressors, exclusive of the 5F20 and 5F30. Tight location of this unit may make it impossible to install this control in the field and thus it should be installed prior to final placement on location.

This point at which the compressor starts to unload is set by the external adjustment stem. This method of external capacity control utilizes a modulating type electric damper motor with gears to connect this motor to the adjusting stem. Either Honeywell or Barber-Colman motors are available. The Honeywell motor is suitable for use with all Series 90 controllers. The B-C motor is suitable for use with all TP or EYDQ Series controllers.

Operation of the motor may be controlled by either a temperature or pressure sensing device which reacts to changes in the conditions being controlled. If the control signal is such that less compressor capacity is needed, the modulating motor rotates the capacity control stem clockwise and thus raises the control point at which the compressor starts to unload. The opposite movement of the stem occurs when more compressor capacity is needed. Figure 11 shows a typical electric compensation arrangement.

The modulating motor and gear train provides two full turns of the capacity control stem. These two turns will move the unloading point thru a range of 16 psi for R-12 and R-500 and 22 psi for R-22 and R-502.

Pneumatic Compensation of Compressor Capacity Control - Adding a control air line to the external pneumatic control connection permits pneumatic resetting of the control point in accordance with changes in operating conditions. Each pound of change in the air pressure resets the control one pound in the same direction. Thus, a one-pound rise in air pressure will cause unloading to begin at a suction pressure one pound higher than the original control point, etc. Figure 12 shows a typical pneumatic control arrangement.

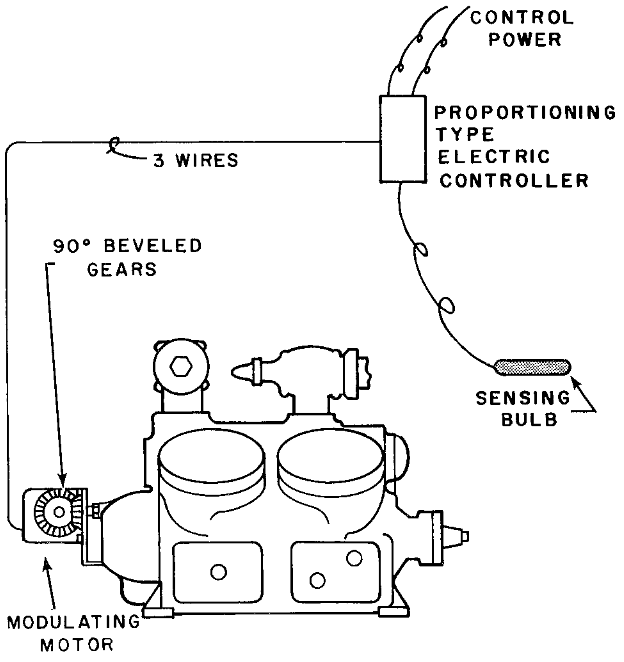


Fig. 11 - Electrical Compensation

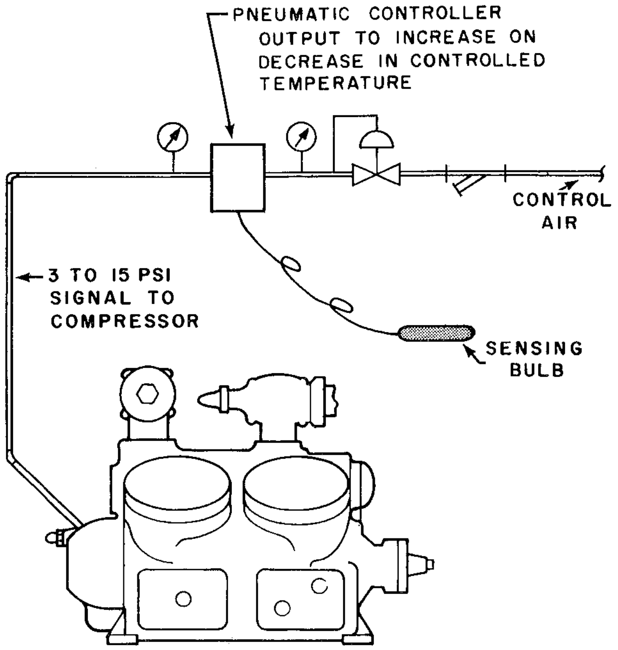


Fig. 12 - Pneumatic Compensation

CONTROL PRESSURESTATS - Dual pressurestats are furnished with all 5F,H compressors. They are often referred to as high and low pressure cutouts. Their function is to cut the circuit to the holding coil of the compressor motor starter whenever the pressure setting limits are exceeded.

The high pressurestat has an operating range from 175 to 375 psig with a differential range from 40 to 60 psig. The low pressurestat has an operating range from 20" Hg. to 110 psig and a differential range from 9 to 50 psi.

Pressurestat settings should be adjusted on the job to meet the particular operating conditions for which the compressor (s) have been selected. Directions for setting these pressurestats will be found in the 5F,H Installation Manual.

PERMANENTLY UNLOADED CYLINDERS - The 5F60, 5H40 and 5H60 compressors are available with one cylinder permanently unloaded. The 5H120 is available with two cylinders permanently unloaded. These compressors are unloaded by removing the suction valve and suction valve springs from one or two of the cylinders. The unloaded cylinders are the first one or two which unload during the normal unloading sequence of the compressor.

CAPACITY CONTROL MODIFICATION FOR HEAT PUMP APPLICATION - Where 5F40, 5F60, and all 5H compressors are used in refrigerant cycle reversing heat pump applications, it is usually necessary to modify the standard capacity control arrangement to satisfy the unloading requirements. On the summer cycle, the compressor is required to unload as the circulating water or air temperature drops. During the winter cycle, it is necessary for the control to work in reverse, so that the compressor unloads as this same circulating water or air temperature increases. To accomplish these results, it is necessary for the compressor to unload in response to either a summer or winter temperature sensing device, depending on the particular cycle in operation.

Where the summer and winter design suction temperatures are within the design range of either electric or pneumatic compensation devices, the capacity control may be external. This however, is not too common and another means is normally required.

Usually modification to the compressor capacity control system will be required. The compressor can be modified in two ways: (1) for application requiring 50% capacity reduction, (2) for applications requiring more than one step of capacity reduction. See Fig. 13 for a typical two-step external capacity control arrangement.

1. *Application Requiring 50% Capacity Reductions* - This is the usual specification on heat pump applications of this type and should cover the majority of cases. The necessary modifications to the compressor capacity control for these arrangements can be accomplished by special ordering from factory and with certain field modifications.
   a. Factory Modifications - The compressor order should state that the compressor is to be special for heat pump application, and is to include only enough unloader power elements to unload the compressor down to 50% displacement. The unloaded cylinders will be those closest to the pump end of the compressor.

b. Field Modifications - Install a 1/4 inch or 3/8 inch bypass line between the control oil pressure connection and the crankcase and install a solenoid valve in this line.

Unloadable cylinders may be loaded or unloaded by operation of this solenoid valve. When solenoid valve is closed, full oil pressure is available to the controlled cylinders and these will be loaded so that compressor will be operating on 100% capacity. When solenoid valve is open, oil pressure will be bled from controlled cylinders and they will be unloaded, so that compressor will then be operating at 50% capacity. A two-step thermostat controlling compressor can thus utilize two capacity steps by operating compressor starter and solenoid bypass valve.

2. *Application Requiring More Than One Step of Capacity Reduction* - This can be furnished on special order for compressors having 6, 8, or 12 cylinders. Arrangement consists of furnishing a Freon compressor with ammonia external solenoid unloading type capacity control. Control can be furnished with or without three-way valves (Table 11).

Table 11 - Capacity Control Steps and Heat Pump Modification

COMPRESSOR	AVAILABLE CAPACITY STEPS (%)	EXTERNAL 3-WAY SOLENOID VALVES
5F40, 5H40, 46	100, 50	1
5F60, 5H60, 5H120	100, 66-2/3, 33-1/3	2
5H80	100, 62-1/2, 37-1/2	2

Motor Selection Data - Motor selection data based on the brake horsepower occurring at the designed operating condition is usually a satisfactory procedure for applications in the air conditioning suction temperature range. For selections at lower design suction temperatures, it is necessary to consider the pulldown operating condition, and this consideration will frequently dictate the motor size rather than the brake horsepower at the design operating condition.

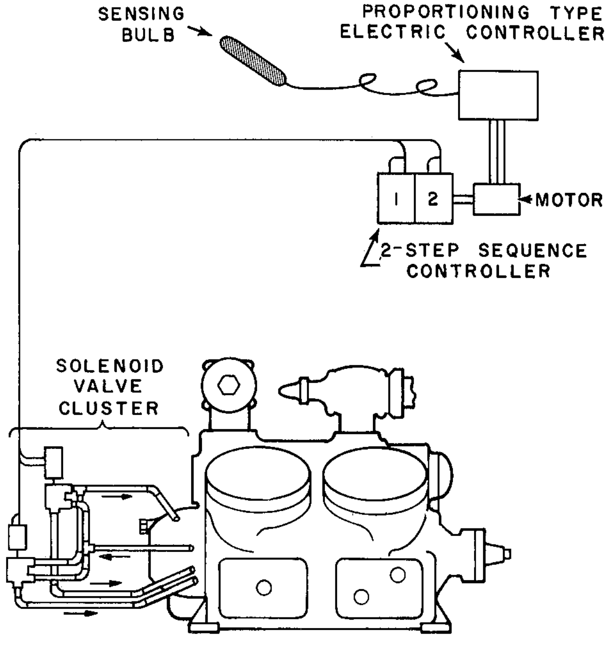


Fig. 13 - External Solenoid Type Capacity Control

The required compressor starting torque is dependent on the discharge pressure as well as the pressure differential occurring during start-up and is the same for any compressor speed. The values shown in Table 12 indicate the maximum starting torque for R-12, R-22, R-500 and R-502.

The starting torque for duplex units can be determined by adding together the torque for each compressor in the duplex arrangement. For instance, the starting torque for a 5H40-60 duplex unit, operating with R-12 at a saturated discharge of 100 F, would be 57 + 69 = 126 lb ft.

In the selection of a motor, it must be noted that the required motor starting torque must exceed the compressor starting torque only when the compressor is operating at the same speed as the motor. If the compressor speed is less than the motor speed, as on some belt drive units, the motor starting torque requirements are reduced in proportion to the speed ratio between the compressor and the motor because of the mechanical advantage available to the motor.

Table 12 - Compressor Starting Torques (At 1750 Rpm)

COMPRESSOR SIZE	% UNLOADING DURING STARTING	SATURATED DISCHARGE TEMPERATURE F											
		80 F				100 F				120 F			
		R-12	R-500	R-22	R-502	R-12	R-500	R-22	R-502	R-12	R-500	R-22	R-502
		Maximum Starting Torque - lb-ft											
5F20	None	19	23	30	32	27	32	42	45	34	40	53	57
5F30	None	22	26	34	37	30	35	47	50	39	46	61	65
5F40	75	18	21	28	30	25	30	39	42	32	38	50	53
5F60	66-2/3	22	26	34	37	30	35	47	50	39	46	61	65
5H40	75	42	49	65	70	57	67	89	95	74	87	115	123
5H46	75	55	64	85	91	74	87	116	124	96	113	150	160
5H60	66-2/3	51	60	79	85	69	81	107	115	90	106	140	149
5H80	75	58	68	90	96	79	93	123	130	102	120	158	169
5H120	66-2/3	91	107	141	151	123	144	191	204	160	189	249	266

Motor Selection - High starting torque motors must be used with the 5F20 and 5F30 compressors if these machines are not equipped with capacity control.

Normal starting torque motors are normally used with the 5F40 and larger models because of their partially unloaded starting feature. Where the starting motor voltage tap must be kept to an absolute minimum, coincident with actual compressor starting, it is sometimes necessary to use a high starting torque motor or a larger motor.

NEMA standards permit continuous overloading of 40 C rise open squirrel cage motors to 15% above the nameplate rating, when operated at full rated voltage and frequency, and at ambient temperatures not exceeding 40 C. Whether or not part of this service factor should be used in making an initial motor selection depends on accurate information concerning: local voltage and frequency variations, ambient temperatures, compressor speed, and the maximum suction and discharge pressures. Where these conditions are comparatively unknown, motors should positively not be overloaded.

Wherever possible, across-the-line starting is most desirable because it is less costly and more trouble-free than the reduced voltage type of starting equipment. However, limitations of the power system often necessitate the use of reduced voltage starters for motors of the horsepower sizes required for 5F,H compressors.

In each case, the power company concerned should be consulted and a ruling obtained with respect to the particular application. The point on the network where the installation is to be made may often be of importance in obtaining a ruling, so approval in one case may not hold true for the entire network.

The starting torque which a motor develops is approximately proportional to the square of the voltage at the motor terminals. Thus, at half voltage, a motor will develop only one-quarter of the torque that it will develop at full voltage, or .50 x .50 = .25. To make starting possible, the voltage at the motor terminals must be high enough to provide the starting torque required at the compressor shaft.

On step resistance starters with 75% starting taps, the starting torque is approximately 56% of the rated full voltage starting torque of the motor, assuming that the voltage obtained is actually 75% of nameplate voltage. If subnormal line voltage exists, the starting tap voltage will fall below the 75% and the motor torque will be reduced in proportion to the square of the voltage which is actually obtained. For example, a reduction to 70% line voltage would result in .70 x .70, or only 49% starting torque.

Most power companies impose limitations on the current drawn during motor starting periods. While these limitations vary considerably, depending upon the power system capacity, close voltage control and similar factors, they generally fall into two catagories:

1. The maximum allowable current which may be drawn from the line during the starting period.
2. The maximum increment of current increase during the starting period.

1. *Maximum Allowable Current* - When the limitation is in terms of paragraph (1) above, and the full voltage locked rotor current of the motor being considered is in excess of this maximum permissible limit, it is necessary to use reduced voltage starting equipment. Under this condition it is essential that the motor start and accelerate under reduced voltage. Otherwise, the full locked rotor current of the motor will be drawn as soon as sufficient voltage is applied. If the motor can be started on the first step and accelerated at the reduced voltage, then full voltage locked rotor current will not be drawn from the line during any part of the starting period.

2. *Maximum Increment of Current Increase* - When the limitation is in terms of maximum increment of current increase, the starting equipment need only be selected with a sufficient number of steps so that no single step will exceed the allowable current increase. The starting torque developed at the various steps is not of importance, except that the motor selected must have sufficient torque to start the compressor when full voltage is finally applied. The fact that compressor motor may not start at any of the reduced voltage steps is of no consequence during the few seconds required for the starter mechanism to act.

Reduced voltage starting equipment is now available in several types, both manual and magnetic. The best known are the Step Resistance, Auto Transformer, Wye-Delta and Increment Starter and Motor Combinations. No attempt will be made here to compare the merits of each type, although the starting equipment to be used for any specific application should be discussed with the power company engineers with a view to obtaining their rulings on all matters pertaining to the electrical aspects of the project.

Motors of American manufacture in horsepower ranges used on the 5H compressors have full voltage starting torque amounting to 125% of full load torque on "normal torque" motors and 200% of full load torque on "high torque" motors. When motors or other manufacture are to be used, the starting torque characteristics should be obtained.

Drive Packages - Table 13 indicates the drive package components for the 5F,H standard belt drive packages. Figure 14 and Tables 14 and 15 indicate the data for the flywheel used in each of these packages.

Table 13 - Belt Drive Packages (60-Cycle, 1750 Rpm Motors)

DRIVE PACKAGE PART NUMBER	COMPR SPEED RPM	MOTOR HP	MOTOR PULLEY		FLYWHEEL		CENTER-TO-CENTER (in)	NUMBER OF BELTS
			Bore (in)	Pitch Diameter (in)	Pitch Diameter (in.)	Part Number		
5F20-832	1750	3–5	1-1/8	7.4	7.5	5F20-1053	19.0	2
5F20-466	1750	3–5	1-1/8	7.4	7.5	5F20-1053	19.0	2
5F20-406	1750	7-1/2–10	1-3/8	7.4	7.5	5F20-1053	19.0	2
5F20-496	1750	7-1/2–10	1-3/8	7.4	7.5	5F20-1053	19.0	2
5F20-842	1450	3–5	1-1/8	6.2	7.5	5F20-1053	19.4	2
5F20-476	1450	3–5	1-1/8	6.2	7.5	5F20-1053	19.4	2
5F20-506	1450	7-1/2	1-3/8	6.2	7.5	5F20-1053	19.4	2
5F20-376	1160	3–5	1-1/8	5.0	7.5	5F20-1053	18.4	2
5F20-486	1160	3–5	1-1/8	5.0	7.5	5F30-1053	18.4	3
5F30-476	1750	7-1/2–10	1-3/8	7.4	7.5	5F30-1053	19.0	3
5F30-496	1750	15	1-5/8	7.4	7.5	5F30-1053	19.0	3
5F30-396	1450	7-1/2–10	1-3/8	6.2	7.5	5F30-1053	19.4	3
5F30-466	1450	7-1/2–10	1-3/8	6.2	7.5	5F30-1053	19.4	3
5F30-486	1160	7-1/2	1-3/8	5.0	7.5	5F30-1053	18.4	3
5F30-506	1750	10	1-3/8	7.4	7.5	5F30-1053	26.5	3
5F30-516	1750	15	1-5/8	7.4	7.5	5F30-1053	26.5	3
5F40-376	1750	7-1/2–10	1-3/8	9.4	9.5	5F40-1054	26.3	3
5F40-466	1750	7-1/2–10	1-3/8	9.4	9.5	5F40-1054	26.3	3
5F40 496	1750	15–20	1-5/8	9.4	9.5	5F40-1054	26.3	3
5F40-386	1450	7-1/2–10	1-3/8	8.0	9.5	5F40-1054	25.9	3
5F40-476	1450	7-1/2–10	1-3/8	8.0	9.5	5F40-1054	25.9	3
5F40-506	1450	15	1-5/8	8.0	9.5	5F40-1054	25.9	3
5F40-396	1160	7-1/2–10	1-3/8	6.2	9.5	5F40-1054	25.8	3
5F40-486	1160	7-1/2–10	1-3/8	6.2	9.5	5F40-1054	25.8	3
5F60-726	1750	10	1-3/8	11.0	11.0	5F61-1054	25.8	4
5F60-476	1750	15–20	1-5/8	11.0	11.0	5F61-1054	25.8	4
5F60-756	1750	25	1-7/8	11.0	11.0	5F61-1054	25.8	4
5F60-736	1450	10	1-3/8	9.0	11.0	5F61-1054	25.4	4
5F60-486	1450	15–20	1-5/8	9.0	11.0	5F61-1054	25.4	4
5F60-766	1450	25	1-7/8	9.0	11.0	5F61-1054	25.4	4
5F60-746	1160	10	1-3/8	7.4	11.0	5F61-1054	25.2	4
5F60-466	1160	15–20	1-5/8	6.2	9.5	5F60-1054	25.8	4
5F60-496	1160	15–20	1-5/8	7.4	11.0	5F61-1054	25.2	4
5F60-786	1750	15–20	1-5/8	11.0	11.0	5F61-1054	31.4	4
5F60-776	1750	25	1-7/8	11.0	11.0	5F61-1054	31.4	4
5H40-556	1750	20	1-5/8	11.0	11.0	5H40-1104	31.9	3
5H40-802	1750	25–30	1-7/8	11.0	11.0	5H40-1104	31.9	3
5H40-716	1750	25–30	1-7/8	11.0	11.0	5H40-1104	31.9	3
5H40-766	1750	40–50	2-1/8	11.0	11.0	5H40-1104	31.9	3
5H40-566	1450	20	1-5/8	9.0	11.0	5H40-1104	30.4	3
5H40-726	1450	25–30	1-7/8	9.0	11.0	5H60-1104	30.4	3
5H40-736	1450	25–30	1-7/8	9.0	11.0	5H60-1104	30.4	5
5H60-832	1450	40–50	2-1/8	9.0	11.0	5H60-1104	30.4	5
5H40-776	1450	40–50	2-1/8	9.0	11.0	5H60-1104	30.4	5
5H40-576	1160	20	1-5/8	7.4	11.0	5H60-1104	31.6	5
5H60-812	1160	25–30	1-7/8	7.4	11.0	5H60-1104	31.6	5
5H40-706	1160	25–30	1-7/8	11.4	17.35	5H61-1104	31.0	4
5H60-822	1750	40–50	2-1/8	11.0	11.0	5H60-1104	31.9	5
5H60-636	1750	40–50	2-1/8	11.0	11.0	5H60-1104	31.9	5
5H60-626	1160	40–50	2-1/8	11.4	17.35	5H61-1104	31.0	4
5H60-656	1750	60–75	2-3/8	11.0	11.0	5H60-1104	36.4	5
5H80-626	1750	40–50	2-1/8	11.0	11.0	5H60-1104	36.4	5
5H80-416	1750	60–75	2-3/8	11.0	11.0	5H80-1104	36.4	6
5H80-656	1750	60–75	2-3/8	11.0	11.0	5H80-1104	36.4	6
5H120-812	1750	100	2-7/8	11.0	11.0	5H120-1104	36.4	9
5H80-686	1750	100	2-7/8	11.0	11.0	5H120-1104	36.4	9
5H80-436	1450	40–50	2-1/8	9.0	11.0	5H80-1104	37.9	6
5H80-636	1450	40–50	2-1/8	9.0	11.0	5H80-1104	37.9	6
5H80-666	1450	60–75	2-3/8	9.0	11.0	5H80-1104	37.9	6
5H80-676	1450	60–75	2-3/8	9.0	11.0	5H120-1104	37.9	9
5H80-466	1160	40–50	2-1/8	11.4	17.35	5H81-1104	38.5	5
5H80-646	1160	40–50	2-1/8	11.4	17.35	5H61-1104	38.5	4
5H120-802	1750	60–75	2-3/8	11.0	11.0	5H120-1104	36.4	9
5H120-626	1450	100	2-7/8	9.0	11.0	5H120-1104	37.9	9
5H120-636	1160	60–75	2-3/8	11.4	17.35	5H81-1104	38.5	5

Table 14 - Flywheel - Compressor Dimensions

COMPRESSOR MODEL	FLYWHEEL MODEL	DIMENSIONS F (in.)
5F20	5F20-1053	8-3/16
	5F30-1053	8-9/16
5F30	5F20-1053	9-5/8
	5F30-1053	10
5F40	5F40-1054	10-13/16
5F60	5F40-1054	11-9/16
	5F60-1054 5F61-1054	11-3/4
5H40	5H40-1104	13-3/8
	5H60-1104	13-11/16
	5H61-1104	14-3/4
5H41	5H61-1104	14-3/4
5H60	5H40-1104	14-1/8
	5H60-1104	14-7/16
	5H61-1104	15-1/2
5H61	5H61-1104	15-1/2
5H80	5H60-1104	20-7/16
	5H61-1104	21-1/2
	5H80-1104	18-9/16
	5H81-1104	19-15/16
	5H120-1104	21-5/16
5H81	5H81-1104	19-15/16
5H120	5H60-1104	20-9/16
	5H81-1104	20-1/16
	5H120-1104	21-7/16
5H121	5H81-1104	20-1/16

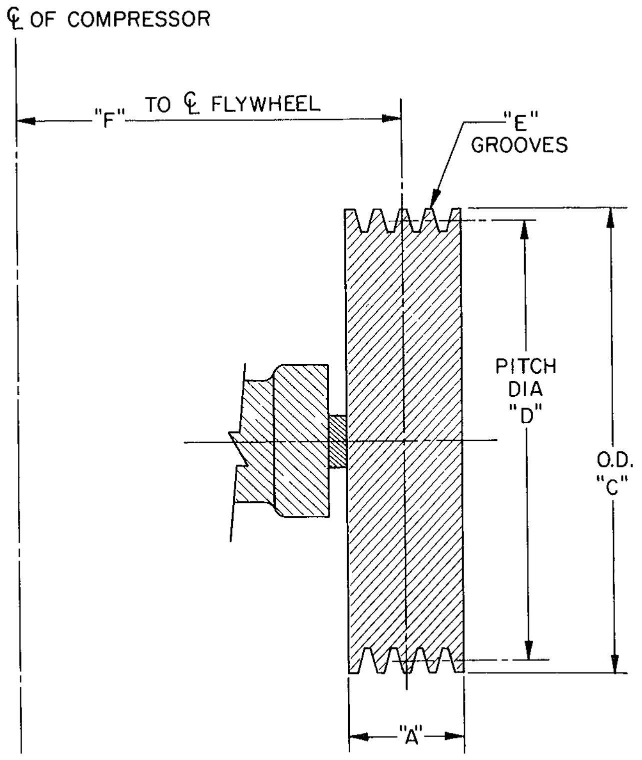


Fig. 14 - Flywheel

Table 15 - Flywheel Data

FLYWHEEL PACKAGE NUMBER	FLYWHEEL PART NUMBER	WIDTH "A" (in)	OD "C" (in)	PITCH DIAM "D" (in)	GROOVES NO. AND TYPE "E"	WR2 (lb - in 2)
5F20-394	5F20-1053	1-3/4	8.0	7 5	2 - B	105
5F30-394	5F30-1053	2-1/2	8.0	7 5	3 - B	134
5F40-394	5F40-1054	2-1/2	10.0	9 5	3 - B	297
5F60-394	5F60-1054	3-1/4	10.0	9.5	4 - B	328
5F61-394	5F61-1054	3-1/4	11 5	11 0	4 - B	583
5H40-394	5H40-1104	3-3/8	11.75	11 0	3 - C	733
5H60-394	5H60-1104	5-3/8	11.75	11 0	5 - C	1073
5H61-394	5H61-1104	4-3/8	18.10	17 35	4 - C	4370
5H80-394	5H80-1104	6-3/8	11 75	11 0	6 - C	1244
5H81-394	5H81-1104	5-3/8	18 10	17.35	5 - C	6000
5H120-394	5H120-1104	9-3/8	11 75	11 0	9 - C	2140

Booster Application Data - The following data supplements single-stage compressor application data, and adds information pertaining to booster application only. Refer to single-stage compressor data for all other information.

Rating Basis - All booster ratings are given in refrigeration effect and are based on:

1. Use of a liquid-suction heat interchanger. (It is important to note here that all liquid-suction interchangers should have a bypass connection on the liquid side so that adjustment can be made in the event that too much superheating of the suction gas causes excessive heating of the compressor. This is especially true in the case of Refrigerant 22, which has a higher compression exponent than Refrigerant 12.)
2. The liquid refrigerant at Point "A" (Fig. 15) being at the saturation temperature corresponding to the booster discharge pressure. This is also often referred to as the "saturated intermediate temperature."

   This situation obtained when booster discharge gas is condensed in a cascade (refrigerant-cooled) condenser, or when using an open flash type intercooler in a direct staged system.

   When subcooling or the liquid takes place in a closed type intercoooler then it is not possible to bring the liquid temperature all the way down to the saturated intermediate temperature because of the temperature difference required for heat transfer thru the liquid coil. In this case, the compressor rating must be decreased 3% for each 10 F, that the liquid temperature at Point "A" is above the saturated intermediate temperature.
3. Use of only one-half the standard number of suction valve springs per cylinder. All 5F,H compressors are factory-assembled with the standard number of suction valve springs; therefore, one-half of the suction valve springs per cylinder must be removed in the field for booster application.

"R" Factors - In a multi-stage compression system, the intermediate or high stage compressor must have sufficient capacity to handle the low stage (booster) compressor load plus the heat added to the refrigerant gas by the low stage machine during compression. Likewise, if an intermediate stage compressor should be used, the high stage compressor must have sufficient capacity to handle the intermediate stage compressor load plus the heat added to the refrigerant gas by the intermediate stage machine during compression.

To assist in the selection of higher stage compressors, Tables 18 thru 20 present "R" factors which depict the approximate required relationship between stages at various saturated temperature conditions.

To determine the required capacity of a higher stage compressor, multiply, the lower stage compressor capacity by the proper "R" factor from either Table 18, 19 or 20. Any additional loads handled at the intermediate pressure must be added to this figure to arrive at the total higher stage load.

Multi-Stage System Pointers - A staged system is essentially a combination of two or more simple refrigerant cycles. In combining two or more simple flow cycles to form a staged system for low temperature refrigeration, two basic types of combination are common (Fig. 15).

DIRECT STAGING - Involves the use of compressors, in series, compressing a single refrigerant.

CASCADE STAGING - Usually employs two or more refrigerants of progressively lower boiling points. The compressed refrigerant of the low stage is condensed in an exchanger (cascade condenser) which is cooled by evaporation of another lower pressured refrigerant in the next higher stage.

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Table 16 - 5F,H Booster Ratings - R-12

SAT. DISCH TEMP* (F)	SATURATED SUCTION		5F20		5F30		5F40		5F60		5H40		5H46		5H60		5H80		5H120	
	Temp (F)	PRESS (In. Hg Vac)	1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm	
			Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp
-50 15.42" Vac.	-85	24.95	0.28	0.93	0.42	1.30	0.57	1.67	0.85	2.42	1.3	3.43	1.6	4.46	2.0	5.52	2.6	7.37	4.0	9.5
	-80	24.05	0.34	0.97	0.51	1.36	0.63	1.75	1.0	2.54	1.6	3.64	2.0	4.73	2.4	5.85	3.2	7.69	4.8	10.2
-40 10.96" Vac	-85	24.95	0.27	0.94	0.40	1.31	0.54	1.68	0.80	2.43	1.2	3.46	1.5	4.50	1.9	5.58	2.5	7.44	3.8	9.7
	-80	24.05	0.33	1.00	0.49	1.40	0.65	1.80	0.98	2.61	1.5	3.70	1.8	4.81	2.3	5.93	3.1	7.90	4.6	10.2
	-70	21.84	0.48	1.11	0.72	1.57	0.95	2.03	1.4	2.96	2.2	4.27	2.7	5.55	3.4	6.79	4.5	9.05	6.7	12.1
-30 5.45" Vac	-85	24.95	0.25	0.94	0.38	1.31	0.50	1.69	0.76	2.45	1.2	3.50	1.5	4.54	1.8	5.63	2.4	7.51	3.6	9.8
	-80	24.05	0.31	1.00	0.47	1.40	0.62	1.80	0.93	2.62	1.5	3.75	1.8	4.87	2.2	6.01	2.9	8.01	4.4	10.5
	-70	21.84	0.46	1.13	0.70	1.60	0.93	2.07	1.4	3.02	2.2	4.36	2.7	5.66	3.3	6.92	4.3	9.22	6.5	11.3
	-60	19.00	0.66	1.27	0.98	1.81	1.3	2.35	2.0	3.44	3.1	5.12	3.8	6.65	4.7	8.06	6.2	10.74	9.3	14.6
-20 0.58" Vac	-85	24.95	0.24	0.95	0.36	1.33	0.47	1.70	0.71	2.46	1.1	3.53	1.3	4.59	1.7	5.68	2.2	7.58	3.4	9.9
	-80	24.05	0.30	1.00	0.45	1.41	0.59	1.81	0.89	2.63	1.4	3.81	1.7	4.95	2.1	6.09	2.8	8.12	4.2	10.7
	-70	21.84	0.45	1.14	0.68	1.62	0.90	2.09	1.4	3.05	2.1	4.45	2.6	5.78	3.2	7.05	4.2	9.40	6.3	12.6
	-60	19.00	0.64	1.31	0.96	1.87	1.3	2.43	1.9	3.56	3.0	5.25	3.7	6.82	4.6	8.25	6.1	11.00	9.1	15.0
	-50	15.42	0.89	1.51	1.3	2.17	1.8	2.83	2.7	4.16	4.2	6.15	5.2	7.99	6.3	9.60	8.3	12.80	12.5	17.7
-10 4.50 psig	-85	24.95	0.20	0.95	0.31	1.34	0.40	1.71	0.63	2.49	1.0	3.58	1.2	4.65	1.5	5.75	2.0	7.67	3.0	10.0
	-80	24.05	0.27	1.00	0.40	1.42	0.54	1.82	0.80	2.64	1.3	3.85	1.6	5.00	1.9	6.15	2.6	8.19	3.9	10.8
	-70	21.84	0.42	1.14	0.63	1.63	0.84	2.10	1.3	3.07	2.0	4.49	2.4	5.84	3.0	7.11	4.0	9.47	5.9	12.7
	-60	19.00	0.61	1.32	0.92	1.89	1.2	2.45	1.8	3.59	2.9	5.31	3.6	6.90	4.4	8.35	5.8	11.13	8.7	15.2
	-50	15.42	0.86	1.53	1.3	2.20	1.7	2.87	2.6	4.22	4.0	6.30	4.9	8.19	6.1	9.83	8.1	13.10	12.1	18.2
	-40	10.96	1.2	1.77	1.8	2.56	2.4	3.35	3.5	4.94	5.5	7.43	6.8	8.83	8.3	11.53	11.1	15.37	16.6	21.6
0 9.17 psig	-85	24.95	0.18	0.95	0.27	1.35	0.36	1.73	0.55	2.51	0.88	3.63	1.1	4.72	1.3	5.82	1.8	7.76	2.7	10.1
	-80	24.05	0.24	1.01	0.36	1.42	0.48	1.76	0.72	2.66	1.2	3.88	1.5	5.04	1.7	6.20	2.3	8.27	3.5	10.9
	-70	21.84	0.39	1.15	0.58	1.63	0.77	2.11	1.2	3.08	1.9	4.52	2.3	5.87	2.8	7.12	3.7	9.55	5.6	12.7
	-60	19.00	0.58	1.33	0.86	1.90	1.2	2.47	1.7	3.62	2.8	5.38	3.5	6.99	4.2	8.44	5.6	11.26	8.3	15.4
	-50	15.42	0.83	1.56	1.2	2.25	1.7	2.93	2.5	4.31	3.9	6.45	4.8	8.38	5.9	10.06	7.8	13.41	11.7	18.6
	-40	10.96	1.1	1.83	1.7	2.65	2.3	3.47	3.4	5.12	5.4	7.74	6.7	10.05	8.1	11.98	10.8	15.98	16.2	22.5
	-30	5.45	1.5	2.17	2.3	3.16	3.1	4.15	4.6	6.14	7.3	9.41	9.0	12.22	11.0	14.50	14.6	19.33	21.9	27.5
10 14.65 psig	-80	24.05	0.21	1.01	0.31	1.43	0.42	1.84	0.63	2.67	1.0	3.96	1.2	5.15	1.5	6.31	2.0	8.42	3.0	11.1
	-70	21.84	0.35	1.15	0.53	1.64	0.70	2.12	1.1	3.09	1.7	4.58	2.1	5.95	2.6	7.25	3.4	9.66	4.3	13.0
	-60	19.00	0.54	1.39	0.82	1.99	1.1	2.59	1.6	3.80	2.6	5.43	3.2	7.06	3.9	8.52	5.2	11.36	7.8	15.5
	-50	15.42	0.79	1.58	1.2	2.28	1.6	2.97	2.4	4.37	3.7	6.52	4.6	8.47	5.6	10.24	7.4	13.65	11.2	19.0
	-40	10.96	1.1	1.90	1.7	2.76	2.2	3.61	3.3	5.33	5.2	7.95	6.4	10.32	7.8	12.30	10.4	16.41	15.6	23.1
	-30	5.45	1.5	2.23	2.3	3.25	3.0	4.27	4.5	6.32	7.1	9.65	8.8	12.53	10.6	14.84	14.1	19.79	21.2	28.2
20 21.05 psig	-75	23.01	0.23	1.08	0.35	1.53	0.47	1.97	0.70	2.87	1.1	4.31	1.3	5.60	1.7	6.84	2.3	9.12	3.4	12.2
	-70	21.84	0.31	1.16	0.46	1.65	0.60	2.13	0.93	3.11	1.5	4.65	1.8	6.04	2.3	7.34	3.0	9.79	4.5	13.2
	-60	19.00	0.50	1.45	0.75	2.08	1.0	2.71	1.5	3.98	2.4	5.49	3.0	7.14	3.6	8.60	4.8	11.47	7.2	15.7
	-50	15.42	0.74	1.60	1.1	2.30	1.5	3.01	2.2	4.43	3.5	6.62	4.3	8.60	5.2	10.31	7.0	13.74	10.5	19.1
	-40	10.96	1.1	1.90	1.6	2.78	2.1	3.64	3.2	5.38	5.0	8.04	6.2	10.45	7.4	12.44	9.9	16.58	14.8	23.4
	-30	5.45	1.4	2.29	2.2	3.34	2.9	4.39	4.4	6.50	6.8	9.88	8.4	12.83	10.2	15.19	13.6	20.26	20.5	28.9
30 24.46 psig	-70	21.84	0.27	1.17	0.40	1.66	0.53	2.15	0.80	3.14	1.3	4.71	1.6	6.12	2.0	7.44	2.6	9.92	3.9	13.4
	-60	19.00	0.45	1.35	0.68	1.94	0.90	2.52	1.4	3.69	2.2	5.54	2.7	7.20	3.2	8.69	4.3	11.58	6.5	15.9
	-50	15.42	0.69	1.61	1.0	2.32	1.4	3.03	2.1	4.46	3.3	6.67	4.1	8.80	4.9	10.38	6.5	13.84	9.8	19.3
	-40	10.96	1.0	1.93	1.5	2.80	2.0	3.67	3.0	5.42	4.7	8.13	5.8	10.58	7.1	12.57	10.7	16.76	14.1	23.6
	-30	5.45	1.4	2.34	2.1	3.41	2.8	4.49	4.2	6.65	6.5	10.11	8.0	13.13	9.8	15.54	13.0	20.72	19.6	29.6

*Also often referred to as "Saturated Intermediate Temperature."

NOTE:

Direct interpolation between rating points shown is permissible.

Do not extrapolate beyond rating points shown.

Table 17 - 5F,H Booster Ratings - R-22

SAT. DISCH. TEMP* (F)	SATURATED SUCTION		5F20		5F30		5F40		5F60		5H40		5H46		5H60		5H80		5H120	
	Temp (F)	Press. (In. Hg Vac.)	1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm		1750 rpm	
			Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp	Tons	Bhp
-50 6.03" Vac.	-100	25.06	0.27	0.95	0.40	1.35	0.54	1.75	0.80	2.25	1.3	3.10	1.6	4.03	1.9	5.50	2.5	7.00	3.8	9.5
	-90	22.96	0.42	1.05	0.62	1.53	0.83	1.95	1.4	2.65	1.9	3.70	2.3	4.80	2.9	6.18	3.8	8.00	5.8	10.9
	-80	20.18	0.63	1.25	0.94	1.80	1.3	2.20	1.9	3.20	2.8	4.49	3.5	5.84	4.3	7.30	5.7	9.50	8.5	13.1
-40 0.610 psig	-100	25.06	0.22†	1.00	0.33†	1.36	0.43†	1.75	0.65†	2.45	1.1†	3.50	1.3†	4.55	1.6†	5.58	2.2†	7.25	3.3†	9.6
	-90	22.96	0.38	1.11	0.56	1.55	0.75	1.95	1.1	2.75	1.7	3.98	2.1	5.17	2.6	6.40	3.4	8.25	5.1	11.3
	-80	20.18	0.57	1.25	0.85	1.81	1.1	2.20	1.7	3.25	2.6	4.79	3.2	6.22	3.9	7.50	5.2	10.0	7.8	13.5
	-70	16.55	0.83	1.45	1.2	2.11	1.7	2.70	2.5	3.94	3.8	5.90	4.7	7.66	5.8	9.18	7.7	12.1	11.5	16.9
-30 5.02 psig	-100	25.06	0.18†	1.05	0.28†	1.38	0.37†	1.80	0.55†	2.50	0.92†	3.50	1.1†	4.55	1.4†	5.78	1.8†	7.50	2.8†	10.1
	-90	22.96	0.35†	1.14	0.53†	1.58	0.70†	2.00	1.1†	2.80	1.6†	4.04	2.0†	5.25	2.4†	6.58	3.2†	8.50	4.8†	11.6
	-80	20.18	0.54	1.28	0.81	1.82	1.1	2.25	1.6	3.30	2.4	4.89	3.0	6.35	3.6	7.68	4.8	10.3	7.3	13.9
	-70	16.55	0.79	1.48	1.2	2.15	1.6	2.72	2.4	4.00	3.6	5.98	4.4	7.77	5.4	9.28	7.2	12.5	10.8	17.1
	-60	11.89	1.1	1.75	1.7	2.45	2.4	3.30	3.4	4.78	5.2	7.08	6.4	9.19	7.8	11.3	10.4	15.0	15.4	21.0
-20 10.31 psig	-100	25.06	0.15†	1.10	0.23†	1.38	0.30†	1.80	0.45†	2.60	0.79†	3.68	0.97†	4.78	1.2†	6.00	1.6†	7.75	2.4†	10.5
	-90	22.96	0.29†	1.19	0.44†	1.59	0.58†	2.00	0.88†	2.81	1.4†	4.09	1.7†	5.31	2.1†	6.58	2.8†	8.87	4.3†	11.6
	-80	20.18	0.50	1.30	0.75	1.85	1.0	2.25	1.5	3.35	2.3	4.94	2.8	6.41	3.4	7.78	4.5	10.5	6.8	14.1
	-70	16.55	0.75	1.50	1.1	2.18	1.5	2.72	2.2	4.05	3.3	5.97	4.1	7.75	5.0	9.28	6.7	12.7	10.0	17.1
	-60	11.89	1.1	1.79	1.6	2.48	2.1	3.30	3.2	4.80	4.9	7.28	6.1	9.45	7.4	11.6	9.9	15.2	14.8	21.8
	-50	6.03	1.5	2.12	2.3	3.05	3.0	4.00	4.6	5.50	6.9	8.88	8.5	11.5	10.3	14.0	13.7	18.7	20.6	26.5
-10 16.59 psig	-100	25.06	0.1†	1.15	0.15†	1.40	0.20†	1.85	0.30†	2.70	0.67†	3.75	0.83†	4.87	1.0†	6.08	1.3†	8.12	2.0†	10.6
	-90	22.96	0.27†	1.24	0.40†	1.61	0.54†	2.05	0.80†	2.90	1.3†	4.14	1.6†	5.38	2.0†	6.65	2.7†	9.00	4.0†	11.8
	-80	20.18	0.46†	1.33	0.69†	1.86	0.92†	2.30	1.4†	3.40	2.2†	5.00	2.7†	6.50	3.3†	7.88	4.3†	10.6	6.5†	14.3
	-70	16.55	0.71	1.53	1.1	2.19	1.4	2.80	2.1	4.10	3.3	6.08	4.1	7.90	4.9	9.50	6.5	12.7	9.8	17.5
	-60	11.89	1.0	1.82	1.6	2.60	2.1	3.40	3.1	5.00	4.8	7.34	5.9	9.53	7.2	11.8	9.6	15.5	14.4	22.0
	-50	6.03	1.4	2.16	2.2	3.10	2.9	4.10	4.3	6.00	6.8	9.00	8.4	11.7	10.2	14.5	13.5	19.0	20.3	27.5
	-40	.61‡	1.9	2.60	2.9	3.50	3.9	4.88	5.8	7.50	9.0	10.3	11.2	13.4	13.6	17.2	18.0	23.0	27.1	33.0
0 24.09 psig	-90	22.96	0.24†	1.23	0.36†	1.62	0.48†	2.10	0.73†	3.00	1.2†	4.19	1.5†	5.44	1.8†	6.75	2.3†	9.00	3.5†	12.0
	-80	20.18	0.43†	1.36	0.65†	1.90	0.87†	2.30	1.3†	3.50	1.9†	5.12	2.3†	6.65	2.9†	7.99	3.8†	10.6	5.8†	14.5
	-70	16.55	0.67†	1.59	1.0†	2.20	1.3†	2.85	2.0†	4.17	3.1†	6.19	3.8†	8.04	4.6†	9.75	6.2†	13.0	9.3†	18.0
	-60	11.89	0.99	1.88	1.5	2.62	2.0	3.50	3.0	5.08	4.5	7.70	5.6	10.00	6.8	12.1	9.0	15.8	12.6	22.8
	-50	6.03	1.4	2.10	2.2	3.15	2.9	4.15	4.3	6.19	6.4	9.25	7.9	12.0	9.6	14.6	12.9	19.2	19.3	27.7
	-40	.61‡	1.9	2.50	2.8	3.88	3.8	5.08	5.6	7.68	8.7	11.6	10.5	15.1	13.0	17.7	17.4	23.7	26.0	34.0
	-30	5.02‡	2.4	2.85	3.6	5.19	4.8	7.40	7.3	9.78	11.5	15.1	14.3	19.6	17.2	22.5	22.9	29.0	34.4	43.5
10 10.31 psig	-80	20.18	0.36†	1.39	0.53†	1.91	0.71†	2.40	1.1†	3.50	1.7†	5.25	2.1†	6.82	2.5†	8.00	3.3†	10.8	5.0†	14.5
	-70	16.55	0.59†	1.50	0.89†	2.21	1.2†	3.00	1.8†	4.20	2.7†	6.25	3.3†	8.42	4.1†	10.0	5.4†	12.6	8.1†	18.5
	-60	11.89	0.91†	1.81	1.4†	2.65	1.8†	3.60	2.7†	5.25	4.1†	7.75	5.1†	10.05	6.2†	12.3	8.2†	16.0	12.3†	23.0
	-50	6.03	1.3	2.23	2.0	3.25	2.6	4.25	4.0	6.28	6.0	9.50	7.4	12.3	9.3	14.7	12.0	19.5	18.1	28.0
	-40	.61‡	1.8	2.78	2.7	4.17	3.6	5.40	5.4	7.96	8.2	12.0	10.2	15.6	12.3	18.2	16.4	24.2	24.5	35.0
	-30	5.02‡	2.3	3.60	3.5	5.34	4.6	7.58	7.0	10.0	11.1	15.5	13.7	20.1	16.7	23.2	22.2	30.0	33.3	45.0
20 43.28 psig	-70	16.55	0.51†	1.55	0.75†	2.22	1.0†	3.00	1.6†	4.42	2.4†	6.25	2.9†	8.12	3.6†	10.1	4.8†	13.3	7.3†	18.7
	-60	11.89	0.82†	1.82	1.2†	2.68	1.6†	3.57	2.5†	5.29	3.8†	7.75	4.7†	10.05	5.6†	12.3	7.5†	16.4	11.3†	23.0
	-50	6.03	1.2	2.22	1.9	3.30	2.5	4.30	3.7	6.40	5.6	9.66	6.9	12.6	8.5	15.0	11.3	20.0	16.9	28.5
	-40	.61‡	1.7	2.82	2.6	4.08	3.5	5.40	5.2	8.09	7.9	12.3	9.8	16.00	11.9	18.6	15.9	25.0	23.8	38.2
	-30	5.02‡	2.3	3.62	3.4	5.44	4.5	7.00	6.8	10.1	10.9	15.8	13.5	20.5	16.3	24.0	21.7	31.0	35.6	46.5
30 55.23 psig	-60	11.89	0.73†	1.84	1.1†	2.70	1.5†	3.50	2.2†	5.40	3.5†	7.87	4.3†	10.2	5.2†	12.5	6.9†	16.5	10.4†	23.5
	-50	6.03	1.2†	2.28	1.7†	3.31	2.3†	4.20	3.5†	6.50	5.3†	9.75	6.6†	12.7	7.9†	15.1	10.5†	20.2	15.8†	28.8
	-40	.61‡	1.7	2.85	2.5	4.17	3.3	5.50	5.0	8.19	7.7	12.4	9.5	16.1	11.5	18.9	15.4	25.2	23.0	36.2
	-30	5.02‡	2.2	3.70	3.3	5.47	4.4	7.87	6.6	10.2	10.6	16.1	13.1	20.9	15.9	24.6	21.2	31.2	31.8	47.7

*Also often referred to as "Saturated Intermediate Temperature." †Requires water-cooled heads. ‡Denotes psig

NOTE:

Direct interpolation between rating points shown is permissible. Do not extrapolate beyond rating points shown.

Table 18 - Booster "R" Factors - R-12 Air-Cooled Heads

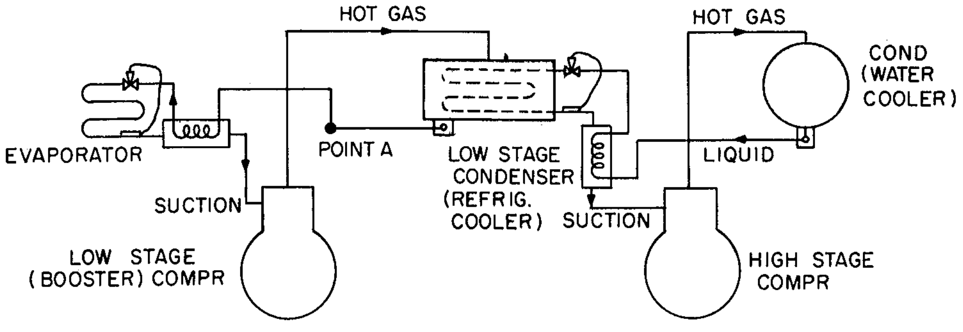
DISCHARGE TEMPERATURE	SUCTION TEMPERATURE							
	-100	-90	-80	-70	-60	-50	-40	-30
-50	–	–	–	–	–	–	–	–
-40	–	–	1.230	1.186	–	–	–	–
-30	–	–	1.276	1.230	1.183	–	–	–
-20	–	–	1.328	1.280	1.233	1.189	–	–
-10	–	–	1.377	1.330	1.284	1.238	1.190	–
0	–	–	1.429	1.380	1.334	1.287	1.240	1.291
10	–	–	1.470	1.421	1.375	1.328	1.280	1.234
20	–	–	–	1.458	1.410	1.363	1.318	1.270
30	–	–	–	1.489	1.441	1.397	1.350	1.307

Table 19 - Booster "R" Factors - R-22 Air-Cooled Heads

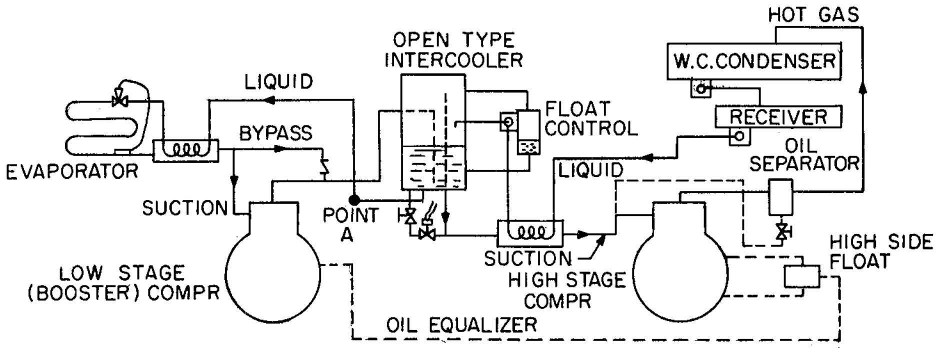
DISCHARGE TEMPERATURE	SUCTION TEMPERATURE							
	-100	-90	-80	-70	-60	-50	-40	-30
-50	1.261	1.214	1.170	–	–	–	–	–
-40	1.310	1.263	1.218	1.172	–	–	–	–
-30	1.360	1.313	1.269	1.221	1.178	–	–	–
-20	1.410	1.361	1.315	1.269	1.220	1.175	–	–
-10	1.453	1.407	1.360	1.313	1.267	1.219	1.171	–
0	–	1.448	1.400	1.351	1.303	1.256	1.209	1.160
10	–	–	1.434	1.388	1.340	1.291	1.245	1.199
20	–	–	–	1.424	1.377	1.329	1.281	1.233
30	–	–	–	–	1.406	1.360	1.311	1.265

Table 20 - Booster "R" Factors - R-22 Water-Cooled Heads

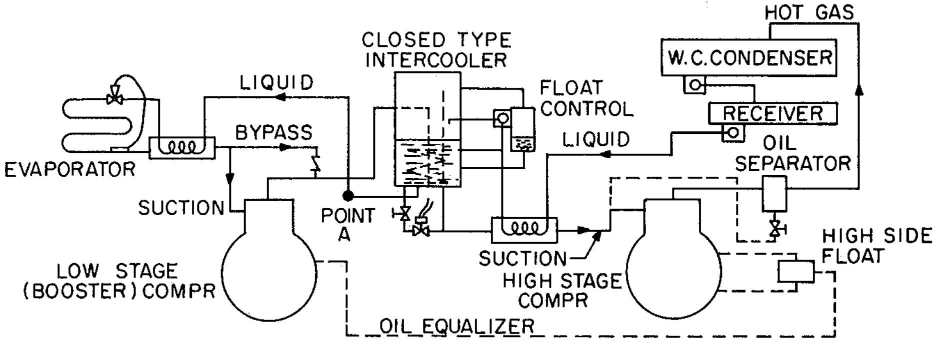
DISCHARGE TEMPERATURE	SUCTION TEMPERATURE							
	-100	-90	-80	-70	-60	-50	-40	-30
-50	1.221	1.175	1.129	–	–	–	–	–
-40	1.271	1.221	1.172	1.125	–	–	–	–
-30	1.319	1.270	1.221	1.173	1.125	–	–	–
-20	1.371	1.321	1.271	1.221	1.172	1.123	–	–
-10	1.414	1.368	1.319	1.270	1.221	1.173	1.126	–
0	–	1.406	1.359	1.311	1.263	1.217	1.169	1.121
10	–	–	1.394	1.348	1.300	1.252	1.205	1.159
20	–	–	–	1.382	1.337	1.289	1.241	1.196
30	–	–	–	–	1.367	1.319	1.261	1.227



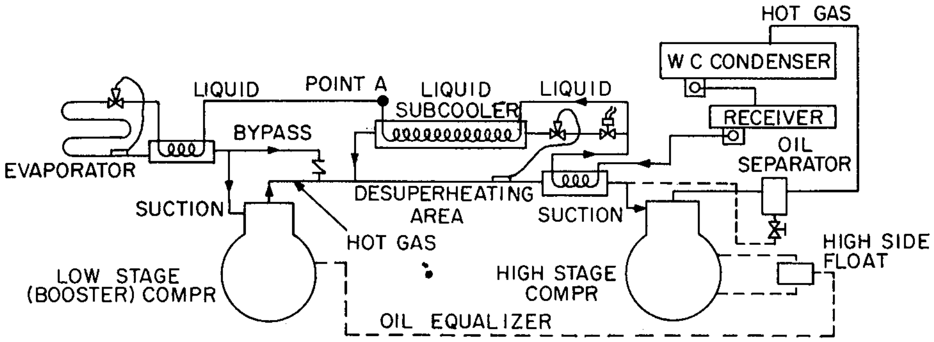
CASCADE SYSTEM (2 STAGES)



DIRECT STAGED SYSTEM-(OPEN TYPE INTERCOOLER)



DIRECT STAGED SYSTEM-(CLOSED TYPE INTERCOOLER)



DIRECT STAGED SYSTEM-(ALTERNATE CLOSED ARR'G'T)

– – – –FIELD PIPING

Fig. 15 - Flow Diagrams for Common Multi-Stage Systems using R-12 (Not to be used as piping diagrams)

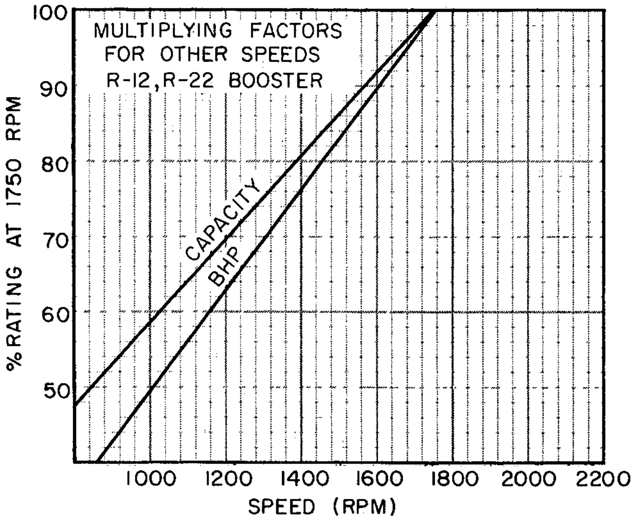


Fig. 16 - Multiplying Factors - Nonstandard Speeds

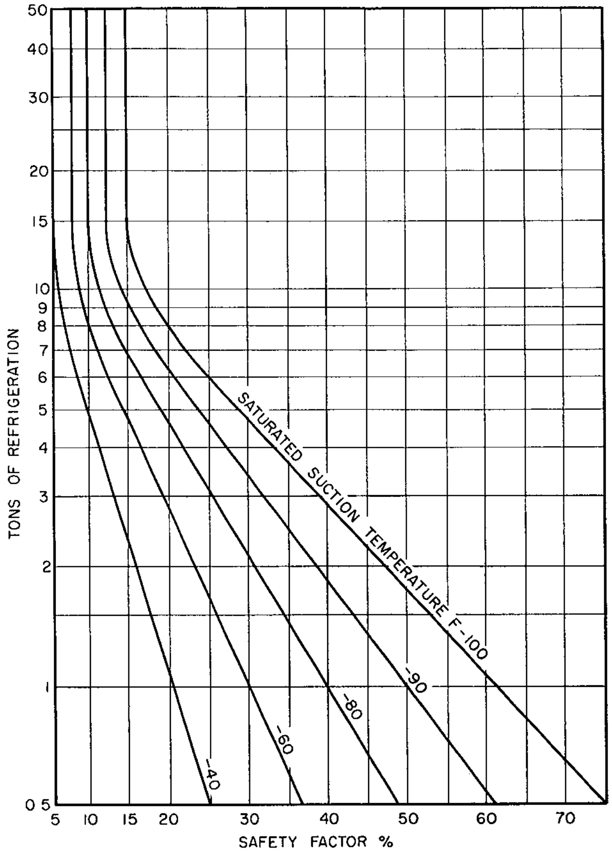


Fig. 17 - Booster Compressor Selection Safety Factors

Safety Factors - The use of capacity safety factors in selecting booster compressors must necessarily be a matter of judgment on the part of the engineer making the selection.

Factors which have a bearing on satisfactory compressor selections are: the accuracy of the load estimate, the amount of safety factor included in the total load, knowledge of the degree of importance of meeting the specified capacity at the given condition, the temperature level of operation and the magnitude of the refrigeration load. All of the factors must be recognized when considering the use of a capacity safety factor in selecting a booster compressor.

Figure 17 presents reasonable safety factors for use in the selection of booster compressors. These can be employed when it is not desired to establish a factor based on the selector's judgment.

When a capacity safety factor is used, the compressor is selected at its maximum speed to handle the design load plus the amount of safety factor.

Whether or not the added capacity offered by the safety factor is incorporated at once is a matter of judgment. If it is, then the compressor will be operated at maximum speed right at the start and any excess capacity achieved will be reflected in faster pulldowns or lower temperatures. It is also, however, good practice to drive the machine at the speed which will provide slightly more rated capacity than is required by the design load. The additional speed-up available will then constitute reserve capacity in the event that it is needed. Motors should be sized to run the compressor at maximum speed to forestall any motor changes, should this maximum compressor speed be required in the future.

Determining Intermediate Pressure - In the application of commercial compressors to staged systems, it is found that the lowest total bhp per ton and most economical equipment selection results when using approximately equal compression ratios for each stage. However, it is also economical to juggle assigned compression ratios slightly to fit available sizes of machines.

The use of Fig. 18 will allow direct determination of the proper intermediate pressure which will result in equal compression ratios per stage for direct two-stage system. The information in Fig. 18 is given in terms of saturated temperature instead of pressures, for easier use with the compressor ratings.

The existence of a second appreciable load, at some higher suction pressure level, will very often dictate the most convenient intermediate pressure.

Gas Desuperheating - The operation of a direct staged system requires cooling of the gas between stages. Otherwise, the highly superheated discharge gas from the low stage machine would be taken directly into the suction of the higher stage compressor and further compression would result in excessive heating of this compressor.

Liquid Cooling - It is also necessary to employ liquid cooling between stages and increase the refrigeration effect of the liquid delivered to the evaporator to realize the rated capacity of the booster compressor. The amount of refrigeration expended in cooling the liquid between stages is accomplished much more economically at the level of the high stage compressor suction than at the level of the low stage suction.

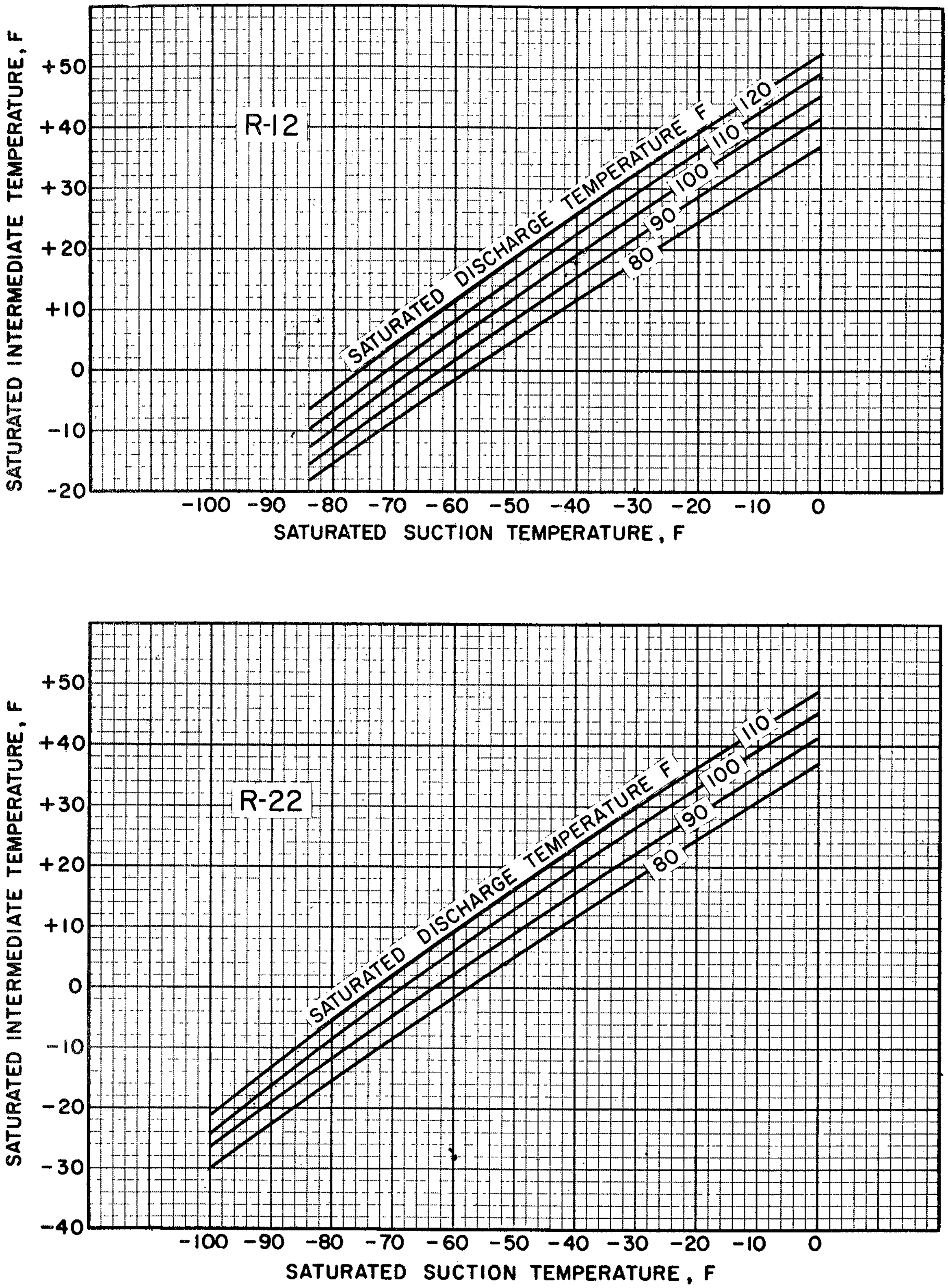


Fig. 18 - Optimum Intermediate Temperature for Two-Stage Compression

(Incorporating equal compression ratios per stage.)

Three common methods of gas desuperheating and liquid cooling for direct stage systems are illustrated in Fig. 15. In the open type systems, the refrigerant liquid is cooled down to the saturation temperature corresponding to the intermediate pressure. In the closed type systems, good intercooler design usually results in the refrigerant liquid being cooled down to 10 to 20 degrees above the saturation temperature corresponding to the intermediate pressure.

Oil Separators and Lubrication - In Freon cascade type systems, where evaporators and suction lines are properly designed for oil return to the compressor, oil separators are not usually used.

In direct staged systems, however, oil may tend to accumulate in one of the stages and thus result in lack of lubrication in the other machine. By the use of oil transfer lines, equalization of the oil level between crankcases can be achieved by manual operation at periodic intervals. Automatic control of proper oil return to both compressors is effected by the use of a high stage discharge line oil separator, returning oil to the high stage machine, and a high side float, connected to the high stage machine crankcase, which continually drains excess oil from this crankcase down to the next lower stage compressor (Fig. 15).

For booster application, the factory oil charge should be drained and replaced with a suitable viscosity oil for the low temperature application.

Control Pressurestat for Booster Application - The standard dual pressure switch furnished with the 5F,H compressors is not suitable for use with booster application. It must be replaced with one of the appropriate low temperature dual pressurestats from Table 21.

Table 21 - Control Pressurestats for Low Stage Application

	REFRIGERANT 12	REFRIGERANT 22
CARRIER PART NO	HK04HN-068	HK04HN-164
Switch Action - High	Open on press. rise	Open on press rise
- Low	Open on press fall	Open on press fall
Range - High	20" Vac. to 65 psig	30" Vac to 110 psig
- Low	30" Vac to 20 psig	30" Vac to 25 psig
Differential - High	8 to 30 psi adjust.	12 to 30 psi adjust
- Low	5 to 15 psi adjust.	9 to 30 psi adjust.
Max Pressure - High	200 psig	300 psig
- Low	120 psig	300 psig

Discharge Valve Springs - When 5H compressors are used for booster applications where the discharge pressure is below 10 psig, the standard discharge valve springs furnished with the machine should be replaced with an equal number of lighter weight springs, Part Number 5H41-1801.

No change in discharge valve springs is recommended for the 5F compressors.

Water-Cooled Heads - The standard 5F,H compressors are not equipped with water-cooled heads but they are available on special order. Water cooling of the heads is not generally necessary in R-12 and R-22 booster applications. For these applications with R-22 involving high compression ratios, 5 or above, 5F,H booster compressors should be equipped with water-cooled heads.

Motor Selection Data - In staged refrigeration systems, the high stage compressor starts first and runs until the low stage pressure has been reduced to a predetermined level before the low stage machine starts. With direct staged arrangements, the high stage machine draws gas from the evaporator thru the low stage machine bypass during this initial period. The size of the selected motor must be related to the maximum condition at which the booster compressor can operate.

The compressor may run under heavy loads during periods of high suction pressure, especially on starting when the system is warm. To handle these situations the motor must be sized larger than the actual balanced operation brake horsepower indicates, or special attention must be paid to the operation of the system when starting initially.

If the system is to operate only at a fixed low temperature, it is generally possible to avoid oversizing of motors to any great extent, providing careful operation is followed when the system is first put in operation.

For those cases where definite pulldown periods are involved, the motors must be sized to handle the highest brake horsepower occurring during pulldown.

On applications requiring reduction in temperature from ambient conditions to some extremely low temperature, the compression system will be operated at high suction pressures for considerable periods of time. General practice here is to drive the high stage compressor with a motor that will carry the compressor at the highest expected evaporator temperature. This is generally the "air conditioning" rating of the unit. For intermediate or low stage compressors, it is generally sufficient to size the motor to take care of double the balance load indicated horsepower plus the friction horsepower.

It is also necessary to consider compressor starting torque requirements when selecting the motor for a booster compressor. The starting torque of a motor only large enough to provide the required normal operating bhp for booster applications, may not be large enough to start the compressor. The recommended minimum motor sizes shown in Table 22 have been selected to assure adequate starting torque. The actual motor size selected is usually larger; however, depending on the maximum bhp conditions under which the compressor will run during pulldown or other abnormal operating periods.

It is good practice to select motors with allowance for 10% voltage reduction unless there is a certainty that this cannot occur.

Compressor Starting Torque - The required compressor starting torque is dependent on the discharge pressure as well as the pressure differential occurring during start-up. The maximum expected torque required during the starting period for 5F,H compressors, used as boosters, is shown in Table 22 at two saturated discharge temperatures.

Selection Procedure - The selection of a 5F,H booster compressor requires that the load, saturated suction temperature, saturated discharge temperature, type of system and refrigerant be known.

After the saturated intermediate temperature is determined from Fig. 18, the booster rating on pages 22 thru 24 can be entered and the compressor selected. The low stage load is then multiplied by the "R" factor from Table 18, 19 or 20 to obtain the high stage compressor load. With this information, the single stage ratings (Application Ratings 5F,H-1XR) can be entered and the high stage compressor selected.

SELECTION EXAMPLE:

Given:

Refrigeration load	= 5.7 tons
Saturated Suction Temperature	= -60 F
Saturated Condensing Temperature	= 80 F
Open Type Intercooler	
Refrigerant 22	

Find: Compressor size and motor size.

Solution:

1. Figure 18 on page 27 indicates an optimum saturated intermediate temperature of -1 F. Allow for 1 F drop from the booster compressor to the intercooler and from the intercooler to the high stage compressor.

   Booster Saturated Suction Temperature = - 60 F

   Booster Saturated Discharge Temperature = 0 F

2. At - 60 F suction and 0 F discharge, the 5H60 booster compressor has a capacity of 6.8 tons with 12.1 bhp input at 1750 rpm.

   The safety factor at 1750 rpm.

   $$\left(\frac{6.8}{5.7}\right) \times 100 \quad - \quad 100 \text{ or } 20\%$$

   This is satisfactory from Fig. 17 and a 5H60 compressor is selected.

3. Indicated hp = bhp - fhp

   where bhp is given in the compressor ratings, fhp is given in Table 22.

   Indicated hp = 12.1 - 3.07 = 9.03
   Recommended minimum hp
   = (2 x ihp) + fhp
   = (2 x 9.03) + 3.07 = 21.13

   Tentatively select a 25 hp motor. Assume that the low stage will never start against a saturated discharge higher than 30 F. At 30 F discharge Table 22 indicates a starting torque of 54 lb-ft. Therefore, a normal starting torque 25 hp motor is selected.

4. With - 60 F suction and 0 F discharge, Table 19 indicates an "R" value of 1.303. Therefore, the high stage load is:

   1.303 x 6.8 = 8.86 tons (actual load)

5. Allowing a 1 F drop from the intercooler, the high stage saturation suction temperature is - 2 F.

   Allowing a 2 F drop between the compressor and condenser, the high stage saturated discharge temperature = 80 + 2 = 82 F.

6. Referring to the 5F,H single stage ratings (5F,H-1XR) the 5F60 at 1450 rpm has a capacity of 9.10 tons at - 2 F suction and 82 F discharge. The 5F60 is selected and requires 13.7 bhp at 1450 rpm.

7. Assume that the maximum load during pull-down occurs at 50 F suction and 90 F discharge. For this condition, the rating tables indicate 17.6 bhp, thus a 20-hp motor is selected.

Table 22 - Booster Compressor Starting Data

COMPR SIZE	UNLOADING DURING STARTING	MAX COMPR STARTING TORQUE-LB-FT				RECOMMENDED MIN MOTOR SIZE HP				FRICTION HP* (FHP)
		Refrigerant 12		Refrigerant 22		Refrigerant 12		Refrigerant 22		
		Saturated Discharge Temperature (F)				High Torque	Normal Torque	High Torque	Normal Torque	
		10 F	30 F	10 F	30 F					
5F20	None	9	13	15	21	–	2	3	3	67
5F30	None	10	15	16	24	3	3	5	5	.91
5F40	75%	8	12	13	19	3	3	5	5	1 15
5F60	66-2/3%	10	15	16	24	3	5	5	7-1/2	1.64
5H40	75%	19	28	30	45	5	7-1/2	7-1/2	10	2.25
5H46	75%	25	36	39	59	7-1/2	10	10	15	2.79
5H60	66-2/3%	23	34	37	54	7-1/2	10	10	15	3 07
5H80	75%	26	38	41	60	10	15	15	20	3 82
5H120	66-2/3%	41	60	65	94	15	20	20	30	5 25

*Based on 1750 rpm with 5FH compressors Will vary directly with rpm at other speeds

Limitations - On most installations the condenser is selected within the recommended conditions that are specified in the ARI Standards. The two main considerations are:

1. The water velocity is within a range of 3 to 10 feet per second. (The purpose of this is to minimize corrosion and erosion.)
2. It is considered good practice to select the condensers on the basis of a leaving terminal difference between 6 F and 12 F. In general, terminal differences higher than these are used only where the condensing water temperature is quite low or where special conditions make it economical to do so. A high terminal difference not only makes the effect of fouling more pronounced but since the condenser volume is likely to be small the effect on noncondensable gases will be greater.

Table 23 lists maximum water velocities as stated in the Carrier System Design Manual. These limits are above the ARI recommended values but are generally accepted by industry on jobs where ARI conformance is not specified. See Part 5 of the Carrier System Design Manual for further details.

Table 24 lists the condenser water quantities for various water velocities. Higher velocities may be calculated by use of the formulas given under Table 24.

Table 23 - Max Condenser Tube Water Velocity

OPERATING HOURS PER YEAR	MAXIMUM TUBE WATER VELOCITY (fps)
Up to 1500	12
2000	11 5
3000	11
4000	10
6000	9
8000	8

The table below gives a convenient means of obtaining tube water velocities at various gpm values.

Table 24 - Condenser Gpm at Various Water Velocities‡

	MINIMUM PASS*					MAXIMUM PASS†				
	Water Velocity – Fps									
CONDENSER	3	5	7	9	10	3	5	7	9	10
5F20	6	11	15	20	22	3	5	8	10	11
5F30	8	15	22	29	32	4	7	11	14	16
5F40	16	27	39	50	56	8	14	19	25	28
5F60	20	35	50	65	72	10	17	25	32	36
09RH027	42	70	98	126	140	21	35	49	63	70
09RH043	63	105	147	189	210	31 5	52 5	73.5	94 5	105
09RH054	63	105	147	189	210	31.5	52.5	73.5	94 5	105
09RH070	79	131	183	236	262	39 5	65 5	91 5	118	131
09RH084	93	155	216	279	310	46 5	77.5	108	139.5	155
09RH097	93	155	216	279	310	46.5	77 5	108	139 5	155
09RH127	148	247	346	445	494	74 0	123.5	173	222 5	247

*Double circuit for 5F20 and 30.

†Single circuit for 5F20 and 30

‡Within ARI Standard Recommendations

Water velocity formulas: (Use for velocities above 10 fps.)

5F20 Condener: $V = \frac{\text{gpm x 0.92}}{\text{no. of circuits}}$

5F30 Condenser: $V = \frac{\text{gpm x 0.65}}{\text{no. of circuits}}$

5F40 thru 09RH127: $V = \frac{\text{gpm x passes x 1.4}}{\text{total tubes}}$

Condenser Duty - The capacity of a given compressor is greatest at high saturated suction temperatures. Because of this, the compressor normally requires the largest condenser at these conditions, or for air conditioning duty.

On refrigeration or low temperature applications, the same compressor displacement results in a lower refrigeration capacity and, consequently, less heat rejection. Thus, the condenser size is smaller than would normally be required with the same compressor on air conditioning duty.

Condenser size is also affected by the refrigerant used, since compressor capacities (and thus heat rejection) differ with Refrigerants 12, 22, 500, and 502.

Pulldown - Condensers for systems subject to pulldown periods, especially low temperature or multi-stage systems, should be oversized to some extent beyond the capacity required at the final balanced load condition. The condenser must adequately handle the load during the first stages of pulldown, when the system capacity is substantially greater than at the final condition.

There are a few general rules that can be followed to determine the amount of oversizing that is required. Much depends, of course, on job conditions and how often pulldown will be required.

If the pulldown load is sizable, such as in most water or brine cooling applications, check condenser performance when it is handling the total heat rejection at the maximum rated suction temperature (50 F for most compressors). The condenser size and water quantity must be adequate to handle this start-up load without resulting in excessive head pressure or excessive water pressure drop. As a rough guide, condenser selected should have a maximum total heat rejection rating which is equal to or greater than the compressor heat rejection at the pulldown conditions.

If this pulldown occurs very infrequenctly, then it may be possible to select the condenser for the design conditions and on each start-up limit the compressor capacity by manually throttling the suction gas flow. This can be done by partially closing the suction valve but this will extend the time required to reach design conditions.

If the pulldown is of short duration, such as on a direct expansion coil, the suction temperature will drop very rapidly and more than likely design conditions will be reached before the compressor would cut out on high pressure. No oversizing of the condenser would be required.

Whenever possible the selected condenser should never be of a larger size than the largest that will match the compressor used and still be a standard combination. This should be considered especially when the condensers are to be used with the 5 Series open reciprocating compressors.

Fouling Factors - The 5F and 09RH condenser capacity ratings in the 5F,09RH-1XR are given for water side fouling factors of 0.0005, 0.0001 and 0.0002. These fouling factors are the resistance to heat flow introduced by scale and other water impurities.

Condensers should not be normally selected for less than 0.0005 fouling factor, even when high quality water is available. For lower quality water, use the larger fouling factors from the condenser ratings, but temper the factor according to the operating conditions.

The following items affect the magnitude of the fouling factor selected:

1. Percentage of yearly operating time.
2. Frequency of tube cleaning.
3. Condensing temperature.
4. Type of water treatment.

For instance, reduce the fouling factor when the operating time is less than 4000 hours per year, when frequent cleaning of tubes takes place, or when low condensing temperatures exist.

Water Circuiting Arrangements - The water circuiting arrangement selected for the 5F and 09RH condensers depends on the available condenser water pressure, temperature, quantity and source. Refer to Table 25.

Piping - On the 5F shell and tube and the 09RH condensers, excluding those with 14- and 18-inch diameter shells, it is possible to interchange the condenser heads. This, however, should not become a common practice but done only when absolutely necessary. When it has to be done extreme caution and care should be taken to not ruin or dislocate the microbaffling.

The hot gas discharge line from the compressor to the condenser should be as short as possible to reduce the hot gas pressure drop.

Refer to the Carrier System Design Manual for specific information and recommendations for refrigerant and water piping.

Economics - The selection of a condenser requires the balancing of certain economic variables, including:

1. First cost of compressor-condenser combination.
2. Operating costs.
3. Ratio between power costs and water costs.

Where first cost is the most important consideration, the best combination of compressor and condensers is the one which has the lowest total equipment cost.

If owning and operating costs are both important, the combination must be selected on the basis of both considerations.

A condenser selection that permits operation of the system at a low condensing temperature, results in the lowest compressor motor brake horsepower and consequently, the lowest operating cost. A condenser selection that is heavily loaded requires the compressor to operate at a higher condensing temperature, results in higher compressor motor brake horsepower and operating cost.

For a given compressor-condenser combination, the selection of a condensing temperature may depend on the ratio between power costs and water costs, on the quantity of water available, on the condensing temperature required to achieve compressor capacity, or possibly the requirement to remain within the allowable loading on a given motor size.

Table 25 - Condenser Water Circuiting

WATER CIRCUITING ARRANGEMENTS	CONDENSER SIZE	CONDENSER CHARACTERISTICS	NORMAL USE
Double Circuit	5F20, 5F30	High Water Quantity Low Pressure Drop	Cooling Tower
4 Passes	5F40, 5F60		
3 Passes	All 09RH		
Single Circuit	5F20, 5F30	Low Water Quantity High Pressure Drop	City or Well Water
8 Passes	5F40, 5F60		
6 Passes	All 09RH		

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