Installation, Start-Up and Service Instructions

CONTENTS

SAFETY CONSIDERATIONS

Installation and servicing of air-conditioning equipment can be hazardous due to system pressure and electrical components. Only trained and qualified service personnel should install, repair, or service air-conditioning equipment.

Untrained personnel can perform basic maintenance functions of cleaning coils and filters and replacing filters. All other operations should be performed by trained service personnel. When working on air-conditioning equipment, observe precautions in the literature, tags and labels attached to the unit, and other safety precautions that may apply.

Follow all safety codes, including ANSI (American National Standards Institute) Z223.1. Wear safety glasses and work gloves. Use quenching cloth for unbrazing operations. Have fire extinguisher available for all brazing operations.

It is important to recognize safety information. This is the safety-alert symbol ⚠. When you see this symbol on the unit and in instructions or manuals, be alert to the potential for personal injury.

Understand the signal words DANGER, WARNING, CAUTION, and NOTE. These words are used with the safety-alert symbol. DANGER identifies the most serious hazards which **will** result in severe personal injury or death. WARNING signifies hazards which **could** result in personal injury or death. CAUTION is used to identify unsafe practices, which **may** result in minor personal injury or product and property damage. NOTE is used to highlight suggestions which **will** result in enhanced installation, reliability, or operation.

⚠ WARNING

Before performing service or maintenance operations on unit, turn off main power switch to unit. Electrical shock could cause personal injury.

⚠ WARNING

Do not provide power to unit or turn-on compressor unless suction and discharge service valves are open.

⚠ WARNING

CONTENTS UNDER PRESSURE

Compressor contains oil and refrigerant under pressure. Pressure must be relieved before installation, servicing or opening any connections.

⚠ WARNING

RISK OF PERSONAL INJURY
HOT and COLD surface temperatures can occur during operation and can result in severe burns of frostbite.

⚠ WARNING

RISK OF PERSONAL INJURY
Exposed moving parts of the compressor drive can cause severe injury. Appropriate guards must be utilized. Guards must be in place before operating.

⚠ WARNING

RISK OF PERSONAL INJURY
Only approved refrigerants and refrigeration oils may be used.

⚠ WARNING

Use nitrogen or inert gas for tightness/pressure testing. DO NOT USE oxygen or other industrial gases.

⚠ WARNING

System strength/tightness test pressure should not exceed 440 psig on the high-side and 270 psig on the low-side. Close shutoff valves to isolate compressor if necessary.

⚠ WARNING

Charge only with refrigerant that conforms to AHRI Standard 700.

⚠ CAUTION

This compressor shipped without oil. Do not run without adding required lubricant.

IMPORTANT: Install all safety decals/labels that come with the compressor.

INSTALLATION

Step 1 — Prepare for Installation

PREPARE EQUIPMENT ROOM

Locate compressor in a well ventilated area. If natural ventilation is inadequate, provide forced ventilation through ductwork. Check applicable code requirements. See Tables 1 and 2 for compressor models and details.

Provide sufficient clearance for removal of compressor cylinder heads and valve plates. Allow space on the oil pump end for crankshaft removal as follows:

5H40, 41, 46, 60, 61, 66, and 81 compressors —20 in.

5H80, 86, 120, and 126 compressors — 30 in.

PREPARE FOUNDATION

The 5H compressors may be fastened to:

- A steel base and vibration isolators on the floor
- A steel base and condenser support stand
- A concrete base

In each case, the foundation must be of sufficient strength for the expected load and should be resistant to vibration. See to Fig. 1 for vibration isolator mounting.

Floor Foundations

Locate the unit over joists or beams wherever possible. Weak floors in old buildings must be reinforced with steel beams or timbers to support the heavy compressors or condensing units. Use care in placing supports to avoid the transmission of objectionable vibrations to other areas.

Concrete Foundations

The foundation weight should be 1 to 2 times the weight of the machinery it is to support in order to absorb vibration. Let the foundation set for approximately 3 days before installing compressor. Allow for 3/8-1/2 in. grout thickness after compressor has been installed.

Heavy aggregate concrete weighs about 150 pounds per cubic foot.

Table 1 — 5H HFC Compressor Models

5H40/46	5H60/66	5H80/86	5H120/126	MODEL NOMENCLATURE	CAPACITY CONTROL	SERVICE VALVES	WATER-COOLED HEAD	OPSS	HIGH/LOW PRESSURE SWITCHES
X	X	X		-C145	Pressure Unloading	Yes	No	Yes	No
X	X	X		-C155			Yes		
X	X	X		-C835	Electric Unloading		No		
X	X	X		-C875			Yes		
X	X	X		-C915	Low Torque Start[a] (No Unloading)		No		
X	X	X		-C925			Yes		
X	X	X		-C935	VFD (No Unloading)[b]		No		
X	X	X		-C945			Yes		
			5H120 only	-A204	Pressure Unloading[c]		No	No	Yes
			5H126 only	-A404			No		
			X	-C14901			No		No
			X	-C86401			Yes		
			X	-C89401	VFD (No Unloading)[b]		No		

NOTES:
a. Compressor unloaders will start fully loaded on elevated oil pressure after compressor start.
b. Compressor has no unloading installed. Typically for VFD (variable frequency drive) applications.
c. Compressor can be applied with external electrical unloading kit 5H120-4FI-A.

Table 2 — 5H Ammonia Compressor Models[a,b]

5H41	5H61	5H81	5H121	MODEL NOMENCLATURE	CAPACITY CONTROL	UNLOADER ELEMENTS INSTALLED	SERVICE VALVES	WATER-COOLED HEADS	OPSS	HIGH/LOW PRESSURE SWITCHES
X	X	X		- C835	Electric Unloading	Yes	Yes	No	Yes	No
X	X	X		- C875				Yes		
X	X	X		- C915	Low Torque Start (No Unloading)			No		
X	X	X		- C925				Yes		
X	X	X		- C935	(VFD) No Unloading	No		No		
X	X	X		- C945				Yes		
			X	-C934				No	No	
			X	-C944				Yes		

NOTES:
a. Example: 5H61-C875 model number is a compressor configured with Electric Unloading, Service Valves, Water Cooled Heads, and OPSS oil safety sensor.
b. VFD compressor models will start fully loaded. VFD range is 30 Hz to 60 Hz.

Step 2 — Receive Compressor

BEFORE UNLOADING

Check unit nameplates against model and serial numbers recorded in job specifications. Check all items against shipping list, and examine items carefully for any shipping damage. If damage is found or any major component has torn loose from its anchorage, have transportation inspectors examine it before unloading. File claim immediately with shipping company for any loss or damage. See to Fig. 2-17 for compressor component locations and details.

RIG UNIT CAREFULLY

Check that rigging equipment can safely handle the approximate equipment weights for compressor units.

Rig and move unit carefully to prevent damage to mounting brackets, refrigerant piping or connections. See to Fig. 7, 8, 10, 11, 13,14,16, and 17 for rigging details.

Step 3 — Install Unit

TO MOUNT MOTOR ON BASE

The motor fastening set, available as an accessory for all 5H base-mounted compressors, includes motor blocks and shims for motor alignment; cap screws, plate washers and lock washers for fastening motor to base; taper dowel pins for securing motor position after alignment; and beveled washers for fastening the unit base to accessory vibration isolators.

If vibration isolators are used, attach to base (see Fig. 1). To avoid damaging the isolators, lift unit from ends when attaching isolators.

With compressor and motor positioned on the base, check the height of the vibration isolators. Shim between isolators and floor as required to level compressor base. When level, secure vibration isolators to floor. Check that bevel washer (see Fig. 1) is in place.

Step 4 — Assemble Refrigerant Piping

COMPRESSOR PIPING

- Provide economical line sizes without excessive pressure drop, but maintain adequate refrigerant velocities, at all capacity steps, to promote oil return.
- Protect the compressor by preventing excessive lubricating oil from being trapped in the system.
- Prevent liquid refrigerant from entering the compressor during operation and shutdown.

FELT FILTERS

Install felt filter supplied with compressor in suction strainer (see Fig. 2-17). Remove filter after 50 hours of operation. If clean, discard it; if dirty, clean with kerosene or neutral spirits and insert for another 50 hours of operation. Tag unit to show date that filter was cleaned and reinstalled.

See Table 3 for information on replacement filter packages. See Physical Data Tables 4 and 5 for refrigerant connection sizes.

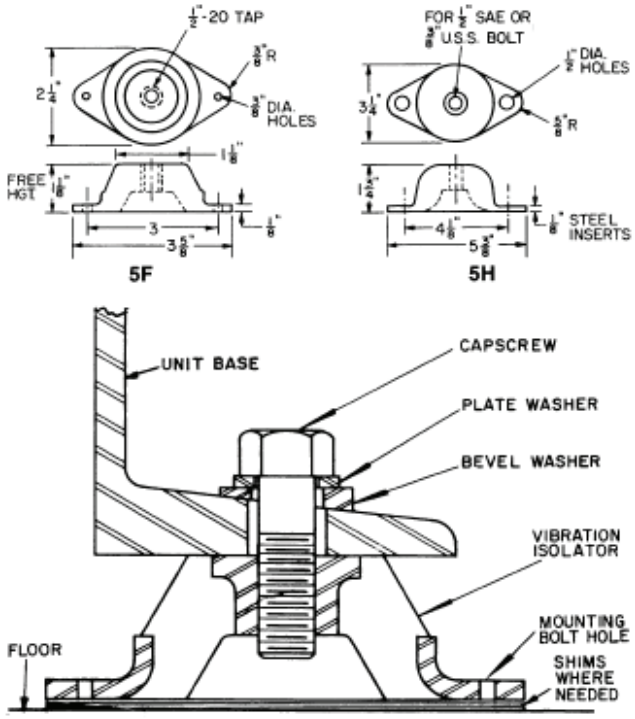


Fig. 1 — Typical Vibration Isolator Mounting

Table 3 — Suction (Felt) Filter Packages

COMPRESSOR	FILTER PACKAGE PART NO.
5H40, 46	5H40-A382
5H60, 66	5H60-A382
5H80, 86	5H80-A382
5H120, 126	5H120-A382

Table 4 — Physical Data (HFC Refrigerants)

COMPRESSOR MODEL		5H40	5H46	5H60	5H66	5H80	5H86	5H120	5H126
NOMINAL Hp	R-134a/R-407C	25	40	40	50	50	75	75	100
	R-22	40	60	60	75	75	100	125	150
	R-507/404A/448A/449A	40	60	60	75	75	100	125	150
NUMBER OF CYLINDERS		4	4	6	6	8	8	12	12
Bore (in.)		3-1/4	3-1/4	3-1/4	3-1/4	3-1/4	3-1/4	3-1/4	3-1/4
Stroke (in.)		2-3/4	3-7/16	2-3/4	3-7/16	2-3/4	3-7/16	2-3/4	3-7/16
DISPLACEMENT cfm at 1750 rpm		92.4	115.5	138.4	173.0	184.7	231.0	276.8	346.0
RATINGS IN TONS[a]	R-134a/R-407C	24.7	30.6	37.0	45.9	49.5	61.1	74.0	91.8
	R-22	39.6	49.1	59.4	73.8	79.2	98.2	119.0	145.0
	R-507/404A, R-448A/R-449A	38.5	47.7	57.7	71.6	77.0	95.5	115.5	143.2
MAX ALLOWABLE PRESSURES (psig)	Low Side	245							
	High Side	400							
MAX SPEED (rpm)		1750	1750	1750	1750	1750	1750	1750	1750
MIN SPEED (rpm)	For Lubrication	400	400	400	400	400	400	400	400
	For Unloader Action	800	800	900	900	1100	1100	900	900
NET OIL PRESSURE (psig)[b]		45	45	45	45	45	45	45	45
OIL CHARGE (pt)		18	18	21	21	41	41	61	61
NORMAL OIL LEVEL IN SIGHT GLASS		C.L.	C.L.	C.L.	C.L.	C.L.	C.L.	C.L.	C.L.
MIN OIL PRESSURE FOR UNLOADER ACTION (psig)		35	35	35	35	35	35	35	35
SUCTION LINE ODF (in.)		2-5/8	2-5/8	3-1/8	3-1/8	3-1/8	3-1/8	4-1/8	4-1/8
DISCHARGE LINE ODF (in.)		2-1/8	2-1/8	3-1/8	3-1/8	3-1/8	3-1/8	4-1/8	4-1/8
BARE COMPRESSOR WEIGHT (lb)		610	610	795	795	1115	1115	1580	1580

LEGEND

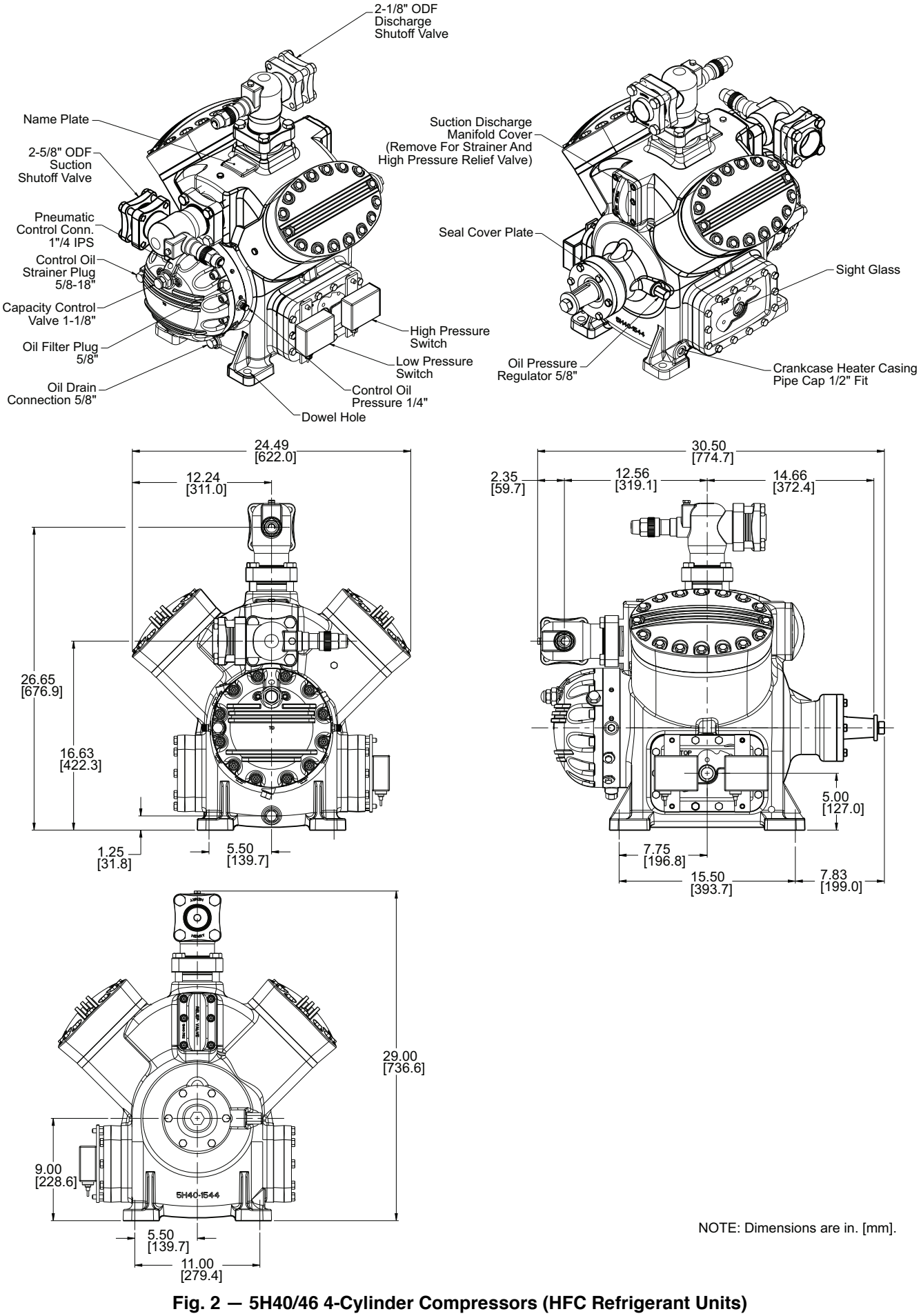
C.L. — Center Line
ODF — Outside Diameter Female (in.)

NOTES:

a. 40°F saturated suction, 105°F saturated discharge, 15°F superheat, 0°F subcooling.
b. Net oil pressure = oil pressure gauge reading – suction pressure. The above oil pressure is typical with mineral or alkylbenzene oils. A slight increase in oil pressure may result with the use of Polyolester (POE) oil.

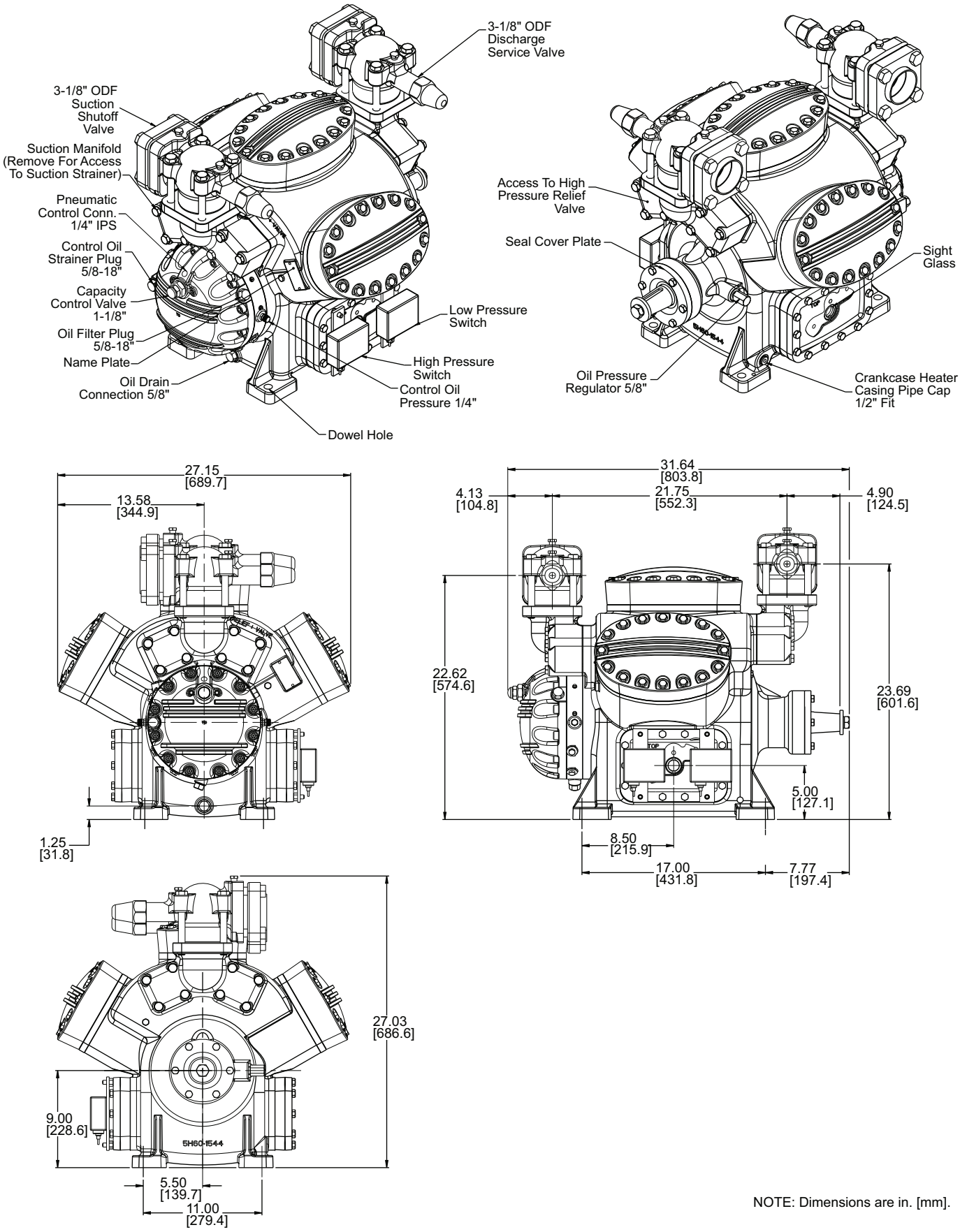
Table 5 — Physical Data (Ammonia R-717)

COMPRESSOR MODEL	AMMONIA	5H41	5H61	5H81	5H121
NOMINAL HP	—	25	40	50	75
NUMBER OF CYLINDERS	—	4	6	8	12
UNLOADING CYLINDERS	Standard	2	4	5	0
SUCTION SERVICE VALVE	Standard	2-1/8 in.	2-1/8 in.	2-5/8 in.	3-1/8 in.
DISCHARGE SERVICE VALVE	Standard	1-5/8 in.	2-1/8 in.	2-1/8 in.	3-1/8 in.
OIL PRESSURE SAFETY	Standard	Yes	Yes	Yes	No
MAXIMUM SPEED (rpm)	Single High Stage	1275	1275	1275	1275
	Low Stage Booster	1600	1600	1600	1600
DISPLACEMENT at 1275 rpm	cfm	67	101	135	202
DISPLACEMENT at 1600 rpm	cfm	85	127	169	253
MINIMUM SPEED (rpm)	For Unloading	800	900	900	N/A
	For Lubrication	400	400	400	400
RECOMMEND NET OIL DP PRESSURE	psid	45	45	45	45
RECOMMEND OIL TYPE CAMCO 717-HT	Pint	20	24	45	81
WEIGHT (WATER COOLED HEADS)	lbs	715	965	1340	1800
LOW SIDE (MAXIMUM ALLOWABLE PRESSURE)	psig	150	150	150	245
HIGH SIDE (MAXIMUM ALLOWABLE PRESSURE)	psig	300	300	300	400



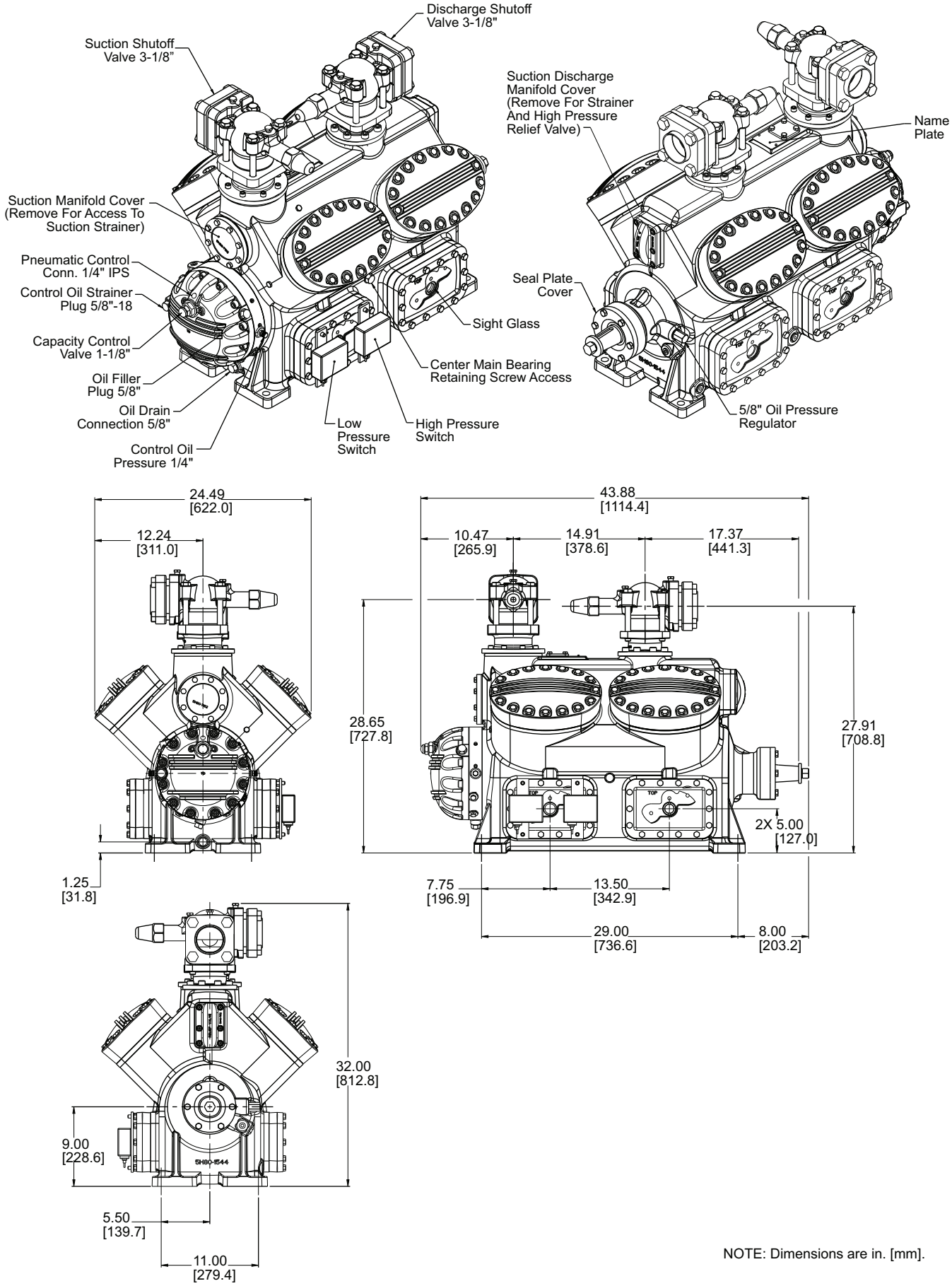
NOTE: Dimensions are in. [mm].

Fig. 2 — 5H40/46 4-Cylinder Compressors (HFC Refrigerant Units)



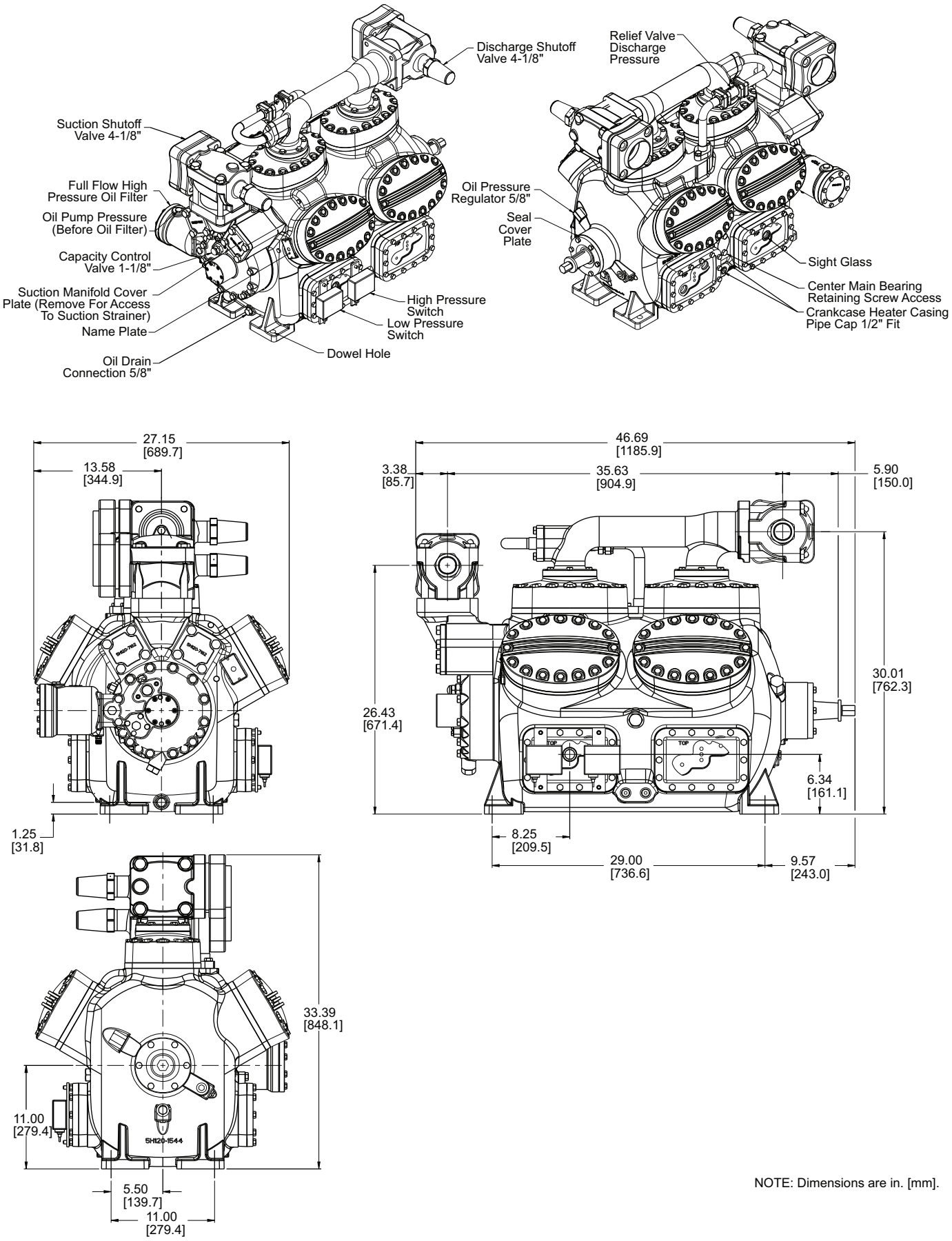
NOTE: Dimensions are in. [mm].

Fig. 3 — 5H60/66 6-Cylinder Compressors (HFC Refrigerant Units)



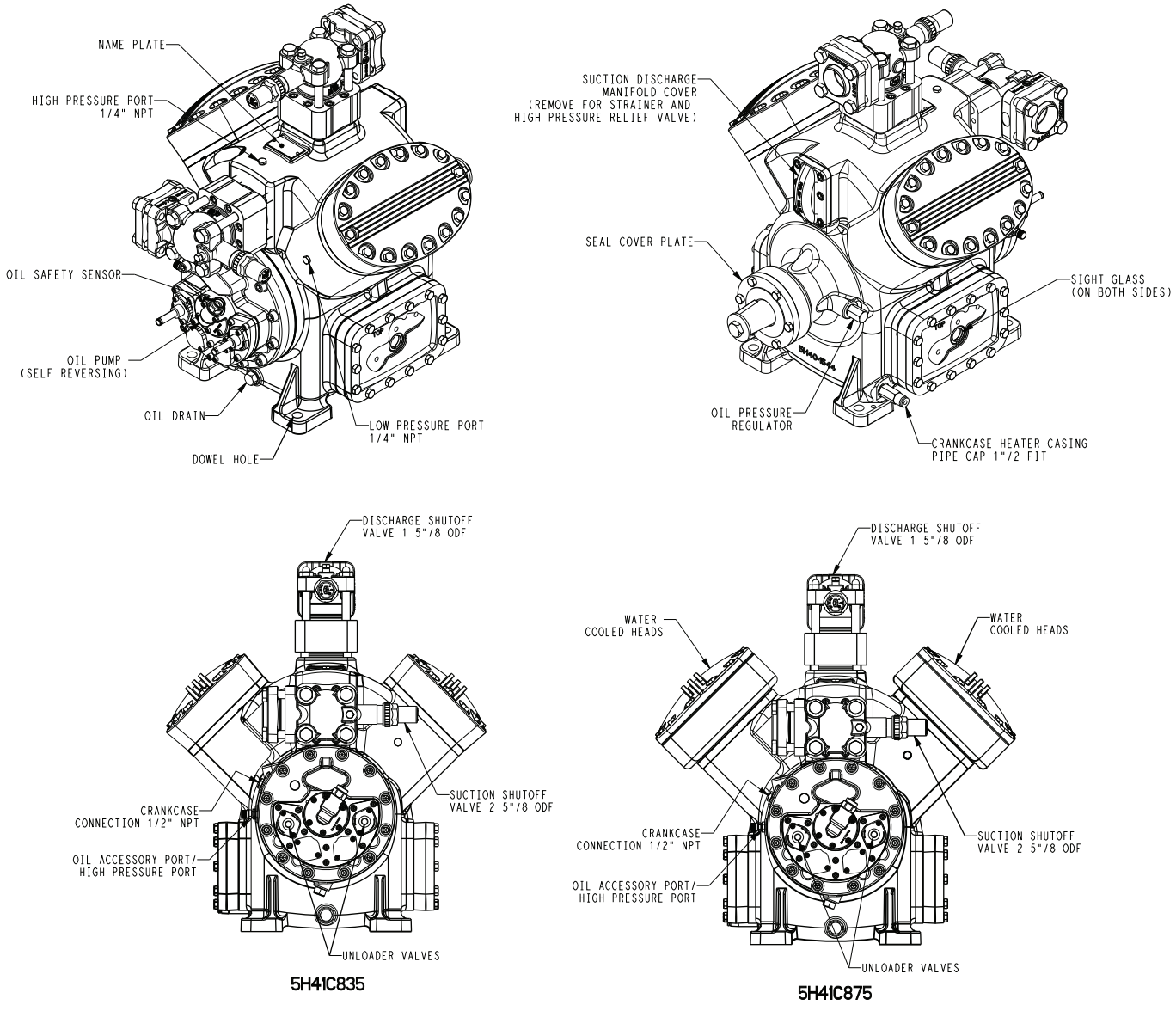
NOTE: Dimensions are in. [mm].

Fig. 4 — 5H80/86 8-Cylinder Compressors (HFC Refrigerant Units)



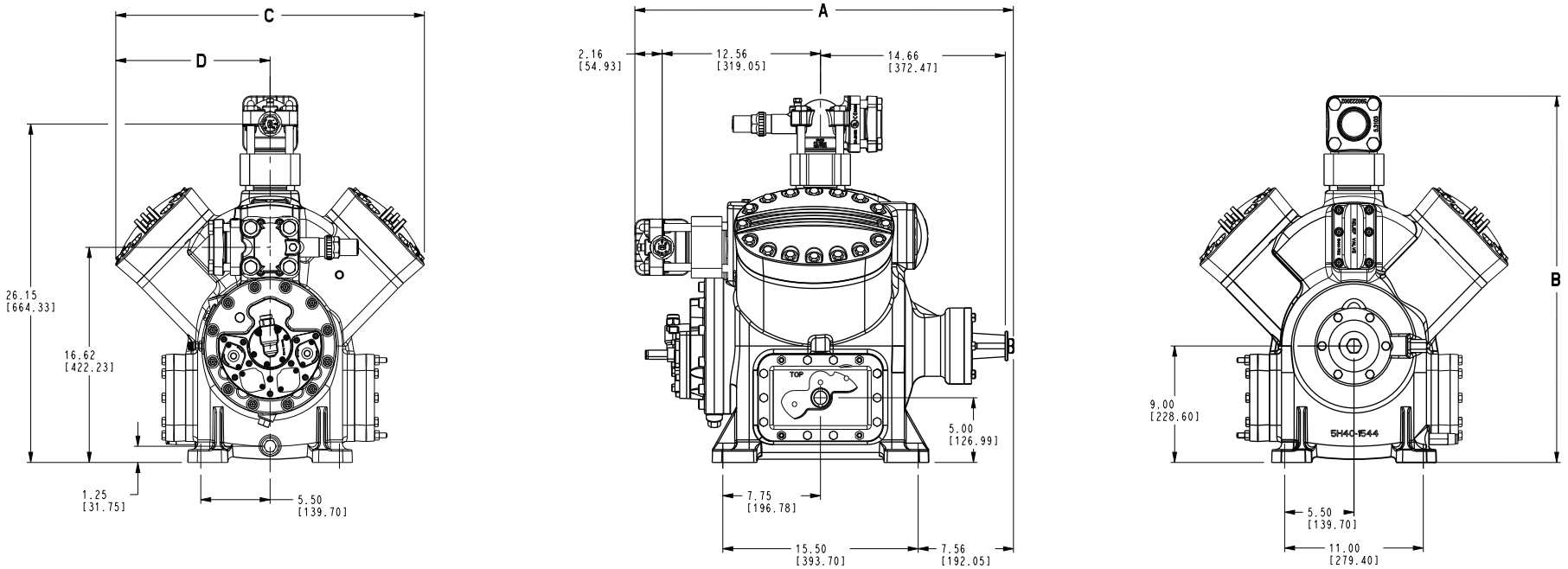
NOTE: Dimensions are in. [mm].

Fig. 5 — 5H120/126 12-Cylinder Compressors (HFC Refrigerant Units)



NOTE: Dimensions are in inches (mm).

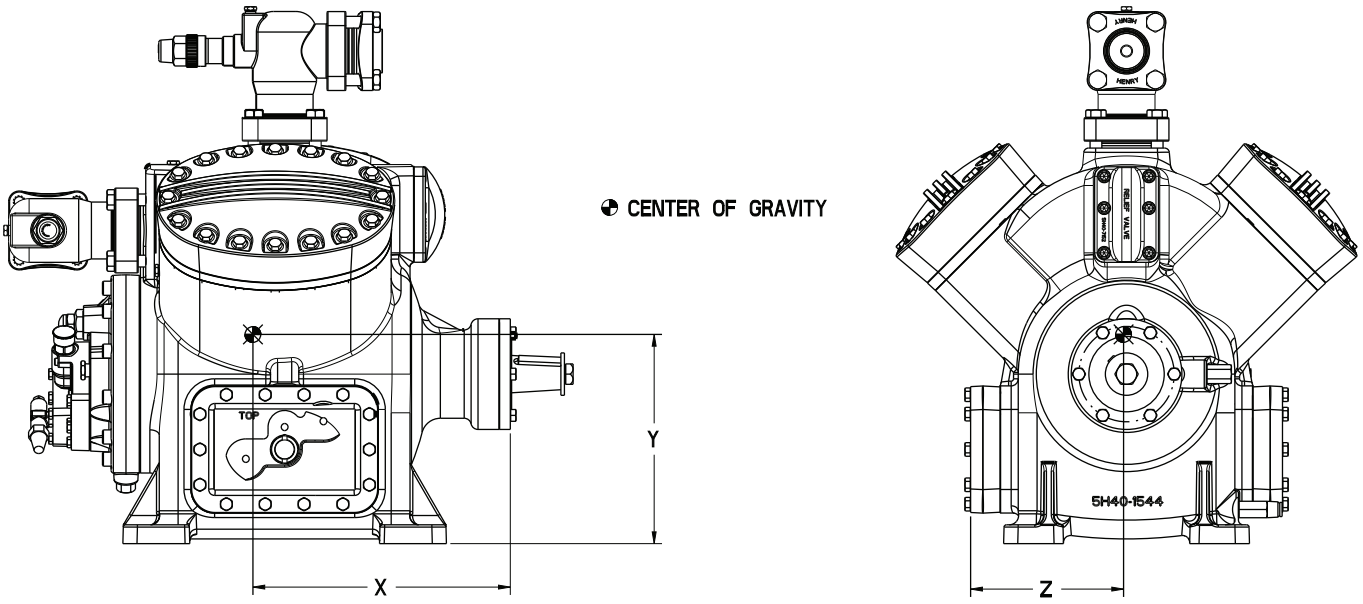
Fig. 6 — 5H41 Ammonia Units



NOTE: Dimensions are in inches (mm).

MODEL NO.	A	B	C	D
5H41-C835D	30.03 [762.88]	28.32 [719.25]	24.49 [621.98]	12.24 [310.96]
5H41-C875D	30.03 [762.88]	28.32 [719.25]	27.64 [702.09]	13.81 [350.66]
5H41-C895D	27.65 [702.33]	22.70 [563.02]	24.49 [621.98]	12.24 [310.96]
5H41-C905D	27.65 [702.33]	23.20 [589.27]	27.64 [702.09]	13.81 [350.68]

Fig. 6 — 5H41 Ammonia Units (cont)



NOTES:

1. SAFETY :

   A) LIFTING ROPES AND LIFTING RINGS MUST BE CAPABLE TO LIFT 3200LBS.
   B) DONT USE THE SERVICE VALVES OR DISCHARGE MANIFOLD PIPE AS THE RIGGING POINTS.

SIZE	DRAWING NUMBER	REV	ITR
D	0AHA001462 SHEET 3 OF 4	-	11

5H41 APPLICATION

MODEL NO.		CENTER OF GRAVITY (in.)			WEIGHT (lbs)
		X	Y	Z	
5H40	5H40-C145	13.69	11.13	8.12	694.50
	5H40-C155	13.51	11.82	8.14	764.96
	5H40-C835	12.76	11.96	8.29	581.66
	5H40-C875	12.69	12.67	8.29	649.70
	5H40-C915	12.74	11.94	8.29	578.54
	5H40-C925	12.67	12.68	8.29	649.00
	5H40-C935	12.73	11.92	8.31	569.38
	5H40-C945	12.66	12.67	8.31	639.38
5H41	5H41-C835	12.99	12.38	8.28	609.19
	5H41-C875	12.90	13.03	8.27	679.64
	5H41-C915	12.98	12.38	8.27	608.71
	5H41-C925	12.89	13.04	8.27	679.17
	5H41-C935	12.97	12.38	8.32	602.25
	5H41-C945	12.88	13.04	8.31	672.72
	5H41-C895	12.42	11.37	8.28	538.82
	5H41-C905	12.39	12.22	8.28	609.29
5H46	5H46-C145	13.62	11.09	8.12	701.74
	5H46-C155	13.49	11.78	8.14	772.20
	5H46-C835	12.73	11.90	8.29	588.90
	5H46-C875	12.66	11.78	8.29	659.36
	5H46-C915	12.72	11.90	8.29	588.20
	5H46-C925	12.65	12.63	8.29	658.85
	5H46-C935	12.71	11.88	8.31	579.04
	5H46-C945	12.64	12.63	8.31	649.05

Fig. 7 — 5H40/41/46 Unit Rigging and Center of Gravity Diagram (5H41 Model Shown)

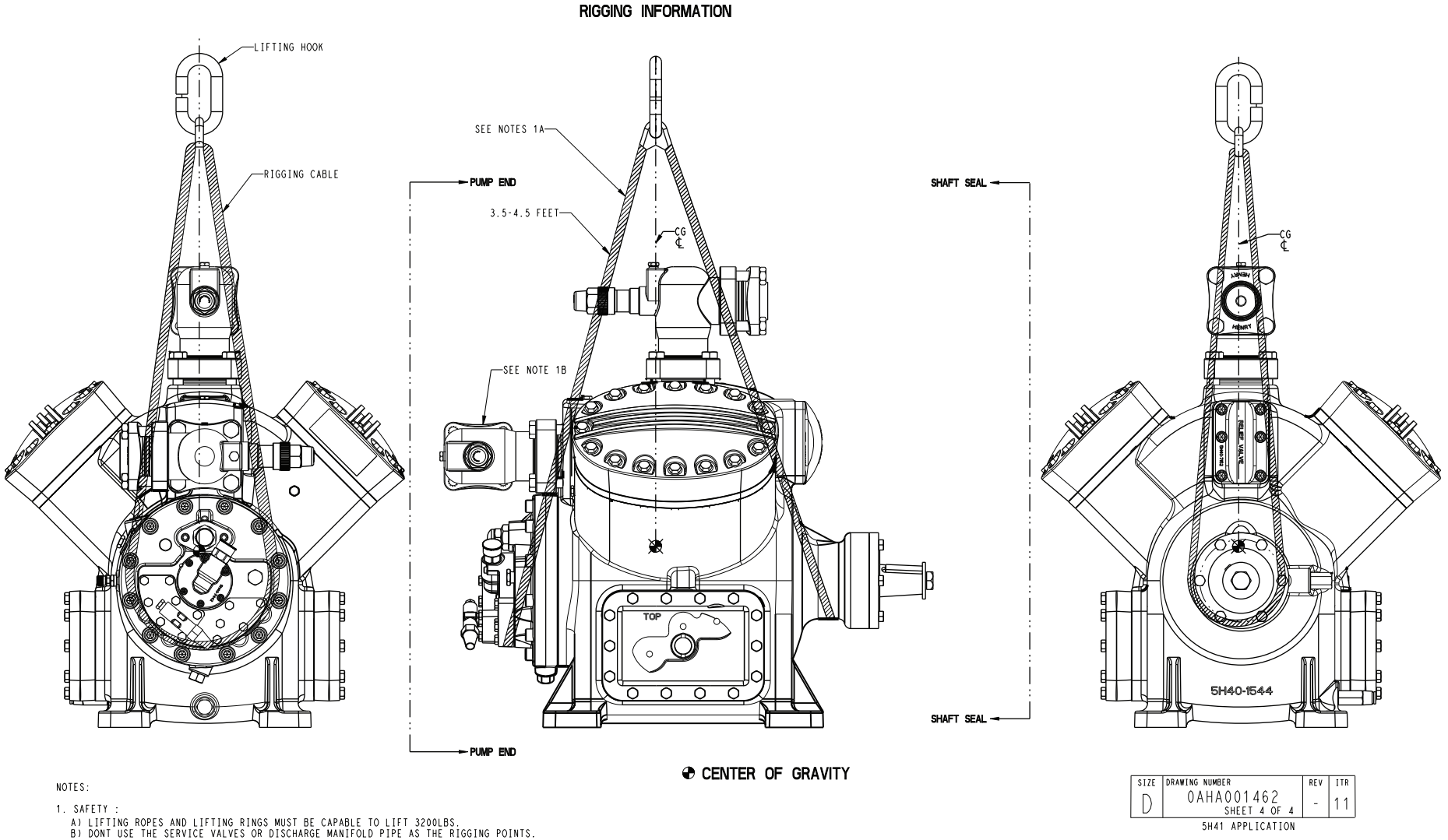
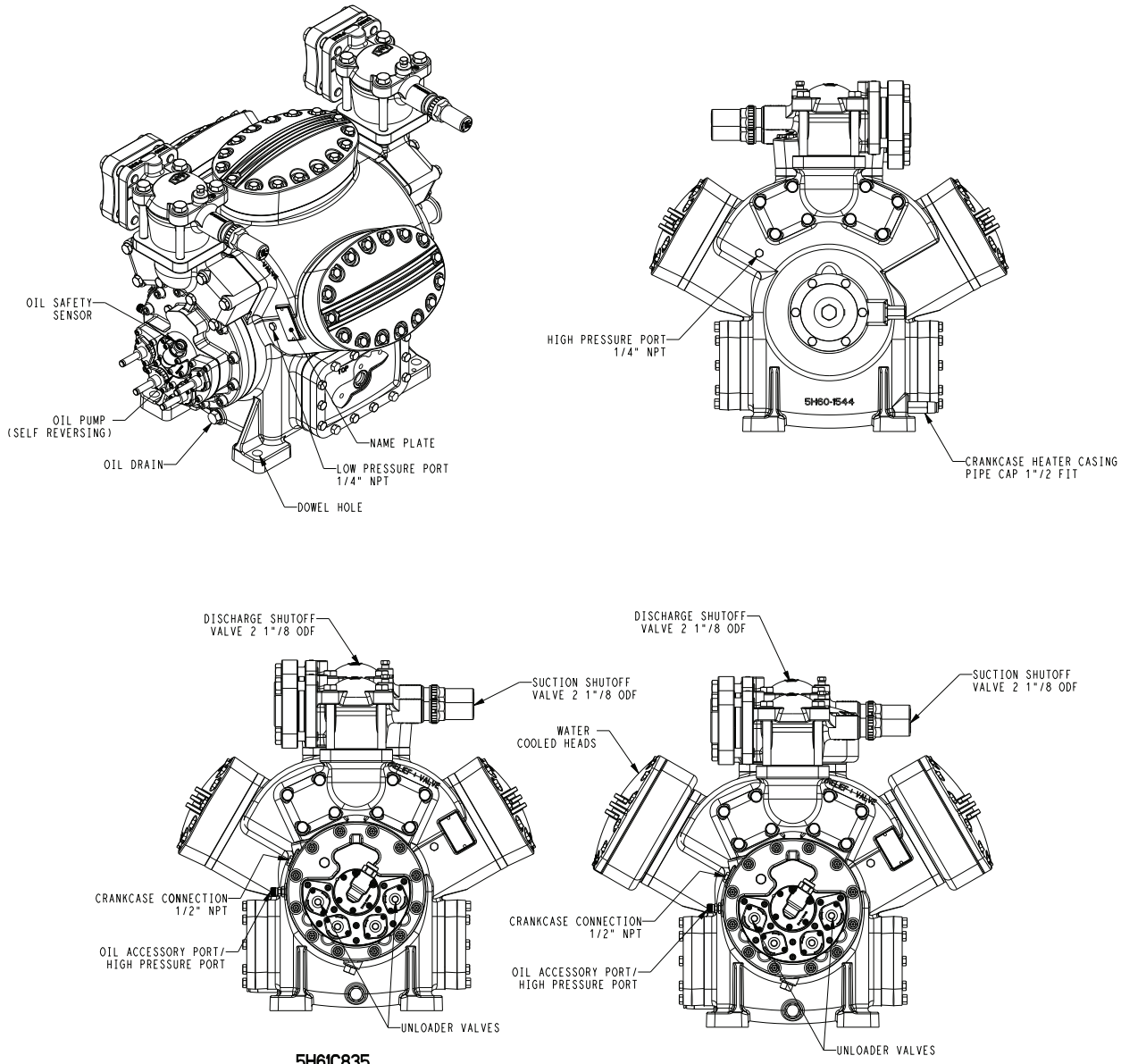
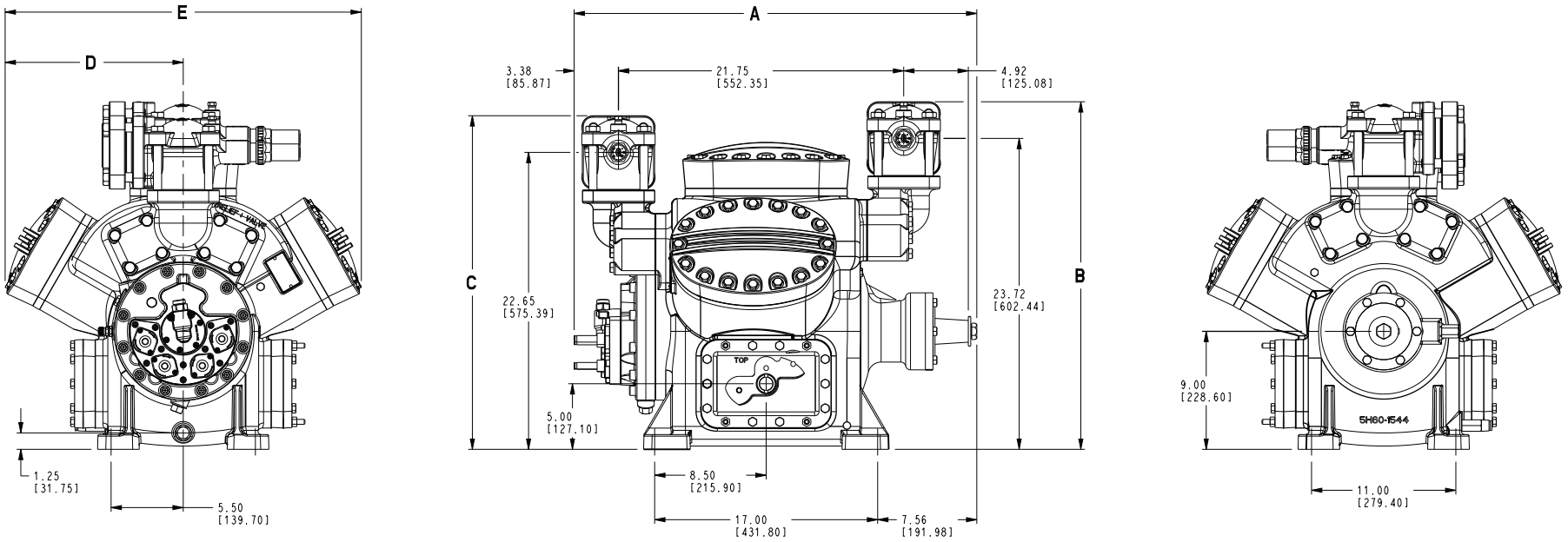


Fig. 8 — 5H40/41/46 Unit Rigging and Center of Gravity Diagram, Pump End (5H41 Model Shown)



NOTE: Dimensions are in inches (mm).

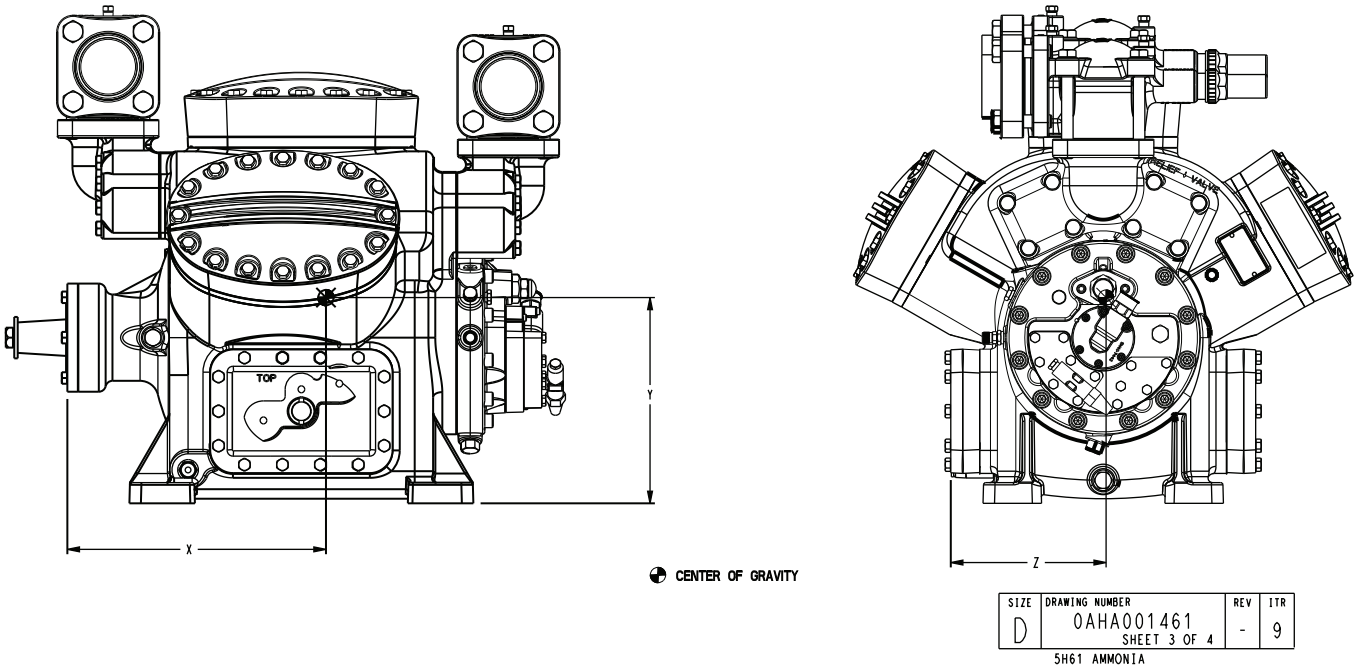
Fig. 9 — 5H61 Ammonia Unit



NOTE: Dimensions are in inches (mm).

MODEL NO.	A	B	C	D	E
5H61-C835D	30.70 [779.76]	26.50 [673.44]	25.45 [646.39]	13.58 [344.86]	27.15 [689.72]
5H61-C875D	30.70 [779.76]	26.50 [673.44]	25.45 [646.39]	15.11 [383.80]	30.25 [768.32]
5H61-C895D	32.75 [831.75]	23.42 [663.76]	—	13.58 [344.86]	27.15 [689.72]
5H61-C905D	32.75 [831.75]	26.13 [663.70]	—	15.11 [383.80]	30.25 [768.32]

Fig. 9 — 5H61 Ammonia Unit (cont)



MODEL NO.		CENTER OF GRAVITY (in.)			WEIGHT (lbs)
		X	Y	Z	
5H60	5H60-C145	14.05	11.18	8.44	801.24
	5H60-C155	13.91	11.99	8.42	906.93
	5H60-C835	13.12	11.88	8.30	688.62
	5H60-C875	13.08	12.72	8.30	794.31
	5H60-C915	13.10	11.89	8.30	687.67
	5H60-C925	13.06	12.73	8.30	793.37
	5H60-C935	13.09	11.89	8.29	675.83
	5H60-C945	13.05	12.74	8.29	781.52
5H61	5H61-C835	13.11	13.23	8.13	783.02
	5H61-C875	13.08	13.82	8.15	888.71
	5H61-C915	13.10	13.24	8.13	782.07
	5H61-C925	13.07	13.83	8.15	887.76
	5H61-C935	13.09	13.26	8.13	770.23
	5H61-C945	13.06	13.85	8.15	875.92
	5H61-C895	13.09	12.03	8.29	687.82
	5H61-C905	13.05	12.85	8.29	793.52
5H66	5H66-C145	14.04	11.18	8.43	802.84
	5H66-C155	13.90	11.99	8.42	908.53
	5H66-C235	13.11	11.89	8.30	690.22
	5H66-C875	13.08	12.72	8.30	795.91
	5H66-C915	13.10	11.90	8.27	689.27
	5H66-C925	13.06	12.73	8.29	794.97
	5H66-C935	13.08	11.89	8.30	677.43
	5H66-C945	13.05	12.74	8.29	783.13

Fig. 10 — 5H60/61/66 Unit Rigging and Center of Gravity Diagram (5H61 Model Shown)

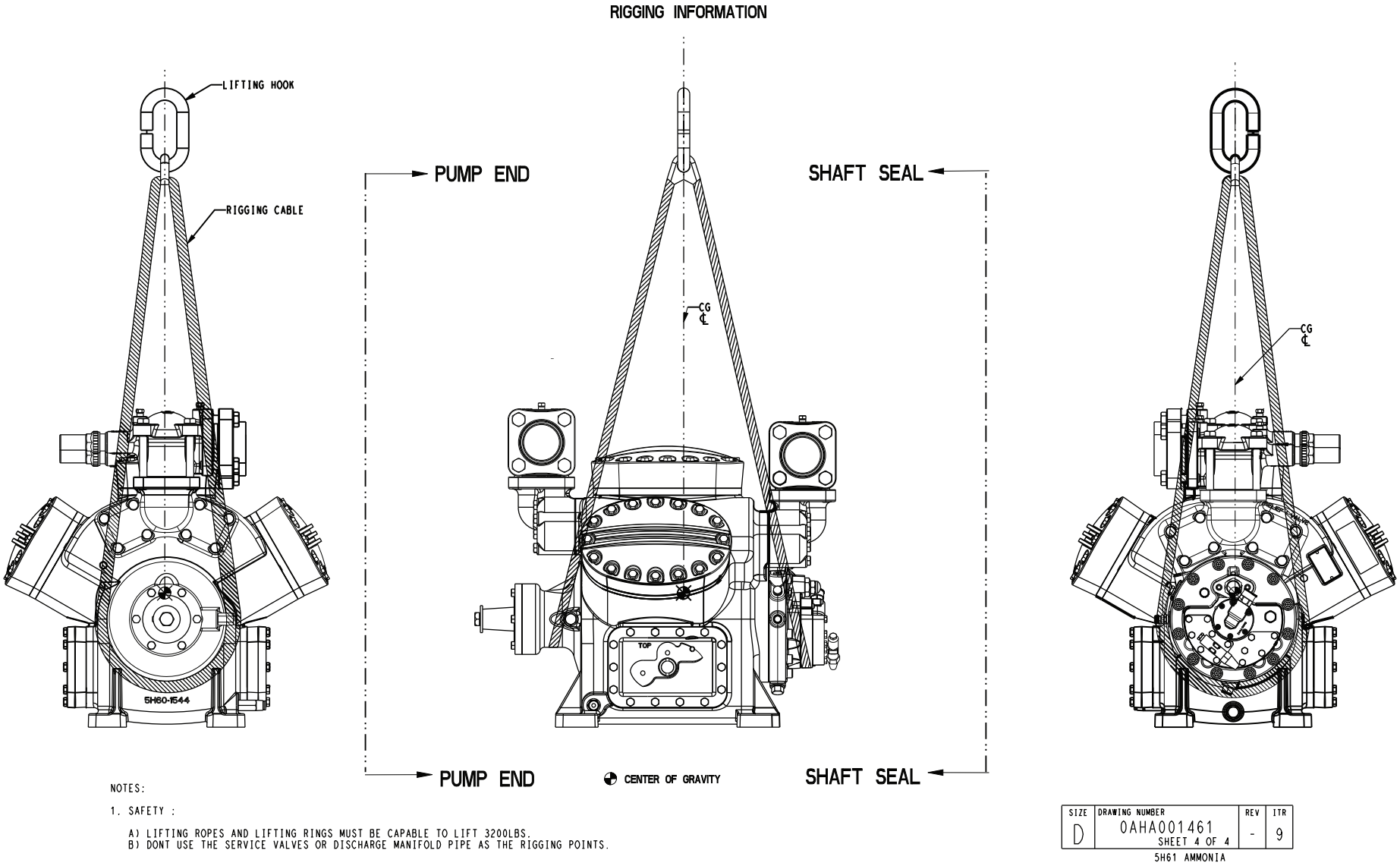
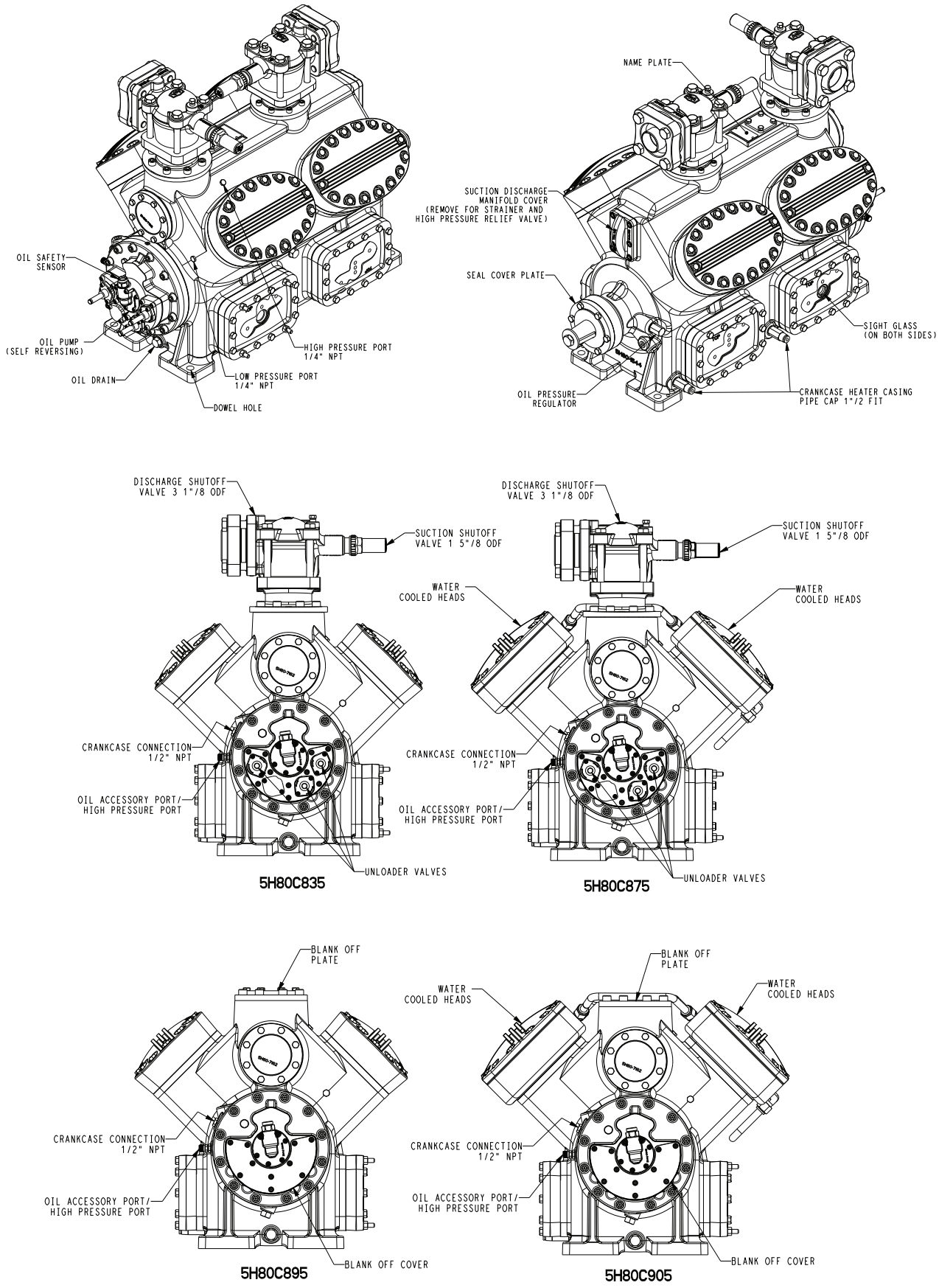
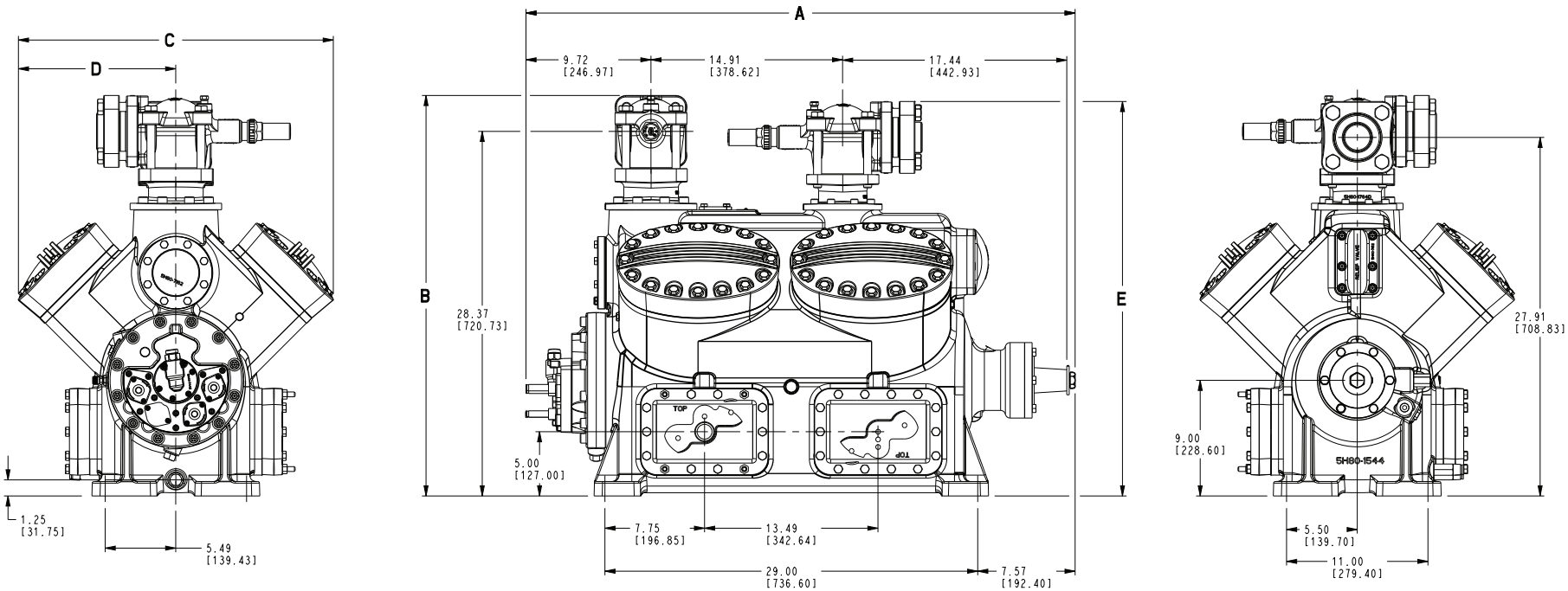


Fig. 11 — 5H60/61/66 Unit Rigging and Center of Gravity Diagram, Pump End (5H61 Model Shown)



NOTE: Dimensions are in inches (mm).

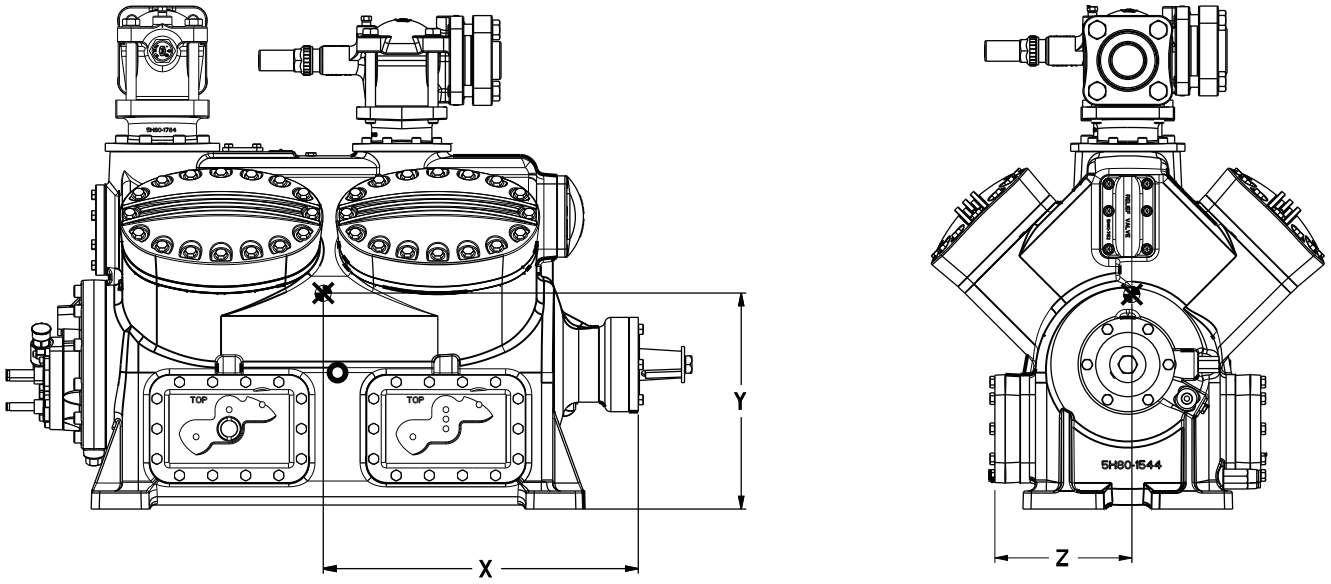
Fig. 12 — 5H81 Ammonia Unit



NOTE: Dimensions are in inches (mm).

MODEL NO.	A	B	C	D	E
5H81-C835D	42.72 [1084.99]	31.17 [791.72]	24.49 [622.12]	12.25 [311.06]	30.70 [779.96]
5H81-C875D	42.72 [1084.99]	31.17 [791.72]	27.67 [702.73]	13.83 [351.37]	30.70 [779.96]
5H81-C895D	41.16 [1045.51]	23.38 [593.93]	24.49 [622.12]	12.25 [311.06]	—
5H81-C905D	41.16 [1045.51]	23.38 [593.93]	27.67 [702.73]	13.83 [351.37]	—

Fig. 12 — 5H81 Ammonia Unit (cont)



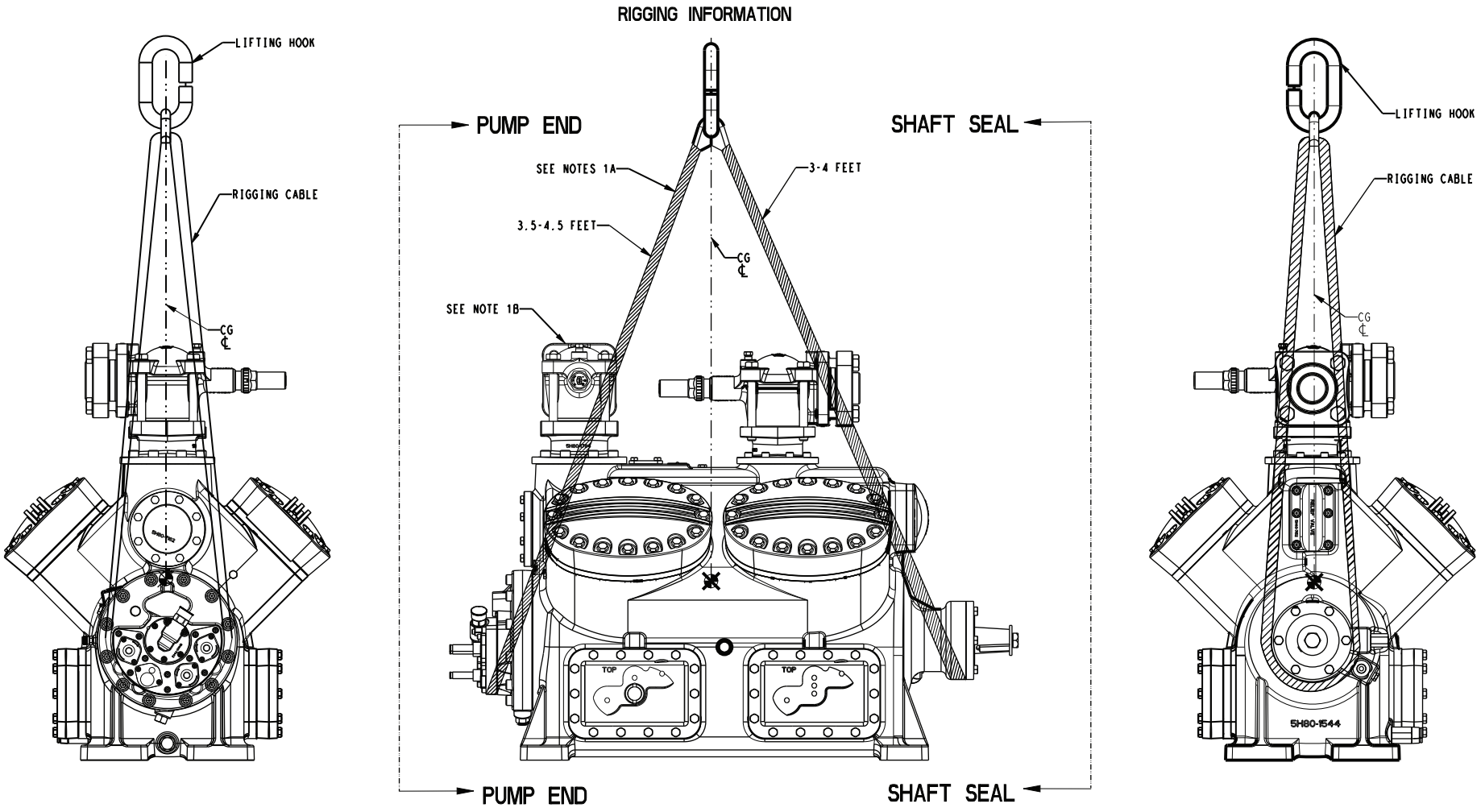
CENTER OF GRAVITY

SIZE	DRAWING NUMBER	REV	ITR
D	0AHA001460 SHEET 3 OF 4	-	9

5H81 AMMONIA

MODEL NO.		CENTER OF GRAVITY (in.)			WEIGHT (lbs)
		X	Y	Z	
5H80	5H80-C145	18.8	10.75	8.27	950.09
	5H80-C155	19.24	12.3	8.32	1100.39
	5H80-C835	19.42	11.90	8.32	955.60
	5H80-C875	19.30	12.9	8.32	1105.97
	5H80-C915	19.42	12.00	8.32	954.80
	5H80-C925	19.30	12.90	8.32	1051.08
	5H80-C935	19.30	11.90	8.29	938.15
	5H80-C945	19.23	12.90	8.39	1088.42
5H81	5H81-C835	19.60	13.45	8.39	1202.62
	5H81-C875	19.50	14.10	8.38	1205.34
	5H81-C915	19.59	13.48	8.39	1054.48
	5H81-C925	19.48	14.10	8.38	1204.74
	5H81-C935	19.59	13.48	8.39	1040.33
	5H81-C945	19.46	14.10	8.38	1190.62
	5H81-C895	19.46	11.70	8.38	924.41
	5H81-C905	19.46	12.60	8.38	1074.78
5H86	5H86-C145	19.09	11.16	8.55	1055.06
	5H86-C155	19.00	12.04	8.51	1205.59
	5H86-C235	19.10	11.10	8.51	1060.81
	5H86-C875	19.01	12.10	8.50	1211.11
	5H86-C915	19.01	11.10	8.50	1059.96
	5H86-C925	19.00	12.01	8.50	1210.29
	5H86-C935	19.01	11.10	8.50	1043.24
	5H86-C945	19.06	12.07	8.49	1193.59

Fig. 13 — 5H80/81/86 Unit Rigging and Center of Gravity Diagram (Model 5H81 Shown)



NOTES:

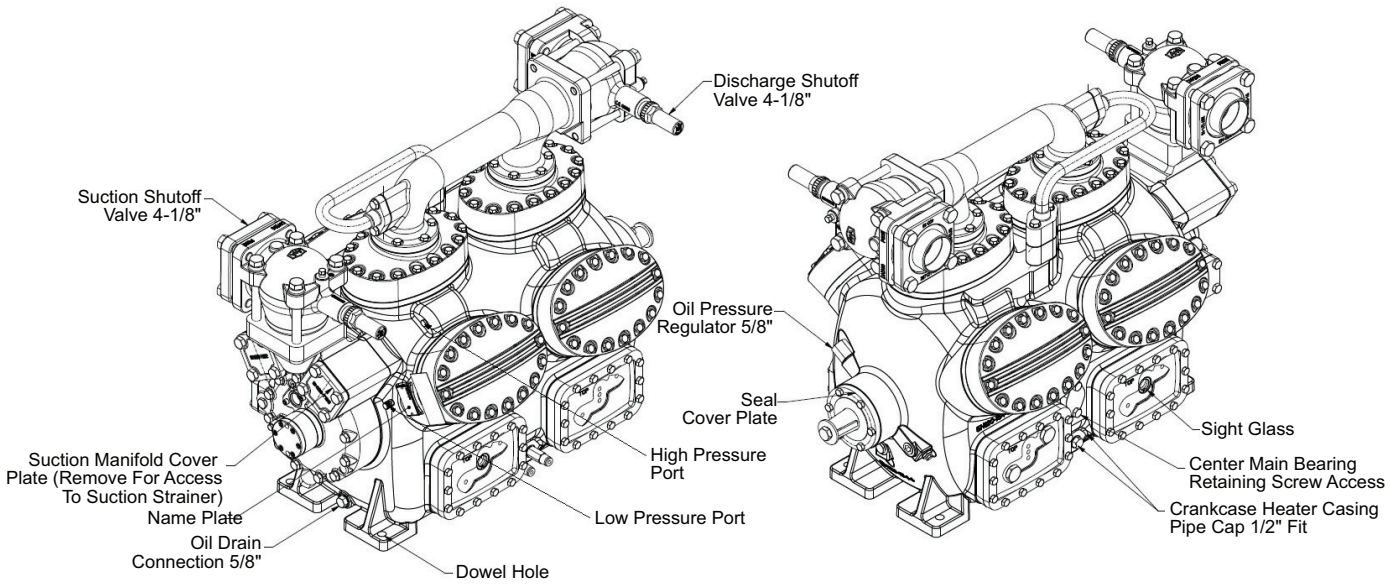
1) SAFETY :

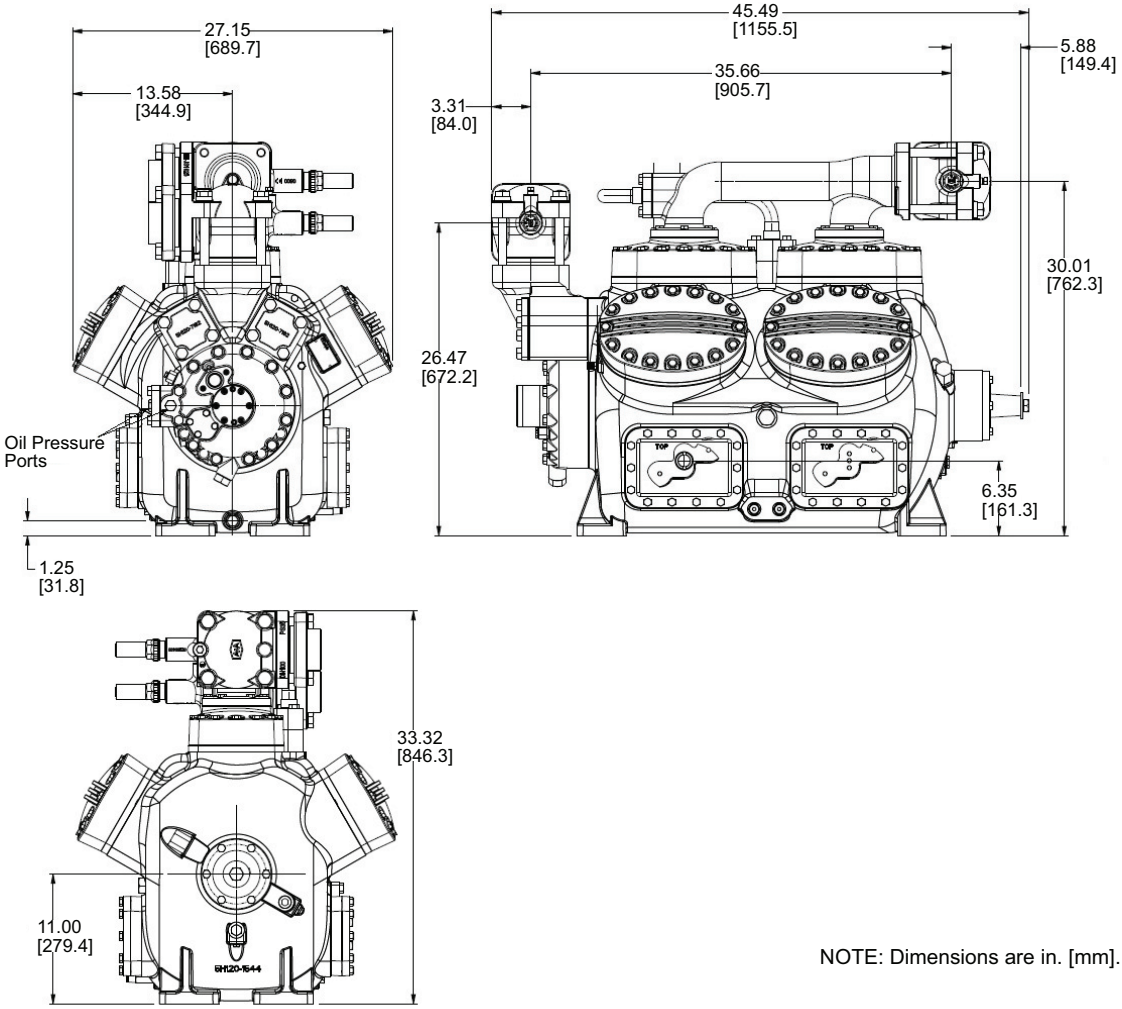
A) LIFTING ROPES AND LIFTING RINGS MUST BE CAPABLE TO LIFT 3200LBS.
B) DONT USE THE SERVICE VALVES OR DISCHARGE MANIFOLD PIPE AS THE RIGGING POINTS.

SIZE	DRAWING NUMBER	REV	ITR
D	0AHA001460 SHEET 4 OF 4	-	9

5H81 AMMONIA

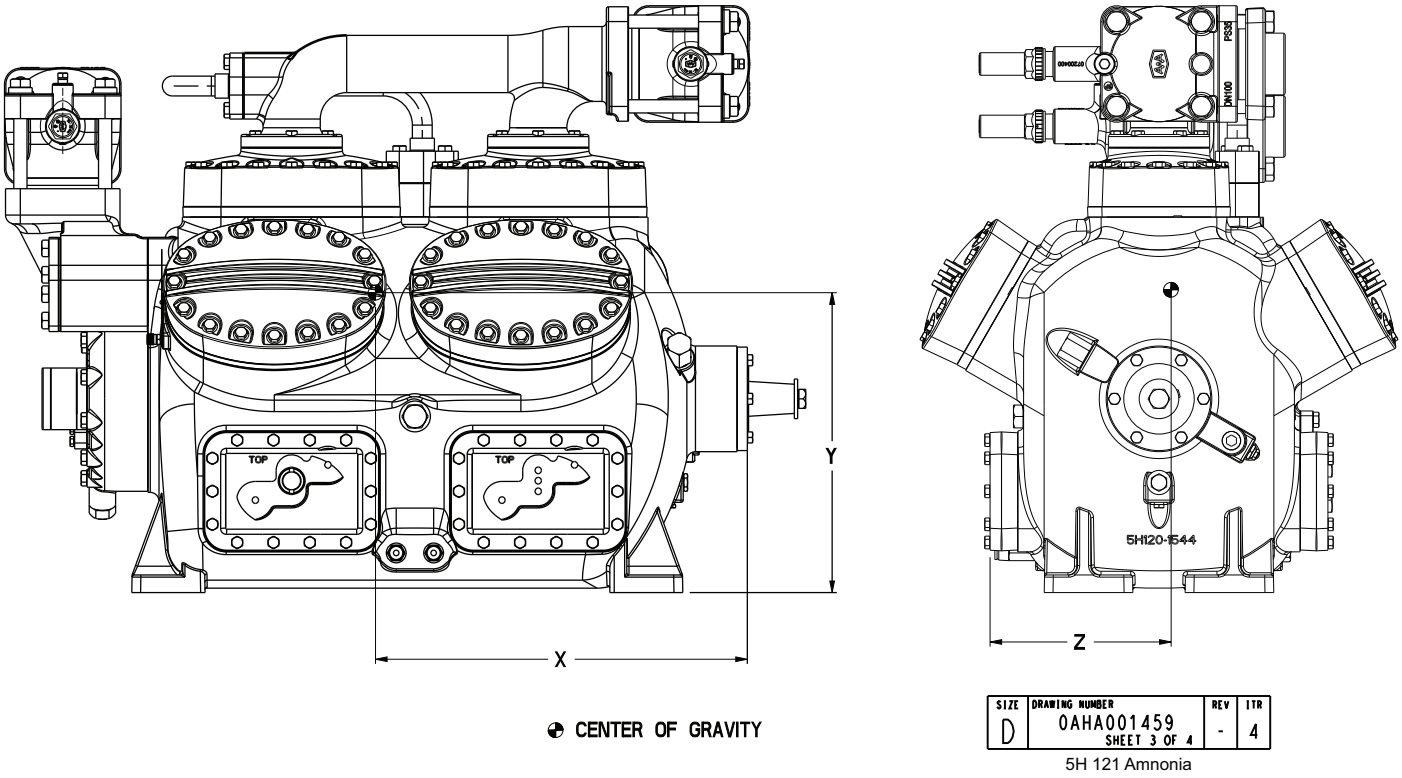
Fig. 14 — 5H80/81/86 Unit Rigging and Center of Gravity Diagram, Pump End (5H81 Model Shown)





NOTE: Dimensions are in. [mm].

Fig. 15 — 5H121 Ammonia Unit



MODEL NO.		CENTER OF GRAVITY (in.)			WEIGHT (lbs)
		X	Y	Z	
5H120	5H120-C149	20.5	13	9.8	1077.8
	5H120-C149_SV	20.5	13	9.8	1077.8
	5H120-C864	19.5	13	9.8	917.5
	5H120-C64_SV	20.5	13.57	10	1177.8
5H121	5H121-C934	21.11	17.03	10.26	1639
	5H121-C944	21.25	17.20	10.26	1600
	5H121-C904	21.15	17.36	10.15	1639
	5H121-C994	21.36	17.14	10.26	1639
	5H121-C914	21.50	17.26	10.26	1639

Fig. 16 — 5H120/121/126 Unit Rigging and Center of Gravity Diagram

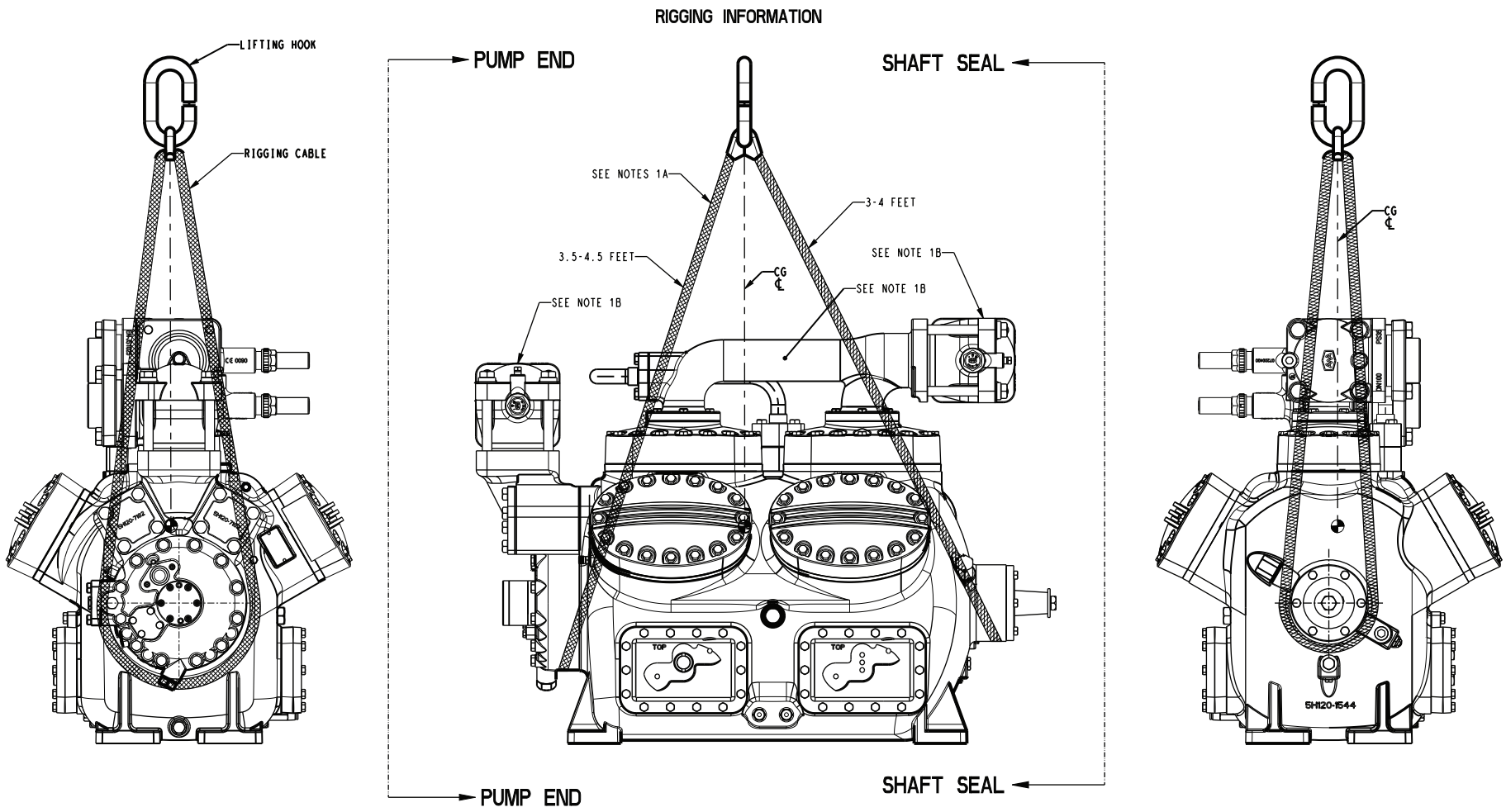


Fig. 17 — 5H120/121/126 Unit Rigging and Center of Gravity Diagram, Pump End (5H Model Shown)

Step 5 — Install Multiple Compressors

EQUALIZING LINES

5H40-86 Compressors

Compressors operating in parallel require interconnecting lines for oil and gas pressure equalization. Special handhole cover plates, equipped with tapped holes for equalizing lines, are available as options for sizes 5H40-86 compressors (see Fig. 18). An oil float system is an acceptable alternative to equalizer lines.

5H120 and 126 Compressors

5H120 and 126 compressors include factory-supplied, tapped cover plate. On these compressors, use only lower connection for oil equalization (see Fig. 18). Connect gas equalizing line to flange connection shown. Mating flange for 1-1/8 in. line is Mueller Part No. A-5151; gasket Part No. is Mueller Part No. A-5152.

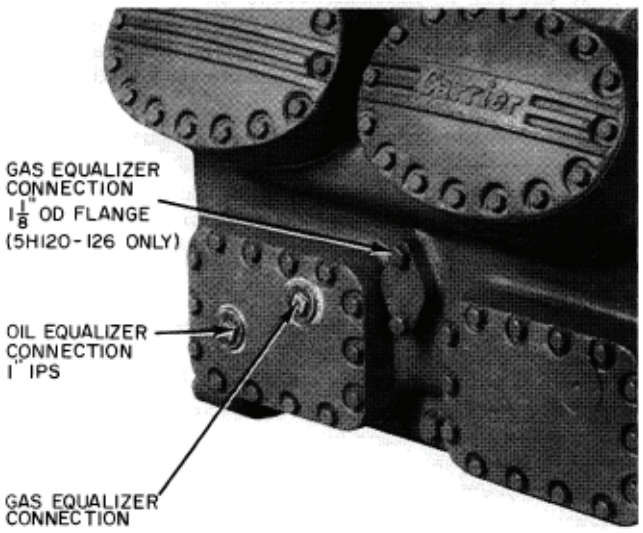


Fig. 18 — Special Hand-Hole Cover and Equalizer Connections (Typical)

APPROVED REFRIGERANTS

Compressor models 5H40, 5H46, 5H60, 5H66, 5H80, 5H86, 5H120 and, 5H126 are approved for the following refrigerants: R-134a, R-404A, R-407C, R-448A, R-449A, R-452A R-507, and R-513A. Refer to Tables 1 and 4.

Ammonia compressor models 5H41, 5H61, 5H81 and, 5H121 are approved for R-717. Refer to Tables 2 and 5.

⚠ CAUTION

If the special gasket between oil pump cover and oil pump is damaged, replace with correct gasket only. Check oil pressure immediately after starting compressor.

INSTALL CRANKCASE HEATER

1. Wire heater to relay or set of normally closed (NC) auxiliary contacts on compressor starter to de-energize it when compressor is operating.
2. Remove rubber plug from crankcase heater casing (refer to Fig. 2-17), and
3. Insert heater element entirely into casing. Element should fit snugly, not loosely. Complete wiring to comply with applicable electrical codes.

When crankcase heater is installed, system can be operated on single pumpout cycle, unless used with a DX cooler.

Table 6 lists crankcase heater packages. Table 7 shows corresponding relays.

NOTE: Use of 2 heaters on a 5H80-126 compressor requires only one relay.

Control circuit voltage determines relay coil voltage. This voltage must be specified when ordering relays.

See Accessory Compressor Crankcase Heater Installation Instructions for additional information.

ATTACH POWER WIRES TO COMPRESSOR MOTOR

Attach power wires in accordance with motor manufacturer's instructions and in compliance with NEC and applicable local codes.

CHECK MOTOR ROTATION

Before connecting motor to compressor, check direction of motor rotation. *Rotation must be in same direction as indicated by arrow on compressor pump cover (or on plate attached near pump-end bearing housing).* For 3-phase motors reverse motor rotation by reversing any two power leads to the motor. Refer to motor nameplate for directions on how to reverse the rotation of the other motor types.

If rotation of oil pump is reversed, reverse direction of pump rotation arrow as well. At that time make the following adjustments:

5H40-86 Compressors

Drain oil below level of pump-end cover (refer to Fig. 2-4). Remove pump-end cover to expose oil pump cover in center of main bearing housing. Rotate oil pump cover 180 degrees and replace it. Replace pump end cover and reverse external arrow to match new direction of rotation. Proper direction can later be checked without removing pump-end cover.

⚠ CAUTION

If the special gasket between oil pump cover and oil pump is damaged, replace with correct gasket only. Check oil pressure immediately after starting compressor.

Table 6 — 5H Compressor Crankcase Heater Package

COMPRESSOR	ELECTRICAL CHARACTERISTICS		PACKAGE NO.
	Volts	Watts	
5H40,46,60,66	115	200	-5-H--40---381
	230	200	-5-H--40---391
5H80,86,120,126	115	200	(2) 5H40-381
	230	200	(2) 5H40-391

Table 7 — Crankcase Heater Relay (60 Hz)

CONTROL CIRCUIT VOLTAGE	PART NO.
115	HN61AJ-101
208/230	HN61AJ-108

Step 6 — Check Compressor/Motor Alignment

BELT DRIVE

See Accessory Belt Drive Package manual for installation and alignment instructions.

⚠ WARNING

Exposed moving parts of the compressor drive can cause severe injury.

Appropriate guards must be utilized. Guards must be in place before operating.

DIRECT DRIVE

Install and align compressor, coupling, and motor as described in manual for Flexible Couplings for Direct-Drive Units.

⚠ WARNING

Exposed moving parts of the compressor drive can cause severe injury.

Appropriate guards must be utilized. Guards must be in place before operating.

HOT CHECK AND DOWELING

To help maintain alignment, and to ensure exact repositioning of the motor after servicing, the motor and compressor must be doweled to the base. *Install doweling only after motor/compressor alignment has been hot checked (after the compressor has warmed up to operating temperature after initial alignment).*

After hot check and while components are still at operating temperature, drill and ream 2 holes through diagonally opposite motor and compressor feet and the base. Use a 9/32 in. drill and a no. 6 taper reamer. Secure the motor and compressor to the base with the no. 6 x 2-1/2 in. taper dowel pins provided in the motor fastening set.

Coat the dowels with white lead or other lubricant to prevent rusting, and tap the dowel lightly into position so that 1/16 of taper is left above the motor foot.

Check that all dowels are tight and that they do not bottom.

Step 7 — Assemble Water Piping

For compressors using water-cooled cylinder heads (WCH), following the instructions associated in the accessory kits 5H660009, 5H660010, and 5H660011 for water-cooled heads and water-cooled hose kits.

Step 8 — Prepare Lubrication System

INSTALL OPTIONAL EQUIPMENT

Consult local Carlyle representative for information on these accessories.

Oil Filter

The oil filter for 5H40-86 compressors is available as a separate accessory package. Refer to Accessory Oil Filter Package Installation Instructions for installation procedures.

If an accessory oil cooler is also installed (see Oil Cooler section), pipe oil filter into system as shown on diagrams in Accessory Oil Cooler Installation Instructions.

Oil Cooler

Refer to Accessory Oil Cooler Installation Instructions included with this accessory package. Adjust water flow rate through oil cooler to maintain 100°F to 120°F oil temperature returning to compressor.

Oil Separator

If oil separator is used in system piping, pipe oil return line to compressor suction line. To minimize possibility of flooding compressor with oil, oil return line diameter should not exceed 1/4 in. In addition, line should have manual shutoff valve to throttle oil flow as required and to isolate separator for service.

CHECK OIL LEVEL

Check that oil level is visible at center of compressor sight glass. Compressors that use optional equipment such as filter, cooler, and oil separator described above will require a greater oil charge than listed in Tables 4 and 5 on page 4. Recheck oil level after operating compressor.

APPROVED OILS

The following POLYOL-ESTER (POE) are approved oils for HFCs:

Totaline® (see Note 5)	P903-1001, 1701
Castrol (see Note 5)	E68
ICI Emkarate	RL68H
CPI	CP-2916S
CPI	Solest 68
BP Marine Enersyn	MP-S68

All POE oils are very hygroscopic (will readily pick up and retain moisture from the air) and should be used completely once the container is opened. It is extremely difficult to reseal the oil container effectively enough to prevent moisture absorption, which in turn forms damaging acids. Refer to notes 1-7 for HFC guidance.

NOTE: For HFCs not listed above, please contact Carlyle Engineering for oil recommendations.

1. The use of any non-approved refrigerant may be dangerous and may void the warranty. Contact the Carlyle Compressor engineering department before using any refrigerant or oil not listed in this guide as approved for use in a Carlyle open-drive compressor.
2. Using the wrong type or weight of oil for the refrigerant selected will void the warranty.
3. Follow the refrigerant and/or oil manufacturer instructions when installing or retrofitting.
4. Castrol SW68 (Totaline® P903-1001) is approved for use in Carrier chiller applications as well as Carrier and Carlyle open-drive compressors for air conditioning and medium temperature applications. **Castrol SW68 (Totaline® P903-1001) cannot be used in any new low temperature refrigeration applications using Carlyle OEM semi-hermetic compressors. Castrol E68 is approved for use in Carlyle OEM compressors for low, medium, and high temperature ranges.**
5. All HFC/POE applications require a crankcase heater.
6. Moisture must be kept below 50 ppm for POE oils.
7. In retrofit applications, a high flow oil pump is required.

Ammonia

AMMONIA R-717: CAMCO-717-H Oil — 5H41, 5H61, and 5H81, 5H121

For CFCs

The following MINERAL/ALKYLBENZINE are approved oils for CFCs:

Totaline®	P903-2001
Witco	Suniso 3GS
Shrieve Chemical	Zerol 150
Texaco Capella	WFI-32-150
IGI Petroleum Ind	CRYOL-150

NOTE: For CFCs not listed above, please contact Carlyle Engineering for oil recommendations.

PREPARE FOR INITIAL START-UP

Evacuate, Dehydrate and Leak Test

Evacuate, dehydrate, and leak test the entire refrigerant system as described in Carlyle Standard Service Techniques Manual, Chapter 1, Sections 1-6 and 1-7.

LEAK TESTING

Preferred Method

Charge the system to 10 psig with refrigerant. Add dry nitrogen or dry air (DO NOT USE OXYGEN) until system pressure is 150 psig.

NOTE: DO NOT EXCEED 250 psig. Check for leaks with a halide or electronic leak detector.

Alternate Method

Charge the system with dry nitrogen or dry air (DO NOT USE OXYGEN) to 40 psig and use soap-bubble test to find large leaks.

⚠ CAUTION

Do not use compressor to build up pressure. Do not overcharge the system.

START-UP

Preliminary Steps

1. Energize crankcase heater for at least 24 hours before starting unit.
2. If control transformer is not used, operate electrical control circuit with main power switch set to OFF to ensure that field connections have been properly made.
3. Install felt sock filter for the first 50 hours of compressor operation. Remove and inspect the filter, clean it if required and replace it for another 50 hours. Remove sock when system is clean.
4. Check that motor rotates in direction that the arrow on the compressor oil pump cover indicates. Refer to Installation, Check Motor Rotation section on page 24.
5. Check that oil fills 1/3 to 1/2 of the compressor sight glass.
6. Open water supply valve to condenser. Open pressure line valve of water-regulating valve (if used). If compressor unit is equipped with air-cooled condenser, tum on condenser fan.
7. Backseat (open) compressor suction and discharge service valves. Open liquid line valve at receiver.
8. Start evaporator fan or chilled water pump.

Start Compressor

Close main power switch supplying current to the compressor motor.

Immediately recheck oil level and check oil pressure. Pressure should exceed suction pressure by 45 to 55 psi. *If correct pressure is not reached in 10 to 12 seconds, stop compressor immediately and check oil pump.*

⚠ CAUTION

If any safety device shuts down the compressor, do not reset the control more than once before determining cause of shutdown.

High and Low-Pressure Switches

Some 5H units have factory-installed, automatic reset, high and low-pressure switches. Figure 19 illustrates adjustment procedures for both switches.

CHECK HIGH-PRESSURE SWITCH

Throttle the condenser water on water-cooled unit or block the airflow on air-cooled unit, allowing head pressure to rise gradually. Compressor should shut off within 15 psi of cutout value. Reverse procedure; compressor should start within 10 psi of cut-in value given.

CHECK LOW-PRESSURE SWITCH

Slowly close the suction service valve; suction pressure will decrease. Compressor should shut off within 4 psi of cutout value. Reverse procedure; compressor should start within 6 psi of cut-in value given (see Fig. 19).

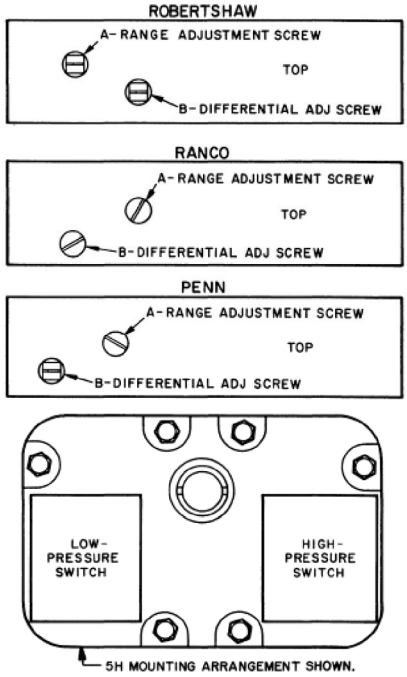


Fig. 19 — High and Low-Pressure Switches

OIL PRESSURE SAFETY SWITCH (OPSS)

Carlyle has approved the following oil pressure safety switch with the 5H ammonia and HFC compressors. The OPSS will mount directly to the oil pump bearing end of the compressor. 5H41-5H81 ammonia models and 5H40-5H86 HFC models will have the OPSS sensor factory-installed, (Part No. 06DA509571) for HFC models and 5H41-7602 for ammonia models. (See Fig. 20). The electronic oil safety switch (Part No. 06DA509570) is provided as an accessory item that is installed by the OEM. The switch must be properly installed and tested for proper operation as a system pre-start condition.

Fig. 20 — Oil Pressure Safety Switch Manual Reset Button

All non-ammonia compressors should apply screw-in sensor no. 06DA509571 as applicable.

The oil safety switch is designed to protect the compressor against the loss of lubrication. The OPSS switch will close the control circuit at compressor startup and allow 120 second oil pressure transitional time delay. The switch will open the control circuit and shut the compressor off when:

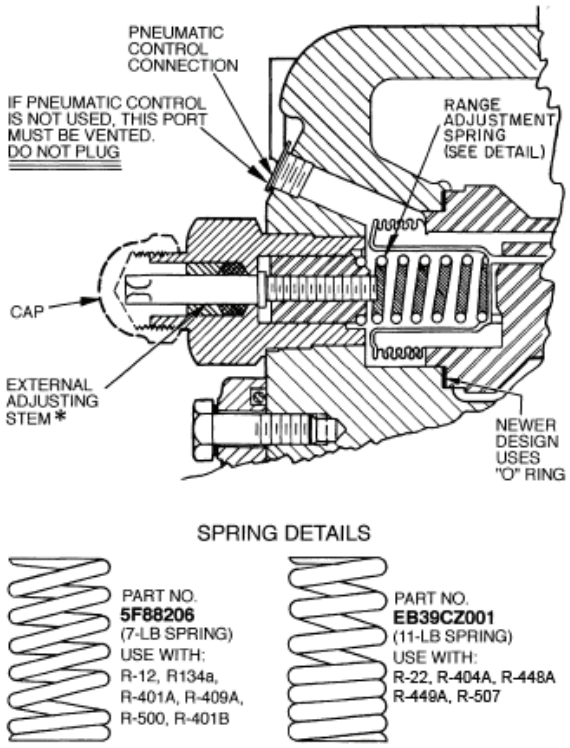
- The oil pump pressure drops to a minimum 9 psig above the oil sump pressure after 120 seconds, or
- A time-integrated low differential oil pressure (9 psig) between the oil pump and oil sump pressure that is fluctuating 60% of the time ≤ to 9 psig over a 5 minute rolling window.
- The OPSS will not reset automatically, but must be manually reset provided the differential pressure between the oil sump and pump pressure is above 13 psig.

CARLYLE P/N	TIME DELAY (sec)	PRESSURE DIFF (psid)		VOLTS	RESET	REMOTE ALARM CIRCUIT CAPABLE
		Cut-out	Cut-in			
06DA509570	120	9-11	12-14	115/ 230	Manual	Yes

Adjust Capacity Control (if required)

DETERMINE THE REFRIGERANT USAGE

If a compressor with a pressure operated capacity control system is to be used with R-134a, replace the 11-lb range adjustment spring (see Fig. 21) with the 7-lb spring supplied with compressor. See instruction tag for spring replacement procedure.



NOTE: When compressor is received, the capacity control adjusting stem will be backseated. (Compressor will be fully loaded under all conditions.) Compressor is supplied with 11-lb spring.

Fig. 21 — Capacity Control Valve

Capacity Control

The 5H compressor line incorporates various configurations for cylinder unloading, which are dependent on the compressor model type.

- 5H40-5H86 legacy models and 5H40-5H86 (except 5H41, 5H61, and 5H81) new production pressure unloading models (refer to Table 1) have a pressure control valve internally installed on the oil pump bearing head. The pressure control valve is manually adjusted to direct compressor oil to the unloader power element(s) to unload and load the compressor's cylinders at defined suction pressures for capacity control. (See Fig. 22 and 24.)
- For new production 5H40-5H86 compressor models (refer to Table 1):
  - Electric unloading models have factory-installed electrical unloading. Unloading solenoid valves are installed on the compressor's bearing head. The bearing head has unloader valves installed that require activation through a solenoid coil. (See Fig. 25, and 28-30.)
  - VFD compressor models do not have unloader elements installed and the cylinders are fully loaded when the compressor is started. A VFD is applied to operate the compressor speed from 400-1750 rpm. Refer to Tables 1 and 4.
  - Unloaded start compressor models have the unloader elements installed. The unloaded cylinders will load upon compressor start as a result of the compressor oil pressure increasing to activate the unloader power elements, loading the cylinders. Refer to Table 1.
- Legacy 5H40-5H86 compressor models that use an external electric unloading conversion kit or apply pressure unloading can be retrofitted with a new electric unloader bearing head, allowing the compressor to be electrically unloaded, see Fig. 25. (See Carlyle retrofit instruction 0AHA001431 and retrofit kit Part No. 6AH001439.)
- 5H120/126 compressor models:
  - Incorporate a pressure control valve that is internally installed on the compressors oil pump bearing head. The pressure control valve is manually adjusted to direct compressor oil to the unloader power element(s) to unload and load the compressor's cylinders at defined suction pressures for capacity control. Refer to Tables 1 and 8 and Fig. 23 and 24.
  - Does not have factory-installed electrical unloading but requires an external electric unloading conversion kit, Part No. 5H120-4FI-A Refer to Tables 1 and 8 to unload the compressor.
  - Can be applied with a VFD to operate the compressor speed from 400-1750 rpm. Refer to Tables 1 and 4.

If cylinder head unloading is not preferred, all 5H compressor models can be applied with a VFD for capacity control. The allowable speed range is 400 to 1750 rpm for non-ammonia models. These compressor models will not have cylinder unloading capability.

The cylinder unloading mechanism is powered by a compressor force-feed lubricating system. This feature assures unloading of all controlled cylinders at start-up regardless of the position of the capacity control valve, since suction valves will be held in open position until the lubricating oil pressure reaches its normal operating level. See Fig. 28 on page 33 for cylinder unloading sequence.

PRESSURE UNLOADING (CAPACITY CONTROL OPERATION)

An external adjusting stem is provided to set control point and maintain desired suction pressure. The control point is adjustable from 0 to 85 psig suction pressure. Differential over the complete range at any temperature level is 10.7 psig. See Fig. 24.

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

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

Major Elements of Control Systems:

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

Principle of Operation of the System

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

CAPACITY CONTROL FOR 5H40-5H86

Major Elements of Capacity Control Systems:

1. *Capacity Control Valve:* Function is to raise or lower the control oil pressure to the hydraulic relay piston in response to refrigerant suction pressure. Increase in suction pressure increases control oil pressure in the hydraulic relay. Refer to Fig. 22.
2. *Hydraulic Relay:* Function is to feed lubrication oil from the oil pump at full pressure in sequence to one or more power elements. Relay is activated by control oil pressure from the capacity control valve.
3. *Power Element:* Supplies power to operate the valve lifting mechanism.
4. *Valve Lifting Mechanism:* Consists of a sleeve and push pin assembly around each controlled cylinder, designed to hold the suction valve open or to permit the valve to remain in a normal operating position, depending on its actuation by the power element.

Principle of Operation of the System

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

5H120/126 CAPACITY CONTROL

This capacity control system is slightly different from the system on 5H40-5H86 compressors. Unloaded starting and capacity reduction is obtained by holding open the suction valves of a number of cylinders. For capacity control purposes, a suction-pressure-actuated capacity control valve pilots a hydraulic relay that loads or unloads cylinders in pairs. See Fig. 23 and Table 8.

Major Difference from the 5H40-5H86 Capacity Control:

The hydraulic relay design provides a wider pressure differential between cylinder cut-in and cutout points. The relay is a small, easily removed cartridge rather than an integral part of pump end cover.

PNEUMATIC COMPENSATION OF COMPRESSOR CAPACITY CONTROL

Adding a control air line to the external pneumatic control connection permits pneumatic resetting of the control point in accordance with changes in operating conditions. Each pound of change in air pressure resets the control one-pound in the same direction. Thus, a one-pound rise in air pressure will cause unloading to begin at a suction pressure one pound higher than the original control point, etc. Refer to Fig. 6 for a typical pneumatic control arrangement. All components and installation instructions are field supplied.

Control Pressurestats

Dual pressurestats come factory-installed with some 5H compressor models. They are often referred to as high and low-pressure cutouts. Their function is to cut the circuit to the holding coil of the compressor motor starter when pressure setting limits are exceeded.

The high pressurestat has an operating range from 50 to 450 psig with a differential range from 170 to 235 psig (adj). The low pressurestat has an operating range from 20 to 60 psig and a differential range from 60 to 90 psig (adj).

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

Permanently Unloaded Cylinders

Operation of an open-drive compressor with its cylinders permanently unloaded requires field modification. 5H60-5H66 compressors can operate with one cylinder unloaded; 5H80-5H126 compressors can operate with 2 cylinders unloaded. Compressors are modified by removing the suction valve and suction valve springs from the cylinder(s) shown in Fig. 28-30.

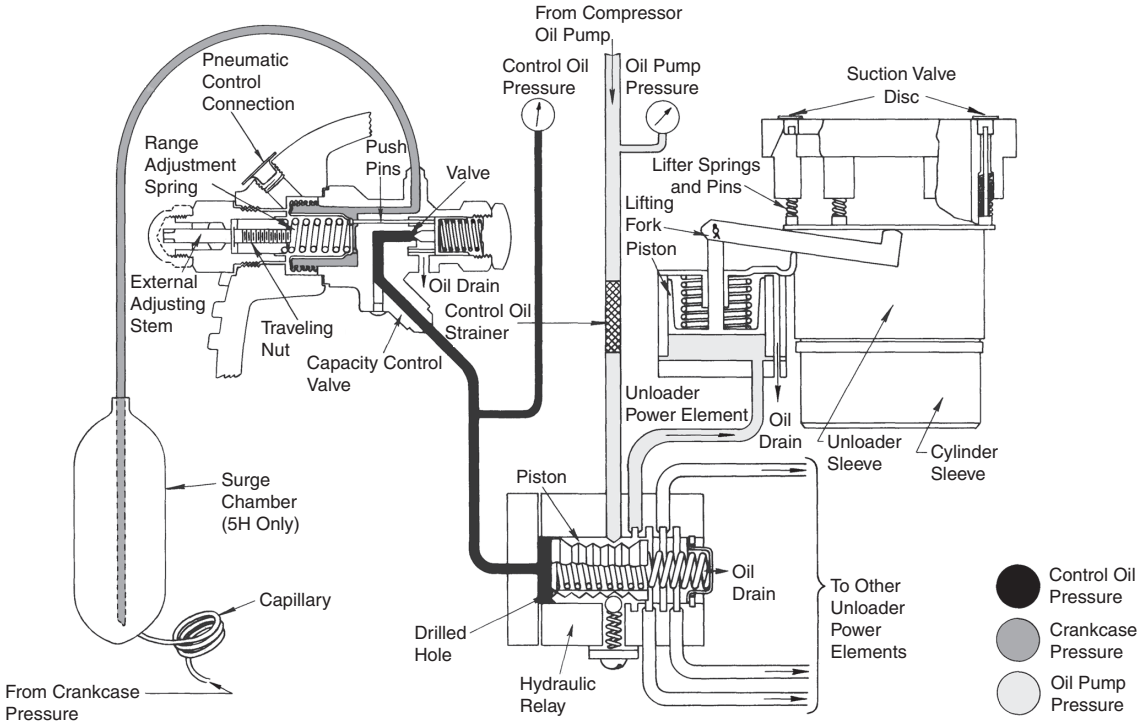


Fig. 22 — Capacity Control — 5H40, 46, 60, 66, 80, and 86

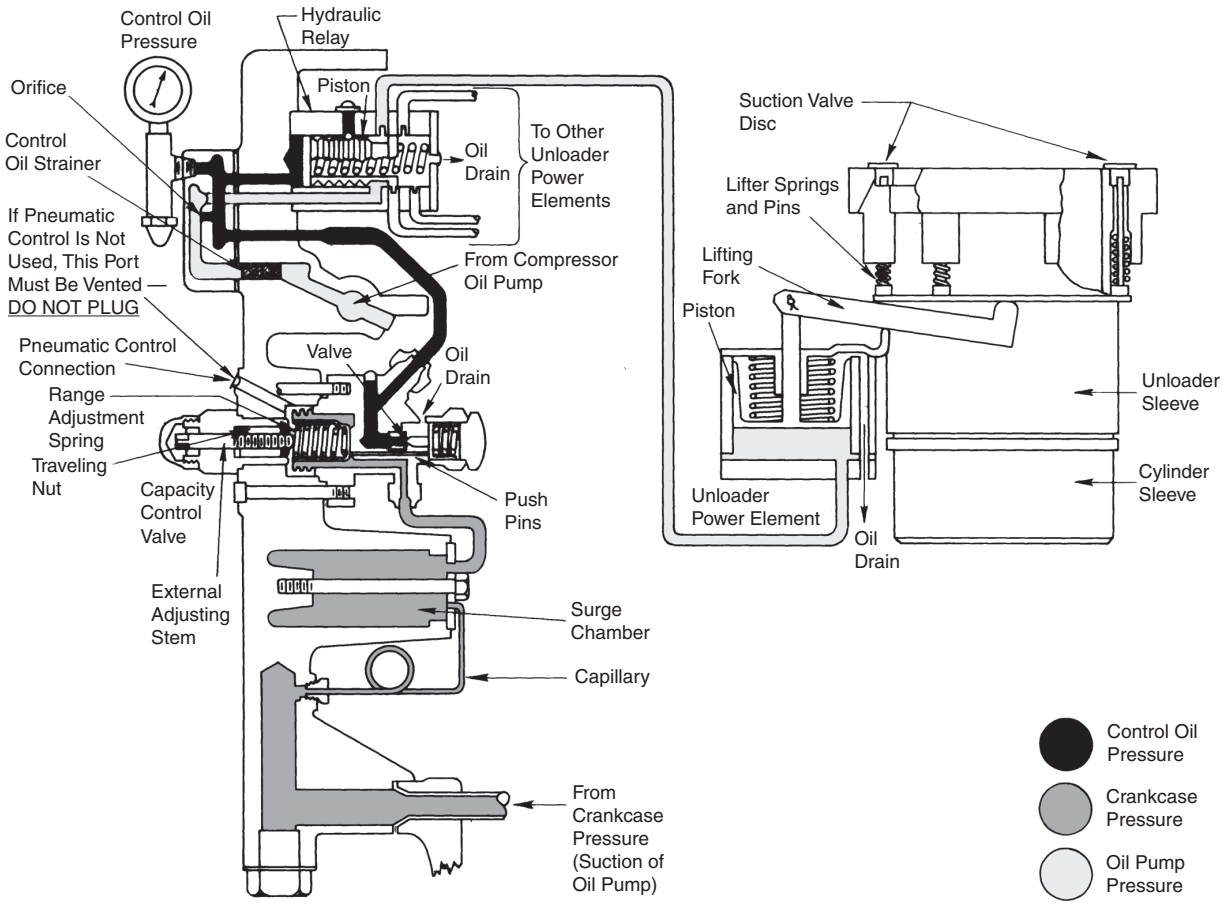


Fig. 23 — Capacity Control — 5H120/126

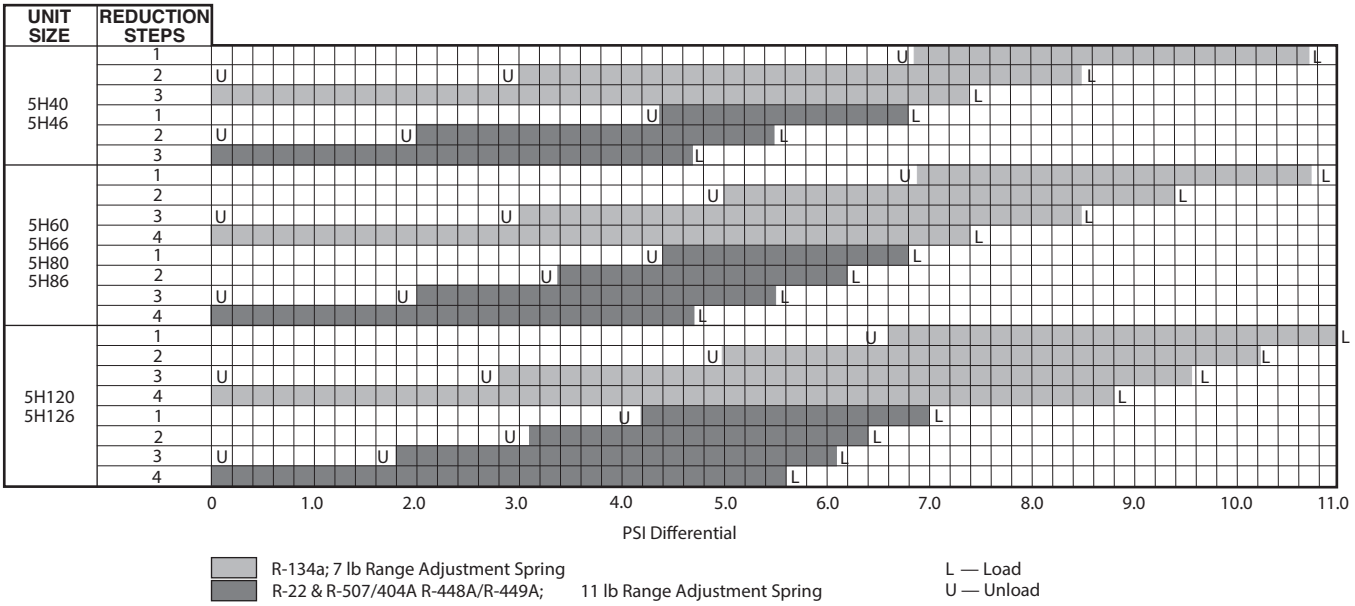


Fig. 24 — Operating Sequence of Pressure Unloading Capacity Reduction Steps

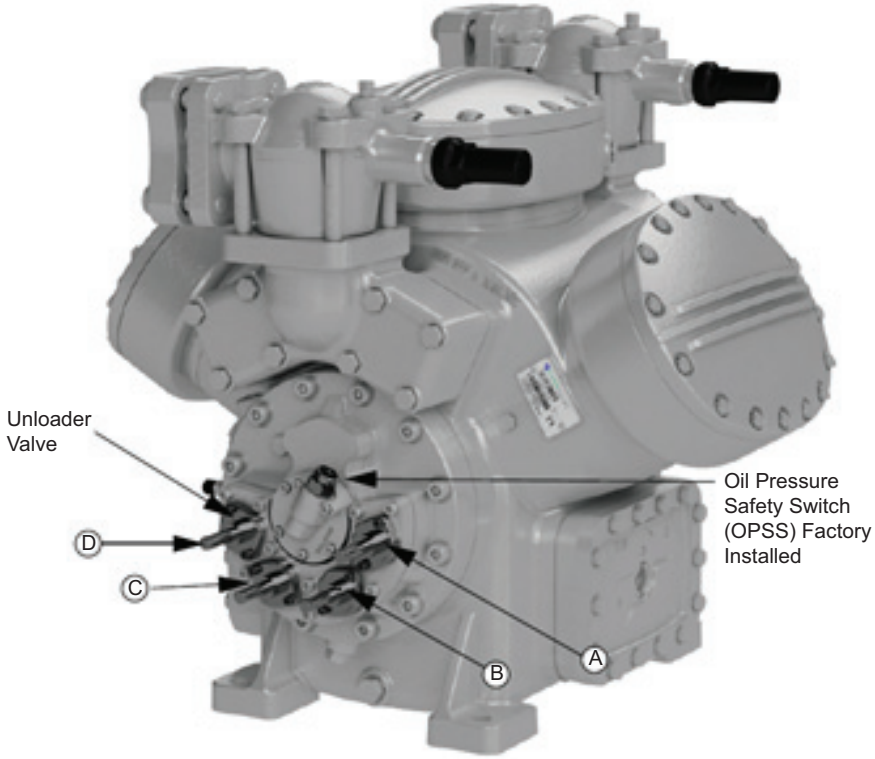
Table 8 — Capacity Control Steps 5H120/126

MODEL	UNLOADING CYLINDERS	CAPACITY (% OF FULL LOAD)	UNLOADER VALVE DESIGNATION	UNLOADING STEPS	CYLINDER NO.[a]
5H120/126[b]	8 of 12 (4 steps)	83	A	1	8 and 11
		67	B	2	7 and 10
		50	D	3	9 and 12
		33	C	4	1 and 3

NOTES:
a. See Fig. 29 for cylinder number designations.
b. 5H120/126 requires external unloading conversion kit 5H120-4FI-A.

5H40-5H86 FACTORY-INSTALLED ELECTRIC UNLOADING

See Fig. 25 for capacity control steps.



CAPACITY CONTROL STEPS — 5H40-5H86					
MODEL	**UNLOADING CYLINDERS**	**CAPACITY (% OF FULL LOAD)**	**UNLOADER VALVE DESIGNATION**	**UNLOADING STEPS**	**CYLINDER NO.[a]**
5H40/46	3 of 4 (3 steps)	75	A	1	1
		50	D	2	3
		25	B	3	2
5H60/66	4 of 6 (4 steps)	83	A	1	1
		67	B	2	4
		50	D	3	3
		33	C	4	6
5H80/86	6 of 8 (4 steps)	87	A	1	1
		63	B	2	2 and 4
		38	D	3	6 and 8
		25	C	4	3

NOTES:
a. See Fig. 28 for cylinder number designations.

Fig. 25 — Unloader Valve/Cylinder Designation (HFC Models)

5H120/126 COMPRESSORS

The following modifications are required to electrically unload 5H120/126 compressors. Refer to Table 8.

1. After closing the compressor service valves and reducing refrigerant pressure to the atmosphere, remove pump end bearing head.
2. Remove hydraulic relay assembly by removal of two 5/16 in. 18 socket head screws. Make a blank metal disc using a hydraulic relay gasket (5H120-3351) as a guide. Using 1/32 to 1/16 in. thick metal, cut holes in the disc for dowel pins *only*.
   NOTE: Do not cut five 9/32 in. diameter holes. Reinstall relay assembly using 2 new 5H120-3351 gaskets, one on each side of the metal disc. Torque 5/16 in. socket head screws evenly to 16 to 20 lb-ft.
3. Reinstall the bearing head using extreme care not to damage the oil pump tang. Align with recess in the end of the crankshaft. DO not force on. See Fig. 26.
4. Mount solenoid valves and run oil lines. See Fig. 27.
5. To minimize vibration, mount the valves on a bracket attached to the compressor.

VALVES

The following 3-way valves have been used in the field and are listed as a guide:

- Alco Controls No. 702RA001
- Alco Controls No. S608-1
- Sporlan Type 180

To Adjust Control Point

1. Impose an artificial load on the compressor until suction pressure exceeds control point.
2. Slowly close suction valve to lower compressor suction pressure to control point pressure.
3. When at control point pressure, turn external adjusting stem clockwise until first step of unloading takes place, as indicated by changes in control oil pressure, current draw and sound of compressor.

Control point is now set. Reopen suction service valve. Compressor will be fully loaded when suction pressure is 3 psig (4 psig with R-22) above control point, and will be fully unloaded when suction pressure is 4 psig (7 psig with R-22) below control point. See Fig. 31-32.

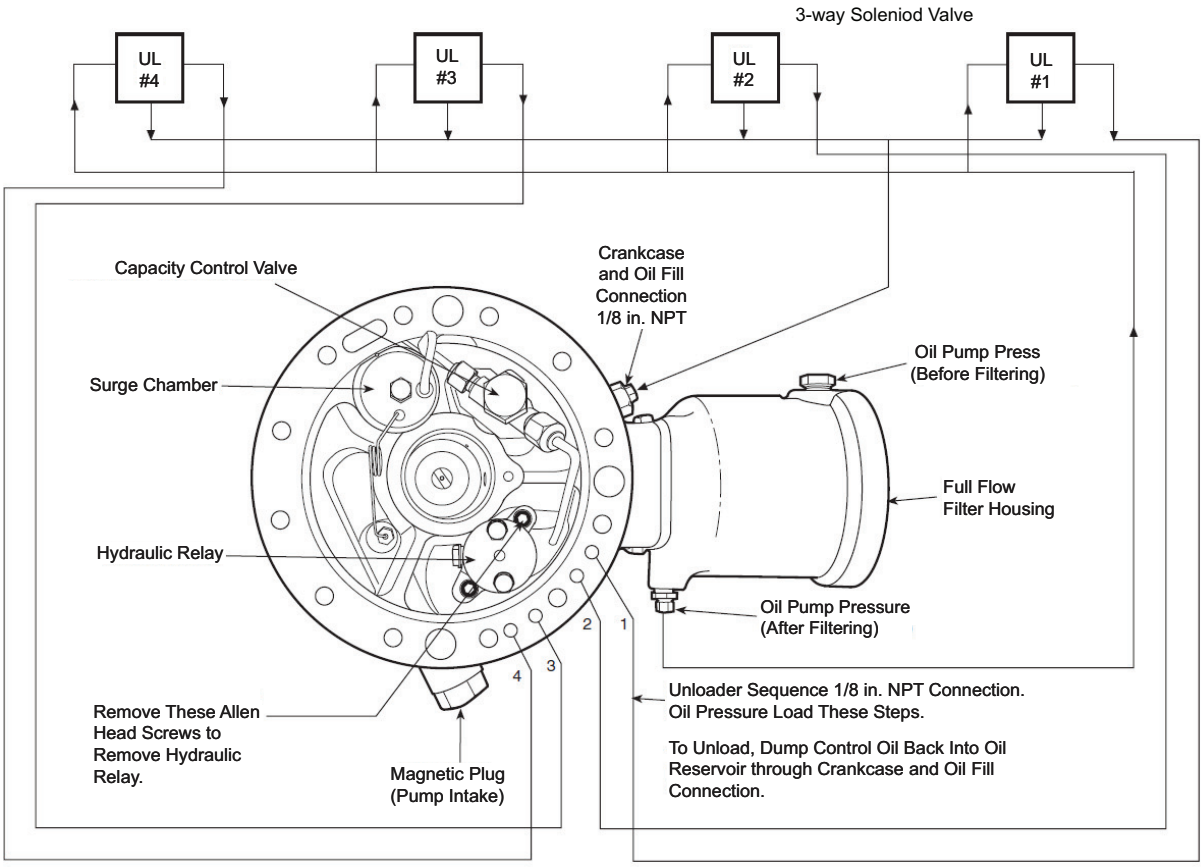
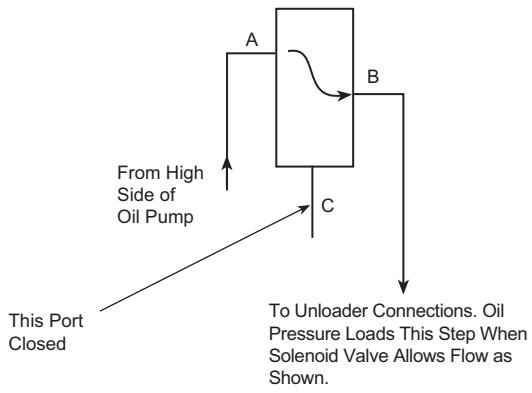
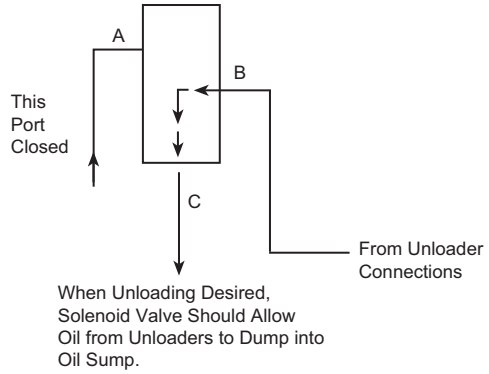


Fig. 26 — 5H 120/126 Bearing Head Assembly

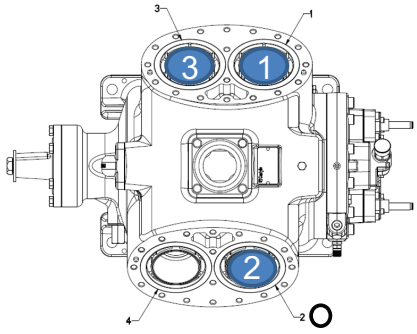


A
De-energized, Flow A-B Load Step

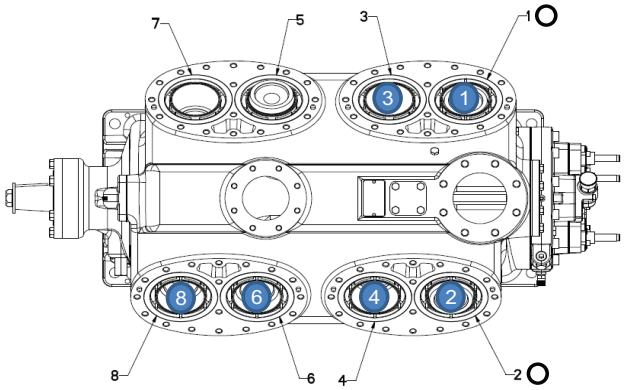


B
Energized, Flow B-C Unloads Step

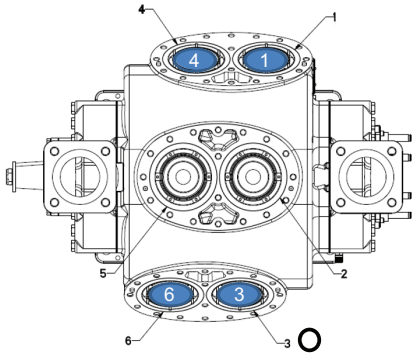
Fig. 27 — Recommended Solenoid Valve Operation



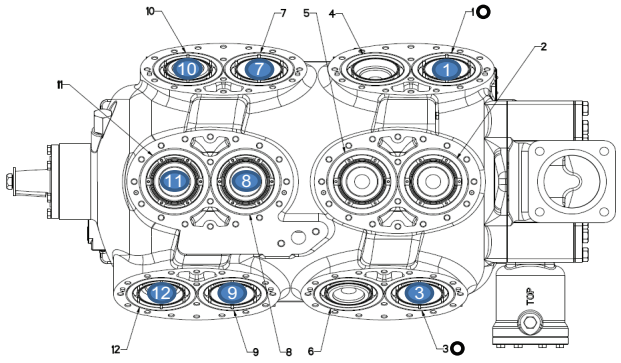
5H40, 56



5H80, 86



5H60, 66

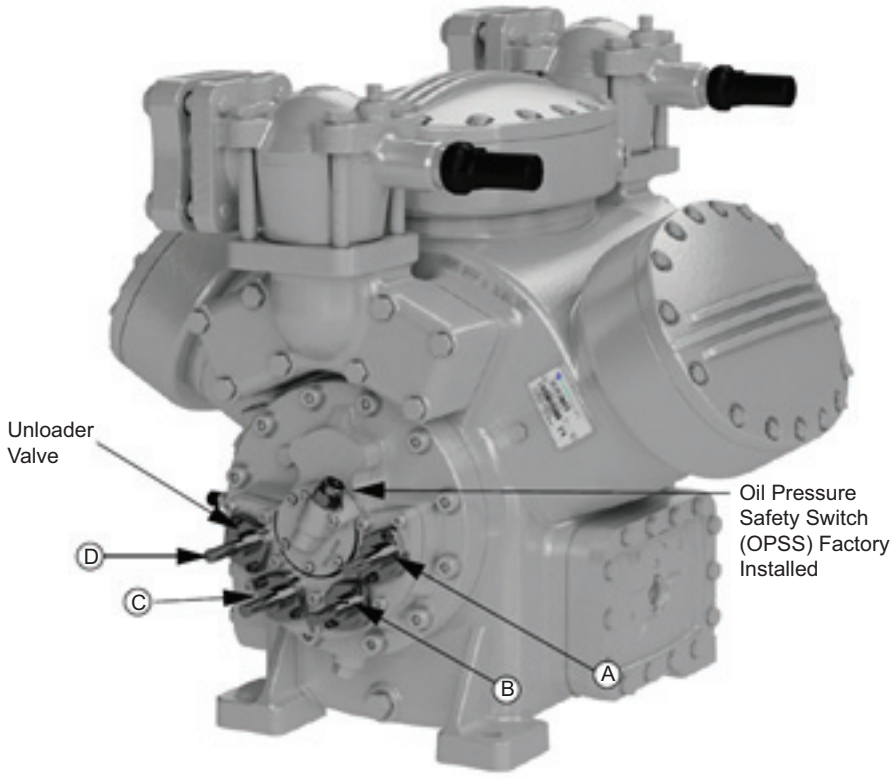


5H120, 126

NOTE: The numerals indicate the unloading sequence and the number of cylinders that unload with each step.

O — Cylinders recommended for permanently unloaded operation.

Fig. 28 — Cylinder Unloading Sequence (HFC)



CAPACITY CONTROL STEPS — AMMONIA					
MODEL	**UNLOADING CYLINDERS**	**CAPACITY (% OF FULL LOAD)**	**UNLOADER VALVE DESIGNATION**	**UNLOADING STEP**	**CYLINDER UNLOADED SEQUENCE**
5H41	2 of 4 (2 steps)	75	A	1	1
		50	D	2	3
5H61	4 of 6 (4 steps)	83	A	1	1
		67	B	2	4
		50	D	3	3
		33	C	4	6
5H81	5 of 8 (3 steps)	87	A	1	1
		63	B	2	2 and 4
		38	D	3	6 and 8

Fig. 29 — Unloader Valve/Cylinder Designation (Ammonia)

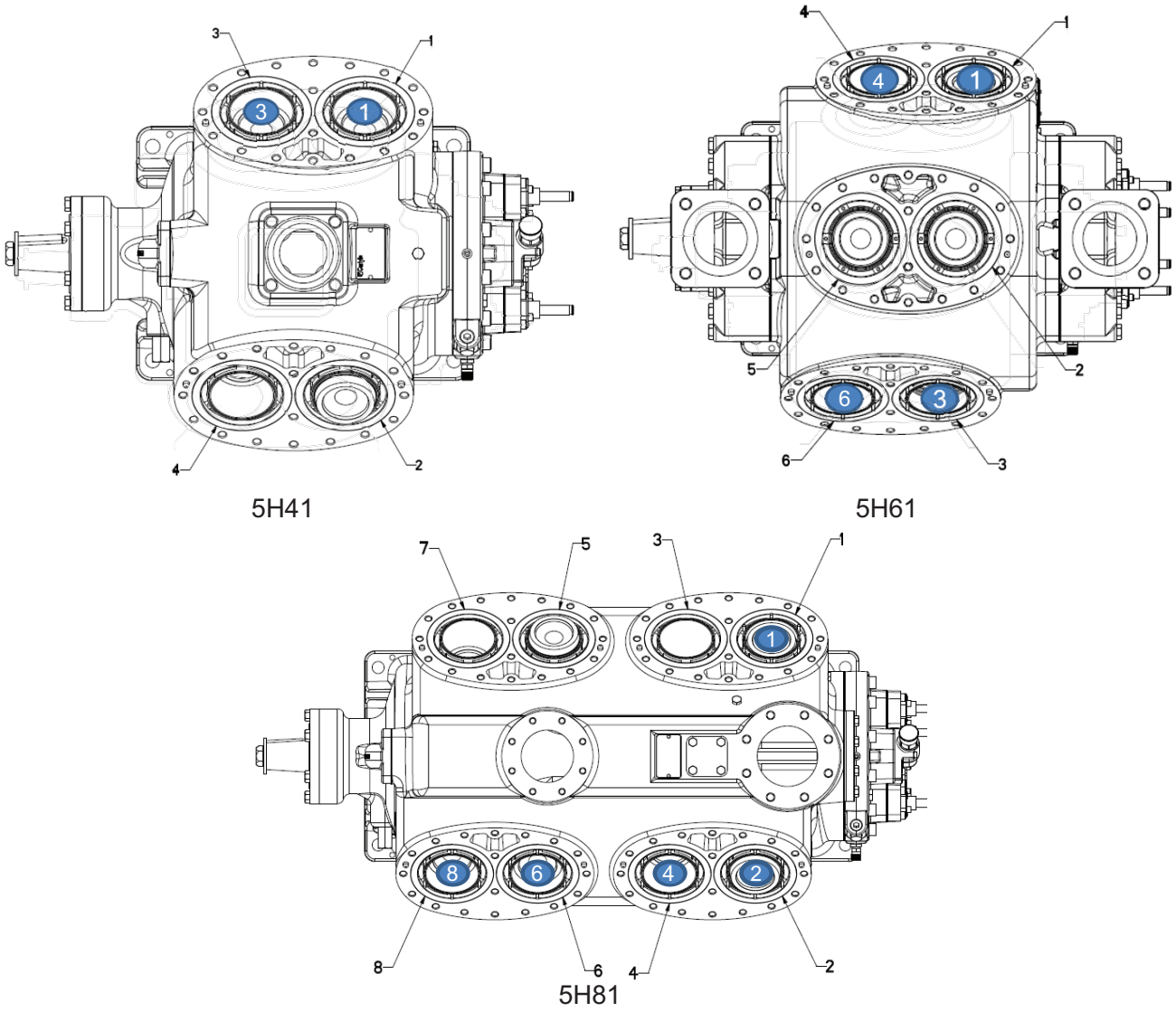


Fig. 30 — Cylinder Unloading Sequence (Ammonia)

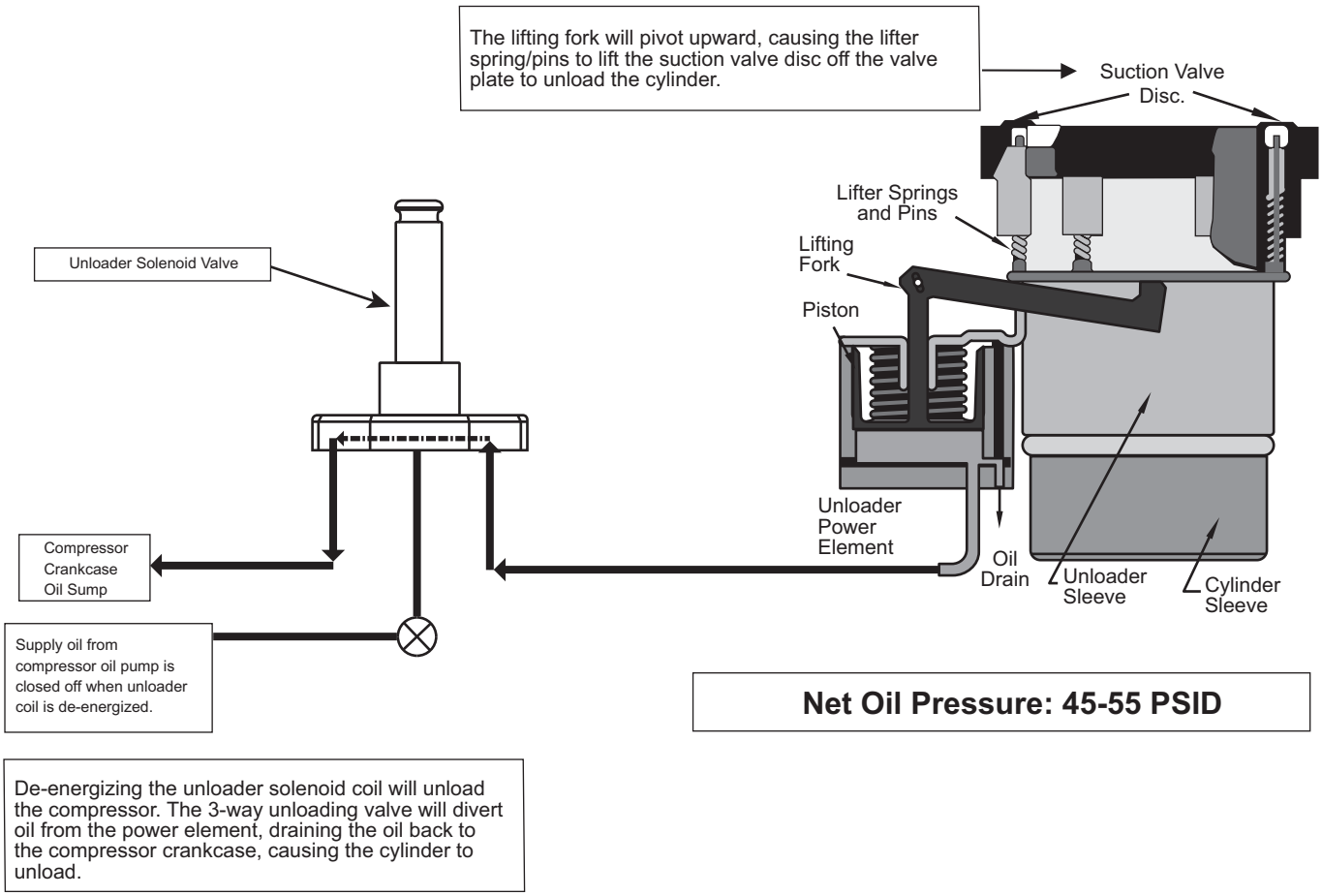


Fig. 31 — Compressor Unloaded

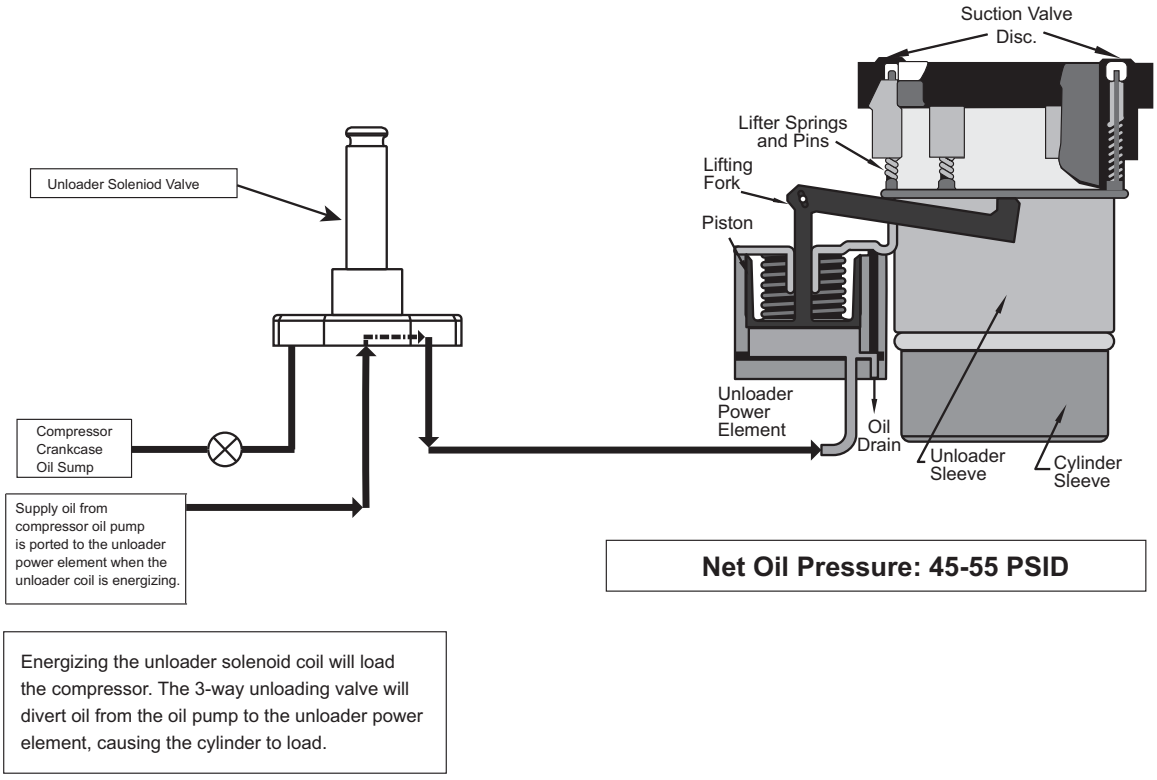


Fig. 32 — Compressor Loaded