Part 5

INSTALLATION AND SERVICE

Section 24. INSTALLATION

Section 25. SERVICING COPELAND COMPRESSORS

Section 26. FUNDAMENTALS OF SERVICE OPERATIONS

Section 27. USEFUL ENGINEERING DATA

INDEX OF TABLES

FAN SCHEDULE:

TAG	CFM	S.P. WG	DRIVE	FAN HP	LOCATION	BASIS OF DESIGN	ACCESSORIES	APPX. WEIGHT LB.	NOTES
EF-1	350	.15	DIRECT	1/8	D5	GREENHECK SP	BD, DISC. INLET GRILLE	12	1,2

NOTES:
1. REFER TO DIVISION 16, ELECTRICAL FOR EQUIPMENT ELECTRICAL CHARACTERISTICS.
2. 4" Ø DUCT TO VAULT CONNECTION, PROVIDE GALVANIZED PLATE AT CONCRETE, SEAL TO CONCRETE, PROVIDE DUCT COLLAR CONNECTION, WALL ON-OFF SWITCH.
3. PROVIDE FLEX DUCT CONNECTIONS AT INLET AND OUTLET, FLARE OUTLET TO FULL SIZE LOUVER, PROVIDE BACKDRAFT DAMPER.

MEDICAL EQUIPMENT CHILLER SCHEDULE:

TAG	TOTAL BTUH OUTPUT	NOMINAL TONS	ENT. WATER °F	LVG. WATER °F	TANK GALLONS	FLOW GPM	HIGH AMBIENT DESIGN	LOW AMBIENT DESIGN	MAX. % GYLCOL SOLUTION	BASIS OF DESIGN	APPX. WEIGHT LB.	NOTES
CH-1	85,000	7.5	78-85	68	55	20	95 °F	30 °F	30%	ARCTICHILL AIR COOLED	1425	1-3

NOTES:
1. REFER TO DIVISION 16, ELECTRICAL FOR EQUIPMENT ELECTRICAL CHARACTERISTICS.
2. PROVIDE ARCTICHILL MATCHING CITY WATER CHANGE OVER ASSEMBLY, WITH ALL CONTROLS, PIPING ACCESSORIES AND CONNECTIONS.
3. VERIFY MEDICAL EQUIPMENT AND HEAT OUTPUT REQUIREMENTS IN WRITING FROM MEDICAL EQUIPMENT VENDOR AND SUBMIT WITH SHOP DRAWINGS. POINT OUT ANY DIFFERENCES.

AIR DISTRIBUTION SCHEDULE (NOT ALL USED)

TAG	TYPE	FACE SIZE	CFM RANGE	NECK SIZE	ADAPTER SIZE IF REQUIRED	FINISH	OPPOSED BLADE DAMPER	LAYOUT BASIS	NOTES
A	RETURN	24" X 24"	350 - 1500	22" X 22"	-	OFF-WHITE	NO	TITUS PAR-AA	1, 2, 4, 5
B	RETURN	16" X 16"	305 - 550	14" X 14"	-	OFF-WHITE	NO	TITUS PAR-AA	1, 2, 4, 5
C	RETURN	12" X 12"	0 - 300	10" X 10"	-	OFF-WHITE	NO	TITUS PAR-AA	1, 2, 4, 5
D	SUPPLY	24" X 24"	650 - 850	18" X 18"	16"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
D2	SUPPLY	24" X 24"	450 - 650	18" X 18"	14"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
D3	SUPPLY	24" X 24"	321 - 450	18" X 18"	12"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
D4	SUPPLY	24" X 24"	116 - 320	12" X 12"	10"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
D5	SUPPLY	12"X12"	51 - 115	9" X 9"	8"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
D6	SUPPLY	12"X12"	0 - 50	6" X 6"	6"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
E	SUPPLY	16" X 16"	116 - 320	12" X 12"	10"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
E2	SUPPLY	16" X 16"	0 - 116	9" X 9"	8"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
F	SUPPLY	12" X 12"	0 - 50	6" X 6"	6"Ø	OFF-WHITE	NOTE 3	TITUS TDC-AA	1 - 5
G	EXHAUST	16" X 16"	351 - 600	14" X 14"	12"Ø	OFF-WHITE	NO	TITUS 350RL	1, 3 - 5
G2	EXHAUST	14" X 14"	151 - 350	12" X 12"	10"Ø	OFF-WHITE	NO	TITUS 350RL	1, 3 - 5
G3	EXHAUST	12" X 12"	51 - 150	10" X 10"	8"Ø	OFF-WHITE	NO	TITUS 350RL	1, 3 - 5
G4	EXHAUST	8"X8"	41- 50	8" X 8"	5"Ø	OFF-WHITE	NO	TITUS 350RL	1, 3 - 5
G5	EXHAUST	8"X8"	0 - 40	8" X 8"	4"Ø	OFF-WHITE	NO	TITUS 350RL	1, 3 - 5
H	SUPPLY	4"Ø	0 - 40	4"Ø	-	OFF-WHITE	NOTE 3	AIR CONCEPTS ANF	2, 3, 4
I	SUPPLY	4' - 2 SLOT	0 - 250	10"Ø	OVAL	OFF-WHITE	NOTE 3	TITUS ML-38	1 - 6
J	SUPPLY	2' - 2 SLOT	0 - 125	8"Ø	OVAL	OFF-WHITE	NOTE 3	TITUS ML-38	1 - 6
K	RAR	SEE DWGS	VARIES	SEE DWGS	-	OFF-WHITE	NO	TITUS 350RL	2 - 5
L	SAR	SEE DWGS	VARIES	SEE DWGS	-	OFF-WHITE	YES	TITUS 350RS	2 - 5

NOTES:
1. PROVIDE WITH FRAME FOR LAY-IN MOUNTING OR GYPSUM CEILING - REFER TO ARCHITECTURAL REFLECTED CEILING PLANS.
2. FLEXIBLE DUCT RUN OUT TO DIFFUSERS SAME SIZE AS DIFFUSER NECK.
3. PROVIDE OPPOSED BLADE DAMPER IF BRANCH DUCT DOES NOT HAVE MANUAL DAMPER. COORDINATE FACE SIZE OF AIR GRILLES WITH STRUCTURAL FRAMING.
4. PROVIDE RADIANT DAMPER WITH DIFFUSER IF TAG LETTER IS FOLLOWED BY "R". (AR)
5. ADJUST FRAME SIZE TO FIT WITHIN CEILING FRAMING, REFER TO STRUCTURAL DRAWINGS.
6. ALL LINEAR SLOT DIFFUSERS SHALL HAVE A INTERNALLY INSULATED PLENUM.
SAR = SUPPLY AIR REGISTER
RAR = RETURN AIR REGISTER

SPLIT SYSTEM HEAT PUMP SCHEDULE:

TAGS	SA CFM	OA CFM	ESP IN WG	MIN. HP	COOLING EAT°F db	COOLING EAT°F wb	COOLING CAP. MBH	COOLING SEN. MBH	HEATING REV. CYCLE	HEATING KW/STAGE	BASIS OF DESIGN	MIN. SEER	APPX. WEIGHT LB.	NOTES
FCU-1 (4 TONS) CU-1	1600	80	.12	1/2	80	67	46.0	35.5	35.5	10/1	CARRIER FV4B CARRIER 38YDB	13.0	75 180	1 - 5
FCU-2 (2.5 TONS) CU-2	1000	80	.8	1/3	80	67	30.0	22.5	22.0	8/1	CARRIER FX4C CARRIER 38YXA	13.0	75 180	1 - 5
FCU-3 (2.5 TONS) CU-3	1000	80	.8	1/3	80	67	30.0	22.5	22.0	8/1	CARRIER FX4C CARRIER 38YXA	13.0	75 180	1 - 5
FCU-4 (4 TONS) CU-4	1600	80	.12	1/2	80	67	46.0	35.5	35.5	10/1	CARRIER FV4B CARRIER 38YDB	13.0	75 180	1 - 5
FCU-5 (2.5 TONS) CU-5	1000	80	.8	1/3	80	67	30.0	22.5	22.0	8/1	CARRIER FX4C CARRIER 38YXA	13.0	75 180	1 - 5
FCU-6 (4 TONS) CU-6	1600	80	.12	1/2	80	67	46.0	35.5	35.5	10/1	CARRIER FV4B CARRIER 38YDB	13.0	75 180	1 - 5
FCU-7 (2.5 TONS) CU-7	1000	80	.8	1/3	80	67	30.0	22.5	22.0	8/1	CARRIER FX4C CARRIER 38YXA	13.0	75 180	1 - 5
FCU-8 (5 TONS) CU-8	1900	350	.12	1/2	80	67	59.0	43.2	35.5	10/1	CARRIER FV4B CARRIER 38YDB	13.0	75 180	1 - 5, 7
FCU-9 (2.5 TONS) CU-9	1000	80	.8	1/3	80	67	30.0	22.5	22.0	8/1	CARRIER FX4C CARRIER 38YXA	13.0	75 180	1 - 5
SS-1 (1.5 TONS) CUSS-1	650	0	-	1/12	80	67	17.0	11.0	19.0	-	MITSUBISHI PLA MITSUBISHI PUZ	13.0	24 55	1 - 6
SS-2 (3 TONS) CUSS-2	950	0	-	1/12	80	67	32.3	26.5	-	-	MITSUBISHI PLA MITSUBISHI PUY	13.0	24 55	1 - 6

NOTES: COOLING BASED ON CONDENSER ENTERING AIR TEMPERATURE OF 95°F, HEATING BASED ON CONDENSER ENTERING AIR TEMPERATURE OF 17°Fdb.
1. REFER TO DIVISION 16, ELECTRICAL FOR EQUIPMENT ELECTRICAL CHARACTERISTICS.
2. CONTRACTOR SHALL VERIFY MINIMUM SEER REQUIREMENTS WITH LOCAL CODE AUTHORITY.
3. ALL DUCT MOUNTED SMOKE DETECTORS ARE TO BE PROVIDED BY THE ELECTRICAL CONTRACTOR WHERE A FIRE ALARM SYSTEM IS PRESENT AND PROVIDED AND INSTALLED BY THE MECHANICAL CONTRACTOR WHERE THERE IS NOT A FIRE ALARM SYSTEM. INSTALL IN THE EXACT LOCATION AS DICTATED BY LOCAL AUTHORITY HAVING JURISDICTION, BY THE MECHANICAL CONTRACTOR. REFER TO SECTION 16720. EXACT SMOKE DETECTOR LOCATIONS PER LOCAL CODE. MANUAL EMERGENCY STOP PER NFPA 90 AND LOCATED PER LOCAL FIRE MARSHALL.
4. KW LISTED IS ACTUAL OUTPUT KW AT RATED VOLTAGE.
5. REFER TO FLOOR PLANS FOR INDOOR UNIT HORIZONTAL OR VERTICAL CONFIGURATION, INDOOR UNIT TO BE SINGLE POINT ELECTRICAL CONNECTION.
6. PROVIDE ACCESSORY CONDENSATE PUMP, COORDINATE DISCHARGE PIPING WITH G.C. GRILLE MOUNTED THERMOSTAT, ADJUSTABLE.
7. PROVIDE 1" PLEATED FILTER IN UNIT.

INTERLOCK SCHEDULE:

LEAD EQUIPMENT	INTERLOCKED EQUIPMENT	LEAD EQUIPMENT CONTROL	SMOKE DETECT.	REMOTE STOP	NOTES
FCU-*	CU	SPACE ADJUSTABLE THERMOSTAT	YES	YES	NOTES 1, 2 & 3, REFER TO SPECS
FCU-*	OA MOD	CU	-	-	NOTE 4
SS-*	CUSS	SPACE ADJUSTABLE THERMOSTAT	NO	NO	NOTES 1, 2 & 3, REFER TO SPECS
EWH-*	N/A	INTEGRAL THERMOSTAT	N/A	N/A	NOTE 1

NOTES:
1. COORDINATE ELECTRICAL CHARACTERISTICS WITH DIVISION 16 - ELECTRICAL.
2. COORDINATE EXACT LOCATION OF REMOTE STOP SWITCHES WITH LOCAL FIRE AUTHORITY.
3. ALL FCU'S TO HAVE DUCT MOUNTED SMOKE DETECTOR PER LOCAL CODE.
4. INTERLOCK MOD FOR OA WITH A REPRESENTATIVE FCU, SO MOD OPENS DURING OCCUPANCY, CLOSES AT NIGHT.
5. INTERLOCK EF TO RESPECTIVE MOD OR RESENTATIVE FCU, SO EF OPERATES DURING OCCUPANCY, OFF AT NIGHT.

WALL LOUVER AND MOD SCHEDULE:

TAG	LOUVER SIZE WIDTH X HEIGHT X DEPTH	MOD SIZE WIDTH X HEIGHT	AREA SERVED	MOD NOTES
L-1	8X12	NONE	DRYER	1
L-2	DELETED	DELETED		
L-3	DELETED	DELETED		
L-4	10"Ø	NONE	EXHAUST	1,2
L-5	10"Ø	NONE	VAULT O.A.	1,2

NOTES:
1. COORDINATE EXACT LOCATION AND ELEVATION WITH ARCHITECT, EXISTING BUILDING AND G.C.
2. VAULT EXHAUST AND OA HOOD: GREENHECK HOODED WALL CAP, WITH 8"Ø BY 10"Ø ADAPTOR, ALUMINUM, SEAL WATERTIGHT.

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DRAWING ISSUES

APPROVED BY: BHD DRAWN BY: SMR

ISSUE	DATE	DESCRIPTION
REV 0	1-10-07	ISSUE FOR PERMIT
REV 1	3-28-08	SHELL REV's - CODE COMTs.

PRESENTED BY:
HAMSA HAND HOLDINGS, LLC
c/o Diversified Realty Development, Inc.
1451 W. Cypress Creek Road, Suite 300
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Manager - Mr. Alan J Goldberg

STRADA TOWN CENTER
BUILDING C
1ST Floor Radiation Center
COCONUT CREEK, FLORIDA

DRAWING TITLE
TENANT: MECHANICAL SCHEDULES

RECEIVED APR 18 2008

JOB NUMBER

SHEET NUMBER
M-5

RELEASED FOR CONSTRUCTION

0355M5.dwg Mar 26, 2008 - 4:23pm Dorsey Engineering

MEDICAL EQUIPMENT PIPING NOTES:

(A) REFER TO MEDICAL EQUIPMENT MANUFACTURER'S INSTALLATION INSTRUCTIONS FOR EXACT INSTALLATION REQUIREMENTS. ALL MECHANICAL, PIPING AND ELECTRICAL INSTALLATION SHALL BE IN STRICT ACCORDANCE WITH THE SELECTED MEDICAL EQUIPMENT VENDOR'S PUBLISHED INSTALLATION INSTRUCTIONS. IMMEDIATELY REPORT ANY DIFFERENCES PRIOR TO PROCEEDING WITH THE WORK.

REFERENCE NOTES INDICATED ARE FROM THE VARIAN MEDICAL SYSTEMS, INSTALLATION DATA PACKAGE, SECTION 1, OCTOBER 2005. THIS INFORMATION IS FOR REFERENCE ONLY AND MUST BE VERIFIED TO BE THE EXACT APPLICABLE INSTALLATION INFORMATION PRIOR TO PROCEEDING WITH THE WORK.

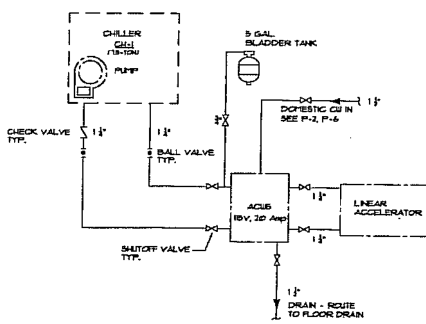
(B) [30.XYZ] BLOCK WITH VARIAN IDP REFERENCE KEYNOTE. THE CONTRACTOR MUST VERIFY THE EXACT MAKE AND MODEL OF ALL MEDICAL EQUIPMENT, THEN THE CONTRACTOR MUST REFER TO THE VARIAN WEBSITE AT WWW.VARIAN.COM/OSUP/SUP202.HTML TO ENSURE THAT THE LATEST APPLICABLE INSTALLATION DATA INFORMATION IS USED.

(1) CHILLED WATER PIPING THRU VAULT MUST BE AT AN ANGLE. REFER TO VARIAN IDP INSTALLATION DIAGRAMS. CHILLED WATER PIPING ABOVE SLAB TO BE TYPE L COPPER. PROVIDE SLEEVE AT WALL PENETRATIONS. TURN UP ON UNISTRUT TO ROOF. ENTER ABOVE VAULT ROOF LOW, SUPPORT ALONG INSIDE OF VAULT PARAPET, 12" ABOVE VAULT ROOF. PROVIDE SS UNISTRUT WITH SS ADJUSTABLE CLAMPS, MAX 10 FEET ON CENTER TO SUPPORT CHILLED WATER PIPING. INSULATE CHILLED WATER PIPING WITH 1 1/2" CLOSED CELL FOAM - ARMAFLEX or AS APPROVED, WITH EXTERNAL ALUMINUM PROTECTIVE JACKET. PROVIDE CLAMP SHIELDS AT PIPE SUPPORTS TO ALLOW CONTINUOUS PIPE INSULATION. COORDINATE ATTACHMENT OF UNISTRUT TO VAULT AND PARAPET WITH G.C.

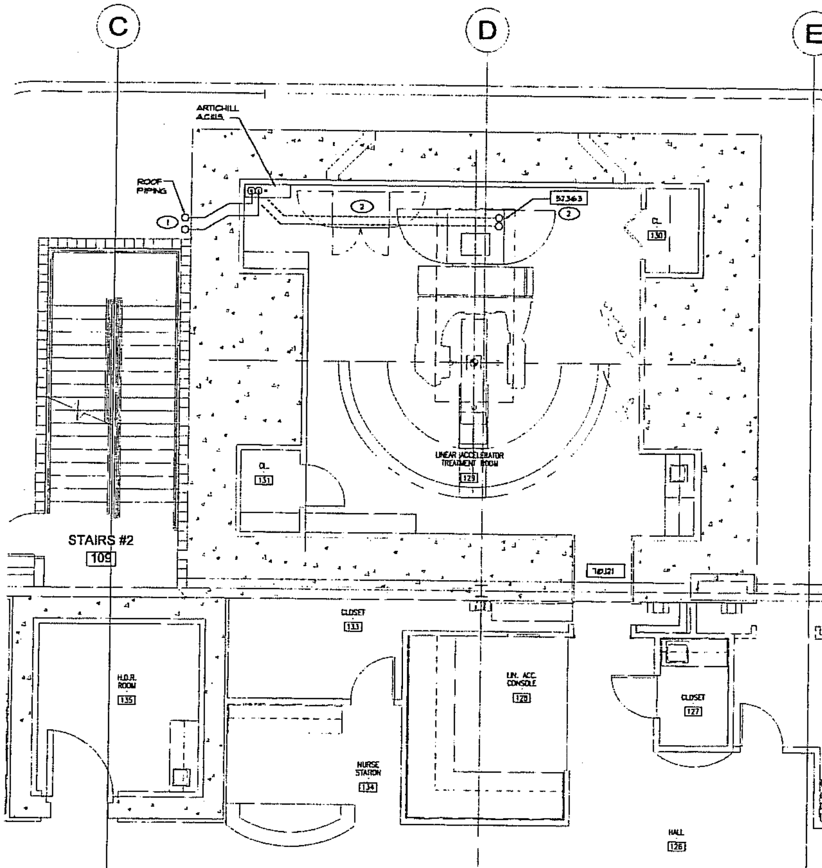
(2) 1 1/4" CHILLED WATER PIPING (SUPPLY AND RETURN) BELOW SLAB USING TYPE K COPPER. TERMINATE COOLING WATER SUPPLY AND RETURN LINES AT BASE FRAME PIT - SEE VARIAN BASE FRAME PIT DETAIL. FINAL CONNECTION FROM VALVES IN BASE FRAME PIT TO VALVES IN CLINAC STAND TO OCCUR AFTER EQUIPMENT INSTALLATION. PROVIDE 2 FEET OF 1 1/4" PIPE, FOUR 90 DEGREE ELLS, AND TWO 1 1/4" FITTINGS FOR COOLANT SUPPLY AND RETURN CONNECTION FROM THE VALVES IN THE PIT TO THE VALVES IN THE CLINAC.

[52.363] Terminate cooling water supply and return lines at Base Frame pit with 3/4" female NPT valves and plugs. Refer to the Base Frame Pit and installation drawing for termination location. Final connection from valves in Base Frame pit to valves in Clinac Stand will be installed by Customer/contractor using Varian provided hose kit during Clinac installation.

[70.121] To reduce radiation exposure outside room, air handling ducts should enter/exit the room through penetration(s) above the maze door. The ducts should be placed as high as possible in order to minimize radiation exposure to occupied space. The ducts should be designed to minimize the area of penetration through the wall. In most cases, duct shielding will not be required, provided the duct design conforms to this criteria. Clear space should be left around the duct (outside the treatment room) for shielding retrofit, in case the post installation radiation survey indicates a requirement. Penetration, including ducts, directly into the treatment room should be avoided. For no-maze treatment rooms, duct design and shielding must be addressed by the Physicist of Record.



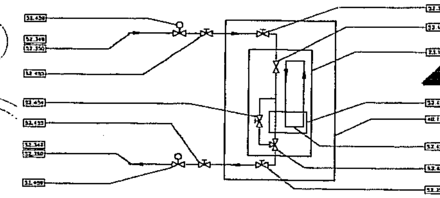
PIPING SCHEMATIC:
(2/M-3) PROCESS CHILLER - MEDICAL GRADE
SCALE: NONE



MECHANICAL DUCTWORK and PIPING:
(1/M-3) PARTIAL FLOOR PLAN - MECHANICAL
SCALE: 1/4" = 1'-0"

NOTES:

1. USE TYPE "K" COPPER PIPE BELOW GROUND AND TYPE "L" COPPER PIPE ABOVE GROUND.
2. ALL PIPING PENETRATIONS THRU VAULT WALLS BE INSTALLED DIAGONALLY TO THE WALL.
3. PROVIDE INSULATION VALVES AT ALL CONTROL PANEL CONNECTIONS.
4. PROVIDE 5 GAL. COMPRESSION TANK IN SUCTION LINE TO PUMP IF EXPANSION PROVISIONS NOT PROVIDED IN CHILLER.
5. ALL CHILLED WATER PIPING (NOT IN FLOOR SLAB) SHALL BE INSULATED WITH 1-1/2" THICK FIBERGLASS PIPE INSULATION OUTDOOR CHILLED WATER PIPING SHALL BE COVERED WITH A VAPOR PROOF ALUMINUM COVER.
6. SEE CHILLER SCHEDULE ON M-5.



[A] Coolant Diagram [10.333]

[52.455] Provide a flow meter on the supply or return line in an accessible location near the Clinac room.

[52.349] Dual Energy Clinac Cooling Requirements: REFER TO VARIAN I.D.P. MANUAL.

[52.350] Dual Energy Clinac CoolANT SPECIFICATIONS: REFER TO VARIAN I.D.P. MANUAL.

[52.455] Provide shut-off valves on the supply and return coolant lines in an accessible location outside the Clinac vault.

[52.454] The bypass shut-off valve is located in the Clinac Stand. During installation, this valve is closed for one-pass coolant systems or opened to provide constant flow for closed-loop coolant systems. If a closed-loop system design with domestic water backup is selected, provide a means to notify the user that the Clinac bypass valve should be closed in the event that the domestic water backup system is used. This valve is present only in systems shipped after January 1994.

[52.352] Terminate cooling water supply and return lines at Base Frame pit with 1" female NPT valves and plugs. Refer to the Base Frame Pit and installation drawing for termination location. Final connection from valves in Base Frame pit to valves in Clinac Stand will be installed by Customer/contractor using Varian provided hose kit during Clinac installation.

[52.450] The pressure reducing valve located within the Clinac Stand regulates the incoming external coolant pressure.

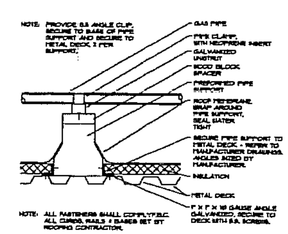
[23.131] This is the outline of the equipment Stand.

[40.130] This is the line of Base Frame pit.

[52.452] This is the heat exchanger located in the Clinac Stand.

[52.453] This is the internal Clinac coolant loop.

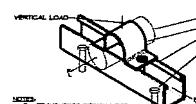
[52.451] The modulating temperature control valve is located in the Clinac Stand. This valve monitors the temperature of the returning coolant in the Clinac's internal coolant loop. It opens or closes to control the flow of external coolant through the Clinac's internal heat exchanger in order to maintain an internal coolant loop temperature of 104 F (40 C). This valve may close completely during minimum demand periods. If the bypass loop shut-off valve is open, the coolant is directed through the bypass loop.



HORZ. PIPE SUPPORT SCHEDULE:		
PIPE SIZE	MAX. SPACING (FT.)	NOTES
1/2"	6	1
3/4" OR 1"	8	1
> 1"	10	1

NOTES:
1. SUPPORT 18" ON EITHER SIDE OF A CHANGE IN DIRECTION.

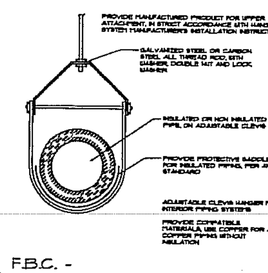
F.B.C. -
(3/M3) PIPE SUPPORT
SCALE: NONE



NOTES:
Ft = TRANSVERSE DESIGN LOAD
Fl = LONGITUDINAL DESIGN LOAD
* = MINIMUM SAFETY FACTOR OF 3.0

B2400 SERIES - STANDARD PIPE STRAPS						
PART NO.	SIZE	BOLT SIZE	BOLT TORQUE	DESIGN LOADS *		
				VERTICAL	Ft	Fl
	In.		Ft./Lbs.	Lbs.	Lbs.	Lbs.
B2400-1/2	1/2"	1/4"-20	6	[illegible]	[illegible]	[illegible]
B2400-3/4	3/4"	1/4"-20	6	[illegible]	[illegible]	[illegible]
B2400-1	1"	1/4"-20	6	[illegible]	[illegible]	[illegible]
B2400-1 1/4	1 1/4"	1/4"-20	6	[illegible]	[illegible]	[illegible]
B2400-1 1/2	1 1/2"	1/4"-20	6	[illegible]	[illegible]	[illegible]
B2400-2	2"	3/8"-16	15	[illegible]	[illegible]	[illegible]
B2400-2 1/2	2 1/2"	3/8"-16	15	[illegible]	[illegible]	[illegible]
B2400-3	3"	3/8"-16	15	[illegible]	[illegible]	[illegible]
B2400-3 1/2	3 1/2"	3/8"-16	15	[illegible]	[illegible]	[illegible]
B2400-4	4"	1/2"-13	30	[illegible]	[illegible]	[illegible]

F.B.C. DETAIL -
(4/M3) PIPE CLAMP ON RAIL
SCALE: NONE



F.B.C. -
(5/M3) PIPE INTERIOR HANGER
SCALE: NONE

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Bradley H. Dorsey, Sr., PE
FLORIDA LIC # 35680 exp 2/28/09

DRAWING ISSUES		
APPROVED BY: BHD		DRAWN BY: SMR
ISSUE	DATE	DESCRIPTION
REV 0	1-10-07	ISSUE FOR PERMIT
REV 1	3-26-08	SHELL REVS - CODE COMTS.

RECEIVED APR 18 2008

PRESENTED BY:
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Manager - Mr. Alan J Goldberg

STRADA TOWN CENTER
BUILDING C
1ST Floor Radiation Center
COCONUT CREEK, FLORIDA

DRAWING TITLE
TENANT: MECHANICAL FLOORPLAN

JOB NUMBER

SHEET NUMBER
M-3

RELEASED FOR CONSTRUCTION

0555M3.dwg Mar 26, 2008 - 4:25pm Dorsey Engineering

Section 24

INSTALLATION

RECOMMENDED INSTALLATION PROCEDURES

It is quite probable that a majority of operating failures on field installed systems can be traced to careless or inadequate installation procedures. The following instructions have been prepared to help the installation and/or service engineer systematically cover the many points which must be considered to provide each installation with trouble free performance.

These instructions are general in nature, and have been written primarily for field installed and connected systems normally utilizing compressors 2 horsepower in size or larger. However, the procedures can be applied to almost any type of field installed system, utilizing only those procedures which apply to the specific installation.

Design and Application

A location for the compressor should be selected which provides good ventilation, even when remote condensers are to be used, since the motor-compressor and discharge lines give off heat. Air cooled compressors must be provided with forced convection air cooling.

Air cooled condensers must be located to insure adequate air for condensing purposes. Care must be taken to avoid recirculation of air from one condenser to another.

Water cooled units must be provided with an adequate supply of water to maintain desired condensing temperatures. In order to avoid concentration of impurities, fungus, and scaling in cooling towers and evaporative condensers, a continuous waste bleed to a drain of approximately 2 gallons per hour per horsepower must be provided so that a continuous addition of fresh make-up water will be required.

Units and compressors must be level to insure proper lubrication.

Refrigerant suction lines must be sized to maintain adequate velocities for proper oil return.

Handling and Receiving of Equipment

Responsibility should be assigned to a dependable individual at the job site to receive material. Each shipment should be carefully checked against the bill of lading. The shipping receipt should not be signed until all items listed on the bill of lading have been accounted for.

Check carefully for concealed damage. Any shortage or damages should be reported to the delivering carrier. Damaged material becomes the delivering carrier's responsibility, and should not be returned to the manufacturer unless prior approval is given to do so.

When uncrating, care should be taken to prevent damage. Heavy equipment should be left on its shipping base until it has been moved to the final location.

The packing list included with each shipment should be carefully checked to determine if all parts and equipment have been received. Any accessories such as starters, contactors or controls should be fastened to the basic unit to avoid loss and prevent possible interchanging with other units.

Installation, Electrical

The supply power, voltage, frequency, and phase must coincide with the compressor nameplate. All wiring should be carefully checked against the manufacturer's diagrams. Field wiring must be connected in accordance with the National Electric Code, or other local codes that may apply.

Check to insure proper:

(a) Wire sizes to handle the connected load.

(b) Fuses recommended for compressors. (See Copeland Electrical Handbook)

(c) Magnetic starters, contactors, and motor protection devices approved by Copeland.

(d) Operation of oil pressure safety control.

(e) Direction of rotation and speed of fans and/or water pumps.

(f) Wiring with no grounded lines or controls.

Installation, Refrigerant Piping

Take extreme care to keep refrigeration tubing clean and dry prior to installation. The following procedures should be followed:

(a) Do not leave dehydrated compressors or filter-driers open to the atmosphere any longer than is absolutely necessary. (One or two minutes maximum suggested.)

(b) Use only refrigeration grade copper tubing, properly sealed against contamination. Water tubing often contains wax and other troublesome contaminants.

(c) Permanent suction line filters and liquid line filter-driers are recommended in all field installed systems.

(d) Suction lines should slope ½ inch per 10 feet towards the compressor.

(e) Suitable P-type oil traps should be located at the base of each suction riser to enhance oil return to the compressor.

(f) When brazing refrigerant lines, an inert gas should be passed through the line at low pressure to prevent scaling and oxidation inside the tubing. Dry nitrogen is preferred.

(g) Use only a suitable silver solder alloy or 95/5 solder on suction and liquid lines, and a high temperature silver solder alloy only on discharge lines.

(h) In order to avoid damage to the internal joints in vibration eliminators, line connections to vibration eliminators should be made with a silver solder alloy such as Easy-Flo having a melting temperature of 900° F. to 1200° F.

(i) Limit the soldering paste or flux to the minimum required to prevent contamination of the solder joint internally. Flux only the male portion of the connection, never the female. After brazing, remove surplus flux with a damp cloth.

(j) If vibration absorbers are to be installed in suction or discharge lines they must be applied according to the manufacturer's recommendations. With Copelametic motor-compressors, the preferred position is parallel to the crankshaft, as close to the compressor as possible. Vibration eliminators may be installed in a vertical position if joints are sealed against trapping of condensation which might damage the vibration absorber bellows due to freezing. Filling of the joints with soft solder as a means of sealing is recommended. Installation of the vibration absorber in a horizontal plane at right angles to the crankshaft is not acceptable since the resulting stress from compressor movement may cause failure of the bellows or of the refrigerant line.

(k) Two evacuation valves are necessary. One should be in the suction line and one in the liquid line at or near the receiver.

(l) After all lines are connected, the entire system must be leak tested. The complete system should be pressurized to not more than 175 psig with refrigerant and dry nitrogen (or dry CO_2). The use of an electronic type leak detector is highly recommended because of its greater sensitivity to small leaks. As a further check it is recommended that prior to charging, the system be evacuated to a pressure of 1 PSIA or less, and sealed for 12 hours. Any leakage of air into the system will cause the vacuum reading to decrease. If an air leak is indicated, the system should again be leak tested, and leaks repaired. For a satisfactory installation, the system must be leak tight.

(m) After the final leak test, refrigerant lines exposed to high ambient conditions should be insulated to reduce heat pick-up and prevent the formation of flash gas in the liquid lines. Suction lines should be insulated, if exposed, to prevent condensation.

Installation, Plumbing

Good practice requires the following:

(a) Lines should be sloped adequately to drain by gravity any water accumulated from condensing, defrosting, or cleaning operations.

(b) All plumbing connections should be made in accordance with local plumbing codes.

(c) Condensate lines from refrigerated fixtures must be trapped and run to an open drain. They must not be connected directly to the sewer system.

IF THE SYSTEM IS WATER-COOLED:

(d) Water pipe sizes should be adequate to provide the required flow at the lowest inlet pressure anticipated.

(e) Control devices such as solenoid valves, modulating valves, or hand valves that could cause hydraulic hammer should be protected by a stand-pipe and air pocket to absorb this shock. Electrical or pressure operated water control valves should be installed between the water supply and the condenser inlet — never between the condenser and the drain. If water supply pressure is excessive, a pressure reducing valve must be used since the allowable working pressure of water valves is normally 150 psig. Pressures above this level can also cause damage to the condenser.

(f) The water pump must be checked for rotation and proper performance.

(g) Check for water leaks.

Evacuation

A good high vacuum pump should be connected to both the low and high side evacuation valves with copper tube or high vacuum hoses (¼" ID minimum). If the compressor has service valves, they should remain closed. A high vacuum gauge capable of registering pressure in microns should be attached to the system for pressure readings.

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

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

Repeat this operation a second time.

Open the compressor service valves (if supplied) and evacuate the entire system to 500 microns absolute pressure.

Raise the pressure to 2 psig with the refrigerant and remove the vacuum pump.

Under no conditions is the motor-compressor to be started or operated while the system is under a high vacuum. To do so may cause serious damage to the motor windings because of the reduced dielectric strength of the atmosphere within the motor chamber.

Check-Out and Start-Up

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

(a) Check electrical connections. Be sure they are all tight.

(b) Observe compressor oil level before start-up. The oil level should be at or slightly above the center of the sight glass. Use only Suniso 3G or 3GS compressor oil.

(c) Remove or loosen shipping retainers under motor-compressors. Make sure hold down nuts on spring mounted compressors are not touching the compressor feet.

(d) Check high and low pressure controls, water valves, pressure regulating valves, oil pressure safety controls, and all other safety controls, and adjust if necessary.

(e) Check thermostat for normal operation.

(f) Suitable tags or other means should be provided to indicate refrigerant used in the system. Some Copeland condensing unit nameplates have two detachable corner tabs. One should be removed so that the nameplate indicates the refrigerant used.

(g) Wiring diagrams, instruction bulletins,etc., attached to motor-compressors or condensing units should be read and filed for future reference.

(h) Make the proper refrigerant connections and charge the unit with the refrigerant to be used. Weigh the refrigerant drum before charging so an accurate record can be kept of the weight of refrigerant put in the system. If the refrigerant must be added to the system through the suction side of the compressor, charge in vapor form only. Liquid charging must be done in the high side only.

(i) Observe system pressures during charging and initial operation. Do not add oil while the system is short of refrigerant, unless oil level is dangerously low.

(j) Continue charging until system has sufficient refrigerant for proper operation. Do not overcharge. Remember that bubbles in a sight glass may be caused by a restriction as well as a shortage of refrigerant.

(k) Do not leave unit unattended until the system has reached normal operating conditions and the oil charge has been properly adjusted to maintain the oil level at the center of the sight glass.

Operational Check-Out

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

(a) Check compressor head and suction pressures. If not within system design limits, determine why and take corrective action.

(b) Check liquid line sight glass and expansion valve operation. If there are indications that more refrigerant is required, leak test all connections and system components and repair any leaks before adding refrigerant.

(c) Observe oil level in compressor crankcase sight glass, and add oil as necessary to bring level to center of the sight glass.

(d) Thermostatic expansion valves must be checked for proper superheat settings. Feeler bulbs must be in positive contact with the suction line. Valves with high superheat settings produce little refrigeration and poor oil return. Too little superheat causes low refrigeration capacity and promotes liquid slugging and compressor bearing washout. Liquid refrigerant must be prevented from reaching the crankcase. If proper control cannot be achieved with the system in normal operation, a suction accumulator must be installed in the suction line just ahead of the compressor to prevent liquid refrigerant from reaching the compressor.

(e) Using suitable instruments, carefully check line voltage and amperage at the compressor terminals. Voltage must be within 10% of that indicated on the compressor nameplate. If high or low voltage is indicated, notify the power company. The current normally should not exceed 120% of the nameplate rating. If amperage draw is excessive, immediately determine the cause and take corrective action. On three phase motor-compressors, check to see that a balanced load is drawn by each phase.

(f) All fan motors on air cooled condensers, evaporators, etc. should be checked for proper rotation. Fan motor mounts should be carefully checked for tightness and proper alignment. If belt drives are used, check the belt tension. All motors requiring lubrication should be oiled or greased as necessary.

(g) The maximum approved settings for high pressure controls on Copeland condensing units are as follows:

	R-12	R-22 and R-502
Air Cooled	295 psig	395 psig
Water Cooled	295 psig	295 psig

Check as follows: On air cooled systems, disconnect the fan motors or block the condenser inlet air. On water cooled systems, shut off the water supply. Watch high pressure gauge for cut-out point. Recheck all safety and operating controls for proper operation and adjust if necessary.

(h) Check defrost controls for initiation and termination setting, and length of defrost period. Check crankcase heaters if used.

(i) Check winter head pressure controls for pressure setting.

(j) Check crankcase pressure regulating valves, if any, for proper setting.

(k) Adjust water valves on water cooled systems to maintain desired condensing temperatures. Check water pumps for proper rotation.

(l) Install instruction card and control system diagram for use of store manager or owner.

Identification

Each refrigerated fixture and cooler coil should be numbered starting at No. 1. These numbers should be not less than ½″ in height and should be stenciled or marked neatly on the fixture in an inconspicuous location easily available to the serviceman. The compressors or condensing units serving the fixtures should be marked with the numbers of the cases and coils served with figures not less than 1″ in height.

Service Record

A permanent data sheet should be prepared on each installation, with a copy for the owner and the original for the installing contractor's files. If another firm is to handle service and maintenance, additional copies should be prepared as necessary.

The form of the data sheet may vary, but a complete record of sizes and identification of all components used in the installation, together with any pertinent information should be included. Following is a suggested check-off list:

(a) Compressor manufacturer, model, and serial number.

(b) Equipment manufacturer, model, and serial number.

(c) Design operating temperatures.

(d) Condensing unit model, and serial number. (If package condensing unit.)

(e) If remote condenser, type, manufacturer, model, fan data.

(f) Refrigerant and weight of charge.

(g) Electrical service, volts, cycles, phase, wire size.

(h) Control circuit, voltage, fuse size.

(i) Contactor or starter, manufacturer, model, size, part number.

(j) Compressor motor protection, type, size, part number.

(k) Data on capacitors, relays, or other electrical components.

(l) Pressure control, type, size, model number, setting.

(m) Oil pressure safety control, type, model number.

(n) Defrost control, type, manufacturer, model number, setting.

(o) Data on miscellaneous refrigeration components such as pressure controls, winterizing controls, oil separators, crankcase heaters, solenoids, valves, etc.

(p) Liquid line drier, manufacturer, size, model number, connections.

(q) Schematic diagram of refrigerant piping.

(r) Final settings on all pressure, regulating, and safety controls.

FUNDAMENTALS OF EVACUATION AND DEHYDRATION

Although millions of dollars have been spent on refrigeration research, many of the reactions inside air conditioning and refrigeration systems are still a mystery. We do know that the presence of moisture, heat, and oxygen under certain conditions can result in many forms of system damage. Corrosion, sludging, copper plating, oil breakdown, carbon formation, and eventual compressor failure can be caused by these contaminants.

The absence of any one of the three, or its reduction to an acceptable level can greatly extend compressor life and slow down harmful reactions. If all three can be controlled, then a sound foundation has been made for a trouble free installation.

Copeland compressors are carefully tested to determine limits within which operation is possible without creating excessive heat in the compressor. But under the best operating conditions, heat is going to be produced as a natural consequence of compression of the refrigerant gas. Discharge temperatures in excess of 200° F. are unavoidable. Therefore, major efforts must be directed at preventing moisture and air from entering the system.

Moisture In A Refrigeration System

Moisture exists in three forms; as a solid when it is frozen into ice, as liquid water, and as a vapor or gas. It is extremely rare that moisture will enter a refrigeration system in the form of ice or water. It is the invisible water vapor that exists in the air around us that creates the real hazard.

The ability of air to hold water vapor increases with the temperature of the air. On a hot, humid summer day, the air may be actually loaded with moisture. Relative humidity is the term commonly used to express the percentage of saturation, that is, the existing moisture content of the air expressed as a percentage of the maximum moisture that the air could contain at a given temperature.

The relative humidity determines the dew point, or the temperature at which moisture will condense out of the air. Condensation occurs on the outside of a cold glass of water in a warm room, and it can occur in exactly the same fashion inside a cold evaporator which has been opened and exposed to the atmosphere.

Despite the fact that water vapor exists as part of the air around us, it acts quite independently of the air. Vapor pressure is independent of air pressure, and its speed of movement is astonishing. This means that water vapor cannot be stopped by air movement.

Normally it is considered good refrigeration practice to introduce a slight positive refrigerant pressure into any part of the system to be opened, so that when the lines are exposed there will be no tendency for air to rush in. This does provide reasonably good protection against air entry, but it does not prevent water vapor from entering, and if the coil is below the dew point of the air, water vapor will condense inside the coil. This process can continue until the coil temperature rises above the dew point, or until the system is again sealed.

Obviously it is impossible to prevent water vapor from entering the system any time it is opened to the atmosphere. However, if the temperature of the exposed part of the system is above the dew point, or if the time of exposure is short, the amount of moisture actually entering the system will be small. If a new drier is installed in the liquid line each time the system is opened for maintenance, the drier will normally have sufficient capacity to lower the moisture in the system to a safe level.

However, at the time of original installation, or after exposure for long periods during maintenance, the amount of moisture in the system may be greater than a drier's effective capacity. In such cases, evacuation is the only effective means of removing large quantities of moisture from the system, and to successfully dehydrate a system by evacuation, pressures within the system must be reduced to levels which will cause the trapped moisture to vaporize.

Air In A Refrigeration System

The air we breathe is primarily composed of nitrogen and oxygen. Both elements remain in a gaseous form at all temperatures and pressures encountered in commercial refrigeration and air conditioning systems. Therefore, although these gases can be liquified under extremely low temperatures, they may be considered as non-condensable in a refrigeration system.

Scientists have discovered that one of the basic laws of nature is the fact that in a combination of gases, each gas exerts its own pressure independently of others, and the total pressure existing in a system is the total of all the gaseous pressures present. A second basic characteristic of a gas is that if the space in which it is enclosed remains constant, so that it cannot expand, its pressure will vary directly with the temperature. Therefore, if air is sealed in a system with refrigerant, the nitrogen and oxygen will each add their pressure to the system pressure, and this will increase as the temperature rises.

Since the air is non-condensable, it will usually trap in the top of the condenser and the receiver. During operation the compressor discharge pressure will be a combination of the refrigerant condensing pressure plus the pressure exerted by the nitrogen and oxygen. The amount of pressure above normal condensing pressures that may result will depend on the amount of trapped air, but it can easily reach 40 to 50 psig or more. Any time a system is running with abnormally high head pressure, air in the system is a prime suspect.

Nitrogen is basically an inert gas and does not easily enter into chemical reactions. Oxygen, however, is just the reverse, and at the slightest opportunity will combine with other elements. Rust, corrosion, and burning are all common oxidation processes.

In the refrigeration system, oxygen and moisture quickly join in a common attack on the refrigerant and oil, and can cause corrosion, copper plating, acid formation, sludging, and other harmful reactions. Tests have shown that in the presence of heat, the combination of air and moisture is far more apt to cause breakdown of the refrigerant and oil mixture than greatly increased amounts of moisture alone.

Blowing out lines with refrigerant, or purging refrigerant from the top of the condenser and receiver may remove a major part of the air from a system, but if air is trapped in the compressor during installation, it is practically impossible to remove from the compressor crankcase by purging. Neither is there any assurance that trapped areas in coils or piping can be adequately purged. And unlike moisture, there is no drier to remove residual quantities to a safe operating level. Again evacuation is the only dependable and effective means of removing air from a system.

Pressure - Temperature - Evaporating Relationships

Anyone familiar with refrigeration knows that refrigerants follow a definite fixed pressure-temperature relationship, and that at a given pressure the refrigerant will boil or vaporize at a corresponding saturation temperature. Water follows exactly the same pattern, and this is the basis for dehydration by evacuation.

The pressure which determines the boiling points of refrigerants and water is absolute pressure, normally expressed in terms of psia, which is defined as the pressure existing above a perfect vacuum.

The atmosphere surrounding the Earth is composed of gases, primarily oxygen and nitrogen, extending many miles above the surface of the Earth. The weight of that atmosphere pressing down on the Earth creates the atmospheric pressure we live in. At a given point, the atmospheric pressure is relatively constant except for minor changes due to changing weather conditions. For purposes of standardization and as a basic reference for comparison, the atmospheric pressure at sea level has been universally accepted, and this has been established at 14.7 pounds per square inch, which is equivalent to the pressure exerted by a column of mercury 29.92 inches high.

At very low pressures, it is necessary to use a smaller unit of measurement since even inches of mercury are too large for accurate reading. The micron, a metric unit of length, is commonly used for this purpose, and when we speak of microns in evacuation, we are referring to absolute pressure in units of microns of mercury. Relationships of the various units of measurement are as follows:

1 pound per sq in.	= 2.03 inches mercury
1 inch mercury	= .491 pounds per sq in.
1 inch mercury	= 25,400 microns mercury
1 inch	= 25,400 microns
1 millimeter	= 1,000 microns
1 micron	= .001 millimeter

The refrigeration serviceman's bourdon tube gauge reads 0 pounds per square inch when not connected to a pressure producing source.

Therefore the standard relationship has been established that absolute pressure is equal to gauge pressure plus 14.7 psi. Pressures below 0 psig are actually negative readings on the gauge, and are referred to as inches of vacuum. The gauge is calibrated in the equivalent of inches of mercury.

Table 49

BOILING POINT OF WATER AT VARYING PRESSURES

Absolute Pressure			Boiling Point Of Water	Corresponding Gauge Pressure At Sea Level		Absolute Pressure			Boiling Point Of Water	Corresponding Gauge Pressure At Sea Level	
PSIA	In. Hg	Microns Hg		PSIG	In. Vac.	PSIA	In. Hg	Microns Hg		PSIG	In. Vac.
14.7	29.92	759,968	212° F.	0	0	.30	.62	15,748	65° F.	-	29.3
12.24	24.92	632,968	203° F.	-	5	.26	.52	13,208	60° F.	-	29.4
9.78	19.92	505,968	192° F.	-	10	.21	.42	10,668	54° F.	-	29.5
7.33	14.92	378,968	179° F.	-	15	.16	.32	8,128	47° F.	-	29.6
4.88	9.92	251,968	161° F.	-	20	.11	.22	5,588	37° F.	-	29.7
2.41	4.92	124,968	133° F.	-	25	.06	.12	3,048	23° F.	-	29.8
.95	1.92	48,768	100° F.	-	28	.04	.08	2,000	15° F.	-	29.84
.45	.92	23,368	77° F.	-	29	.03	.06	1,500	9° F.	-	29.86
.41	.82	20,828	74° F.	-	29.1	.02	.04	1,000	1° F.	-	29.88
.35	.72	18,288	69° F.	-	29.2	.01	.02	500	-12° F.	-	29.90

The above table clearly illustrates the reduction of the boiling point of water with a reduction of pressure. It is clear that at normal room temperatures, dehydration by evacuation requires pressures below 0.40 psia, which means a corresponding vacuum reading at sea level of 29.2 inches of mercury. At pressures above that, boiling simply would not take place. From a practical standpoint, much lower pressures are necessary to create a temperature difference to the boiling water so that heat transfer can take place, and also to offset pressure drop in the connecting lines which is extremely critical at very low pressures. Pressures from 1,500 to 2,000 microns are required for effective dehydration, and equipment to accomplish this is normally described as being designed for high vacuum work. Heat should be applied to systems which are known to contain free water to aid in evacuation.

Table 50

COMPARISON OF GAUGE AND ABSOLUTE PRESSURES AT VARYING ALTITUDES

Altitude	PSIG	PSIA	Pressure In Inches Hg	Boiling Point Of Water	Refrigerant Boiling Points		
					R-12	R-22	R-502
0 ft.	0	14.7	29.92	212° F.	-22° F.	-41° F.	-50° F.
1000 ft.	0	14.2	28.85	210° F.	-23° F.	-43° F.	-51° F.
2000 ft.	0	13.7	27.82	208° F.	-25° F.	-44° F.	-53° F.
3000 ft.	0	13.2	26.81	206° F.	-26° F.	-45° F.	-54° F.
4000 ft.	0	12.7	25.84	205° F.	-28° F.	-47° F.	-56° F.
5000 ft.	0	12.2	24.89	203° F.	-29° F.	-48° F.	-57° F.

It is important to remember that gauge pressures are only relative to absolute pressure. The table shows relationships existing at various elevations assuming that standard atmospheric conditions prevail. Obviously, a given gauge pressure at varying elevations may actually reflect a wide variation in actual absolute pressures.

Factors Affecting Vacuum Pump Performance

A vacuum pump suitable for refrigeration work must not only be capable of pulling a high vacuum, but must be capable of maintaining that vacuum on the system for prolonged periods. As moist air is pumped through the vacuum pump, the moisture will seek to condense in the vacuum pump oil sump, and once the oil is saturated, water vapor escaping from the oil may prevent the pump from achieving a high vacuum. Unless the pump is specifically designed to prevent this condition, the oil may become saturated before one evacuation job is completed.

In order to prevent condensation, some vacuum pumps have a vented exhaust or gas ballast feature. Basically this involves allowing a small bleed of atmospheric air to enter the second stage of a two stage pump, or the discharge chamber of a single stage pump prior to the discharge stroke to prevent condensation of water during compression.

Since reciprocating pumps lose efficiency at vacuums greater than 27 inches of mercury, rotary pumps are primarily used for high vacuum work. Single stage vacuum pumps are available which are capable of pulling a very high vacuum, but in general they are vulnerable to oil contamination, and if the exhaust is vented to protect the oil, then the pump's efficiency is reduced. Although single stage pumps may be quite satisfactory for small systems, for best high vacuum performance in refrigeration usage a two stage vacuum pump with gas ballast on the second stage is recommended.

Even at extremely low pressures, it is essential that the system to be evacuated is at a temperature high enough to insure boiling of any water to be removed. With pressures of 2000 microns and below, normal room temperatures of 70° F. to 80° F. are adequate. Evacuation at temperatures below 50° F. is not recommended.

If a great deal of moisture must be removed from a system by the vacuum pump, the oil may become saturated with moisture despite the gas ballast feature or the best pump design. Once this has occurred, the only solution is to change the oil in the vacuum pump. Even with the best vacuum pump, frequent oil changes are necessary to maintain efficiency. It is recommended that the oil be changed before each major evacuation.

If there is any possibility that large amounts of water may be trapped in a system, the lines should be blown out with refrigerant or dry nitrogen prior to attaching the vacuum pump. This will not only aid in prolonging the life of the pump, it will materially decrease the time required to evacuate the system. If it is known that a system is saturated with water, for example after the rupture of tubes in a water cooled condenser, a special low temperature moisture trap should be installed in the suction line ahead of the vacuum pump intake. Suitable traps are available from vacuum pump manufacturers.

One factor that is not fully appreciated by most servicemen is the critical nature of the pressure drop that occurs due to restrictions in the line during evacuation. For field evacuation with portable vacuum pumps, lines connecting the vacuum pump to the system should be a minimum of ¼″ I.D. on small systems, and on larger systems at least ½″ I.D. copper tubing should be used. Evacuating valves are recommended for every system. These should be installed in both the suction and liquid lines, and should be at least as large as the connecting lines. The typical serviceman's manifold and charging hose will cause sufficient restriction to prevent a high vacuum being reached, and compressor service valves are also unsatisfactory for high vacuum work. If restrictions exist in the connecting lines, gauges at the vacuum pump will reflect pump pressure, but will not give a true picture of pressures in the system.

The speed with which a system may be evacuated depends on both the displacement of the vacuum pump and the size of the connecting lines and fittings. A good high vacuum pump has a very high pumping efficiency down to absolute pressures of 1,000 microns and below, possibly as high as 85% to 90% or more. This means that a vacuum pump with 1 CFM displacement may still be capable of pumping up to .9 CFM with a suction pressure of 1,000 microns and discharging to atmosphere.

However, a vacuum pump's performance can be greatly reduced by the size of connecting lines and fittings. In the low or medium vacuum range, this may not greatly affect a pump's efficiency, but at pressures below 5,000 microns the pump's net capacity can decrease rapidly. The following comparison is based on one pump manufacturer's catalog information on pumping speed of rotary vacuum pumps.

Basic Pumping Speed with no restriction on inlet	Net Pumping Speed with 6 foot connection		
	¼″ I.D.	⅜″ I.D.	½″ I.D.
Inlet pressure, 2,000 microns			
1 CFM	.37 CFM	.74 CFM	.93 CFM
2 CFM	.46 CFM	1.18 CFM	1.75 CFM
5 CFM	.54 CFM	1.84 CFM	3.7 CFM
Inlet pressure, 1,000 microns			
1 CFM	.23 CFM	.60 CFM	.87 CFM
2 CFM	.26 CFM	.83 CFM	1.5 CFM
5 CFM	.29 CFM	1.11 CFM	2.95 CFM

It is interesting to note that more efficiency can be gained by increasing the connecting line size on a 1 CFM pump from ¼″ I.D. to a larger size than can be gained by putting a 5 CFM pump on the same ¼″ connection.

Calculations to determine pull down time are quite complicated, since the pump's efficiency changes with the reduced pressure, and the size and length of the connecting lines may greatly affect the performance of a given pump. The following estimate of pull down time is based on one manufacturer's catalog data, but because of the assumptions that must be made in the calculation, the figures are at best an approximation.

ESTIMATED TIME REQUIRED FOR SYSTEM PULL DOWN
based on 5 cubic feet internal volume

Pump Displ.	Conn. Line (6′)	Final absolute pressure	
		1,500 microns	500 microns
1 CFM	¼″ I.D.	57 min.	78 min.
2 CFM	¼″ I.D.	39 min.	56 min.
5 CFM	¼″ I.D.	28 min.	43 min.
1 CFM	⅜″ I.D.	40 min.	51 min.
2 CFM	⅜″ I.D.	22 min.	29 min.
5 CFM	⅜″ I.D.	12 min.	16 min.
1 CFM	½″ I.D.	37 min.	45 min.
2 CFM	½″ I.D.	19 min.	23 min.
5 CFM	½″ I.D.	8 min.	10 min.

The above table provides a good comparison of relative pump performance. It is quite clear that if a connecting line no larger than ¼″ I.D. is to be used, there is little to be gained by going to a larger vacuum pump. For large systems it is obvious that both a good sized vacuum pump and a large connecting line are necessary if the required time is to be held to a minimum. The pull down time will vary directly with the internal volume of a given system, so for smaller systems the 1 CFM pump may be perfectly satisfactory.

Measurement of Vacuum

As indicated earlier, the refrigeration serviceman's gauge reads pressure only in relation to absolute pressure, and a given gauge reading may cover a wide range of actual pressures. For this reason, and also because the ordinary bourdon tube compound gauge is not designed for the extreme accuracy required in evacuation work, a special vacuum gauge is required for high vacuum readings.

For accurate pressure readings in the micron range for refrigeration use, a thermocouple vacuum gauge is recommended. This type of gauge is relatively inexpensive, easy to operate, rugged enough for field use, and requires little or no maintenance. The advantage of this gauge where moisture may be encountered in a system is that it measures not only the pressure due to residual gases, but also the pressure contributed by any water vapor remaining in the system. The McLeod type gauge is widely used in laboratory work, and is highly accurate for readings where moisture is not a factor, but it is not recommended for use in refrigeration work since it will not measure the pressure due to water vapor.

Triple Evacuation

In order to insure a complete evacuation, Copeland recommends a triple evacuation, twice to 1,500 microns and the final time to

500 microns. The vacuum should be broken to 2 psig each time with the same type of refrigerant to be used in the system.

It is quite possible that the original evacuation, if not continued for a sufficient period of time may not completely remove all of the air and moisture from the system. Breaking the initial vacuum with dry refrigerant allows the fresh refrigerant to absorb and mix with any residual moisture and air, and the succeeding evacuation will remove a major portion of any remaining contaminants. If for example, each evacuation removed only 98% of the contents of the system, and any remaining contaminants mixed thoroughly with the refrigerant used to break the vacuum, after the triple evacuation the remaining contaminant percentage would be 2% x 2% x 2% or .0008%. The residual contaminants have been reduced to such a low level they no longer are a danger to the system. This illustrates why triple evacuation is increasingly important if the vacuum pump is not of the highest efficiency, or if the evacuation time is not adequate to insure complete evacuation.

Many manufacturers use process pressures of 50 to 100 microns. However, in field evacuation, pressures in this range are very difficult to reach, particularly if refrigerant has been allowed to mix with oil in the system. The refrigerant will escape from the oil very slowly, and the time required to reach such low pressures might be quite unreasonable. The triple evacuation method to a pressure of 500 microns is practical under field conditions, and represents a specification that can be met.

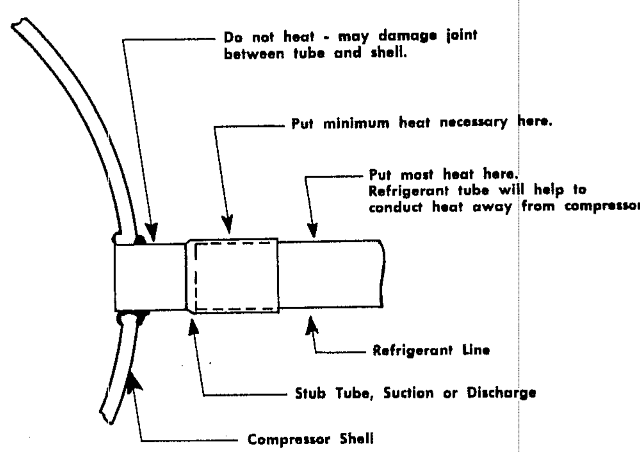
For manufacturers having process equipment, the use of dry air with a dew point below -60° F. in place of refrigerant for dehydration in connection with a triple evacuation to the pressures described above is also highly recommended.

To evacuate a system properly requires time and care. Any slight carelessness in protecting the sealed system can undo all the precautions taken previously. But the slight extra effort required to make an evacuation properly and completely will pay big dividends in reduced maintenance and trouble free operation.

BRAZING CONNECTIONS ON COPELAWELD MOTOR-COMPRESSORS

Suction and discharge line connections to Copelaweld motor-compressors are normally made by brazing the refrigerant lines directly into stub tubes on the compressor with a silver brazing alloy. Occasionally the joint between the stub tube and the steel shell is damaged by overheating during factory or field installation when the refrigerant line connections are made. This type of damage can be avoided by proper care during the brazing operation.

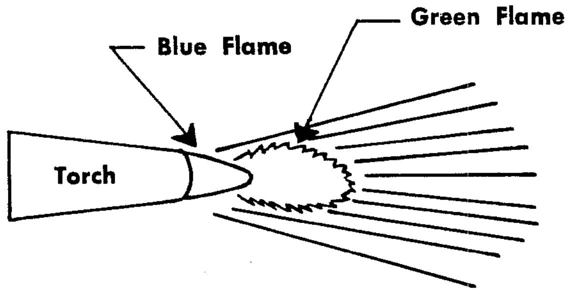
The connection between the stub tube and the shell is made with a 35% silver brazing alloy which has a melting range of 1125° F. to 1295° F. The temperature of this joint must be kept below this range during the line brazing operation to avoid damage.



TYPICAL BRAZED CONNECTION TO COMPRESSOR STUB TUBE

Figure 111

Figure 111 illustrates a typical suction line connection. The torch flame should be used primarily on the refrigerant line, with only enough heat applied to the stub tube to make the connection properly. Heat will be conducted into the joint area from the refrigerant line. The torch flame should have a greenish "feather" extending from the tip of the inner blue cone as illustrated in Figure 112. Heat should be applied to both sides of the tube, and the flame should be moved continuously in a circular motion to distribute the heat, and prevent overheating of the tubing. Compressors with damaged joints usually show evidence of the torch flame having been allowed to burn directly on the compressor shell and the stub tube-shell joint.



RECOMMENDED BRAZING FLAME

Figure 112

Copeland recommends that a low melting point alloy such as Easy-Flo or Easy-Flo 45 be used in making the line joint rather than a higher melting point alloy such as Sil-Fos. The heat necessary to make a Sil-Fos joint is somewhat greater than required for Easy-Flo, making it more difficult to avoid overheating. Another advantage of a lower temperature brazing alloy is the reduced annealing effect which takes place, thus resulting in a stronger joint.

To assure a sound, leak tight tubing connection without overheating, the surfaces must be properly cleaned and a suitable flux must be used. A low temperature brazing flux that is fully liquid and active below the flow point of the silver brazing alloy is required. Only the male connection should be fluxed, and only enough flux should be used to adequately cover the surface. Excess flux allowed to enter the system can cause starting failures on PSC motors, plug filters and valves, and may cause other complications due to chemical reactions.

Table 51

MELTING POINTS OF TYPICAL COMMERCIAL BRAZING COMPOUNDS

Type	Typical Commercial Description	Silver Content	Starts To Flow	Free Flowing At
Silver Solder	Easy-Flo, Unibraze 50	50%	1160	1175
Silver Solder	Easy-Flo 45, Unibraze 45	45%	1125	1145
Silver Solder	Easy-Flo 35, Unibraze 35	35%	1125	1295
Phosphor-Copper-Silver	Sil-Fos, Unibraze 15	15%	1185	1300 - 1460
Phosphor-Copper-Silver	Sil-Fos, Unibraze 5	5%	1185	1300 - 1485
Phosphor-Copper	Phos-Copper, Unibraze 0	—	1300	1450

INSTALLATION OF SUCTION AND DISCHARGE LINE VIBRATION ABSORBERS

In order to prevent the transmission of noise and vibration from the compressor through the refrigeration piping, vibration eliminators are often required in the suction and discharge lines. On small units where small diameter soft copper tubing is used for the refrigerant lines, a coil of tubing may provide adequate protection against vibration. On larger units, flexible metallic hose is frequently used.

Metallic vibration absorbers should be selected to have the same or greater internal diameter than the connecting piping. Because of the convolutions of the inner wall of the absorber, excessive refrigerant gas velocity can cause whistling and noise problems.

Unless properly installed, stress resulting from line movement may cause failure of the vibration absorber, and possibly can lead to line breakage. Because of its construction, a metallic vibration absorber can easily adjust to movement in a radial direction, but it must not be subjected to stress in either compression or extension. Some manufacturers recommend using two vibration absorbers at right angles, but normally this is not necessary on Copeland compressors.

Copeland recommends installation parallel to the crankshaft, as close to the compressor as possible. The starting torque of the motor will tend to rock the compressor from side to side when starting, and mounting parallel to the crankshaft will allow the absorber to easily adjust to the movement.

Vibration absorbers may be installed in a vertical position if the joints are sealed against trapping of condensation which might damage the bellows due to freezing. Filling of the joints with soft solder as a means of sealing is recommended. Flexible metal hoses are available with a neoprene jacket which protects the absorber against any possible damage from condensation or moisture.

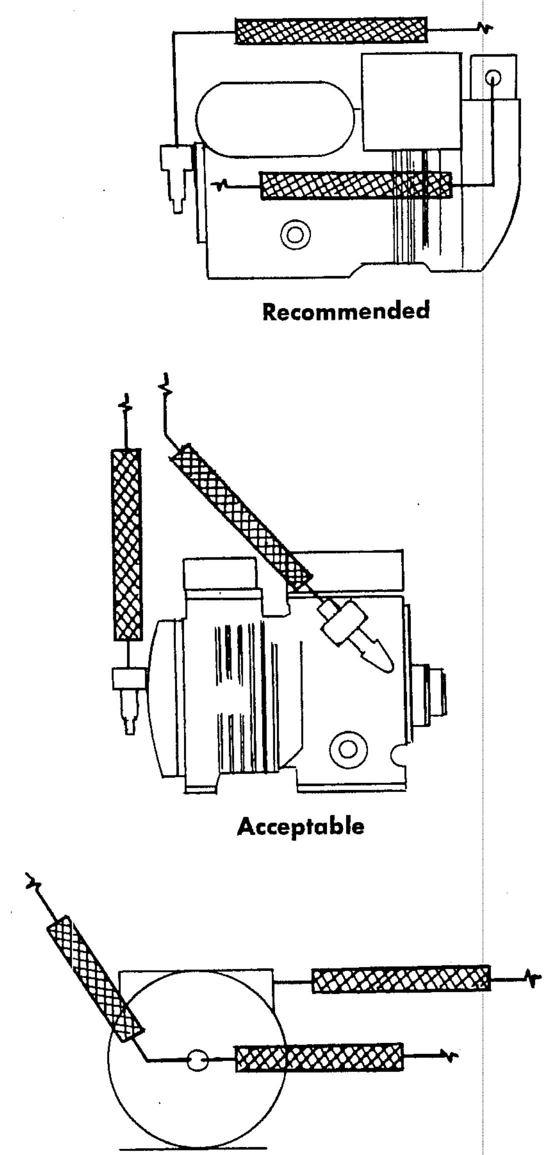
Installation at an angle 45° from the vertical and parallel to the crankshaft is acceptable, although horizontal or vertical installation is preferred. A 45° angle installation at right angles to the compressor crankshaft can actually act as a brace, causing compression stress, and is not acceptable.

Installation in the horizontal plane at right angles to the crankshaft is not acceptable, since compressor movement would tend to either compress or extend the absorber, and early failure of the absorber or connecting fittings could result.

The line connected to the end of the absorber opposite the source of vibration should be firmly anchored to a solid member. No movement will then be transmitted into the refrigerant lines beyond. Where a vertical or 45° mounting is used, the piping must be arranged so that sufficient allowance for movement is made. As a convenient means of checking the installation, a spring mounted compressor should be free to bottom solidly on the mounting pad or mounting snubber without stressing the absorber. The refrigerant lines should be in proper alignment prior to installation of the absorber, and sufficient space should be allowed so that it can be installed without being either stressed or compressed.

Internal joints of metallic vibration absorbers are often made up with a brazing compound which has a melting point of approximately 1,300° F. In order to avoid damage to the internal joints, line connections should be made with a silver solder alloy having a melting temperature below 1,200° F.

NOTE: Mount as close to the compressor as possible.



Recommended

Acceptable

Not Acceptable

INSTALLATION OF VIBRATION ABSORBERS

Figure 113

TYPICAL INSTALLATION SPECIFICATIONS

On large field installed refrigeration and air conditioning systems, it is advisable to have a written specification covering the work to be done and the responsibilities of each party. The specification is an aid in assuring a clear understanding of the contractor's responsibility prior to the start of the job, so that disputes and disagreements may be eliminated.

Specifications may vary from a short paragraph covering the scope of the work to a detailed description of the work to be done. The following specification is typical of the type frequently used on supermarket or other large commercial refrigeration installations, and is readily adaptable to different types of applications.

Typical Specification

Large Commercial Refrigeration and Air Conditioning Installation

1. Definition of Terms

   1.1 "Contractor" shall mean the refrigeration installation contractor.

   1.2 "Owner" is ....

   1.3 "Manufacturer" shall mean the company or companies which will supply various equipment such as fixtures, compressors, coils, etc.

   1.4 "Refrigeration Installation" shall mean the necessary labor and all parts and accessories necessary to complete the work outlined in this specification.

2. Scope of Work

   2.1 These specifications are intended to cover the installation of compressors, condensers, coils, condensing units, fixtures, and all other fittings, devices, and accessories required to complete the refrigeration systems as shown or called for on the refrigeration plans and schedules. The omission from these specifications or from the refrigeration plans and schedules of express reference to any parts necessary for the complete installation is not to be construed as releasing the contractor from responsibility for furnishing such parts.

   2.2 For details of installation refer to the fixture plan, refrigeration schedule, floor plan, plumbing plan, electric plan, air conditioning, heating, and ventilating plan, manufacturer's installation instructions, and to applicable codes and ordinances.

   2.3 The Contractor shall furnish and install any necessary refrigerant piping, fittings, vibration eliminators, line valves, solenoid valves, crankcase pressure regulating valves, thermostatic expansion valves, dehydrators, strainers, sight glasses, moisture indicators, refrigerant, oil, filters, insulation and all fittings and accessories necessary to make a complete installation unless otherwise specified, together with all labor required to complete the installation and perform the service covered by this specification. The Contractor is responsible for unloading, assembling, and installing all fixtures, coolers, coils, compressors, condensing units, air conditioners, condensers, and other refrigeration equipment unless otherwise specified. The Contractor shall also arrange for the removal of crating and packing materials, and shall leave the uncrating area and the compressor room clean and neat.

   2.4 The Contractor shall familiarize himself with the project, and shall cooperate with other contractors doing work on the building. If any conflict, interference, or discrepancies come to the attention of the contractor, he shall notify the owner immediately before proceeding any further with the installation.

2.5 No additional payment over and above the contract price will be made unless the Contractor receives a written order by the Owner or his representative for the addition.

2.6 Equipment and services shall be furnished as follows:

	To Be Furnished By		
	Owner	Contractor	Others
Refrigerated fixtures			
Coils for coolers			
Air conditioning units			
Air conditioning temperature controls			
Air cooled condensers			
Compressors			
Condensing units			
Refrigeration system controls			
Coolers & freezers (walk in)			
Coolers & freezers (reach in)			
Ventilation and exhaust fans and controls			
Cooling tower and controls			
Plumbing			
Sheet metal, duct work, dampers, etc.			
Motor starters and protectors			
Electrical wiring, disconnect switches, and connections			

3. Fees, Permits, Licenses, and Insurance

3.1 All necessary permits and licenses incident to the work and required by local ordinance shall be secured and paid for by the contractor. All equipment shall be installed in strict compliance with all local building codes and ordinances.

3.2 The Contractor shall not commence work under this contract until he has obtained all the insurance required hereunder, and has filed certificates to that effect with the Owner. The Contractor shall indemnify and hold harmless the Owner for any and all claims, suits, losses, damages, or expenses on account of bodily injury, sickness, disease, death, and property damage as a result of the Contractor's operations, acts, omissions, neglect or misconduct in connection with this project. Insurance coverage shall include but is not limited to

(a) Contractor's Public Liability Insurance
(b) Contractor's Contingent Liability Insurance
(c) Property Damage Insurance
(d) Automotive Public Liability Insurance
(e) Automotive Property Damage Insurance

4. Refrigerants

4.1 Refrigerants used shall be R-12, R-502, or R-22. R-502 or R-12 shall be used in all cases where the refrigerant evaporating temperature is to be -20° F. or below. Use only that refrigerant in any equipment for which the equipment was designed by the Manufacturer. Use only one refrigerant in a system.

4.2 The refrigerant shall be delivered to the job in original containers.

5. Refrigerant Piping Materials

5.1 Unless otherwise specified, all refrigeration piping shall be refrigeration grade Type L or Type K hard drawn degreased sealed copper tubing. Alternate proposals may be submitted for the use of Type L refrigeration grade soft copper tubing for long under-floor runs only providing runs are straight and free from kinks and bends.

5.2 Extreme care shall be taken to keep all refrigerant piping clean and dry. It shall be kept sealed except when cutting or fabricating. Each length shall be inspected and swabbed with a cloth soaked in refrigeration oil if any dirt, filings, or visible moisture are present.

5.3 All sweat-type fittings shall be wrought copper or forged brass. All elbows and return bends shall be of the long radius type. If flare fittings are required, they shall be of the frost proof type, (except on connections not subject to condensation), and constructed of forged brass. Soldered joints are preferred and shall be used wherever practical.

6. Refrigerant Piping Installation

6.1 Tubing shall be installed in a neat, workmanlike manner with horizontal runs sloped toward the compressor at a rate of 1″ per 20′. All lines shall be supported at intervals of not more than 8′ and suitably anchored. Rubber grommets shall be used between tubing and clamps to prevent line chafing.

6.2 Where vertical risers of more than 5 feet occur in a suction line, the riser shall be trapped at the bottom.

6.3 Where a branch suction line enters a main suction line it shall enter at the top. Piping shall be arranged so refrigerant or oil cannot drain from the suction line into the coil.

6.4 Individual fixture or unit suction and liquid lines shall be of the size recommended by the Manufacturer as shown in the applicable installation and service instructions. Liquid and hot gas refrigerant lines shall be sized in accordance with good industry practice to avoid excessive pressure drops. Branch and main suction lines shall be sized to maintain adequate velocities to properly return oil to the compressor under minimum load conditions at the lowest saturated suction pressure to be expected.

6.5 All joints in the compressor discharge line shall be brazed with a suitable high temperature silver solder alloy containing not less than 15% silver. Use only a suitable silver solder alloy on all copper to copper connections in the suction line and liquid line. At any copper to brass joint where damage could occur from excess heat use 95/5 solder. Use a solder with at least 35% silver content on all copper to steel, brass to steel, or steel to steel joints. During the brazing operation, dry nitrogen must be bled through the piping at very low pressure to prevent oxidation and scaling.

6.6 In order to avoid damage to the internal Silfos joints in vibration eliminators, line connections to vibration eliminators are to be made with a silver solder alloy such as Easy-Flo having a melting temperature of 900° F. to 1,200° F. (well below the 1,300° F. melting point of Silfos).

6.7 To prevent contamination of the line internally, limit the soldering paste or flux to the minimum required. Flux only the male portion of the connection, never the female.

6.8 Suction lines from low temperature cases shall be insulated where run below the floor level. All exposed suction lines, both low and medium temperature, shall be insulated as necessary to prevent condensation.

6.9 Insulation shall be of the cellular type such as Armstrong "Armaflex" or equal, shall fit the tubing snugly, and shall be applied and sealed in accordance with the Manufacturer's instructions.

6.10 The refrigerant piping shall be adequately protected. Permanent guards shall be installed as required to protect the piping and fittings from damage. Metal pipe sleeves shall be provided where tubing passes through a concrete wall or floor, and the space around the tubing shall be filled with a mastic insulating compound.

6.11 Arrange the piping so that normal inspection and servicing of the compressor and other equipment is not hindered. Do not obstruct the view of the crankcase oil sight glass, or run piping so that it interferes with removal of the compressor or other components.

6.12 Tubing installed in trenches or conduit under the floor must be level to prevent oil trapping. Guard against deformation or damage from trucks carrying heavy loads, or cement being poured.

7. Installation of Accessories

7.1 Vibration eliminators shall be installed in the suction and discharge lines of all compressors with spring or flexible mounting. The vibration eliminator must be applied according to the Manufacturer's recommendations. For Copelametic compressors, the vibration eliminator should be mounted parallel to the crankshaft, as close to the compressor as possible. Installation in a horizontal plane at right angles to the crankshaft is not acceptable, since the resulting stress from compressor movement may cause failure of the vibration absorber. If installed in a vertical position, the eliminator joints must be sealed against dripping from condensation to protect from freezing.

7.2 A solder type combination liquid sight glass and moisture indicator shall be installed in each system and located for easy visibility.

7.3 If liquid line driers are not otherwise specified, they shall be of the filter-drier type, and of the size recommended by the Manufacturer. Drier cartridges shall not be installed until the second evacuation has been completed.

7.4 Two evacuation fittings are necessary. One should be in the suction line at the inlet side of the suction line filter, and one should be in the liquid line at the outlet side of the filter-drier. If properly valved, the connection in the liquid line may serve as a charging valve. After evacuation and charging, the fittings are to be capped or removed. Connections should be at least 3/8" and preferably 1/2" in size.

7.5 A permanent suction line filter shall be installed in each compressor suction line. A pressure fitting must be provided ahead of the filter, preferably in the shell, to facilitate checking the pressure drop. If the pressure drop across the filter is in excess of 1 psig after the initial 24 hours of operation, the suction line filter cartridge shall be replaced, or if the filter is of the sealed permanent type, the filter shall be replaced.

8. Drain Connections

8.1 Unless otherwise specified, condensate drains from coils and cases to the floor drain will be the responsibility of the Contractor. No drain line shall be smaller than the coil drain pan connection. All drain lines shall be hard copper tubing except for those in reach-in coolers. Lines should be sloped adequately to drain by gravity any water accumulated from condensing, defrosting, or cleaning operations. All condensate lines from refrigerated fixtures must be trapped and run to an open drain. They must not be connected directly to the sewer system. If necessary for cleaning, threaded unions shall be provided in the most accessible location near the fixture.

9. Testing, Evacuation, and Charging

9.1 The Contractor shall notify the Owner 24 hours in advance of any test so that the Owner and/or Manufacturer's representative may be present for the test if desired.

9.2 When the refrigeration connections have been completed, the system shall be tested at a minimum of 150 psig with the compressor suction and discharge valves closed, and all other valves in the system open. (If local codes require higher test pressures, such codes must be complied with). Sufficient liquid refrigerant shall be charged into the system to raise the pressure to 35 psig, and dry nitrogen added to obtain the desired test pressure. Leak testing shall be performed with an electronic leak detector, unless the use of a halide torch is specifically authorized by the Owner. Refrigeration piping will not be acceptable unless it is gas tight. If any leaks are found, isolate the defective area, discharge the gas and repair the leaks, and then repeat the test. When testing has been completed, release all pressure freely to the atmosphere.

9.3 The system shall be evacuated with a vacuum pump specifically manufactured for vacuum duty, having a capability of pulling a vacuum of 50 microns or less. Evacuation of the system must never be done by the use of the refrigeration compressor. The pump should be connected to both the low and high side evacuation valves with copper tube or high vacuum hoses. (¼" I.D. minimum). The compressor service valves should remain closed. A high vacuum gauge capable of registering pressure in microns should be attached to the system for pressure readings. Hermetic or accessible-hermetic motor compressors must not be operated during evacuation because of the reduced dielectric strength of the atmosphere within the motor chamber. To check system pressure, a hand valve must be provided between the pressure gauge and the vacuum pump which can be closed to isolate the system and check the pressure.

9.4 Evacuate each system to an absolute pressure not exceeding 1,500 microns. Break the vacuum to 2 psig with the refrigerant to be used in the system. Repeat the evacuation process, again breaking the vacuum with refrigerant. Install a drier of the required size in the liquid line, open the compressor suction and discharge valves, and evacuate to an absolute pressure not exceeding 500 microns. Leave the vacuum pump running for not less than two hours without interruption. Raise the system pressure to 2 psig with refrigerant, and remove the vacuum pump.

9.5 Refrigerant shall be charged directly from the original drums through a combination filter-drier. Each drier may be used for a maximum of three cylinders of refrigerant, and then must be replaced with a fresh drier. Charge the system by means of a charging fitting in the liquid line. Weigh the refrigerant drum before charging so that an accurate record can be kept of the weight of refrigerant put in the system. If refrigerant is added to the system through the suction side of the compressor, charge in vapor form only.

10. Start-Up

10.1 Compressors and condensing units will normally be delivered to the job with sufficient oil for the average installation. Check all compressors for proper oil level, and if necessary add sufficient oil to bring the level to the center of the crankcase sight glass. Use only the refrigeration oil recommended by the compressor manufacturer. All oil must be delivered to the job in factory sealed, unopened containers.

10.2 Before operating any motor or other moving parts, they are to be lubricated with the proper oil or grease as necessary.

10.3 Remove or loosen shipping retainers under motor compressors. Make sure hold down nuts on spring mounted compressors are not touching the compressor feet, and are not more than 1/16" above the mounting foot.

10.4 Check high and low pressure control cut-in and cut-out points. Check water valve settings. Adjust if necessary.

10.5 After the compressor is started, continue charging until system has sufficient refrigerant for proper operation. Do not overcharge. During start-up, no compressor is to be left operating unattended and unwatched until the system is properly charged with refrigerant and oil.

10.6 Do not add refrigeration oil while the system is short of refrigerant unless oil level is dangerously low. If oil has been added during charging, carefully check the compressor crankcase sight glass after reaching a normal operating condition to be sure the system does not contain an excessive amount of oil which can cause slugging or loss of refrigerating capacity.

10.7 The temperature controls shall be set to maintain the following temperatures in the center of the fixture before stocking:

FIXTURE	TEMPERATURE °F. (Minimum)	(Maximum)
Meat walk-in cooler	31	33
Meat holding cooler	29	31
Self-Service meat counter	31	33
Dairy walk-in cooler	36	38
Self-Service dairy case	36	38
Produce walk-in cooler	38	40
Self-Service produce counter	38	40
Self-Service beverage case	38	40
Frozen food storage cooler	-15	-10
Self-Service frozen food case	-5	0
Self-Service ice cream case	-15	-10
Meat preparation room	54	56

11. Operation and Check-Out

11.1 The Contractor shall be responsible for the proper adjustment of all controls in the system, including the controls on each refrigeration circuit, air temperature controls in the machine room, remote condenser or water tower controls, water regulating valves, or such other controls as may be required.

11.2 The Contractor shall check the compressor overload protectors with the manufacturer's specifications, and inform the Owner if they are incorrect.

11.3 The Contractor shall furnish a competent refrigeration service mechanic to check and make any necessary adjustments to the controls during the time the fixtures are being stocked. The mechanic shall remain at the store for at least 8 hours during the first day the store is open for business beginning 1 hour before opening time.

12. Identification and User Instruction

12.1 Each refrigerated fixture and cooler coil should be numbered starting at No. 1. These numbers shall be not less than 1″ in height and shall be stenciled or marked neatly on the fixture in an inconspicuous location easily available to the serviceman. The compressors or condensing units serving the fixtures should be marked with the numbers of the cases and coils served with figures not less than 1½″ in height.

12.2 All switches, starters, and controls shall be identified as to the fixture or condensing unit they serve.

12.3 The Contractor shall turn over to the Owner one copy of all manufacturer's literature furnished with each piece of equipment. Within 30 days after the store is opened, the Contractor shall instruct the store management on the proper operation, care and upkeep of all equipment.

12.4 A permanent data sheet shall be prepared on each installation with two copies for the Owner and the original for the installing Contractor's files. The data sheet shall contain a complete record of sizes and identification of all components used in the installation together with any pertinent information. The data sheet should include but is not limited to the following:

A. Compressor manufacturer, model, and serial number.
B. Fixture manufacturer, model, and serial number.
C. Design operating temperatures.
D. Condensing unit model, and serial number. (If package condensing unit)
E. If remote condenser, type, manufacturer, model, fan data.
F. Refrigerant and weight of charge.
G. Electrical service, volts, phase, cycles, wire size.
H. Control circuit, voltage, fuse size.
I. Contactor or starter, manufacturer, model, size, part number.
J. Compressor motor protection, type, size, part number.
K. Data on capacitors, relays, or other electrical components.
L. Pressure control, type, size, model number, setting.
M. Oil pressure safety control, type, model number.
N. Defrost control, type, manufacturer, model number, setting.
O. Data on miscellaneous refrigeration system components such as pressure controls, winterizing controls, oil separators, crankcase heaters, solenoid valves, valves, etc.
P. Liquid line drier, manufacturer, size, model number, connections.
Q. Schematic diagram of refrigerant piping.

13. Warranty and Guarantees

13.1 All equipment and material supplied and installed by the Contractor shall be guaranteed for one year from the date of the store opening. The Contractor shall provide the necessary labor, materials, and incidental expenses to maintain the equipment in proper operation for a period of one year from the date the store opens for business, without additional cost to the owner. (Temperature rises caused by improper stocking or abnormal air currents shall not be the responsibility of the Contractor). The service shall not include repairs or replacements due to damage by fire, earthquake, tornado, the elements or act of God, or damage caused by misuse of the system by the Owner, power failures, broken glass, or lightning.

13.2 Official acceptance of the completed job shall be when the job is complete in every detail and has been run under load conditions with satisfactory performance for a period of at least one week.

13.3 In the event any equipment furnished by the Owner is found to be defective, the Owner will compensate the Contractor for the labor and material used in replacing the equipment or repairing the defects.

13.4 The first year service shall include at least three complete lubrications at approximately 4 month intervals. At the time the equipment is lubricated, each system shall be checked for proper adjustment, and any necessary repairs or corrections shall be made.

13.5 Approximately 30 days prior to the expiration of the one year warranty period, the Contractor shall make a final inspection, checking each system for proper adjustment, and correcting any deficiencies, and shall write the Owner a letter certifying that each system is free of leaks and is operating at the specified temperature.

Section 25
SERVICING COPELAND COMPRESSORS

Copeland manufactures both welded (Copelaweld) and accessible hermetic (Copelametic) motor-compressors. Welded compressors cannot be repaired internally in the field, and service operations on these compressors are limited to external electrical components and normal system repairs.

Copelametic motor-compressors are specifically designed for field accessibility if required. Removable heads, stator covers, bottom plates and housing covers allow access for easy field repairs in the event of compressor damage.

The description of service operations that follows is general in nature, but those sections dealing with internal maintenance apply only to Copelametic compressors.

COPELAND NAMEPLATE IDENTIFICATION

The model number designation on Copeland compressors and condensing units provides a basic identification of the electrical and physical characteristics. The model numbering system for Copelametic compressors is shown in Figure 114, for Copelaweld compressors in Figure 115, and for condensing units in Figure 116.

For example, model number 4RH1-2500-TMK-105 identifies a Copelametic motor-compressor as follows:

4	Identifies compressor family
R	Identifies refrigerant cooled
H	Identifies 3020 CFH displacement
1	Identifies basic physical characteristics
2500	Identifies nominal 25 HP
T	Identifes three phase
M	Identifies Thermotector motor protection
K	Identifies 208/220/440/3/60 motor winding
105	Identifies specific bill of material identifying valves or other optional features

The serial number provides both an identification number and a record of the date of manufacture. It is comprised of 8 digits. The first two identify the year of manufacture. The third digit is a code letter identifying the month of manufacture, the twelve months of the year being denoted by the first twelve letters of the alphabet (A for January, B for February, etc.). The last five digits are assigned in numerical order during each month's production.

The manufacturer of the motor used in the motor-compressor is also shown by a code letter preceding the serial number. Code letters are as follows:

C	Century
D	Delco
E	Emerson
G	General Electric
S	A. O. Smith
W	Wagner

To illustrate, a typical serial number might be C 69G19417. This would indicate:

C	Century Motor
69G	Manufactured in July, 1969
19417	Indentification number

The motor electrical characteristics are also stamped on the nameplate. The motor may be operated at voltages plus or minus 10% of the nameplate rating.

Most Copeland motor-compressors have a basic nameplate rating for both locked rotor and full load amperes based on motor test data. The designation full load amperage persists because of long industry precedent, but in reality a much better term is nameplate amperage. On all Copelaweld compressors, all new motors now being developed for Copelametic compressors, and on most of the motors developed with inherent protection or internal thermostats, nameplate amperage has been

XXXX – XXXX – XXX – XXX

COPELAMETIC COMPRESSOR MODEL TYPE

Air-Cooled

Code	Description
A	Std. Air Cooled
B	Extended Shaft

Refrigerant-Cooled

Code	Description
R	Std. Refrig. Cooled
J	Extended Shaft

Water-Cooled

Code	Description
W	Std. Water Cooled

Two Stage

Code	Description
T	Std. Two Stage

Tandem Style Models

Indicated by the digit representing the comp. model series connected in TANDEM with a comp. of the model series indicated by the first digit.

COMPRESSOR FAMILY SERIES

Either a number or a letter established for each product model.

DISPLACEMENT AND VALVE PLATE

A letter only, arbitrarily assigned for each different displacement-valve plate combination within any one family series (Column 1)

MODEL VARIATIONS

A number assigned to indicate major variations within any one family series.

COMP. MOTOR RATING

Nominal (H.P.)	Code
1/12	0008
1/10	0010
1/8	0013
1/6	0017
1/5	0020
1/4	0025
1/3	0033
1/2	0050
3/4	0075
1	0100
1-1/4	0125
1-1/2	0150
1-3/4	0175
2	0200
2-1/2	0250
2-3/4	0275
3 (0310)	0300
3-1/2	0350
4	0400
5	0500
6	0600
7-1/2 (0760)	0750
9	0900
10 (1010)	1000
12	1200
15	1500
20	2000
25	2500
30	3000
35	3500
40	4000
50	5000
60	6000
75	7500
100	1100

COMPRESSOR MOTOR TYPE

Comp. Motor Type	Code
Capacitor Run - Capacitor Start (1 Ø)	C
Induction Run - Capacitor Start (1 Ø)	I
Split Phase - Induction Start & Run (1 Ø)	S
Low Torque - Cap. Start, Ind. Run (1 Ø)	X
Perm. Split Cap. - Cap. Start, Cap. Run (1 Ø)	P
Three Phase - (Except Code E)	T
Two Phase - (All)	D
Wye (Star) - Delta Motor (3 Ø)	E
Three Phase - 6 Lead Motors Only (Except 550V)	F

COMPRESSOR MOTOR PROTECTION

Type Protection	Code
External Inherent Protection - One Protector (SEIP) (Line Break) Use with Contactor (Single or Three Phase)	A *
External Thermal Protection Use with Starter and Heater Element (Three Phase)	B
Internal Thermostat (s); and External Amb. C'pensated Protector (s) and Contactor Assembly. Mt'd. Remote	D
Internal Inherent Protection - One Protector (IIP). Use with Contactor (Single or Three Phase)	F *
External Inherent Protection - Two Protectors (EIP) Use with Contactor mt'd. on Compressor (Three Phase)	G
Internal Thermostat (s); and Ext. Supplementary Protector (s) mt'd. on Compressor. (Two for 3 Ø, One for 1 Ø. Use with Contactor.	H *
Internal Inherent Protection (Pilot Duty) Use with Contactor	K *
Internal Thermostat (s); and Three Ext. Supplementary Protectors mt'd. on Compressor. Use with Contactor	L *
Internal Thermal Protectors - Anticipating Type (Pilot Duty). Use with Contactor (G.E. Thermotector)	M *
Internal Thermal Protectors - Electronic Sensors; and Control Module External. Use with Contactor	S *

*Thermally protected marked on nameplate to comply with N.E.C.

PRODUCT VARIATIONS

Numbers will be assigned as follows:

1. Numbers -001 through -199 are reserved for Sub-B/M Numbers.
2. Number -200 indicates a standard Compressor and Component Parts B/M and Model No.
3. Numbers -201 and larger will be assigned for all other variations of a given model.

VOLTS, PHASE, HERTZ

*(See Note)	Code
115-1-60	A
230-1-60	B
208/220-3-60	C
440-3-60	D
550-3-60	E
115-1-50	F
230-1-50	G
208-1-60	H
208/230-1-50	I
277-1-60	J
208/220/440-3-60	K
220/380-3-50	L
380-3-50	M
230/460-3-60	N
All D.C. Voltages	O
200/380-3-50	P
208/220-3-50	R
220-1-50	S
200-1-50	T
120/208-3-60	U
208/230-1-60	V
200-3-50	W
Miscellaneous Ratings	X
500-3-50	Y
208-1-50	Z

*NOTE: When applicable, 50 Hz rating will be shown as an alternate rating on 60 Hz rated models.

COPELAMETIC COMPRESSOR NAMEPLATE NOMENCLATURE

Figure 114

X X X X — X X X X — X X X — X X X

COPELAWELD (2 Pole Models-All)

Code	Description
R.	High Temperature
S.	Medium Temperature
F.	Low Temperature

COPELAWELD (4 Pole Models; 4U and U)

This second digit has no assignable significance.

COMPRESSOR MOTOR TYPE

Motor Type	Code
Capacitor Run - Capacitor Start (1 Ø)	C
Induction Run - Capacitor Start (1 Ø)	I
Split Phase - Induction Start & Run (1 Ø)	S
Low Torque - Cap. Start, Ind. Run (1 Ø)	X
Perm. Split Cap. - Cap. Start, Cap. Run (1 Ø)	P
Three Phase - (Except code E)	T
Two Phase - (All)	D
Wye (Star) - Delta Motor (3 Ø)	E
Three Phase - 6 Lead Motors Only (Except 550V)	F

PRODUCT VARIATIONS

Number will be assigned as follows:

1. Numbers -001 through -199 are reserved for Sub-B/M Numbers.
2. Number -200 indicates a STANDARD Compressor B/M and Model No.
3. Numbers -201 and larger will be assigned for all other variations of a given model.

COMPRESSOR

Family Series

Either a number or a letter established for each product model.

DISPLACEMENT

A letter only, arbitrarily assigned for each different displacement (CFH) within any one family series.

MODEL SERIES VARIATIONS

A number only, arbitrarily assigned to indicate different model types within any one family series.

COMP. MOTOR RATING

Nominal H.P.	Code
1/12	0008
1/10	0010
1/8	0013
1/6	0017
1/5	0020
1/4	0025
1/3	0033
1/2	0050
3/4	0075
1	0100
1-1/4	0125
1-1/2	0150
1-3/4	0175
2	0200
2-1/4	0225
2-1/2	0250
2-3/4	0275
3	0300
3-1/2	0350
4	0400
5	0500
6	0600
7-1/2	0750
9	0900
10	1000
12	1200
15	1500
20	2000
25	2500
30	3000
35	3500
40	4000

COMPRESSOR MOTOR PROTECTION

Type Protection	Code
External Inherent Protection - One Protector (SEIP) (Line Break) Use with Contactor (Single or Three Phase)	A *
External Thermal Protection Use with starter and heater element (Three Phase)	B
Combination - Protector and Starting Relay Single Phase (Kelvinator Type Models)	E
Internal Inherent Protection - One Protector (IIP) Use with Contactor (Single or Three Phase)	F *
Internal Thermostat (s); and Ext. Supplementary Protector (s) mt'd. on Compressor. (Two For 3 Ø, One For 1 Ø). Use with Contactor	H *
Internal Inherent Protection (Pilot Duty) Use with Contactor	K *
Internal Thermostat (s); and Three Ext. Supplementary Protectors mt'd on Compressor. Use with Contactor	L *
Internal Thermal Protectors - Anticipating Type (Pilot Duty). Use with Contactor (G.E. Thermotectors)	M *
Internal Thermal Protectors - Electronic Sensors; and Control Module External. Use with Contactor	S *

*Thermally Protected Marked on Nameplate to Comply with N.E.C.

VOLTS, PHASE, HERTZ

*(See Note)

Volts-Phase-Hertz	Code
115-1-60	A
230-1-60	B
208/220-3-60	C
440-3-60	D
550-3-60	E
115-1-50	F
230-1-50	G
208-1-60	H
208/230-1-50	I
277-1-60	J
208/220/440-3-60	K
220/380-3-50	L
380-3-50	M
230/460-3-60	N
All D.C. Voltages	O
200/380-3-50	P
208/220-3-50	R
220-1-50	S
200-1-50	T
120/208-3-60	U
208/230-1-60	V
200-3-50	W
Miscellaneous Ratings	X
500-3-50	Y
208-1-50	Z

*NOTE: When applicable, 50 Hz ratings will be shown as an alternate rating on 60 Hz rated models.

COPELAWELD COMPRESSOR NAMEPLATE NOMENCLATURE

Figure 115

XXXX — XXXX — XXX — XXX

SERIES TYPE *

Code R-12	Description	Code R-22 R-502
S	Standard	2
C	2nd Standard	3
D	3rd Standard	4
etc	etc	etc
X	Non-Standard (Special)	9

* Basic component combinations (Compressor, Receiver, Condenser, Base)

REFRIGERANT COOLING

Type of Cooling	Code
Air	A
Water & Air Comb.	C
No Condenser	N
Water	W

COMPRESSOR MOTOR TYPE

Compressor Motor Type	Code
Capacitor Run - Capacitor Start (1 Ø)	C
Induction Run - Capacitor Start (1 Ø)	I
Split Phase - Induction Start & Run (1 Ø)	S
Low Torque - Cap. Start, Ind. Run (1 Ø)	X
Perm. Split Cap. - Cap. Start, Cap. Run (1 Ø)	P
Three Phase	T
Two Phase - (All)	D
Direct Current	W
Three Phase - 6 Lead Motors Only (Except 550V)	F

PRODUCT VARIATIONS

1. Remote Style Units & Self Contained Style

001 thru 099 . . . Eligible for UL and CSA
100 thru 299 . . . Eligible for CSA Only
300 thru 399 . . . Not eligible for either UL or CSA

CONDENSING UNIT

Model Series

A symbol that identifies the Model Series.

APPLICATION TEMP.

Temp. Range	Code
High Temperature 45°F max.; 0°F min.	H
Medium Temperature 25°F max.; -5°F min.	M
Low Temperature 0°F max.; -40°F. min.	L
Extra Low Temperature -20°F max.; -40°F min.	E
Two Stage 0°F max.; -40°F min.	T
Two Stage (extra low) -30°F max.; -80°F min.	U

COND. UNIT RATING

Nominal H.P.	Code
1/12	0008
1/10	0010
1/8	0013
1/6	0017
1/5	0020
1/4	0025
1/3	0033
1/2	0050
3/4	0075
1	0100
1-1/2	0150
2	0200
2-1/2	0250
3	0300
3-1/2	0350
4	0400
5	0500
6	0600
7-1/2	0750
10	1000
15	1500
20	2000
25	2500
30	3000
40	4000
50	5000
75	7500
100	1100

COMPRESSOR MOTOR PROTECTION

Type Protection	Code
External Inherent Protection - One Protector (SEIP) (Line Break) Use with Contactor (Single or Three Phase)	A *
External Thermal Protection Use with Starter and Heater Element (Three Phase)	B
Internal Thermostat (s); and External Amb. C'pensated Protector (s) and Contactor Assembly. Mt'd. Remote	D
Combination - Protector and Starting Relay Single Phase (Kelvinator Type Models)	E
Internal Inherent Protection - One Protector (IIP) Use with Contactor (single or Three Phase)	F *
External Inherent Protection - Two Protectors (EIP) Use with Contactor mt'd. on Compressor (Three Phase)	G
Internal Thermostat (s); and Ext. Supplementary Protector (s) mt'd. on Compressor. (Two For 3 Ø, One For 1 Ø). Use with Contactor	H *
Magnetic Across-The-Line Starter (Belt Drive Unit Models Only)	J
Internal Inherent Protection (Pilot Duty) Use with Contactor	K *
Internal Thermostat (s); and Three Ext. Supplementary Protectors mt'd. on Compressor. Use with Contactor	L *
Internal Thermal Protectors - Anticipating Type (Pilot Duty). Use with Contactor (G.E. Thermotector)	M *
Internal Thermal Protectors - Electronic Sensors; and Control Module External. Use with Contactor.	S *

*Thermally protected marked on nameplate to comply with N.E.C.

VOLTS, PHASE, CYCLES

	Code
115-1-60	A
230-1-60	B
208/220-3-60	C
440-3-60	D
550-3-60	E
115-1-50	F
230-1-50	G
208-1-60	H
208/230-1-50	I
277-1-60	J
208/220/440-3-60	K
220/380-3-50	L
380-3-50	M
230/460-3-60	N
All D.C. Voltages	O
200/380-3-50	P
208/220-3-50	R
220-1-50	S
200-1-50	T
120/208-3-60	U
208/230-1-60	V
200-3-50	W
Miscellaneous Ratings	X
500-3-50	Y
208-1-50	Z

*NOTE: When applicable, 50 Hz ratings will be shown as an alternate rating on 60 Hz rated models.

CONDENSING UNIT NAMEPLATE NOMENCLATURE

Figure 116

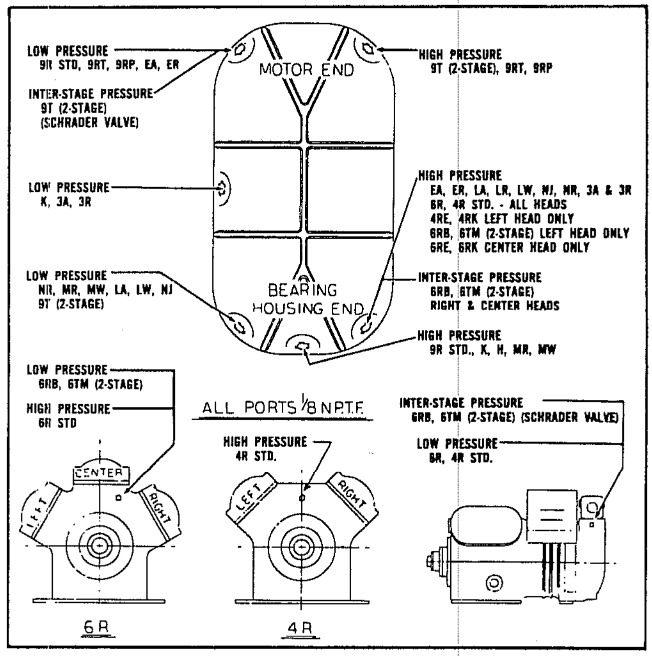
arbitrarily established as 80% of the current drawn when the motor protector trips. The 80% figure is derived from standard industry practice of many years' standing in sizing motor protective devices at 125% of the current drawn at normal load conditions.

In order for the motor to meet Copeland's standards, the trip point must be beyond the prescribed operating limits of the compressor, and is determined during qualification tests by operating the compressor at established maximum load conditions and lowering the supply voltage until the trip point is reached. Use of the standard 80% factor enables the service and installation engineer to safely size wiring, contactors, or other external line protective devices at 125% of the nameplate rating, since the motor-compressor protector will not allow the amperage to exceed this figure.

In most instances, the motor-compressor is capable of performing at nominal rating conditions at less than rated nameplate amperage. Because of standardization, one motor frequently is used in various compressor models for air-cooled, suction-cooled, water-cooled, high temperature, medium temperature, low temperature, R-12, R-22, or R-502 applications as required. Obviously on many applications there will be a greater safety factor than on others.

When Copeland motor-compressors are listed with U. L., the basic compressor nameplate rating is listed as a maximum. This allows O.E.M. users to list a lower unit nameplate rating should the unit electrical load be less than the original compressor rating. Frequently this permits the use of smaller fuses and wire sizes.

In order to avoid any conflict in the nameplate ratings of the compressor and the unit in small packaged equipment, some Copelaweld compressors now have no full load rating stamped on the nameplate, and are assigned an "80% of trip amps" rating on specification sheets. All Copelaweld compressors carry a locked rotor rating on the nameplate, and all Copelametic compressors have both a locked rotor and a full load amperage rating on the nameplate.



HEAD POSITIONS WHEN VIEWED FROM BEARING HOUSING END OF COMPRESSOR

IDENTIFICATION OF PORT LOCATIONS IN HEADS OF COPELAMETIC COMPRESSORS

Figure 117

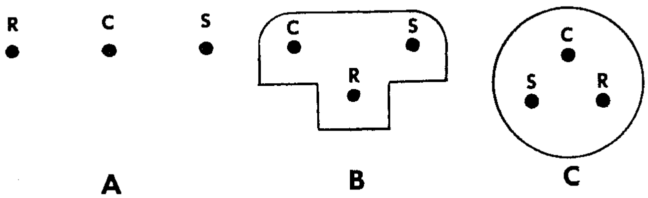
IDENTIFICATION OF PORT LOCATIONS IN HEADS OF COPELAMETIC MOTOR-COMPRESSORS

In addition to the service ports normally available on suction and discharge compressor service valves, on Copelametic compressors high and low pressure ports are provided in the compressor head. These provide a convenient connection for high and low pressure controls, and unlike the ports in service valves, cannot be accidentally closed off.

The port locations in various compressor models are shown in Figure 117.

IDENTIFICATION OF MOTOR TERMINALS ON SINGLE PHASE COMPRESSORS

The terminal plates on Copelametic compressors are stamped with the terminal identification, and identifying the common, run, and start terminals is seldom a problem. This is also true where tee blocks are used on Copelaweld compressors, but many Copelaweld compressors are manufactured with a Fusite terminal which may have no permanent identification.



VARIOUS COPELAND MOTOR TERMINAL CONFIGURATIONS

Figure 118

Fig. 118 shows the various motor terminal configurations used by Copeland.

Type A illustrates the individual terminal posts used on smaller horsepower Copelametic compressors. Type A follows no standard industry pattern and applies only to Copelametic compressors. The terminals are in the order shown when viewed from the stator cover end of the compressor (the end on which the terminal box is mounted).

Type B is a tee block used on larger horsepower compressors, both Copelametic and Copelaweld. Type C is a Fusite connection, normally used with push-on type terminals.

Both Type B and Type C for production convenience and easy identification, follow the general industry rule of identifying common, start, and run terminals, always in that order, in the same fashion as reading a book. In other words, reading from left to right, and from top to bottom, the terminals are always C, S, and R.

PROPER VALVE PLATE AND HEAD GASKETS FOR 3, 4, AND 6 CYLINDER COMPRESSORS

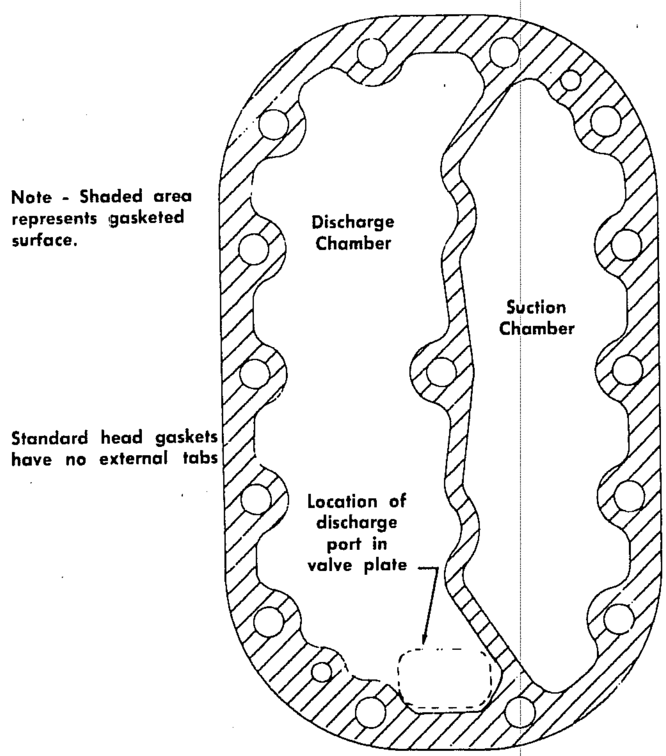
Occasionally when quick delivery of either new or replacement motor-compressors is required from a wholesaler's stock, and the exact model is not on hand, compressor heads may be changed in the field in order to utilize available stock compressors.

WARNING

When compressor heads are changed to convert standard, capacity control, or two-stage compressors to some other model, the correct gaskets must be used to insure proper performance and prevent damage to the compressor. The correct head gasket must exactly match the inner face of the head being used.

Standard Compressor Heads

Figure 119 is an inside view of a typical standard Copelametic compressor head, showing the inner webbing. The discharge port is located in the valve plate in the area indicated, and the proper gasket matches the inner face of the head.



TYPICAL STANDARD COPELAMETIC COMPRESSOR HEAD

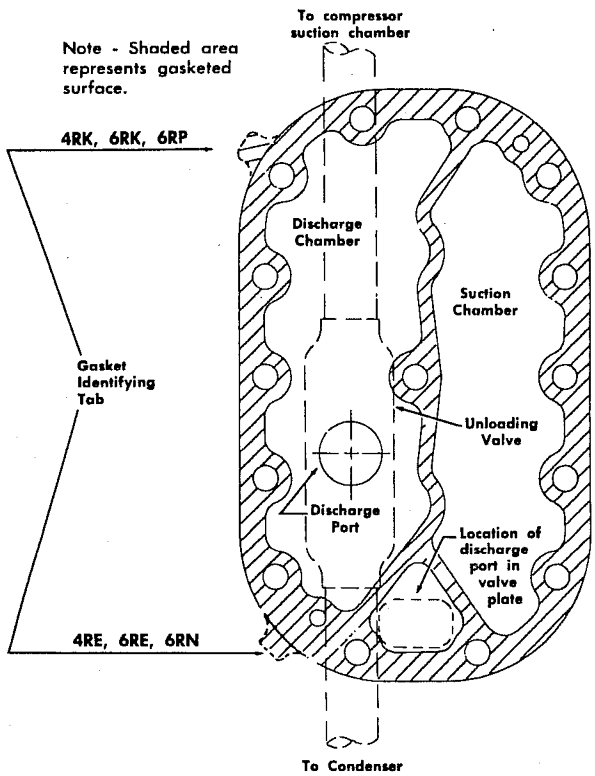
(Inside view - 4RA, 6RA, 4RH, 6RH)
(The standard gasket is also used on compressors equipped with internal unloaders)

Figure 119

External Capacity Control Heads

Figure 120 is an inside view of a Copelametic head equipped with an external unloading valve. The valve is mounted on a discharge port located in the top of the head. The normal discharge port area is fenced off by the "Y" in the inner webbing. The proper gasket exactly matches the inner face of the head, the gasket for the external unloading head being externally identified by the tab shown in Figure 120.

Since the area enclosed by the "Y" in the webbing is exposed to discharge pressure from the other cylinders, any leakage from the discharge port in the valve plate into the discharge chamber of an unloaded head can flow directly



TYPICAL COPELAMETIC COMPRESSOR HEAD WITH EXTERNAL UNLOADING VALVE

(Inside view - 4RE, 6RE, 6RN, 4RK, 6RK, 6RP)

Figure 120

back to the suction chamber. Such leakage can cause the compressor suction pressure to rise immediately when the compressor is pumped down if the unloader valve is not tightly seated.

When a standard head is replaced with a head equipped with an external unloading valve, the gasket must be changed and the correct gasket must be installed to prevent overheating of the compressor.

In the event unloading is not desired on a cylinder bank equipped with a head designed for unloading, both the cylinder head and gasket must be replaced. The correct gasket must be installed to prevent damage to the compressor.

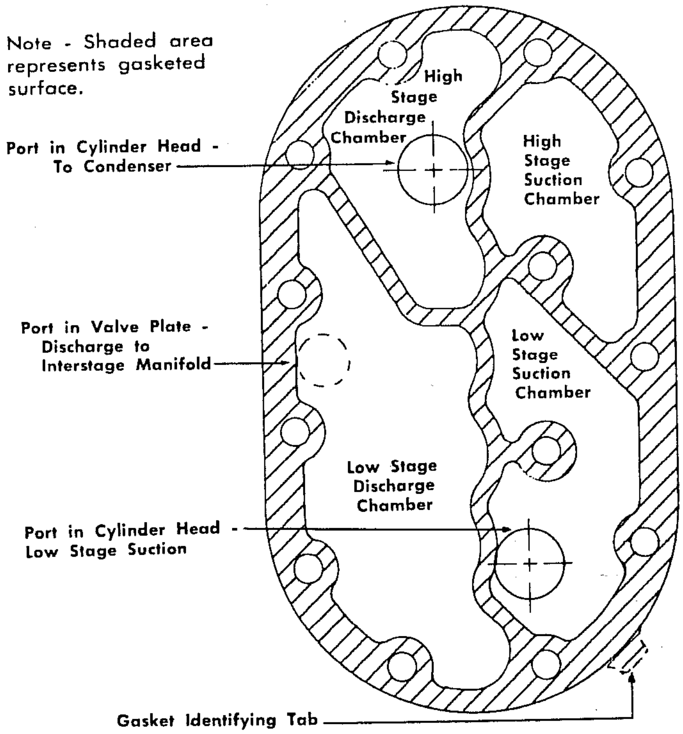
A new internal type unloader is currently under development which will also require a special head, but the inner face of the head will be the same as a standard head, and the standard gasket may be used for the unloaded head as well.

Two Stage Heads, 3 Cylinder

On two stage compressors, special heads are necessary to provide the necessary separation of the two stages of compression. Figure 121 is an inside view of a typical Copelametic head for a 3 cylinder two stage compressor.

Refrigerant vapor is returned directly from the suction line to the port in the cylinder head opening into the low stage suction chamber, and is then discharged by the low stage cylinders into the low stage discharge chamber. The gas (at interstage pressure) then enters the interstage manifold, is desuperheated by liquid refrigerant fed by the desuperheating expansion valve, and is discharged into the compressor motor chamber. The high stage suction gas follows the normal suction gas flow path from the motor chamber to the high stage suction chamber, and is then discharged to the condenser through the high stage discharge chamber.

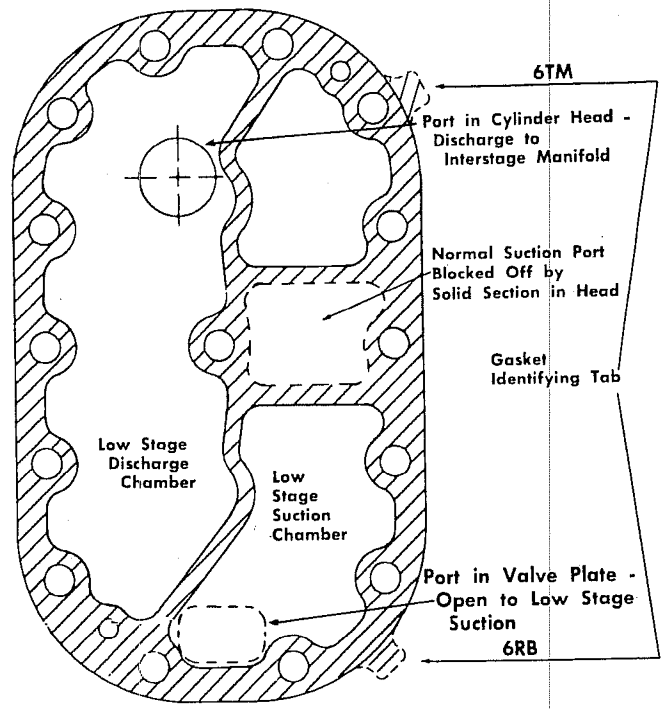
The proper gasket exactly matches the inner webbing of the head, and must be used to prevent leakage between stages and possible overheating of the compressor motor.



TYPICAL TWO STAGE COPELAMETIC CYLINDER HEAD FOR 3 CYLINDER COMPRESSOR

(Inside view - 9TK, 9TL, 9TH)

Figure 121



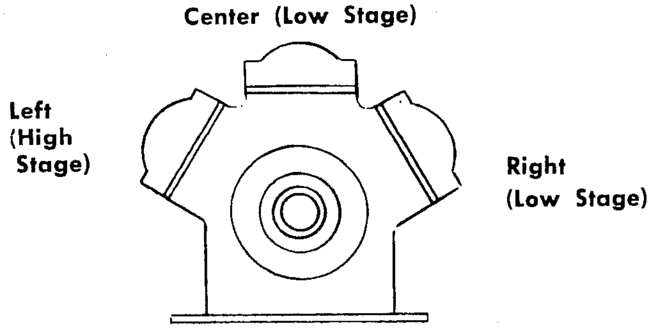
TYPICAL LOW STAGE COPELAMETIC CYLINDER HEAD FOR 6 CYLINDER COMPRESSOR

(Inside view - 6RB, 6TM)

Figure 123

Two Stage Heads, 6 Cylinder Compressor

On 6 cylinder two stage compressors, different heads must be used on the high and low stage cylinders. When viewed from the bearing housing end of the compressor (the end on which the oil pump is mounted) the center and right cylinder banks are low stage, and the left cylinder bank is high stage.



6 CYLINDER COMPRESSOR VIEWED FROM THE OIL PUMP END

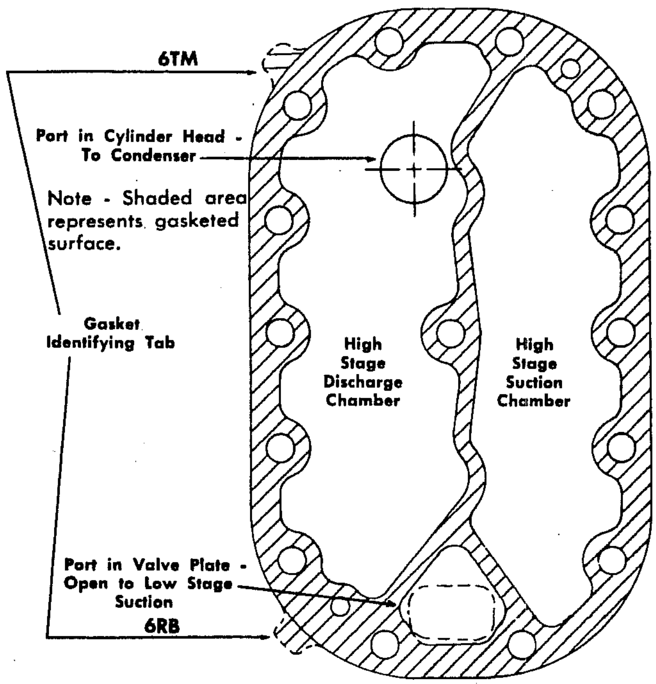
Figure 122

Figure 123 is an inside view of a typical low stage head for a 6 cylinder compressor, while Figure 124 shows an inside view of a typical high stage head.

Refrigerant vapor is returned from the suction line to the normal discharge chamber on the compressor. The vapor enters the low stage suction chamber through the port at the end of the valve plate, and is discharged from the low stage cylinders into the low stage discharge chamber. The gas (at interstage pressure) then enters the interstage manifold, is desuperheated by liquid refrigerant fed by the desuperheating expansion valve, and is discharged into the compressor motor chamber.

The low stage head is made with the area over the normal suction port blocked off. The proper gasket exactly matches the inner face of the head with the exception that the gasket outlines the solid area, but does not cover it completely.

The high stage head on two stage 6 cylinder compressors is similar to the head used on an unloaded head on 6 cylinder compressors, and takes the same head gasket. The high stage suction gas follows the normal suction gas flow path from the motor chamber to the high stage suction chamber, and is then discharged to the condenser through the high stage discharge chamber.



TYPICAL HIGH STAGE COPELAMETIC CYLINDER HEAD FOR 6 CYLINDER COMPRESSOR

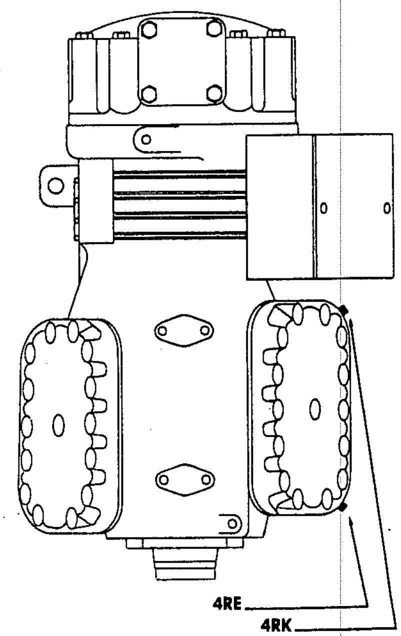
(Inside view - 6RB, 6TM)

Figure 124

Identification of Head Gaskets

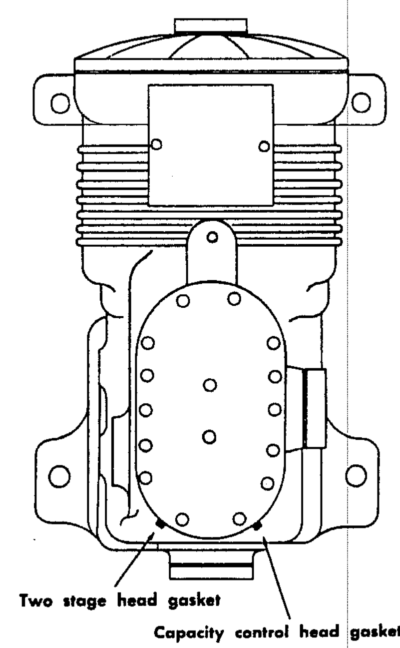
As a means of easily identifying head gaskets, and as a guide to proper installation, tabs have been provided on gaskets used on capacity control and two stage heads on 3, 4, and 6 cylinder compressors. In the event there is a question as to whether the proper gasket has been installed, the external tab provides a convenient means of checking without having to remove the compressor head.

Standard head gaskets have no tab, and follow the configuration of the head. The position of the tab when the gasket is properly installed on external capacity control and two stage compressors is illustrated in Figures 125, 126, 127, and 128.



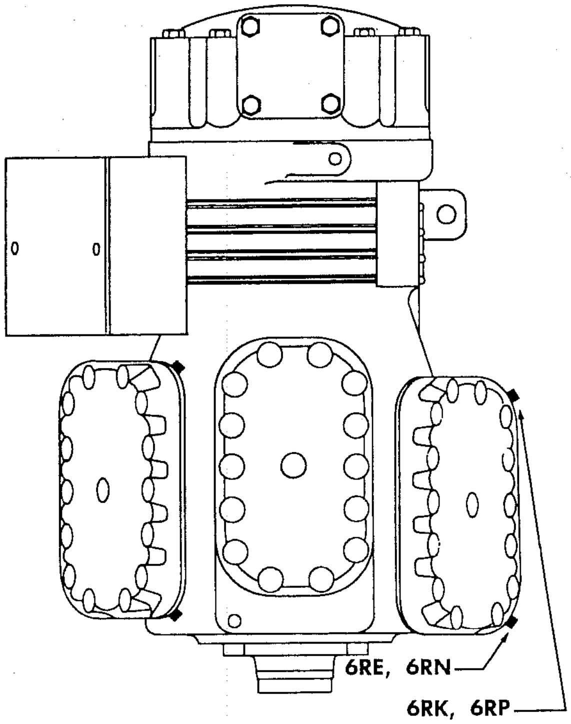
GASKET TAB LOCATION ON EXTERNAL CAPACITY CONTROL 4 CYLINDER COMPRESSORS

Figure 125



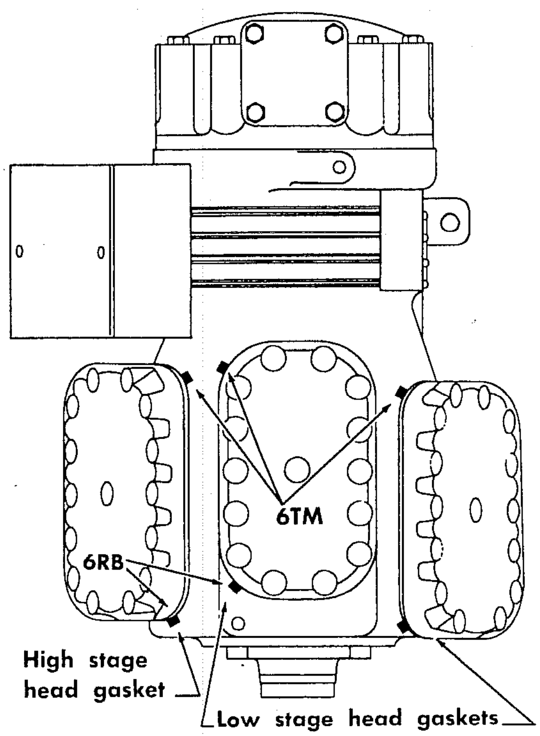
GASKET TAB LOCATION ON TYPICAL MODEL "9" 3 CYLINDER COMPRESSOR

Figure 126



GASKET TAB LOCATION ON EXTERNAL CAPACITY CONTROL 6 CYLINDER COMPRESSORS

Figure 127



GASKET TAB LOCATION ON TYPICAL 6 CYLINDER TWO STAGE COMPRESSOR

Figure 128

Any time a compressor head is changed, the proper gaskets must be used to prevent damage to the compressor. Compressor failures or compressor damage due to use of improper gaskets will be considered as misuse not covered by the Copeland warranty, and regular replacement charges will apply.

COPELAND OIL PUMPS

On all Copelametic compressors 5 HP and larger in size, and on 3 HP "NR" models, compressor lubrication is provided by means of a positive displacement oil pump. The pump is mounted on the bearing housing, and is driven from a slot in the crankshaft into which the flat end of the oil pump drive shaft is fitted.

Oil is forced through a hole in the crankshaft to the compressor bearings and connecting rods. A spring loaded ball check valve serves as a pressure relief device, allowing oil to bypass directly to the compressor crankcase if the oil pressure rises above its setting.

Since the oil pump intake is connected directly to the compressor crankcase, the oil pump inlet pressure will always be crankcase pressure, and the oil pump outlet pressure will be the sum of crankcase pressure plus oil pump pressure. Therefore, the net oil pump pressure is always the pump outlet pressure minus the crankcase pressure. When the compressor is operating with the suction pressure in a vacuum, the crankcase pressure is negative and must be added to the pump outlet pressure to determine the net oil pump pressure. A typical compound gauge is calibrated in inches of mercury for vacuum readings, and 2 inches of mercury are approximately equal to 1 psi.

For example:

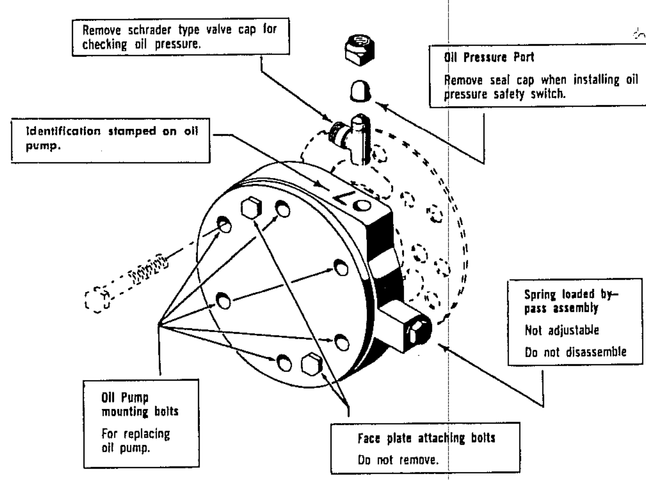
Crankcase Pressure	Pump Outlet Pressure	Net Oil Pump Pressure
50 psig	90 psig	40 psi
8" vacuum (equivalent to a reading of minus 4 psig)	36 psig	40 psi

In normal operation, the net oil pressure will vary depending on the size of the compressor, the temperature and viscosity of the oil, and the amount of clearance in the compressor bearings. Net oil pressures of 30 to 40 psi are normal, but adequate lubrication will be maintained at pressures down to 10 psi. The bypass valve is set at the factory to prevent the net pump pressure from exceeding 60 psi.

Every oil pump is given a 100% operating inspection at the Copeland factory prior to shipment. The pump is installed in a test stand and must lift oil through unprimed oil lines to a height not less than 12 inches, pick up and develop a full flow of oil within 30 seconds, must not exceed an established maximum power requirement, must develop a minimum of 40 psi pressure with the main outlet closed, and must pump a specified quantity of oil at standard test conditions. Operating pressures and reversal of the pump are checked on the test stand, and on larger compressors are checked again after the pump is installed in a compressor.

The oil pump may be operated in either direction, the reversing action being accomplished by a friction plate which shifts the inlet and outlet ports. After prolonged operation in one direction, wear, corrosion, varnish formation, or burrs may develop on the reversing plate, and this can prevent the pump from reversing. Therefore, on installations where compressors have been in service for some time, care must be taken to maintain the original phasing of the motor if for any reason the electrical connections are disturbed. On transport refrigeration applications where power may be provided from both generators and dock power, both sources of power must be phased alike when connected to the unit in order to prevent reversing the compressor rotation.

The presence of liquid refrigerant in the crankcase can materially affect the operation of the oil pump. Violent foaming on start up can result in a loss of oil from the crankcase, and a resulting loss of oil pressure until oil returns to the crankcase. If liquid refrigerant or a refrigerant rich mixture of oil and refrigerant is drawn into the oil pump, the resulting flash gas may result in large variations and possibly a loss of oil pressure. Crankcase pressure may vary from suction pressure since liquid refrigerant in the crankcase can pressurize the crankcase for short intervals, and the oil pressure safety control low pressure connection should always be connected to the crankcase.



TYPICAL COPELAND OIL PUMP

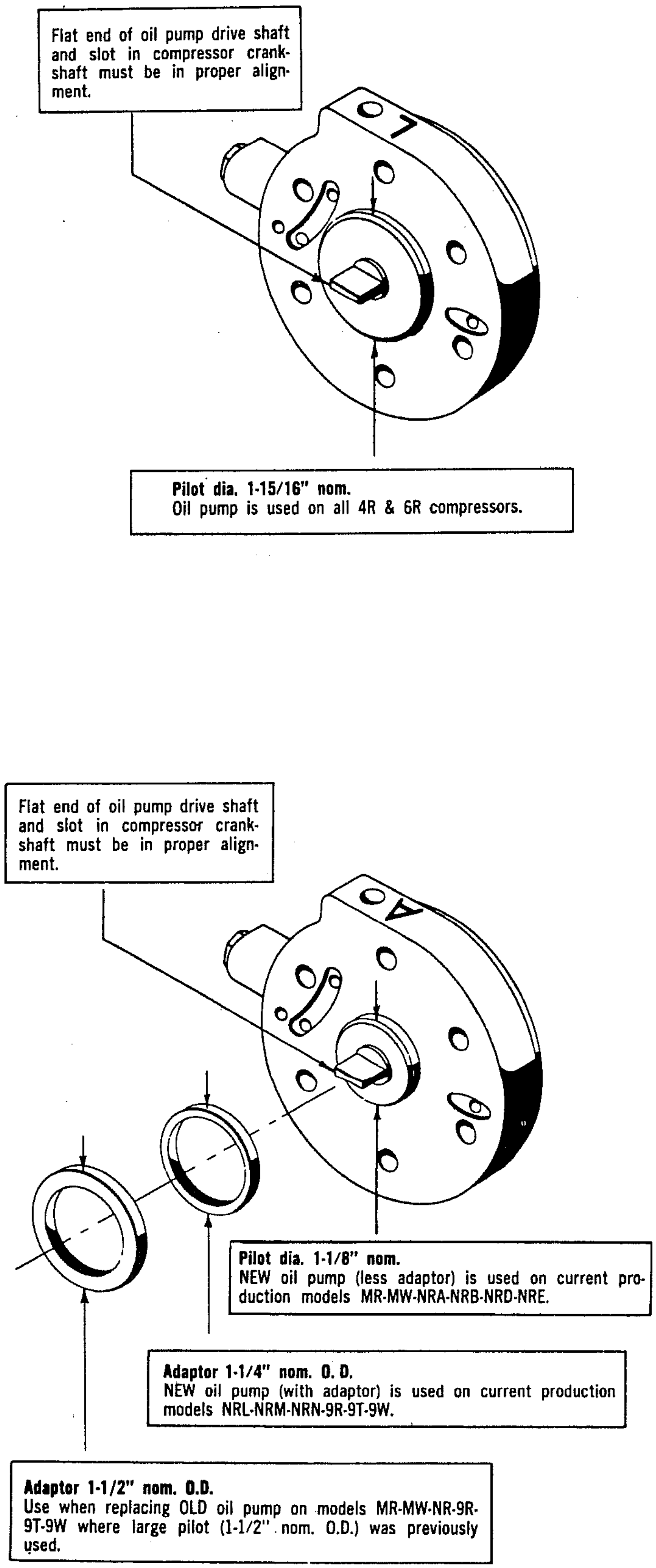
Figure 129

During a rapid pull-down of the refrigerant evaporating pressure, the amount of refrigerant in solution in the crankcase oil will be reduced, and may cause flash gas at the oil pump. During this period the oil pump must pump both the flash gas and oil, and as a result the oil pressure may decrease temporarily. This will merely cause the oil pump to bypass less oil, and so long as the oil pressure remains above 9 psi, adequate lubrication will be maintained. As soon as a stabilized condition is reached, and liquid refrigerant is no longer reaching the pump, the oil pressure will return to normal.

The oil pressure safety control high pressure connection should be made to the oil pressure port on the oil pump as shown. On the initial start-up of a system, or if at any time abnormal noise causes any question regarding lubrication, it is recommended that a gauge be attached to the Schrader type valve so that the oil pressure can be observed while the compressor is in operation. The Schrader type valve is for pressure checking only, and is normally closed, so the oil pressure safety control must never be connected to this port.

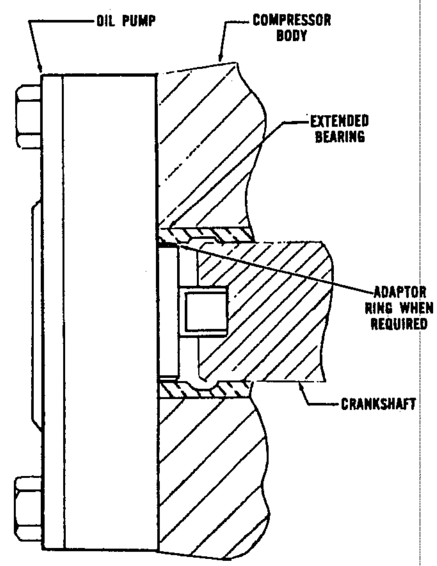
The oil pump face plate is held in place by the two bolts shown in Figure 129. (Note that these are smaller than the six mounting bolts). The face plate seats on an "O" ring seal and should not be removed. Do not put a gasket between the face plate and the oil pump body, or the oil pump will be rendered inoperative.

The bolt holding the spring loaded bypass assembly in place should not be removed. The bypass pressure is not adjustable, and the bolt is provided for access during original assembly or factory maintenance, but it is not intended for field repairs. If the bolt is removed, the spring or other components are easily lost or damaged, rendering the oil pump inoperative.

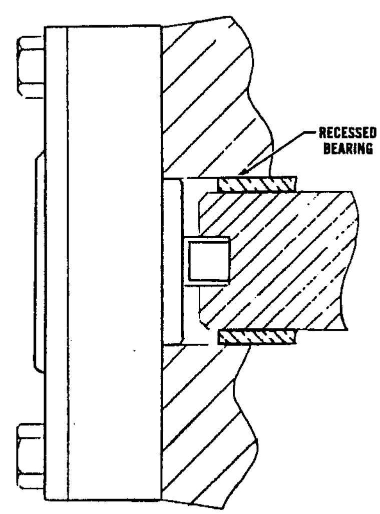


TYPICAL PRODUCTION OIL PUMPS

Figure 130



"A" MODEL OIL PUMP ON N, M, OR 9 MODEL COMPRESSOR WITH EXTENDED LINE BORED BUSHING



"L" OR "S" MODEL OIL PUMP ON 4R, 6R, OR OLDER N, M, OR 9 MODEL COMPRESSOR WITH RECESSED BUSHING

Figure 131

Copeland oil pumps are identified with a letter stamped into the casting as shown in Figures 129 and 130 and all are identical except for the pilot diameter.

Oil pumps identified with an "L" have a 1-15/16" O.D. pilot diameter, are designed for use on all 4R and 6R compressors, and will not fit any other compressor.

"S" oil pumps have a 1½" O.D. pilot diameter, and were standard on all two and three cylinder compressors having oil pumps for many years. The "S" model oil pump is being replaced in current production with the "A" model oil pump, because of a change in bearing design on N, M and 9 model compressors.

The "A" model oil pump has a 1⅛" O.D. pilot diameter. It differs from the "S" and "L" oil pumps in that it is designed to register in the bearing rather than the bearing housing. This makes possible a new style line bored oil pump housing bearing providing accurate alignment of the oil pump.

A larger capacity oil pump with a double impeller has been developed for larger displacement compressors, but it is interchangeable with standard oil pumps with the exception that longer mounting bolts are required.

Field Replacement of Oil Pumps

If it is determined that an oil pump is not functioning properly, replace the oil pump and not the compressor.

The oil pump is mounted on the compressor bearing housing by means of the six bolts shown in Figure 129. Compressor bearing housings are not interchangeable on most compressor bodies and should not be removed.

Gaskets installed between the oil pump and the compressor body are shown in Figure 132. The tab on the gasket has been added solely for aid in identification and alignment. The gasket must be installed with the tab in the position shown (11 o'clock position) when viewed facing the compressor, and the slotted hole must always be to the installer's left in the 9 o'clock position. If the gasket is installed in any other position, the oil ports will be blocked. Gaskets for "L" oil pumps are not interchangeable with gaskets for "A" and "S" pumps.

Some older models of Copelametic compressors are equipped with Tuthill oil pumps, and these may be furnished on service replacement compressors. The Copeland oil pump is perfectly interchangeable with the Tuthill pump, and the same gaskets may be used.

WARNING

The oil pump pilot shoulder must register snugly in either the bearing housing or bearing (depending on compressor design) to insure centering the oil pump. See Figure 131. If not properly registered, the resulting misalignment can result in excessive wear and possible failure of the oil pump. Tolerances are very critical for proper operation and extreme care must be taken to insure that the proper oil pump, and adaptor if required, is used. The following replacement procedures must be followed to insure trouble free operation.

1. Replacement of "L" oil pumps (4R and 6R compressors.)
   Use only "L" oil pumps. Occasionally a serviceman will mount an "A" oil pump on a 4R or 6R compressor by mistake, and since the pilot shoulder will not register on the bearing housing, excessive play and misalignment of the shafts will develop resulting in failure of the oil pump. The pump should register in the bearing housing.
2. Replacement of "S" oil pumps with "A" replacement kit (M, N, 9 model compressors).
   Adaptors have been developed for the "A" oil pump so it can be used as a replacement on all two and three cylinder Copelametic compressors having oil pumps, regardless of the compressor pilot diameter. The "A" replacement kit can be used to replace "S" oil pumps on all older model M, N and 9 compressors which have bearing housing pilot diameters, by using the 1½" O.D. adaptor.
3. Replacement of "A" oil pump on NRL, NRM, NRN, 9R, 9T, 9W model compressors.

The above compressor models with "A" oil pumps have an extended bearing, with a 1 ¼" I.D. nominal register. The "A" replacement kit can be used to replace the original "A" pump by using the 1 ¼" O.D. adaptor.

4. Replacement of "A" oil pump on MR, MW, NRA, NRB, NRD, NRE model compressors. The above compressor models with "A" oil pumps have an extended bearing with a 1 ⅛" nominal I.D. register. The "A" replacement kit can be used to replace the original "A" pump without the use of any adaptor.

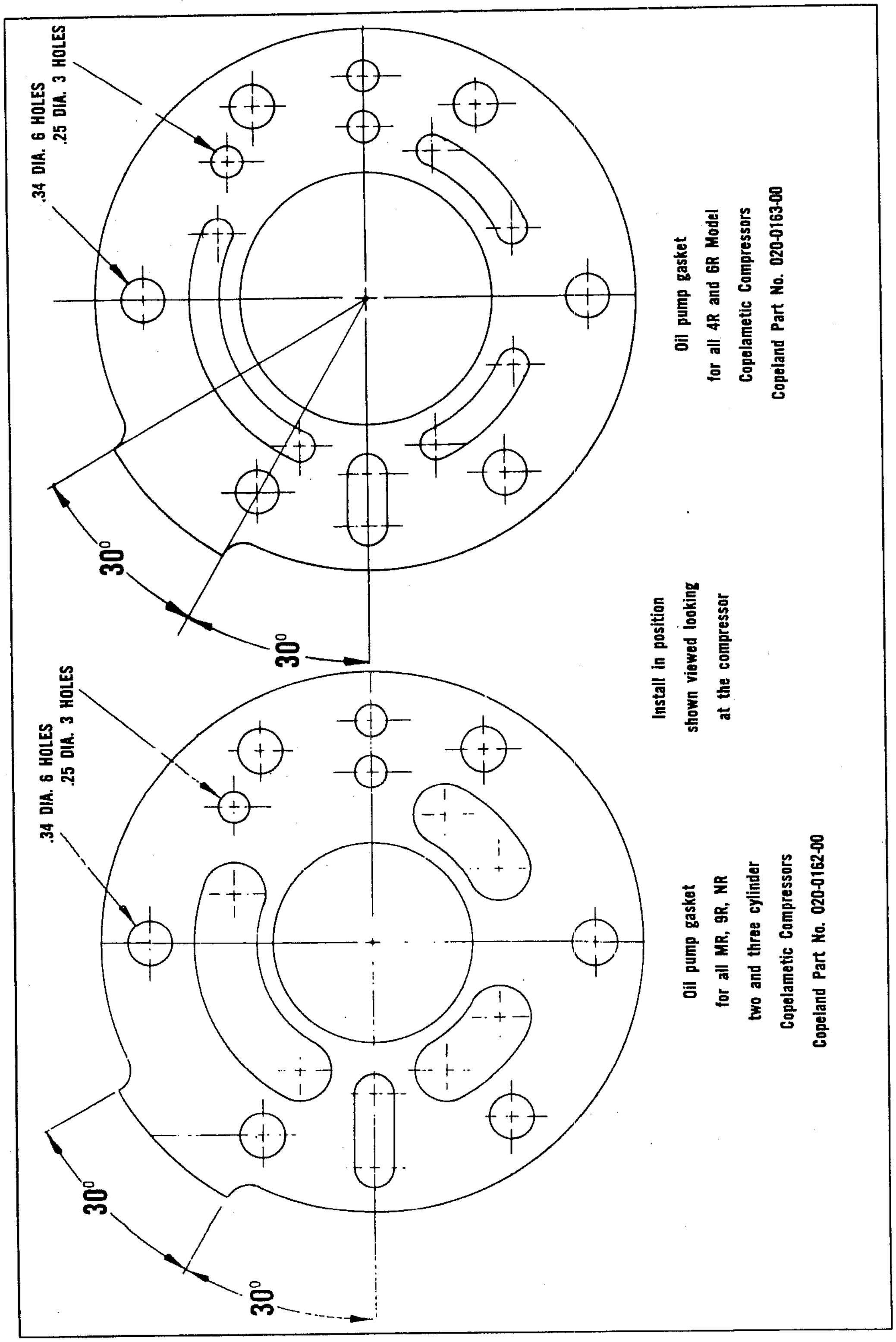
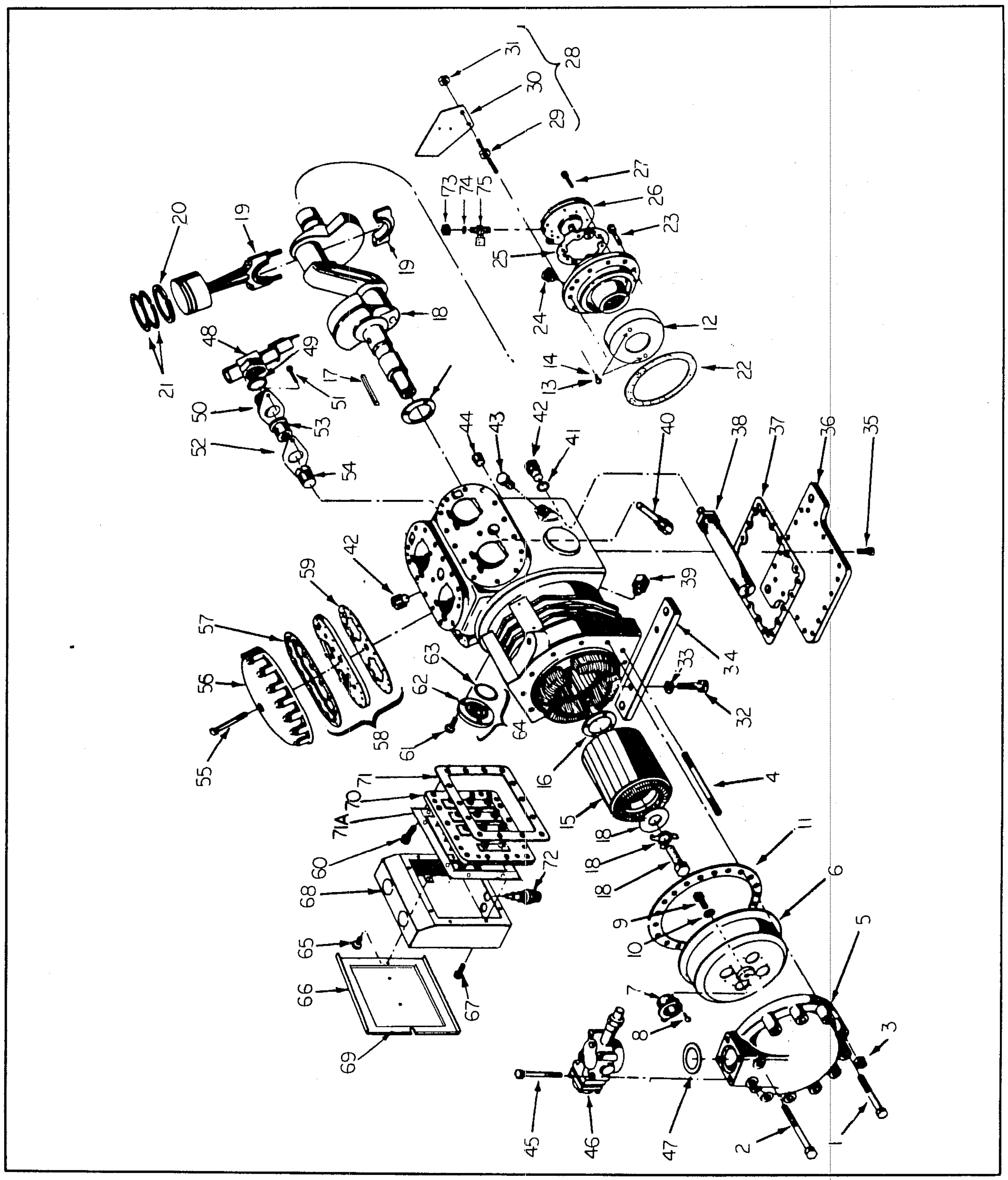


Figure 132

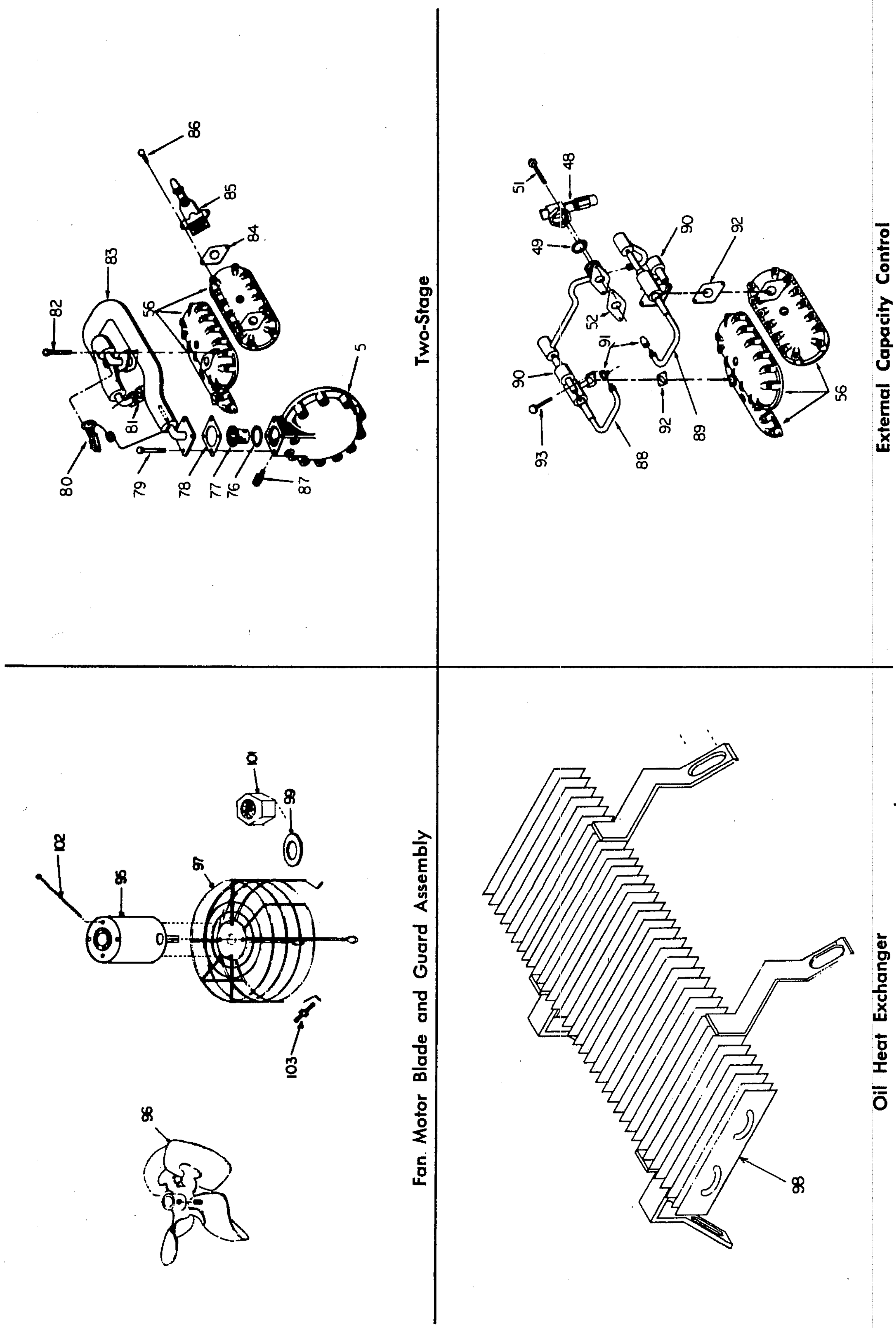
TYPICAL COPELAMETIC COMPRESSOR CONSTRUCTION

The following exploded views illustrate typical Copeland compressor construction details. Individual components will vary with different compressor models, but the basic method of assembly is similar.



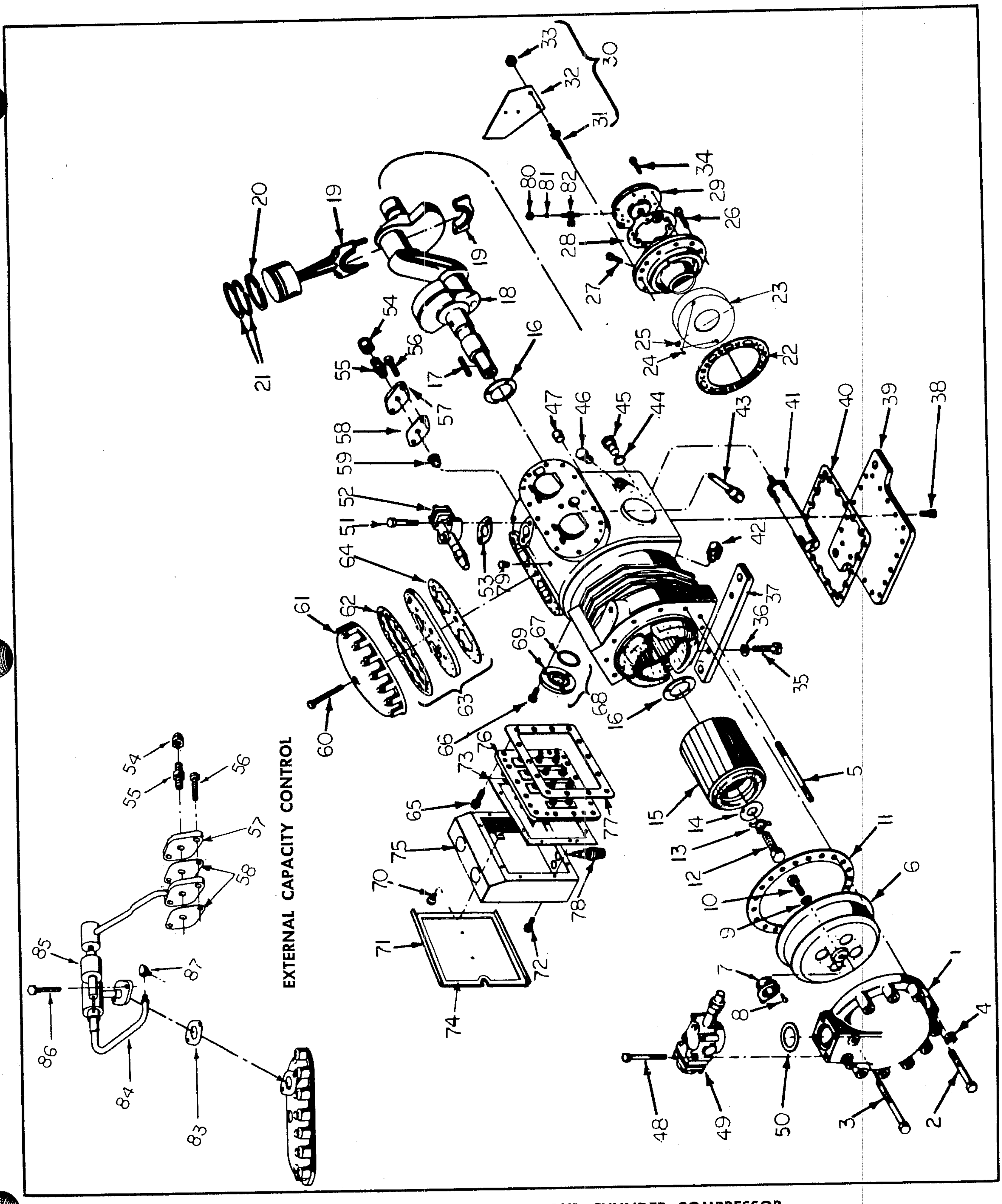
EXPLODED VIEW - TYPICAL SIX CYLINDER COMPRESSOR

Figure 133



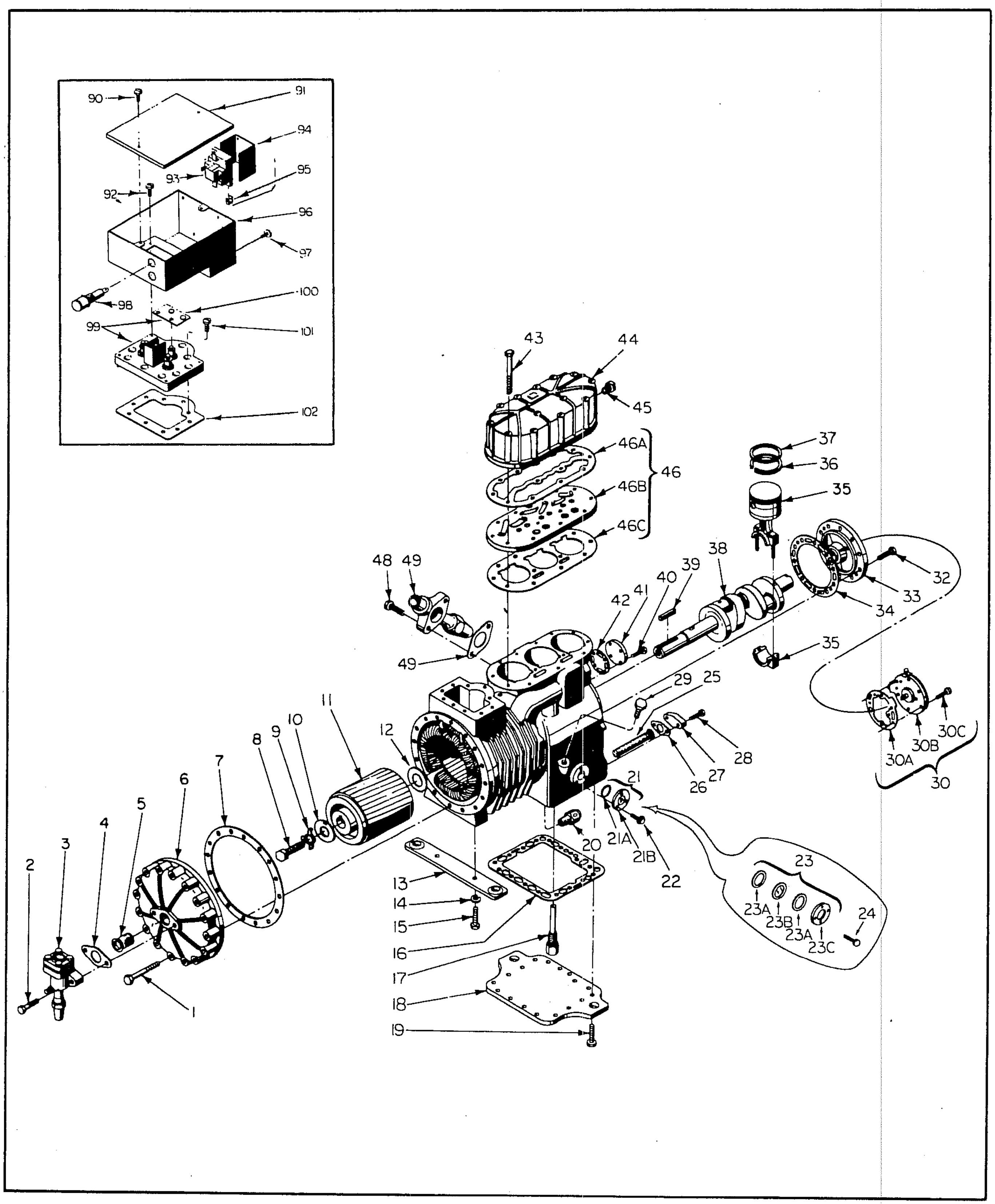
TYPICAL ACCESSORIES AND MODIFICATIONS - SIX CYLINDER COMPRESSOR

Figure 134



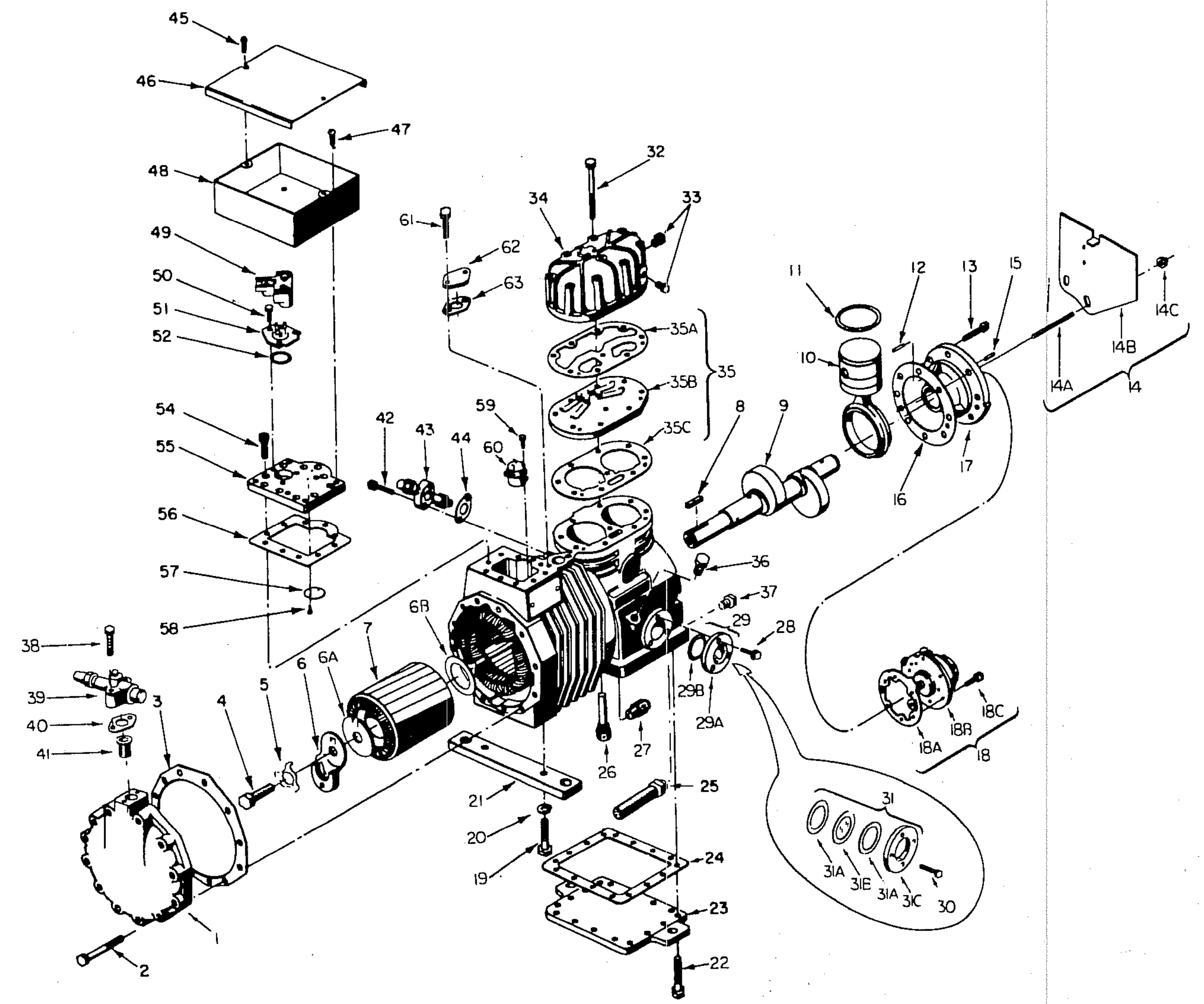
EXPLODED VIEW - TYPICAL FOUR CYLINDER COMPRESSOR

Figure 135



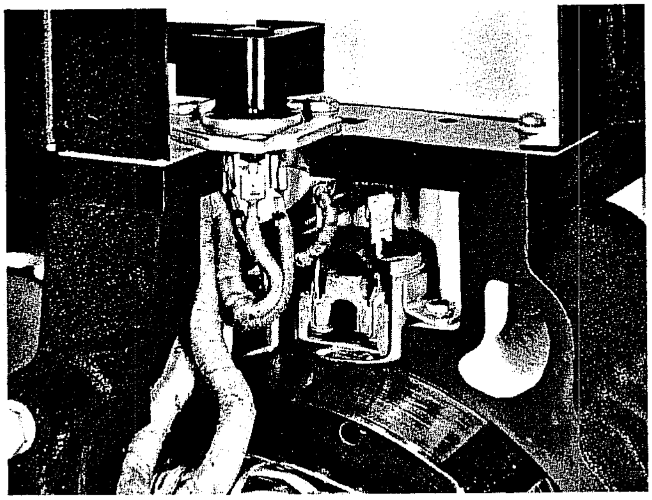
EXPLODED VIEW - TYPICAL THREE CYLINDER COMPRESSOR

Figure 136

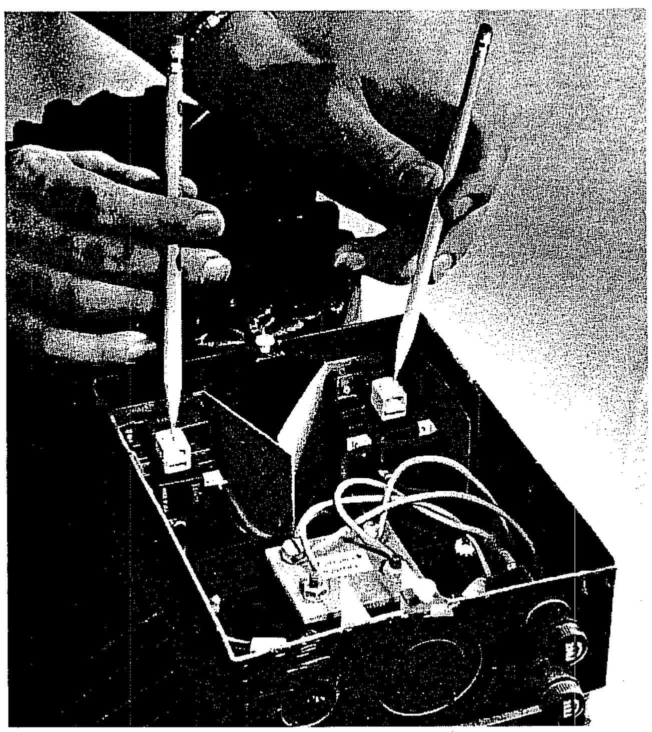


EXPLODED VIEW - TYPICAL TWO CYLINDER COMPRESSOR

Figure 137



Internal Inherent Protector in intimate contact with stator iron provides compressor motor with instant line-break protection from temperature and current overloads.



External Protectors in terminal box supplement thermostat in motor windings to provide protection from excessive current in two legs of three phase electric power supply. Note: Third leg protector optional.

TYPICAL DETAILS OF MOTOR PROTECTORS USED ON COPELAMETIC MOTOR-COMPRESSORS

Figure 138

MAINTENANCE ACCESSIBILITY ON COPELAMETIC COMPRESSORS

The heads may be removed on all Copelametic compressors by removing the head bolts as shown in Figure 139.

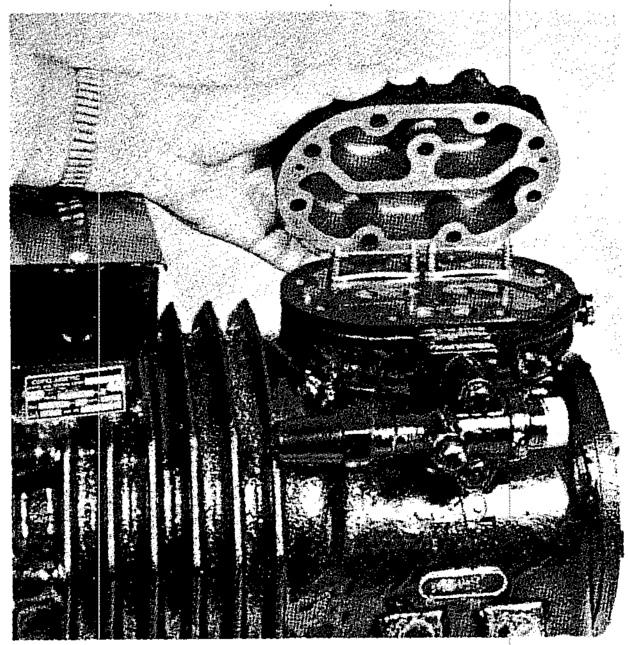


Figure 139

The valve plate is then accessible and may be removed as shown in Figure 140. Note that the suction valve reeds are retained in position by dowel pins in the body.

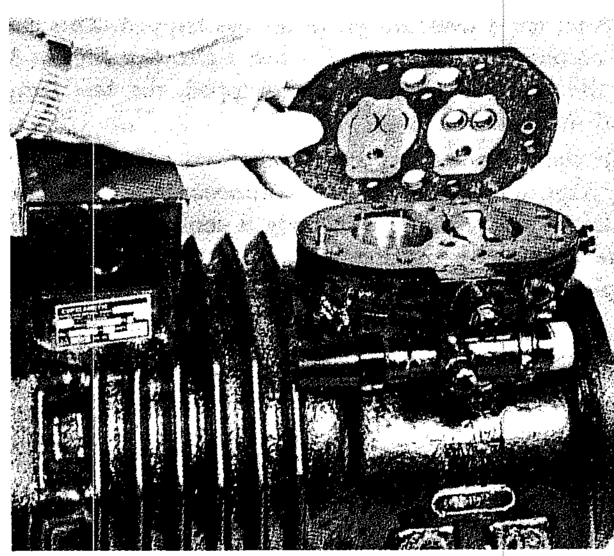


Figure 140

If the motor-compressor is not seized internally it is normally possible to move the pistons by exerting force on the top of the piston, as illustrated in Figure 141. In the event of a broken connecting rod, the piston may "float" in the cylinder during operation. The connecting rod is broken if the piston can be depressed with little or no pressure without affecting the position of the other piston or pistons.

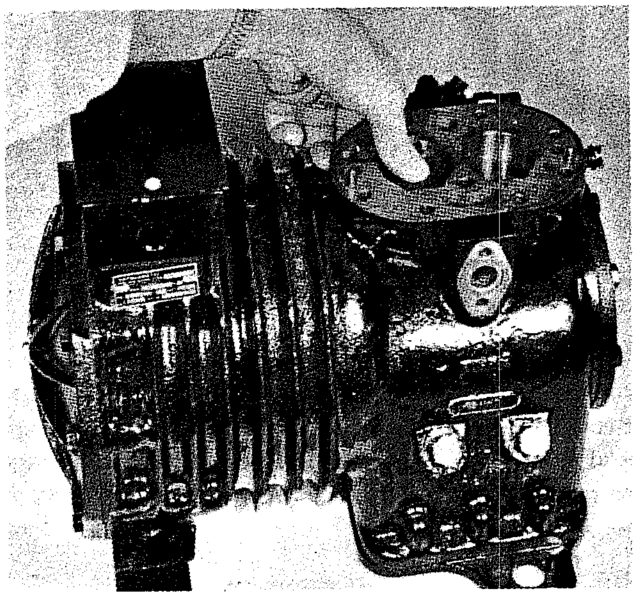


Figure 141

Figure 142 shows the location of the suction strainer screen on small Copelametic compressors. If a restriction somewhere in the low pressure side of the system is indicated, it is advisable to check the strainer for restriction.

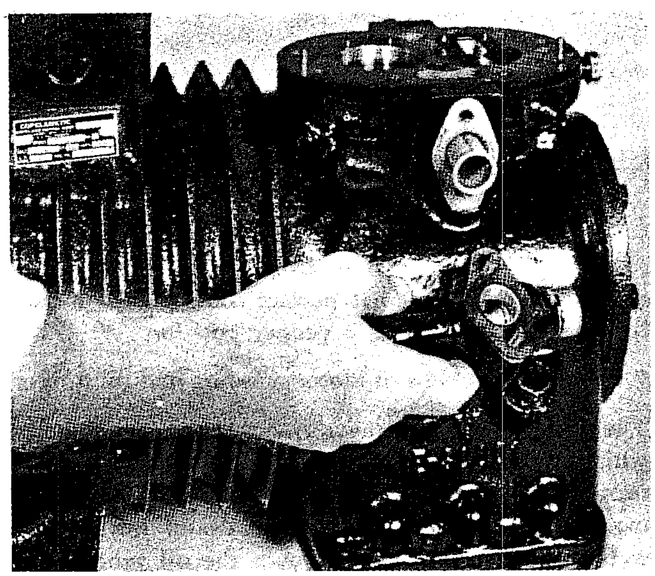


Figure 142

The compressor motor terminals and external protectors are accessible by removing the terminal box lid as shown in Figure 143. The terminal box can be removed by removing the attaching screws.

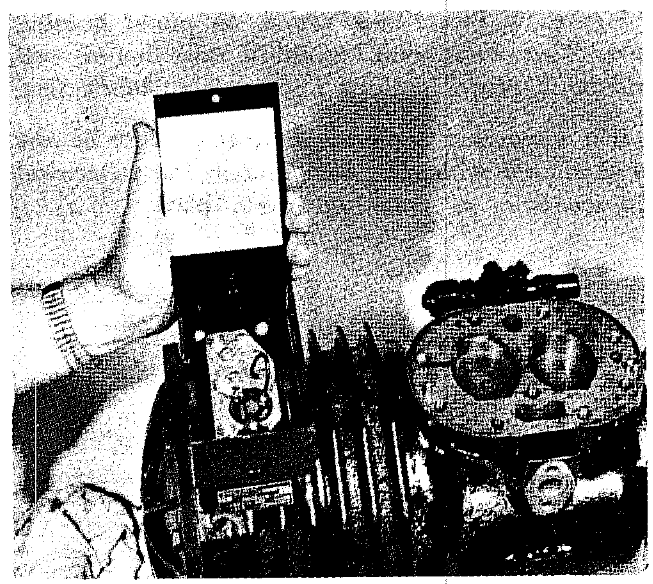


Figure 143

Figure 144 is a view of the motor end of a small compressor with the stator cover removed. Note that the external protector, on top of the body is held in position so that it has perfect contact with the compressor body when in the proper position.

This particular model uses an oil flinger for lubrication. The ends of the oil flinger run through the oil, some of which is picked up by the "V" near the ends of the arms. The flinger deposits the oil at the top of the stator cover, which then drains into the oil well shown on the stator cover in Figure 145. Note that the oil tube which centers in the hollow crankshaft then permits oil to run from the well through the crankshaft to provide lubrication to the moving parts.

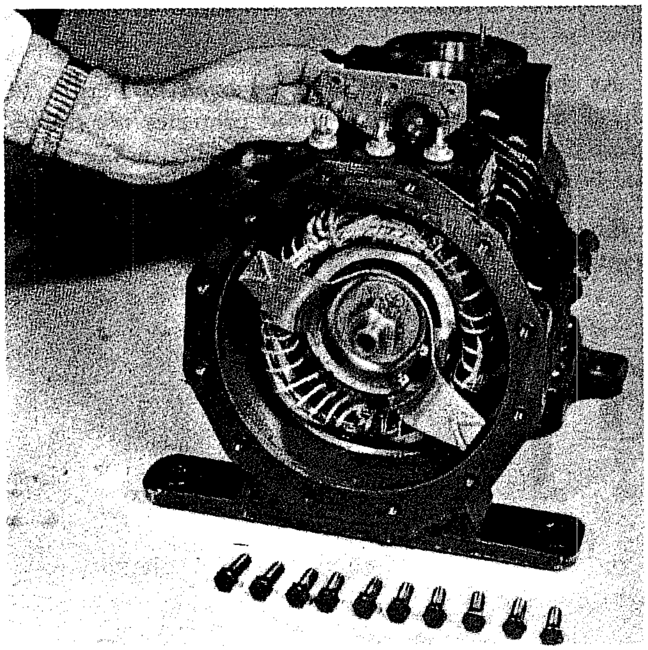


Figure 144

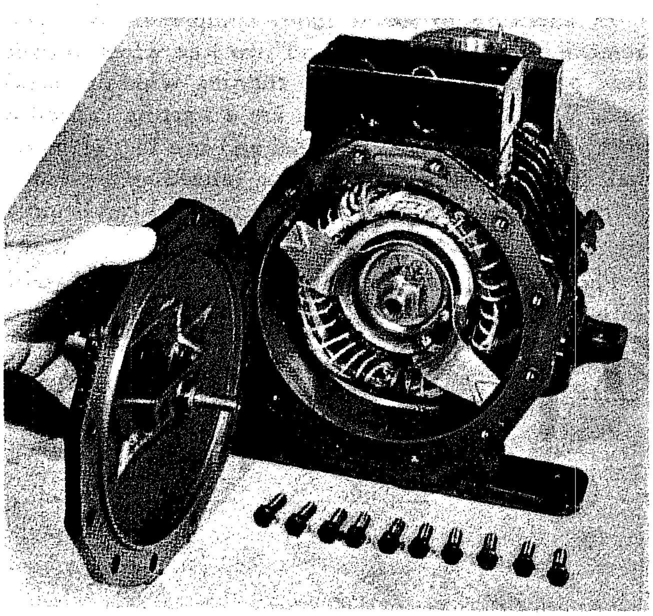


Figure 145

Figure 146 shows arrows on the motor housing cover which must point upward in order that the oil well will be in a proper position to trap the oil.

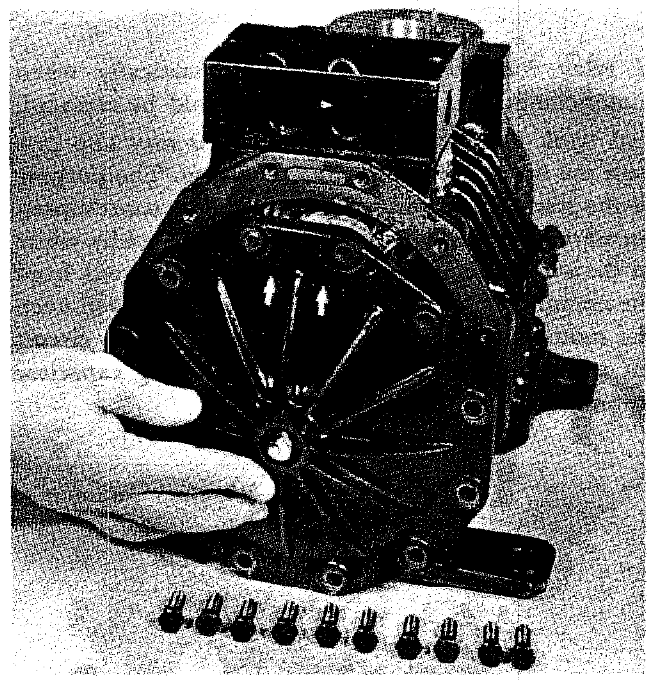


Figure 146

FIELD TROUBLESHOOTING

One of the basic difficulties in preventing compressor failures arises in determining the actual reason for the failure. The compressor is the functioning heart of the refrigeration system, and regardless of the nature of a system malfunction, the compressor must ultimately suffer the consequences. Since the compressor is the component that fails, there often is a tendency to blame any failure on the compressor without determining the actual cause of the malfunction. In far too many cases, the actual cause of failure has not been discovered and corrected, and the result has been recurring failures that could have been prevented.

If the service engineer is to help in eliminating the causes of compressor failure, then he must thoroughly understand both the operation of the system and the possible causes of failure that might occur, and he must be on the alert for any signs of system malfunction.

If a motor compressor fails to start and run properly, it is important that the compressor be tested to determine its condition. It is possible that external electrical components may be defective, the protector may be open, a safety device may be tripped, or other conditions may be preventing compressor operation. If the motor compressor is not the source of the malfunction, replacing the compressor will only result in the unnecessary expenditure of time and money, while the basic problem remains.

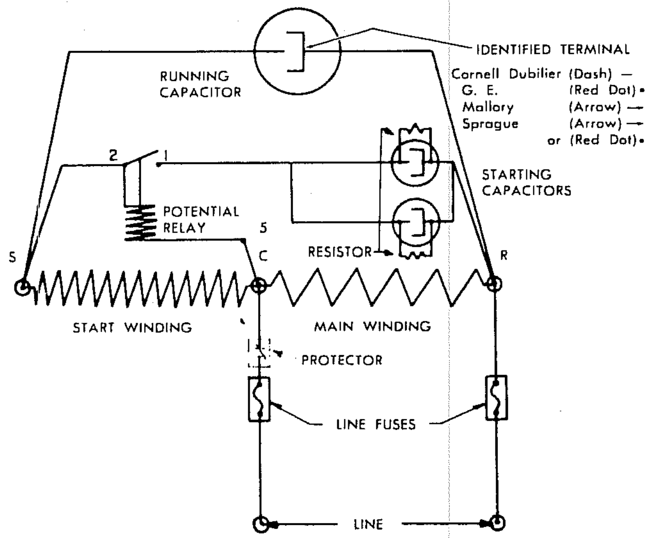
If the service engineer closes his eyes to a basic system malfunction, or an improper control setting, or an operating condition he knows is not right, he is not fooling the system or the compressor; he is only fooling himself.

Every service man should have this motto emblazoned in his mind "Do the job right the first time." If you can't find time to do it right, how can you find time to do it over again?

Schematic Wiring Diagram, Single Phase Motors

Actual field wiring diagrams may vary considerably in style or format, but Figure 147 is a simple schematic illustration of the basic wiring connections and compressor motor winding relationships in a single phase motor. The diagram as shown illustrates a capacitor start, capacitor run motor, but the same diagram can apply to a permanent split capacitor motor if the starting capacitors and relay are removed, and can apply to a capacitor start, induction run motor if the running capacitor is removed.

A thorough understanding of the basic wiring connections is essential to successfully diagnose field electrical problems on single phase compressors.



Capacitor-start, capacitor-run motor is shown. The PSC motor is the same but without starting capacitor and relay.

SCHEMATIC WIRING DIAGRAM, SINGLE PHASE MOTORS

Figure 147

If The Compressor Will Not Run

1. If there is no voltage at the compressor terminals, follow the wiring diagram (Figure 148) and check back from the compressor to the power supply to find where the circuit is interrupted.

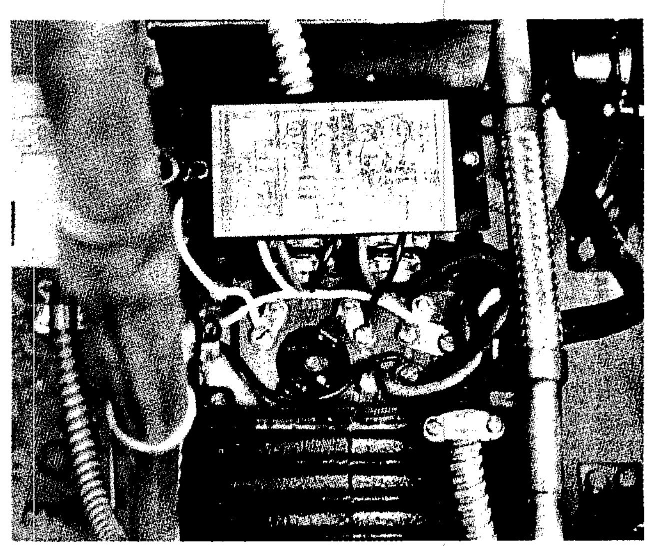


Figure 148

Check the controls to see if the contact points are closed (low pressure control, high pressure control, thermostat, oil pressure safety control, etc.). If a contactor is used check to see if the contacts are closed. Check for a blown fuse, open disconnect switch, or loose connection.

2. If power is available at the compressor terminals, and the compressor does not run, check the voltage at the compressor terminals while attempting to start the compressor (see Figure 149).

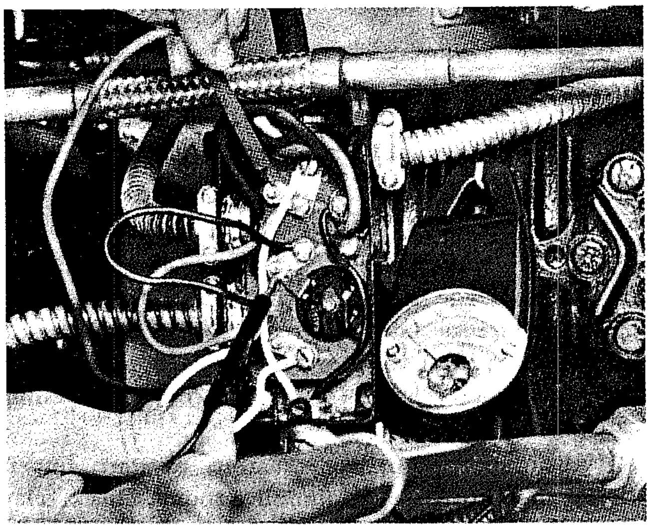


Figure 149

If the voltage at the compressor terminals is below 90% of the nameplate voltage, it is possible the motor may not develop sufficient torque to start. Check to determine if wire sizes are adequate, electrical connections are loose, the circuit is overloaded, or if the power supply is adequate.

3. On units with single phase PSC motors, the suction and discharge pressures must be equalized before starting because of the low starting torque of the motor. Any change in the refrigerant metering device, the addition of a drier, or other changes in the system components may delay pressure equalization and create starting difficulties. If PSC motor starting problems are being encountered, the addition of a capacitor start kit is recommended.

4. On single phase compressors, a defective capacitor or relay may prevent the compressor starting. If the compressor attempts to start, but is unable to do so, or if there is a humming sound, check the relay to see if the relay contacts are damaged or fused. The relay points should be closed during the initial starting cycle, but should open as the compressor comes up to speed.

Remove the wires from the starting relay and capacitors. Use a high voltage ohmmeter to check for continuity through the relay coil. Replace the relay if there is no continuity. Use an ohmmeter to check across the relay contacts. Potential relay contacts are normally closed when the relay is not energized, current relay contacts are normally open. If either gives an incorrect reading, replace the relay.

Any capacitor found to be bulging, leaking, or damaged should be replaced.

Make sure capacitors are discharged before checking. Check for continuity between each capacitor terminal and the case. Continuity indicates a short, and the capacitor should be replaced.

Substitute "a known to be good" start capacitor if available. If compressor then starts and runs properly, replace the original start capacitor. On PSC motors, substitute "a known to be good" run capacitor if available. If compressor then starts and runs properly, replace the original run capacitor.

If a capacitor tester is not available, an ohmmeter may be used to check run and start capacitors for shorts or open circuits. Use an ohmmeter set to its highest resistance scale, and connect prods to capacitor terminals.

(a) With a good capacitor, the indicator should first move to zero, and then gradually increase to infinity.

(b) If there is no movement of the ohmmeter indicator, an open circuit is indicated.

(c) If the ohmmeter indicator moves to zero, and remains there or on a low resistance reading, a short circuit is indicated.

Defective capacitors should be replaced.

5. If the correct voltage is available at the compressor terminals, and no current is drawn,