ARIEL
Heavy Duty Balanced Opposed Compressors

TECHNICAL MANUAL
For Models:

JGH and JGE

ARIEL CORPORATION
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REV: 8/00

⚠ CAUTION

GAS COMPRESSOR UNITS ARE COMPLICATED AND DANGEROUS PIECES OF EQUIPMENT, IF YOU ARE NOT FULLY TRAINED AND FAMILIAR WITH THEIR OPERATION.

BEFORE STARTING THIS UNIT

FAMILIARIZE YOURSELF WITH THE UNIT.

READ AND STUDY START-UP AND SHUT-DOWN INFORMATION FOR BOTH PACKAGE AND COMPRESSOR CAREFULLY!

A GAS/AIR MIXTURE UNDER PRESSURE CAN EXPLODE! YOU CAN BE SEVERELY INJURED OR KILLED. MAKE SURE THE COMPRESSOR IS SUFFICIENTLY PURGED OF ANY EXPLOSIVE MIXTURE BEFORE LOADING.

AFTER COMPLETING THE ABOVE, BEGIN PROPER STARTING PROCEDURE.

⚠ CAUTION

DO NOT ATTEMPT TO START-UP UNIT WITHOUT REFERRING TO THIS MANUAL SECTION 3: START-UP. IT IS ALSO ESSENTIAL TO REFER TO THE PACKAGER'S OPERATING MANUAL.

⚠ CAUTION

THIS MANUAL EDITION IS BASED ON THE CURRENT DESIGN, BUILD AND PRACTICES. THIS MANUAL MAY NOT BE APPLICABLE TO EQUIPMENT BUILT PRIOR TO THE DATE ON FRONT COVER AND IS SUBJECT TO CHANGE WITHOUT NOTICE. CONTACT ARIEL WITH ANY QUESTIONS, SEE "Ariel Telephone and Fax Numbers" on pag e7 -11.

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SECTION 1 - DESIGN SPECIFICATIONS & DATA

General

Ariel compressors are designed for ease of operation and maintenance. Experience has shown that an Ariel compressor will normally provide years of satisfactory performance with minimal proper maintenance.

While Ariel compressors share many similarities, each model has aspects that are unique to the particular type. If you, as an operator, are familiar with Ariel compressors, it is still important to review this manual to determine the differences. If you are new to Ariel compressors, it is critical that you become very familiar with this manual prior to operating the compressor.

This manual is designed to provide information on installation, start up, operation and maintenance of a JGH or JGE compressor. If you have any questions please contact your packager. If they are unable to provide resolution, they will refer your concerns to Ariel Corporation. If you prefer, you may always contact Ariel directly.

This manual provides design specifications for standard current production equipment at publication date. Do not exceed information plates ratings for a particular compressor.

The location of the throws and the data shown on the Information Plates is very important when communicating questions concerning an Ariel compressor.

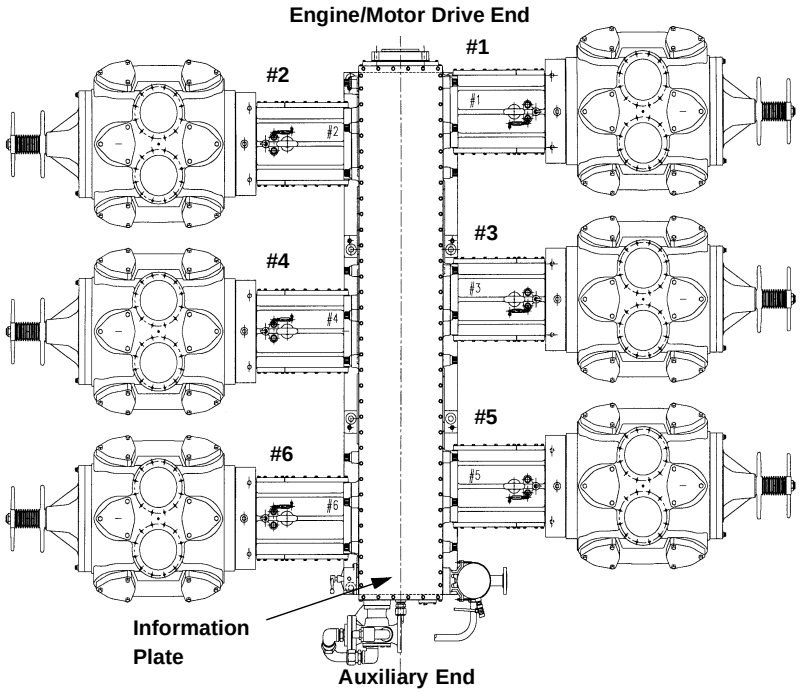


FIGURE 1-1: TYPICAL COMPRESSOR THROW NUMBERING AND INFORMATION PLATE LOCATION

Specifications

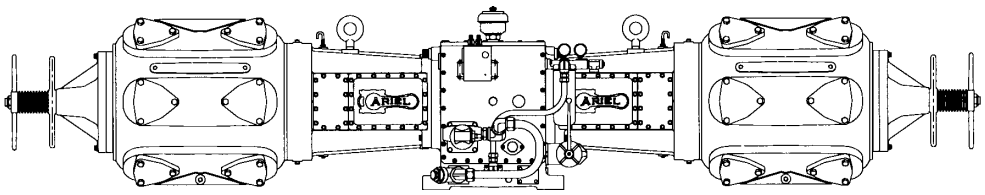


FIGURE 1-2: AUXILIARY END VIEW

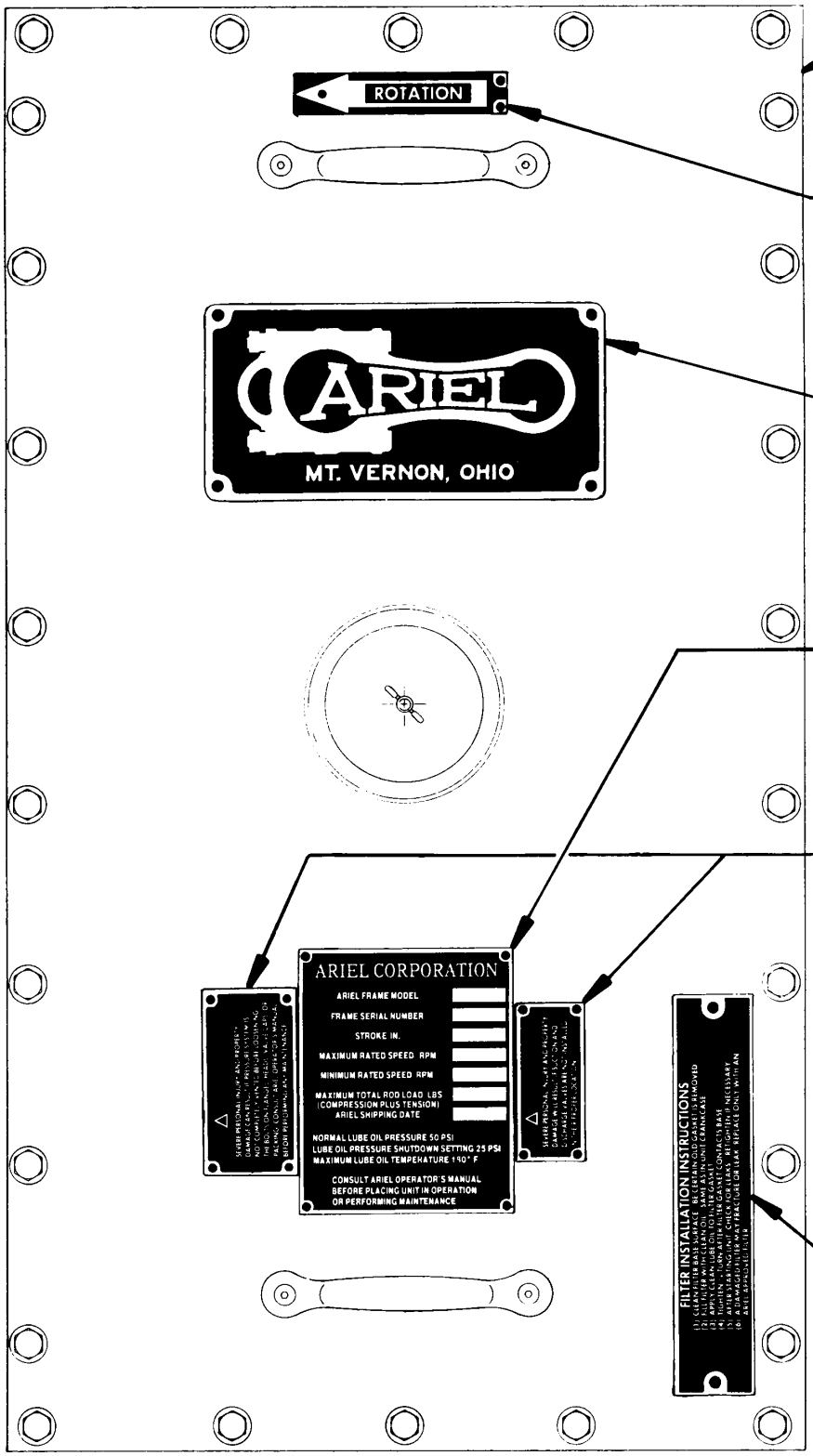
TABLE 1-1: JGH FRAME SPECIFICATIONS

MODEL	JGH/2	JGH/4
Stroke, inches (mm)	4-1/2 (114.3)	4-1/2 (114.3)
Speed, RPM	600 to 1200	600 to 1200
Piston Speed, FPM (m/s)	To 900 (4.57)	To 900 (4.57)
Number of Throws	2	4
Horsepower (kW)	To 680 (507)	To 1360 (1014)
Height - Bottom to Crankshaft ℄, in. (mm)	17 (431.8)	17 (431.8)
Connecting Rod ℄ to ℄, in. (mm)	13.75 (349.25)	13.75 (349.25)
Maximum Width, in. (m)	139 (3.53)	139 (3.53)
Maximum Length, in. (m)	56 (1.42)	102 (2.59)
Approximate Weight with Cylinders, lb. (kg)	7850 (3560)	16200 (7350)
Oil Pump Capacity, GPM (L/s)	14 (0.88)	25 (1.6)
Oil Heat Rejection, BTU/hr. (J/s)	14,000 (4130)	24,000 (7030)
Sump Capacity, US gallons (L)	15 (57)	37 (140)
Piston Rod Diameter, in. (mm)	2.000 (50.80)	2.000 (50.80)
Internal Rod Load - Double Acting:		
Compression + Tension, lbf. (kN)	48,000 (213)	48,000 (213)
Tension, lbf. (kN)	24,000 (107)	24,000 (107)
Compression, lbf. (kN)	30,000 (134)	30,000 (134)
Internal Rod Load - Single Acting:		
Tension, lbf. (kN)	24,000 (107)	24,000 (107)

TABLE 1-2: JGE FRAME SPECIFICATIONS

MODEL	JGE/2	JGE/4	JGE/6
Stroke, inches (mm)	4-1/2 (114.3)	4-1/2 (114.3)	4-1/2 (114.3)
Speed, RPM	750 to 1500	750 to 1500	750 to 1500
Piston Speed, FPM (m/s)	To 1125 (5.7)	To 1125 (5.7)	To 1125 (5.7)
Number of Throws	2	4	6
Horsepower (kW)	To 1070 (798)	To 2140 (1596)	To 3210 (2394)
Height - Bottom to Crankshaft ℄, in. (mm)	17 (431.8)	17 (431.8)	17 (431.8)
Connecting Rod ℄ to ℄, in. (mm)	13.75 (349.25)	13.75 (349.25)	13.75 (349.25)
Maximum Width, in. (m)	139 (3.53)	139 (3.53)	139 (3.53)
Maximum Length, in. (m)	56 (1.42)	101 (2.57)	138 (3.51)
Approximate Weight with Cylinders, lb. (kg)	7850 (3560)	15,900 (7200)	24,300 (11 020)
Oil Pump Capacity, GPM (L/s)	15 (0.95)	27 (1.7)	55 (3.5)
Oil Heat Rejection, BTU/hr. (J/s)	21,400 (6300)	36,400 (10 700)	54,600 (16 000)
Sump Capacity, US gallons (L)	15 (57)	37 (140)	56 (212)
Piston Rod Diameter, in. (mm)	2.000 (50.80)	2.000 (50.80)	2.000 (50.80)
Internal Rod Load - Double Acting:			
Compression + Tension, lbf. (kN)	60,000 (267)	60,000 (267)	60,000 (267)
Tension, lbf. (kN)	30,000 (134)	30,000 (134)	30,000 (134)
Compression, lbf. (kN)	32,000 (142)	32,000 (142)	32,000 (142)
Internal Rod Load - Single Acting:			
Tension, lbf. (kN)	30,000 (134)	30,000 (134)	30,000 (134)

Product Information and Safety Plates



Top Cover

Direction of Rotation plate, located at the drive end

ARIEL LOGO NAME PLATE AND ADDRESS

Information plate: Model, Frame serial number, Stroke, Maximum and minimum speed, Maximum rod load, Ariel shipping date, Normal lube oil pressure, Low oil pressure shutdown and Maximum lube oil temperature.

IMPORTANT SAFETY INFORMATION PLATES
See Page 1-5

Oil Filter Plate with installation instructions. (See Page 4-21)

FIGURE 1-3: TOP COVER

Important Safety Information

⚠ CAUTION

SEVERE PERSONAL INJURY AND PROPERTY DAMAGE CAN RESULT IF PRESSURE SYSTEM IS NOT COMPLETELY VENTED BEFORE LOOSENING THE BOLTS ON FLANGES, HEADS, VALVE CAPS, OR PACKING. CONSULT ARIEL TECHNICAL MANUAL BEFORE PERFORMING ANY MAINTENANCE.

⚠ CAUTION

SEVERE PERSONAL INJURY AND PROPERTY DAMAGE WILL RESULT IF SUCTION AND DISCHARGE VALVES ARE NOT INSTALLED IN THEIR PROPER LOCATION.

⚠ CAUTION

NOISE GENERATED BY RECIPROCATING MACHINERY CAN BE A SOURCE FOR HEARING INJURY. SEE PACKAGER'S INFORMATION FOR ANY SPECIFIC RECOMMENDATIONS. WEAR HEARING PROTECTION WHEN UNIT IS RUNNING.

⚠ CAUTION

HOT GAS TEMPERATURES ESPECIALLY THE CYLINDER DISCHARGE AREAS, 190°F (88°C) OIL AND HIGH FRICTION AREAS CAN BE A SOURCE FOR BURNS. WEAR PROPER INSULATION WHEN WORKING AROUND THESE AREAS. SHUT DOWN UNIT AND ALLOW TO COOL BEFORE DOING MAINTENANCE IN THESE AREAS.

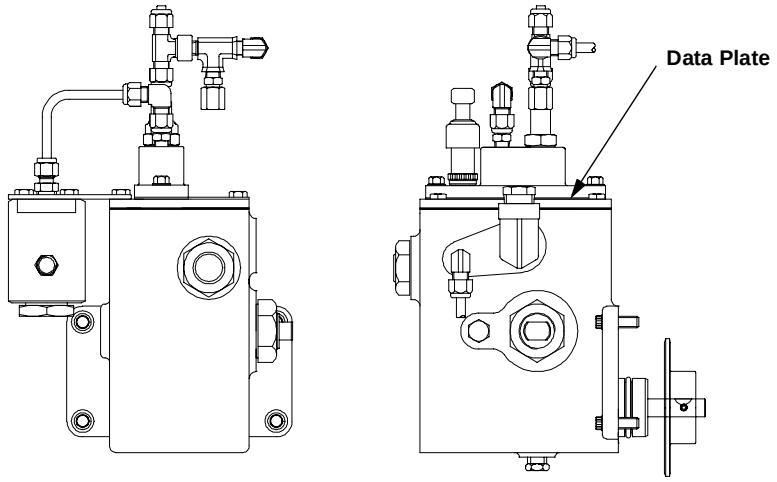


FIGURE 1-4: FORCE FEED LUBRICATOR PUMP - TYPICAL

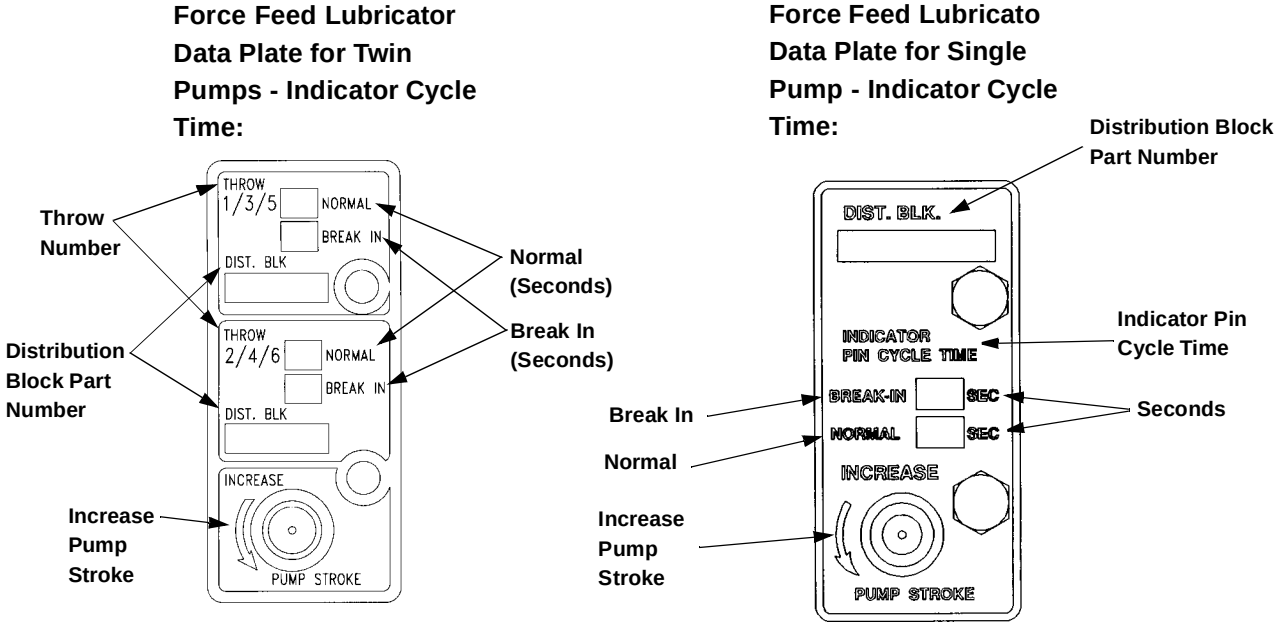


FIGURE 1-5: FORCE FEED LUBRICATOR DATA PLATES

The Force Feed Lubricator provides oil to the piston rod packing and the compressor pistons. The Lubricator Plate gives directions for adjusting the flow of oil. If this plate is missing, please contact Ariel Corporation, Mount Vernon, Ohio for a replacement or directions.

NOTE: THE FORCE FEED LUBRICATOR BOX CONTAINS APPROXIMATELY 1/3 GALLONS (1 L) OF LUBRICANT

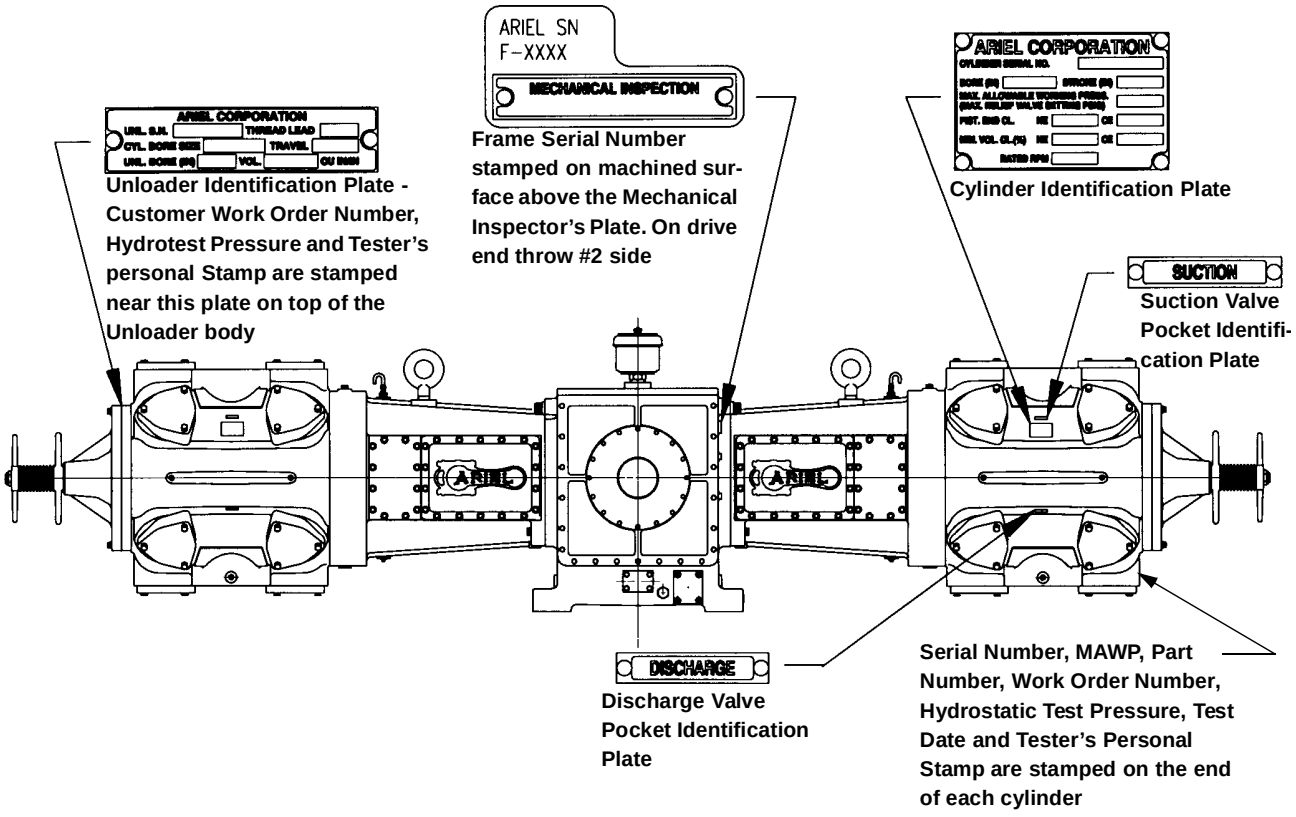
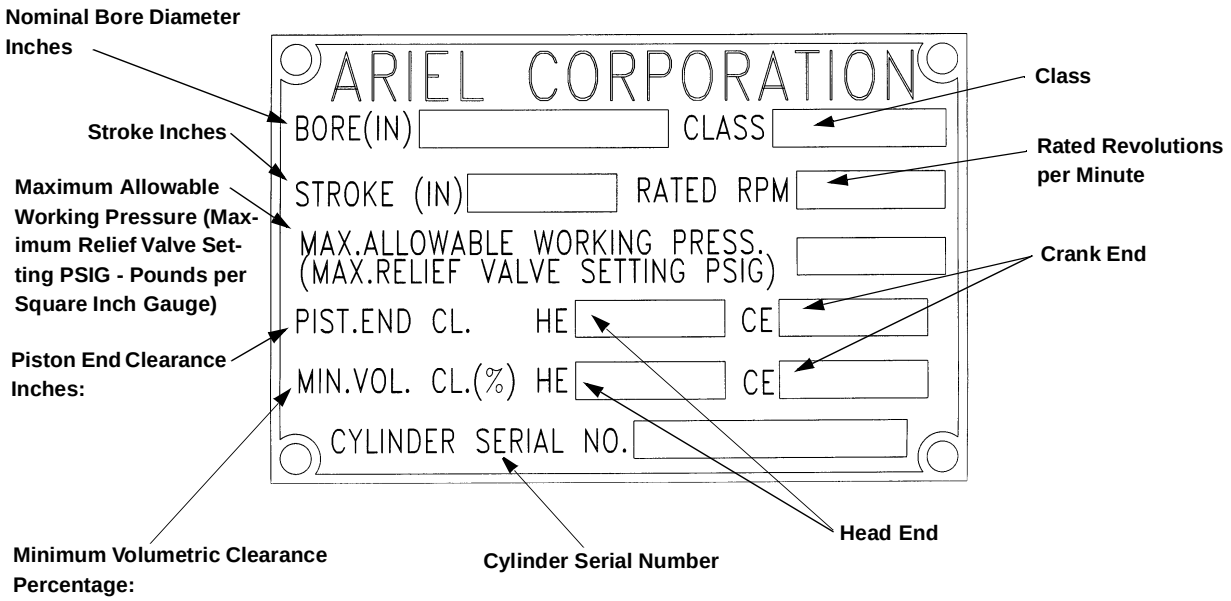


FIGURE 1-6: IDENTIFICATION PLATES - TYPICAL

Cylinder Identification Plates appear on each cylinder. The serial number is also stamped on the end of each cylinder. If any plate is missing, please contact Ariel Corporation, Mount Vernon, Ohio for a replacement or specific directions.

NOTE: USE THE CYLINDER AND FRAME SERIAL NUMBERS IN ALL CORRESPONDENCE.

CYLINDER IDENTIFICATION PLATE:



UNLOADER IDENTIFICATION PLATE

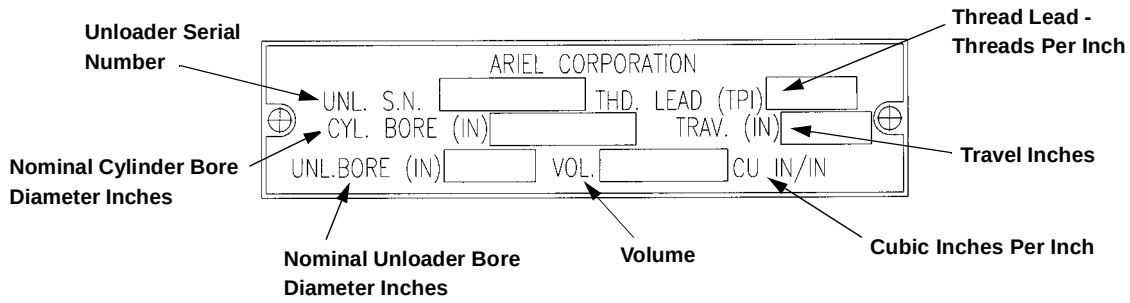


FIGURE 1-7: CYLINDER AND UNLOADER IDENTIFICATION PLATES

Clearances

TABLE 1-3: CLEARANCES

DESCRIPTION	CLEARANCE, IN.	CLEARANCE, (mm)
Crankshaft Dust Seal JGH/2/4 & JGE/2/4 (Feeler Gauge - Centered)	0.008 to 0.010	(0.20 to 0.25)
Crankshaft Dust Seal JGE/6 (Feeler Gauge - Centered)	0.005 to 0.010	(0.13 to 0.25)
Crankshaft Thrust JGH/2/4 & JGE/2/4 (End)	0.0085 to 0.020	(0.215 to 0.51)
Crankshaft Thrust JGE/6 (End)	0.014 to 0.033	(0.36 to 0.84)
Crankshaft Journal Bearing (Jack)	0.0015 to 0.005	(0.04 to 0.13)
Crankshaft Pin to Connecting Rod Bearing (Vertical Jack)[a]	0.0035 to 0.007	(0.09 to 0.18)
Connecting Rod Thrust (Side)	0.007 to 0.018	(0.18 to 0.46
Connecting Rod Bushing to Crosshead Pin	0.002 to 0.004	(0.05 to 0.10)
Crosshead Bronze Bushing to Crosshead Pin - Iron Crosshead	0.002 to 0.0042	(0.05 to 0.107)
Crosshead to Crosshead Pin - Bronze Crosshead	0.002 to 0.0035	(0.05 to 0.09)
Crosshead to Guide - Babbitted Iron (Feeler Gauge[b])	0.007 to 0.0155	(0.18 to 0.39)
Crosshead to Guide - Babbitted Bronze (Feeler Gauge[b])	0.011 to 0.0155	(0.28 to 0.39)
Piston End Clearance for 22-1/2 H/E Class Cylinders - Crank End	0.050	(1.27)
Piston End Clearance for 22-1/2 H/E Class Cylinders - Head End[c]	0.070 to 0.130	(1.78 to 3.30)
Total Piston End Clearance for 22-1/2 H/E Class Cylinders	0.120 to 0.180	(3.05 to 4.57)
Piston End Clearance - All Other H/E Class Cylinders - Crank End	0.040	(1.02)
Piston End Clearance - All Other H/E Class Cylinders - Head End	0.050 to 0.110	(1.27 to 2.79)
Total Piston End Clearance - All Other H/E Class Cylinders	0.090 to 0.150	(2.29 to 3.81)
Piston End Clearance for 17-7/8, 20-1/8, 22, 24-1/8, 26-1/2 T Class Cyls. - CE	0.055	(1.40)
Piston End Clearance for 17-7/8, 20-1/8, 22, 24-1/8, 26-1/2 T Class Cyls. - HE	0.095 to 0.155	(2.41 to 3.94)
Total Piston End Clearance for 17-7/8, 20-1/8, 22, 24-1/8, 26-1/2 T Class Cyls.	0.150 to 0.210	(3.81 to 5.34)
Piston End Clearance for all TL Class Cylinders - Crank End	0.300	(7.62)
Piston End Clearance for all TL Class Cylinders - Head End	No Set	No Set
Total Piston End Clearance for all TL Class Cylinders	0.620 to 0.680	(15.75 to 17.27)
Piston End Clearance for all TM Class Cylinders - Crank End	0.040	(1.02)
Piston End Clearance for all TM Class Cylinders - Head End	0.080 to 0.140	(2.03 to 3.56)
Total Piston End Clearance for all TM Class Cylinders	0.120 to 0.180	(3.05 to 4.57)
Piston End Clearance for all other T Class Cylinders - Crank End	0.040	(1.02)
Piston End Clearance for all other T Class Cylinders - Head End	0.080 to 0.140	(2.03 to 3.56)
Total Piston End Clearance for all other T Class Cylinders	0.120 to 0.180	(3.05 to 4.57)

a. For compressors and/or connecting rod replacement bearing shells, supplied after 2/1/97.

b. Crosshead guide to crosshead clearance at the top is to be checked by inserting a standard 0.5" (13mm) wide feeler stock from one side edge of the crosshead across to the opposite side. The bottom clearance is to be checked with 0.0015" (0.038mm) feeler stock at the 4 corners. If the feeler can be inserted more than 0.5" (13mm), the assembly is not acceptable.
c. If your total piston end clearance is not within table tolerance, crank end + head end, contact packager or Ariel.

NOTE: MEASURED CLEARANCES WILL NOT NECESSARILY AGREE BECAUSE OF OIL FILMS, ASSEMBLY TOLERANCES, WEAR, ETC. PLASTIGAGES, SOLDER, ETC. ARE NOT TO BE USED.

Piston Ring, Packing Ring and Wearband Side Clearances

The standard side clearance in inches for JGH and JGE compressor piston rings, packing rings and wearbands when new are as follows:

TABLE 1-4: PISTON RING SIDE CLEARANCE, INCHES (mm)

NOMINAL WIDTH	ACTUAL GROOVE WIDTH	TEFLON ONE-PIECE	BRONZE
3/16 (4.76)	0.187 to 0.189 (4.75 to 4.80)	0.0035 to 0.0075 (0.09 to 0.19)	0.004 to 0.008 (0.10 to 0.20)
1/4 (6.35)	0.250 to 0.252 (6.35 to 6.40)	0.005 to 0.011 (0.13 to 0.28)	0.004 to 0.008 (0.10 to 0.20)
5/16 (7.94)	0.312 to 0.314 (7.92 to 7.98)	0.006 to 0.012 (0.15 to 0.30)	0.004 to 0.008 (0.10 to 0.20)
3/8 (9.53)	0.375 to 0.377 (9.53 to 9.58)	0.007 to 0.013 (0.18 to 0.33)	0.004 to 0.008 (0.10 to 0.20)
1/2 (12.70)	0.500 to 0.502 (12.70 to 12.75)	0.009 to 0.015 (0.23 to 0.38)	0.004 to 0.008 (0.10 to 0.20)
5/8 (15.88)	0.625 to 0.627 (15.88 to 15.93)	0.011 to 0.016 (0.28 to 0.41)	0.005 to 0.009 (0.13 to 0.23)
3/4 (19.05)	0.750 to 0.752 (19.05 to 19.10)	0.013 to 0.020 (0.33 to 0.51)	0.006 to 0.010 (0.15 to 0.25)

TABLE 1-5: RIDER RING SIDE CLEARANCE, INCHES (mm)

ACTUAL GROOVE WIDTH	CLEARANCE
1.000	0.012 to 0.018 (0.30 to 0.46)
2.000	0.024 to 0.030 (0.61 to 0.76)
3.000	0.036 to 0.042 (0.91 to 1.07)
4.000	0.048 to 0.054 (1.22 to 1.37)

TABLE 1-6: PACKING RING SIDE CLEARANCE, INCHES (mm)

ACTUAL GROOVE WIDTH	TEFLON	PEEK	BRONZE
0.375 to 0.377 (9.53 to 9.58)	0.011 to 0.015 (0.28 to 0.38)	0.011 to 0.015 (0.28 to 0.38)	0.006 to 0.008 (0.15 to 0.20)
0.572 to 0.574 (14.53 to 14.58)	0.017 to 0.022 (0.43 to 0.56)	0.017 to 0.022 (0.43 to 0.56)	

TABLE 1-7: WEARBAND SIDE CLEARANCE, INCHES (mm)

ACTUAL GROOVE WIDTH	TEFLON
0.875 to 0.877 (22.23 to 22.28)	0.010 to 0.024 (0.25 to 0.51)
2.000 to 2.002 (50.80 to 50.85)	0.024 to 0.034 (0.61 to 0.86)
3.000 to 3.003 (76.20 to 76.28)	0.036 to 0.048 (0.91 to 1.22)

TABLE 1-8: PISTON TO BORE CLEARANCES AND PISTON RING/RIDER RING END GAPS, FOR H&E CLASS CYLINDERS, INCHES

BORE DIAMETER	PISTON TO BORE CLEARANCE		CONVENTIONAL PISTON RING END GAP		PISTON/RIDER RING END GAP[a]
	WITH CONVENTIONAL PISTON RINGS	WITH PISTON/ RIDER RINGS[b]	NEW	MAXIMUM	
4.25	0.011 to 0.016	0.090 to 0.096	0.051 to 0.075	0.225	0.050 to 0.066
4.625	0.012 to 0.017	0.090 to 0.096	0.056 to 0.080	0.240	0.056 to 0.072
5.125	0.012 to 0.017	0.090 to 0.096	0.061 to 0.085	0.255	0.062 to 0.078
5.5	0.013 to 0.018	0.090 to 0.096	0.066 to 0.090	0.270	0.068 to 0.084
6.0	0.013 to 0.018	0.090 to 0.096	0.072 to 0.112	0.336	0.074 to 0.090
6.375	0.014 to 0.019	0.090 to 0.096	0.077 to 0.117	0.351	0.073 to 0.103
7.0	0.015 to 0.020	0.090 to 0.096	0.084 to 0.124	0.372	0.091 to 0.121
7.375	0.015 to 0.020	0.090 to 0.096	0.089 to 0.129	0.387	0.097 to 0.127
8.0	0.016 to 0.022	0.090 to 0.096	0.096 to 0.136	0.408	0.095 to 0.125
8.375	0.017 to 0.023	0.090 to 0.096	0.101 to 0.141	0.423	0.100 to 0.130
9.25	0.019 to 0.025	0.090 to 0.096	0.111 to 0.151	0.453	0.112 to 0.142
9.75	0.020 to 0.026	0.090 to 0.096	0.117 to 0.157	0.471	0.119 to 0.149
11	0.022 to 0.028	0.090 to 0.096	0.131 to 0.179	0.537	0.136 to 0.166
11.5	0.023 to 0.029	0.090 to 0.096	0.138 to 0.186	0.558	0.143 to 0.173
13	0.026 to 0.032	0.090 to 0.096	0.156 to 0.204	0.612	0.182 to 0.212
13.5	0.027 to 0.033	0.090 to 0.096	0.162 to 0.210	0.630	0.190 to 0.220
15.250	0.030 to 0.037	0.090 to 0.097	0.183 to 0.231	0.693	0.216 to 0.246
15.75	0.031 to 0.038	0.090 to 0.097	0.189 to 0.237	0.711	0.224 to 0.254
16.75	0.033 to 0.040	0.090 to 0.097	0.201 to 0.251	0.753	0.239 to 0.269
17.25	0.034 to 0.041	0.090 to 0.097	0.207 to 0.259	0.777	0.247 to 0.277
19	0.038 to 0.046	0.090 to 0.098	0.228 to 0.292	0.876	0.273 to 0.303
19.5	0.039 to 0.047	0.090 to 0.098	0.234 to 0.298	0.894	0.281 to 0.311
22.5	Uses Wearbands, see Table 1-10 on page 1-14				

a. Rider ring radial projection is 0.026” to 0.033” and side clearance is 0.008” to 0.013”.

b. Piston/rider rings are standard on all E Class cylinders. Piston/rider rings are optional on H Class cylinders with bore diameters of 4.25” to 11.5” with the exception of bore diameters 4.625”, 5.5” and 6.375”. Piston/rider ring are standard on H Class cylinders with bore diameters of 4.625”, 5.5”, 6.375” and 13” to 19.5”.

TABLE 1-9: PISTON TO BORE CLEARANCES AND PISTON RING/RIDER RING END GAPS, FOR H&E CLASS CYLINDERS, (MILLIMETERS)

BORE DIAMETER (MM) [INCHES]	PISTON TO BORE CLEARANCE		CONVENTIONAL PISTON RING END GAP		PISTON/RIDER RING END GAP[a]
	WITH CONVENTIONAL PISTON RINGS	WITH PISTON/ RIDER RINGS[b]	NEW	MAXIMUM	
(108) [4.25]	(0.28 to 0.41)	(2.29 to 2.44)	(1.30 to 1.91)	(5.72)	(1.27 to 1.68)
(117) [4.625]	(0.30 to 0.43)	(2.29 to 2.44)	(1.42 to 2.03)	(6.10)	(1.42 to 1.83)
(130) [5.125]	(0.30 to 0.43)	(2.29 to 2.44)	(1.55 to 2.16)	(6.48)	(1.57 to 1.98)
(140) [5.5]	(0.33 to 0.46)	(2.29 to 2.44)	(1.68 to 2.29)	(6.86)	(1.73 to 2.13)
(152) [6]	(0.33 to 0.46)	(2.29 to 2.44)	(1.83 to 2.84)	(8.53)	(1.88 to 2.29)
(162) [6.375]	(0.36 to 0.48)	(2.29 to 2.44)	(1.96 to 2.97)	(8.92)	(1.85 to 2.62)
(178) [7]	(0.38 to 0.51)	(2.29 to 2.44)	(2.13 to 3.15)	(9.45)	(2.31 to 3.07)
(187) [7.375]	(0.38 to 0.51)	(2.29 to 2.44)	(2.26 to 3.28)	(9.83)	(2.46 to 3.23)
(203) [8]	(0.41 to 0.56)	(2.29 to 2.44)	(2.44 to 3.45)	(10.36)	(2.41 to 3.18)
(213) [8.375]	(0.43 to 0.58)	(2.29 to 2.44)	(2.57 to 3.58)	(10.74)	(2.54 to 3.30)
(235) [9.25]	(0.48 to 0.64)	(2.29 to 2.44)	(2.82 to 3.84)	(11.51)	(2.84 to 3.61)
(248) [9.75]	(0.51 to 0.66)	(2.29 to 2.44)	(2.97 to 3.99)	(11.96)	(3.02 to 3.78)
(279) [11]	(0.56 to 0.71)	(2.29 to 2.44)	(3.33 to 4.55)	(13.64)	(3.45 to 4.22)
(292) [11.5]	(0.58 to 0.74)	(2.29 to 2.44)	(3.51 to 4.72)	(14.17)	(3.63 to 4.39)
(330) [13]	(0.66 to 0.81)	(2.29 to 2.44)	(3.96 to 5.18)	(15.54)	(4.62 to 5.38)
(343) [13.5]	(0.69 to 0.84)	(2.29 to 2.44)	(4.11 to 5.33)	(16.00)	(4.83 to 5.59)
(387) [15.25]	(0.76 to 0.94)	(2.29 to 2.46)	(4.65 to 5.87)	(17.60)	(5.49 to 6.25)
(400) [15.75]	(0.79 to 0.97)	(2.29 to 2.46)	(4.80 to 6.02)	(18.06)	(5.69 to 6.45)
(425) [16.75]	(0.84 to 1.02)	(2.29 to 2.46)	(5.11 to 6.38)	(19.13)	(6.07 to 6.83)
(438) [17.25]	(0.86 to 1.04)	(2.29 to 2.46)	(5.26 to 6.58)	(19.74)	(6.27 to 7.04)
(483) [19]	(0.97 to 1.17)	(2.29 to 2.49)	(5.79 to 7.42)	(22.25)	(6.93 to 7.70)
(495) [19.5]	(0.99 to 1.19)	(2.29 to 2.49)	(5.94 to 7.57)	(22.71)	(7.14 to 7.90)
(572) [22.5]	Uses Wearbands, see Table 1-11 on page 1-16				

a. Rider ring radial projection is 0.66mm to 0.84mm and side clearance is 0.20mm to 0.33mm.

b. Piston/rider rings are standard on all E Class cylinders. Piston/rider rings are optional on H Class cylinders with bore diameters of 108mm to 292mm with the exception of bore diameters 130mm, 140mm and 162mm. Piston/ rider rings are standard on H Class cylinders with bore diameters of 130mm, 140mm, 162mm and 330mm to 495mm.

TABLE 1-10: PISTON, PISTON RING AND WEARBAND CLEARANCES, FOR T CLASS CYLINDERS AND 22-1/2 H&E CLASS CYLINDER, INCHES

PISTON TO CYLINDER CLEARANCE		PISTON RING END GAPS		WEAR BANDS NEW	
BORE	CLEARANCE	NEW	MAXIMUM	MINIMUM END GAP	RADIAL PROJECTION
2.5	0.055 to 0.063	0.025 to 0.030	0.090	0.080	0.018 to 0.025
2.625	0.055 to 0.063	0.026 to 0.032	0.096	0.084	0.018 to 0.025
3	0.055 to 0.063	0.030 to 0.036	0.108	0.096	0.018 to 0.025
5	0.081 to 0.089	0.050 to 0.060	0.180	0160	0.027 to 0.035
5.375	0.081 to 0.089	0.053 to 0.064	0.192	0.172	0.027 to 0.035
5.875	0.081 to 0.089	0.059 to 0.070	0.211	0.188	0.027 to 0.035
6.25	0.081 to 0.089	0.062 to 0.075	0.225	0.200	0.027 to 0.035
6.75	0.087 to 0.096	0.068 to 0.081	0.243	0.216	0.029 to 0.037
7.25	0.087 to 0.096	0.072 to 0.087	0.261	0.232	0.029 to 0.037
7.875	0.092 to 0.101	0.079 to 0.094	0.283	0.252	0.031 to 0.040
8.375	0.092 to 0.101	0.084 to 0.100	0.300	0.268	0.031 to 0.040
9.125	0.096 to 0.105	0.091 to 0.109	0.328	0.292	0.033 to 0.042
9.625	0.096 to 0.105	0.096 to 0.116	0.346	0.308	0.033 to 0.042
9.875	0.109 to 0.118	0.099 to 0.119	0.357	0.316	0.037 to 0.047
10.375	0.109 to 0.118	0.104 to 0.125	0.375	0.332	0.037 to 0.047
10.5	0.114 to 0.123	0.105 to 0.126	0.378	0.336	0.039 to 0.049
10.875	0.114 to 0.123	0.109 to 0.131	0.393	0.348	0.039 to 0.049
11	0.114 to 0.123	0.110 to 0.132	0.396	0.352	0.039 to 0.049
11.375	0.114 to 0.123	0.114 to 0.137	0.411	0.364	0.039 to 0.049
12	0.117 to 0.127	0.120 to 0.144	0.432	0.384	0.039 to 0.050
12.25	0.117 to 0.127	0.123 to 0.147	0.441	0.392	0.039 to 0.050
12.5	0.117 to 0.127	0.125 to 0.150	0.450	0.400	0.039 to 0.050
13.125	0.126 to 0.136	0.131 to 0.158	0.474	0.420	0.043 to 0.053
13.625	0.126 to 0.136	0.136 to 0.163	0.490	0.436	0.043 to 0.053
14.125	0.126 to 0.136	0.141 to 0.170	0.508	0.452	0.043 to 0.053
14.25	0.126 to 0.136	0.143 to 0.171	0.513	0.456	0.042 to 0.052
14.75	0.126 to 0.136	0.148 to 0.177	0.531	0.472	0.042 to 0.052
15.375	0.127 to 0.137	0.154 to 0.184	0.553	0.492	0.038 to 0.050
15.875	0.127 to 0.137	0.159 to 0.190	0.570	0.508	0.038 to 0.050
17.375	0.141 to 0.152	0.174 to 0.208	0.625	0.556	0.044 to 0.057
17.875	0.141 to 0.152	0.179 to 0.214	0.643	0.572	0.044 to 0.057
19.625	0.158 to 0.169	0.196 to 0.236	0.706	0.628	0.050 to 0.063

TABLE 1-10: PISTON, PISTON RING AND WEARBAND CLEARANCES, FOR T CLASS CYLINDERS AND 22-1/2 H&E CLASS CYLINDER, INCHES

PISTON TO CYLINDER CLEARANCE		PISTON RING END GAPS		WEAR BANDS NEW	
BORE	CLEARANCE	NEW	MAXIMUM	MINIMUM END GAP	RADIAL PROJECTION
20.125	0.158 to 0.169	0.201 to 0.241	0.724	0.644	0.050 to 0.063
22	0.179 to 0.190	0.220 to 0.264	0.792	0.704	0.059 to 0.072
22.5	0.152 to 0.164	0.270 to 0.345	1.035	0.720	0.060 to 0.073
24.125	0.178 to 0.189	0.241 to 0.290	0.870	0.772	0.056 to 0.069
26.5	0.185 to 0.196	0.265 to 0.318	0.954	0.848	0.058 to 0.071

TABLE 1-11: PISTON, PISTON RING AND WEARBAND CLEARANCES, FOR T CLASS CYLINDERS AND 22-1/2 (572) H&E CLASS CYLINDER (MILLIMETERS)

PISTON TO CYLINDER CLEARANCE		PISTON RING END GAPS		WEAR BANDS NEW	
BORE DIAMETER (mm) [INCHES]	CLEARANCE	NEW	MAXIMUM	MINIMUM END GAP	RADIAL PROJECTION
(63.5) [2.5]	(1.40 to 1.60)	(0.64 to 0.76)	(2.29)	(2.03)	(0.46 to 0.64)
(66.7) [2.625]	(1.40 to 1.60)	(0.66 to 0.81)	(2.44)	(2.13)	(0.46 to 0.64)
(76.2) [3]	(1.40 to 1.60)	(0.76 to 0.91)	(2.74)	(2.44)	(0.46 to 0.64)
(127) [5]	(2.06 to 2.26)	(1.27 to 1.52)	(4.57)	(4.06)	(0.69 to 0.89)
(137) [5.375]	(2.06 to 2.26)	(1.35 to 1.63)	(4.88)	(4.37)	(0.69 to 0.89)
(149) [5.875]	(2.06 to 2.26)	(1.50 to 1.78)	(5.36)	(4.78)	(0.69 to 0.89)
(159) [6.25]	(2.06 to 2.26)	(1.57 to 1.91)	(5.72)	(5.08)	(0.69 to 0.89)
(171) [6.75]	(2.21 to 2.44)	(1.73 to 2.06)	(6.17)	(5.48)	(0.74 to 0.94)
(184) [7.25]	(2.21 to 2.44)	(1.83 to 2.21)	(6.63)	(5.89)	(0.74 to 0.94)
(200) [7.875]	(2.34 to 2.57)	(2.01 to 2.39)	(7.19)	(6.40)	(0.79 to 1.02)
(213) [8.375]	(2.34 to 2.57)	(2.13 to 2.54)	(7.62)	(6.81)	(0.79 to 1.02)
(232) [9.125]	(2.44 to 2.67)	(2.31 to 2.77)	(8.33)	(7.42)	(0.84 to 1.07)
(244) [9.625]	(2.44 to 2.67)	(2.44 to 2.95)	(8.79)	(7.82)	(0.84 to 1.07)
(251) [9.875]	(2.77 to 3.00)	(251 to 3.02)	(9.07)	(8.03)	(0.94 to 1.19)
(264) [10.375]	(2.77 to 3.00)	(2.64 to 3.18)	(9.53)	(8.43)	(0.94 to 1.19)
(267) [10.5]	(2.90 to 3.12)	(2.67 to 3.20)	(9.60)	(8.53)	(0.99 to 1.24)
(276) [10.875]	(2.90 to 3.12)	(2.77 to 3.33)	(9.98)	(8.84)	(0.99 to 1.24)
(279) [11]	(2.90 to 3.12)	(2.79 to 3.35)	(10.06)	(8.94)	(0.99 to 1.24)
(289) [11.375]	(2.90 to 3.12)	(2.90 to 3.48)	(10.44)	(9.25)	(0.99 to 1.24)
(305) [12]	(2.97 to 3.23)	(3.05 to 3.66)	(10.97)	(9.75)	(0.99 to 1.27)
(311) [12.25]	(2.97 to 3.23)	(3.12 to 3.73)	(11.20)	(9.96)	(0.99 to 1.27)
(318) [12.5]	(2.97 to 3.23)	(3.18 to 3.81)	(11.43)	(10.16)	(0.99 to 1.27)
(333) [13.125]	(3.20 to 3.45)	(3.33 to 4.01)	(12.04)	(10.67)	(1.09 to 1.35)
(346) [13.625]	(3.20 to 3.45)	(3.45 to 4.14)	(12.45)	(11.07)	(1.09 to 1.35)
(359) [14.125]	(3.20 to 3.45)	(3.58 to 4.32)	(12.90)	(11.48)	(1.09 to 1.35)
(362) [14.25]	(3.20 to 3.45)	(3.63 to 4.34)	(13.03)	(11.58)	(1.07 to 1.32)
(375) [14.75]	(3.20 to 3.45)	(3.76 to 4.50)	(13.49)	(11.99)	(1.07 to 1.32)
(391) [15.375]	(3.23 to 3.48)	(3.91 to 4.67)	(14.05)	(12.50)	(0.97 to 1.27)
(403) [15.875]	(3.23 to 3.48)	(4.04 to 4.83)	(14.48)	(12.90)	(0.97 to 1.27)
(441) [17.375]	(3.58 to 3.86)	(4.42 to 5.28)	(15.88)	(14.12)	(1.12 to 1.45)
(454) [17.875]	(3.58 to 3.86)	(4.55 to 5.44)	(16.33)	(14.53)	(1.12 to 1.45)
(498) [19.625]	(4.01 to 4.29)	(4.98 to 5.99)	(17.93)	(15.95)	(1.27 to 1.60)

TABLE 1-11: PISTON, PISTON RING AND WEARBAND CLEARANCES, FOR T CLASS CYLINDERS AND 22-1/2 (572) H&E CLASS CYLINDER (MILLIMETERS)

PISTON TO CYLINDER CLEARANCE		PISTON RING END GAPS		WEAR BANDS NEW	
BORE DIAMETER (mm) [INCHES]	CLEARANCE	NEW	MAXIMUM	MINIMUM END GAP	RADIAL PROJECTION
(511) [20.125]	(4.01 to 4.29)	(5.11 to 6.12)	(18.39)	(16.36)	(1.27 to 1.60)
(559) [22]	(4.55 to 4.83)	(5.59 to 6.71)	(20.12)	(17.88)	(1.50 to 1.83)
(572) [22.5]	(3.86 to 4.17)	(6.86 to 8.76)	(26.29)	(18.29)	(1.52 to 1.85)
(613) [24.125]	(4.52 to 4.80)	(6.12 to 7.37)	(22.10)	(19.61)	(1.42 to 1.75)
(673) [26.5]	(4.70 to 4.98)	(6.73 to 8.08)	(24.23)	(21.54)	(1.47 to 1.80)

TABLE 1-12: PISTON, PISTON RING W/EXPANDER RING-SPRING, WEAR BAND CLEARANCE, INCHES

PISTON TO CYLINDER CLEARANCE		PISTON RING END GAP		WEAR BANDS NEW	
BORE	CLEARANCE	NEW	MAXIMUM	MINIMUM END GAP	RADIAL PROJECTION
19.625	0.158 to 0.169	0.235 to 0.267	0.801	0.628	0.050 to 0.063
20.125	0.158 to 0.169	0.242 to 0.274	0.822	0.644	0.050 to 0.063
22	0.179 to 0.190	0.264 to 0.304	0.912	0.704	0.059 to 0.072
24.125	0.178 to 0.189	0.290 to 0.330	0.990	0.722	0.056 to 0.069
26.5	0.185 to 0.196	0.320 to 0.360	1.080	0.848	0.058 to 0.071

TABLE 1-13: PISTON, PISTON RING W/EXPANDER RING-SPRING, WEAR BAND CLEARANCE, (mm)

PISTON TO CYLINDER CLEARANCE		PISTON RING END GAP		WEAR BAND NEW	
BORE [INCHES]	CLEARANCE	NEW	MAXIMUM	MINIMUM END GAP	RADIAL PROJECTION
(498) [19.626]	(4.01 to 4.29)	(5.97 to 6.78)	(20.35)	(15.95)	(1.27 to 1.60)
(511) [20.125]	(4.01 to 4.29)	(6.15 to 6.96)	(20.88)	(16.36)	(1.27 to 1.60)
(559) [22]	(4.55 to 4.83)	(6.71 to 7.72)	(23.16)	(17.88)	(1.50 to 1.83)
(613) [24.125]	(4.52 to 4.80)	(7.37 to 8.38)	(25.15)	(18.34)	(1.42 to 1.75)
(673) [26.5]	(4.70 to 4.98)	(8.13 to 9.14)	(27.43)	(21.54)	(1.47 to 1.80)

Fastener Tightening Torque

Listed in the following tables are fastener tightening torque values required for proper assembly of Ariel JGH & JGE compressors. Refer to the section concerning a subject component for detailed assembly procedures.

Threads are to be clean and free of burrs.

Torque values are based on the use of petroleum type lubricants on both the threads and seating surfaces. Use lubricating oil or Lubriplate 630, except for compressor rods-piston end which use Never-Seez (by Bostik, Boston St., Middleton, MA 01949, phone: 508-777-0100). Molybdenum disulfide lubricants and Never-Seez are not to be used for fastener lubrication unless specified, or excessive stresses can result with the listed values.

TABLE 1-14: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Main Bearing Cap - Cap Screw	7/8 - 9	12 Point - Grade 8	280 (380)
Connecting Rod Cap/Detuner Donut - Cap Screw	7/8 - 14	12 Point - Grade 8 (JGH)	344
	1 - 14	12 Point - Grade 8 (JGE)	90 (122) + 1/4 Turn[a]
Nut Plate to Crankshaft Flange - JGE/6	1/2 - 20	12 Point - Grade 8	41 (56)
Crosshead Pin Thru Bolt - Lock Nut	1/2 - 20	Hex - Prevailing	61 (83)
Spacer Bar - Cap Screw	1-1/8 - 12	12 Point - Grade 8	560 (760)
Crosshead Guide to Frame - Cap Screw	7/8 - 9	12 Point - Grade 8	280 (380)
Crosshead Guide to Cylinder - Cap Screw	5/8 - 11	12 Point - Grade 8	97 (132)
Crosshead Guide Support - Cap Screw	7/8 - 9	Hex - Grade 9	255 (346)
Eccentric Vernier Cap - Cap Screw	5/16 - 18	Hex - Grade 8	Hand Wrench Tight
Idler Sprocket Thru Bolt - Lock Nut	1/2 - 20	Hex - Pin or Prevailing	41 (55)
Ext Thrust Bearing Adapter to Crankshaft-Cap Screw	1/2 - 20	12 Point	66 (90)
Nut Plate to Crankshaft Flange - Cap Screw	1/2 - 20	12 Point	46 (63)
Rod Packing - Cap Screw	3/4 - 10	12 Point	125 (170)
Rod Catcher to Packing	1/2 - 20	12 Point	51 (69)
Piston Nut	1-5/8 - 12	Ariel Design	1590 (2156)[b]
Crosshead Nut	1-3/4 - 12	Ariel Design	1500 (2030)[c]
Roller Thrust Bearing Retainer Clamp Bolt	3/4 -16	Ariel Design	160 (220)
Rupture Disk - Blow-Out Fitting Cap	1/4 Nom. Tube	Hex - Tube Fitting	36 lb x in. (4.1)
Hold Down - Stud Nut	1-1/8 - 7	Hex Stud - Nut	600 (805)[d]
Flywheel to Hub	1 - 8	Hex - Grade 9	460 (620)
	1 - 14	Hex - Grade 9	530 (715)
Piston Rod Oil Slinger - Lock Nut	1/4 - 28	Hex Jam - Prevailing	96 lb x in. (11)
Main Drive Coupling - Adapter to Crankshaft Flange - Cap Screw	1 - 14	12 Point	440 (600)
Lifting Bracket to Frame JGE/6 - Cap Screw	1 -1/4 - 7	12 Point	690 (938)

TABLE 1-14: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Valve Cap/Cylinder Head/Unloader /Gas Passage Cap/Ariel Supplied Companion Flange to Cylinder - Cap Screw[e]	1/2 - 13	Hex - Grade 8/9 or 12 Point - Grade B7M or 8	40 (54)
	5/8 -11		79 (105)
	3/4 - 10		140 (190)
	3/4 - 16		160 (220)
	7/8 - 9		230 (310)
	7/8 -14		260 (350)
	1 - 8		345 (465)
	1 - 14		395 (535)
	1-1/8 - 12		560 (760)
Tandem Cylinder to Cylinder - Cap Screw[e]	1/2 - 13	Hex - Grade 8/9 or 12 Point - Grade 8	44 (60)
	5/8 - 11		88 (120)
	3/4 - 10		160 (215)
Seating Studs in Cylinder	1/2 - 13	Dog Point	22 (30)
	5/8 - 11		44 (60)
	3/4 - 10		79 (105)
	3/4 - 16		90/120
	7/8 - 9		130 (170)
	7/8 - 14		145 (195)
	1 - 8		190 (260)
	1 -14		220/300
	1-1/8 - 12		310/420
Distribution Block Tie Rod - Nut	1/4 - 28	Hex	68 lb x in. (7.7)
Distribution Block Divider Valve - Screw	1/4 - 28	Socket Head	109 lb x in. (12)
Grade 5 - Hex Cap Screw	All	Hex - Grade 5	Hand Wrench Tight

a. See Page 5-4 for complete instructions
b. When using the optional piston nut torquing tool (G-5266), set 3500 psig hydraulic pressure on the tool and 50 lb-ft on the hex pinion gear drive. See Figure 5-18: on page 1-26.
c. When using optional crosshead nut torquing tool (G-7583), nut is tight at 3500 psi (24132 kPa) when it will not move and ram is not fully extended. See Figure 5-6: on page 1-10.
d. Minimum torque for recommended 1-1/8" - 7TPI hold down stud size to provide stress in stud of 55,000 psi (380 MPa). Stud must have an ultimate strength of 100,000 psi(690 MPA) or greater. If greater, increase torque to stress the stud to about 55% of the ultimate strength of the stud material, as specified by packager.
e. When studs are specified for cylinder applications, tighten stud - nuts to the same values as cap screws in similar applications. See Figure 1-8: on page 1-20.

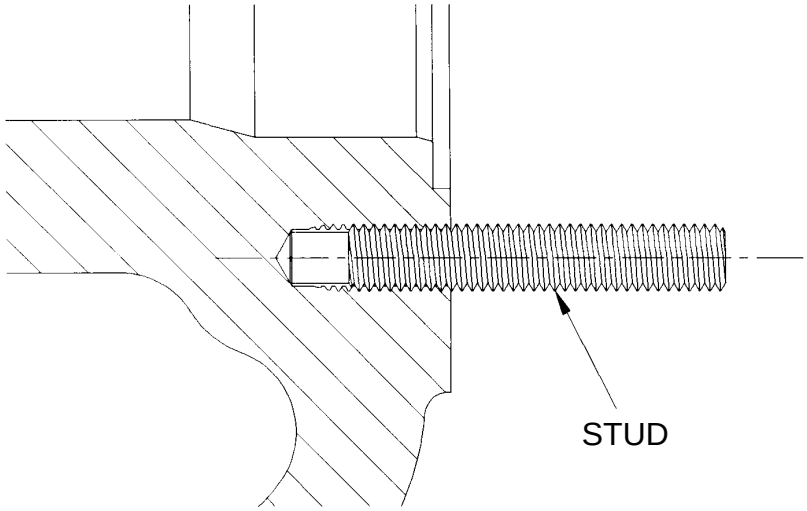


FIGURE 1-8: DOG POINT STUDS

TABLE 1-15: HOERBIGER VALVE ASSEMBLY FASTENERS - TIGHTENING VALUES

FASTENER	NOMINAL SIZE INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Center Cap Screw[a b]	5/16 - 24	12 Point - Steel Grade 5	18 (24)
	3/8 - 24		32 (43)
	7/16 -20		50 (68)
	5/16 - 24	12 Point - Steel Grade 8	26 (35)
	3/8 - 24		45 (61)
	7/16 - 20		62 (83)
	5/16 - 24	12 Point - Stainless Steel Grade B8M	120 lb x in. (13.6)
	3/8 - 24		192 lb x in. (21.7)
	7/16 - 20		24 (33)
Center Stud - Drake Lock Nut	1/4 - 28	Bottom Half	103 lb x in. (11.6)
		Top Half	66 lb x in. (7.5)
	5/16 - 24	Bottom Half	168 lb x in. (18.9)
		Top Half	96 lb x in. (10.8)
	3/8 - 24	Bottom Half	192 lb x in. (21.7)
		Top Half	96 lb x in. (10.8)
	1/2 - 20	Bottom Half	36[c] (49)
		Top Half	20 (27)
	5/8 - 18	Bottom Half	73 (99)
		Top Half	40 (54)
	3/4 - 16	Bottom Half	130 (176)
		Top Half	70 (95)
Peripheral Cap Screws	10 - 32	Hex Socket Head	25 lb x in. (2.8)
	12-28		43 lb x in. (4.9)
	1/4		110 lb x in. (12.4)
	5/16		176 lb x in. (19.9)
	3/8		21 (28)

a. 12 Point Cap Screw Center Fasteners in Valve Assemblies not marked SPL (Spiralock Threads), must be cleaned with Loctite Safety Solvent and locked with one or two drops of Loctite #272 lubricants. Do not use petroleum lubricants.

b. 12 Point Cap Screws in Valve Assemblies with Spiralock Threads and marked SPL (see Figure 1-9: on page 1-22) are lubricated, both threads and seating surfaces, with a petroleum type lubricant only.

c. 29 lb x ft (39 N·m) for 1/2 - 20 Bottom Half - Drake Lock Nut with non-metallic Plates in Liftwasher Type Valves.

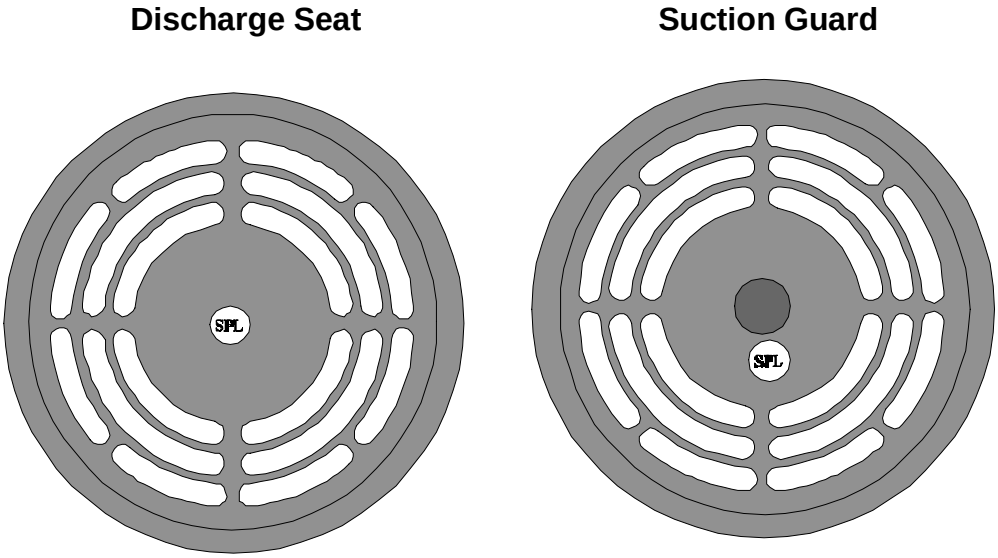


FIGURE 1-9: SPIRALOCK THREADED VALVE ASSEMBLY - MARKED "SPL"

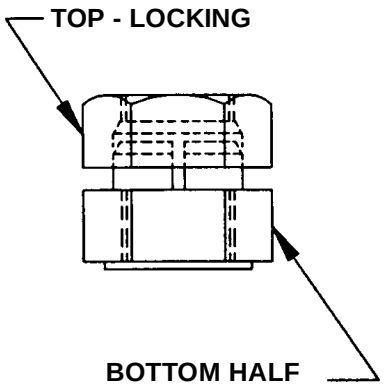


FIGURE 1-10: DRAKE LOCK NUT

Tightening Torque Procedures

Listed below are some procedures which make fastener tightening more accurate and will help ensure that the proper torque is being applied.

1. Ensure that the torque wrench is properly calibrated and used by qualified personnel to achieve the required fastener tightening torque for all critical parts. The exception is the crosshead balance/lock nut which may be tightened using the "tried and true" slugging procedure.
2. Always check to determine over what range the torque wrench is accurate, since most torque wrenches are not accurate over their entire range.

3. Tighten critical multi-bolt assemblies in steps. Tighten each bolt until snug using a criss-cross pattern. Next, tighten each bolt to 25% of full torque, moving across from bolt to bolt, in a criss-cross pattern. Repeat this step for 50%, 75%, and 100% of full torque.
4. Always apply a steady slow force to a torque wrench, do not jerk it. When a torque wrench is jerked the amount of torque applied can be as much as one and a half times the amount set on the wrench. For example, if a wrench is set at 80 lb x ft (108 N·m) but is jerked, 120 lb x ft (163 N·m) torque can be applied.
5. Always do the final tightening with a torque wrench. Do not tighten the fastener with a ratchet or impact wrench and then "check" the torque with a torque wrench.
6. Do not double tap a torque wrench. Rapidly double tapping a torque wrench will make the torque on the bolt more than what is set by a significant amount. If it is desired to check the setting, release all pressure on the wrench and then slowly apply a steady force until the click is felt.
7. Always reset the torque wrench to its lowest setting when the job is complete. If the torque wrench is left in a high setting the spring in it is stressed and will become inaccurate with time. If the torque wrench is put back to its lowest setting the spring will relax and retain its accuracy
8. Do not use a torque wrench to break fasteners loose as it may overload the torque wrench and/or cause loss of calibration.
9. For applications requiring the use of a boxed end or crowsfoot adapter with a torque wrench to reach not readily accessible fasteners, the torque wrench setting will not be the actual torque applied to the fastener.[1]
10. The ratio of actual torque at the fastener with that on the wrench scale is a function of the adapter's length (A) and its position in relation to the torque wrench beam and the location where the force is applied (see Figure 1-11: on page 1-24).

$$Tw = Ta\left(\frac{L}{L + A}\right)$$

Tw = Torque wrench setting, lb x ft or N·m

Ta = Torque required at fastener, lb x ft or N·m

L = Length of wrench, ft or m (from square drive end to center point of force on handle)

A = Length of adapter, ft or m (measured through end of adapter on a line parallel to the center line of the wrench)

These are general guidelines to assist in the proper use of torque wrenches. Consult with your torque wrench dealer for more detailed information.

1. The exception is when the adapter is 90° to the torque wrench. The torque will be the same as on the wrench scale (see Figure 1-12: on page 1-24).

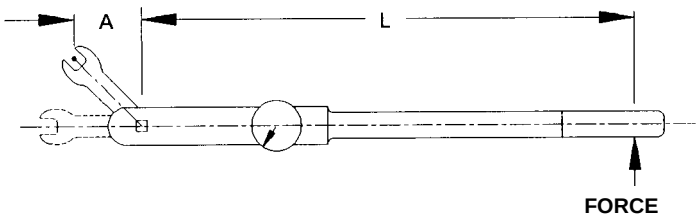


FIGURE 1-11: TORQUE WRENCH WITH ADAPTOR AT ANY ANGLE

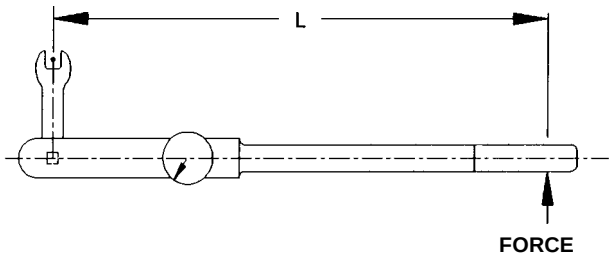


FIGURE 1-12: TORQUE WRENCH WITH ADAPTOR AT RIGHT ANGLE

Ariel Bolting

Bolts have been selected that meet Ariel's strength, elongation, sealing and locking requirements. Proper bolting must be used and tightened to the values listed in Table 1-14 on page 1-18. Figure 1-13: on page 1-25 is provided to assist in the identification of bolts used in an Ariel compressor.

Connecting rod, detuner donuts, valve cap and suction/discharge nozzle-Ariel supplied specialized companion flange-bolting is modified to prevent fatigue and cannot be replaced with standard bolts. If attempting to replace other bolting with standard bolts and there is any question, contact your packager or Ariel. Ariel supplied replacement bolting is recommended.

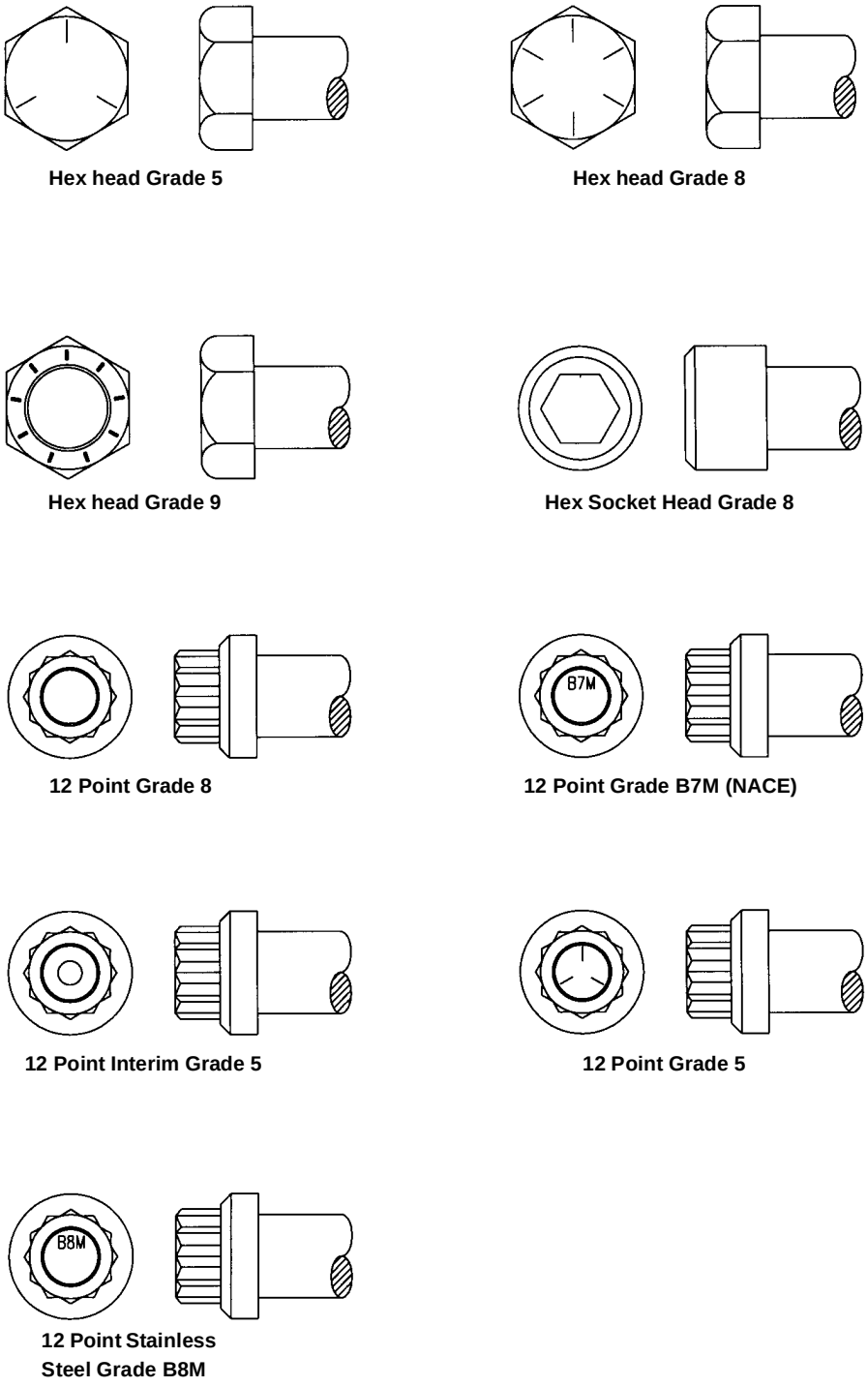


FIGURE 1-13: BOLT IDENTIFICATION

Optional Main Bearing Temperature Instrumentation - Alarm & Shutdown

Amot 4103 Temperature Valve

This eutectic alloy device is selected to melt at 228°F (109°C) to vent control pressure and to provide a shutdown signal. Upon melting, the fuse rod must be replaced. To ensure proper operation of the detector, replace the fuse rod every five years.

Electrical Instrumentation Setting

Set within 10% of normal operating temperature, to a maximum of 220°F (104°C) alarm and 230°F (110°C) shutdown.

SECTION 2 - INSTALLATION

General

The installation of the compressor with the associated driver and piping, is to be done with care and precision. This section does not attempt to address all of the concerns that can arise during installation. This section addresses some of the more critical installation considerations and requirements.

Procedure For Setting and Aligning

The following points deserve special attention during the setting and alignment of the compressor:

1 The skid design should:

Transmit compressor and driver reaction forces to the foundation.
Ensure that there is a sufficient mismatch between the shaking forces and the natural frequency of the skid.
Have sufficient stiffness and strength so that the compressor can be mounted flat with no bending or twisting of the compressor frame, crosshead guides or cylinder. This can be accomplished by shims or careful grouting.
Have enough stiffness and mass to resist vibration induced by the unbalanced couples as specified in the **Ariel Application Data Book**.

2 The feet on the crosshead guides must be supported in a fashion that not only provides vertical support, but also prevents horizontal movement perpendicular to the piston rod.

3 Each crosshead guide will deflect an amount relative to the weight of the cylinder mounted on that throw. This amount of deflection is shown on the Cylinder Outline Drawing in the **Ariel Application Data Book**. Shims equaling the deflection value as listed on the cylinder outline drawing are to be added to the shim pack under the crosshead guide, elevating the crosshead guide to a level positions crosshead guide supports must be capable of carrying the combined weight of the cylinders, bottles and piping.

Setting

The following procedure is to be used for setting the compressor on the skid:

After finding the approximate position of the compressor frame, the mounting bolts are to be tightened in place and then loosened. Shims are then to be adjusted so there is no move-

ment more than a variation of 0.002 inches (0.05 mm) between the bottom of the frame and the skid supports. With the frame again bolted into place, with no bottles or piping attached to the cylinder and with the crosshead guide supports free, the distance from the crosshead guide supports to their respective skid supports is to be measured. To these measurements add the amount of deflection due to the cylinder weight as listed on the appropriate compressor cylinder outline drawing. Raise the cylinder and shim between the guide and guide support before tightening the crosshead guide mounting bolts. Consult Packager's information for mounting bolt tightening torque values. This work must be performed prior to the addition of bottles and piping.

Alignment

Proper alignment is necessary for satisfactory performance. A flexible coupling will not make up for poor alignment. Misalignment can result in:

- High bending moment on the crankshaft
- Large axial forces
- Excessive wear to the bearings
- And if severe, probable damage to various components

An Ariel compressor may be aligned by any of a number of acceptable methods such as:

- Face/peripheral
- Reverse indicator
- Across the disc pack
- Optical
- Laser
- Mechanical direct to computer

When aligning a unit some procedural concerns are:

- Soft foot (compressor and driver are not laying flat)
- Repeatable readings
- Thermal growth
- Indicator sag

When properly aligned the forces on the connected equipment will be at a minimum. This will result in long bearing life and a smooth running unit. Consult Packager's information for alignment procedure.

Vents and Drains[1]

It is critical, for the safe operation of the compressor, to ensure that all vents and drains are open, functional and, if necessary, tubed off of the skid or out of the building. Depending upon your climate and insect population it can be necessary to install screens over the vents

1. Also see Section 4.

and drains to ensure that they do not become blocked. This can be essential if the compressor is shutdown for a long period of time.

Some other points are:

1 A vent should be provided to safely relieve pressure from the system.

2 Adequate vents and drains are to be provided for the distance pieces, primary packing vents and crankcase. Primary vents and drains must be independently vented from the secondary vents and drains. All vents and drains must be installed in such a manner as to prevent the collection of liquids that could cause the build up of either gas or liquid. When a heavier than air gas is involved, vent and drain design must be accommodating.

NOTES

SECTION 3 - START UP

General

To ensure proper start up, it is important to carefully follow the Start Up Check List provided in this section. It is also important that the operator be thoroughly familiar with this manual and with the Packager's Operating Manual.

⚠ CAUTION

BEFORE STARTING A NEW COMPRESSOR, OR AFTER RE-LOCATING OR RE-APPLYING A COMPRESSOR, OR AFTER MAJOR OVERHAUL, BE SURE TO COMPLETE AND CHECK OFF ALL THE ITEMS ON THE START UP CHECK LIST ON PAGES 3-2 THRU 3-4. THIS LIST IS DESIGNED TO ENSURE MAXIMUM SAFETY IN STARTING AND OPERATING THE COMPRESSOR

⚠ CAUTION

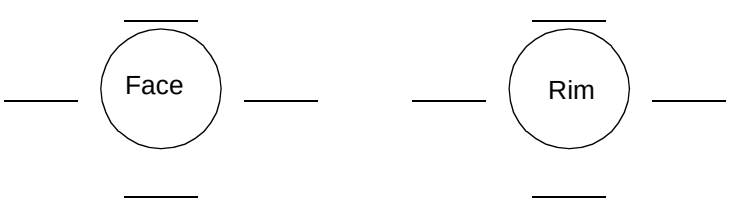
FOR SAFE OPERATION, DO NOT ATTEMPT TO START-UP THE UNIT WITHOUT BEING COMPLETELY KNOWLEGABLE OF THE INFORMATION CONTAINED IN THIS SECTION. IT IS ALSO ESSENTIAL TO REFER TO THE PACKAGER'S OPERATING MANUAL.

Start Up Check List

Compressor Model_____ Serial No. F-_____
Cylinder S/N C-_____ C-_____ C-_____ C-_____ C-_____ C-_____
Driver _____ Rated Speed _____
Packager _____ Packager Unit No. _____
Date Packager Shipped _____ Start Up Date _____
Serviceman _____ Customer _____
Location _____ Field Contact _____
Field Telephone No. _____ Unit Location _____
Frame Oil - Make/Grade_____ _____
Cylinder Oil - Make/Grade_____

Check List - Prior To Starting

	YES	NO
1. Are the correct Ariel parts book, technical manual, special tools, and spares available?	_____	_____
2. Have the design limitations for the compressor model such as rod load, maximum and minimum speed, discharge temperature been checked?	_____	_____
3. Have the design operating conditions been determined? Pressure, PSIG (kPa): Suction _____ Discharge_____ Temperature, °F (°C): Suction _____ Discharge_____ Maximum RPM_____ Minimum RPM_____	_____	_____
4. Soft Foot Check: Have the compressor feet and crosshead guide supports been shimmed so the machine is not twisted or bent?	_____	_____
5. Have bottom crosshead clearances on all corners been checked? Max. 0.0015” (0.038 mm) feeler inserted to 1/2” (12.7 mm) max. depth	_____	_____
6. Record top crosshead minimum feeler clearance below. Throw # 1_____ 2_____ 3_____ 4_____ 5_____ 6_____		
7. Have the piping and supports been checked to be sure they do not bend or stress compressor?	_____	_____
8. Have coupling bolt torque values been rechecked?	_____	_____
9. Has the compressor to driver alignment been checked? Maximum allowable 0.005 inches (0.13 mm) TIR	_____	_____
10. Record coupling dial indicator readings in inches (mm) at the 3, 6, 9 & 12 o’clock positions on lines provided:		



11. Has the crankshaft thrust clearance been checked? Record crankcase thrust clearance here: _____ inches (mm)	_____	_____

Compressor Model _____ Serial No. F-_____

	YES	NO
12. Have piston end clearances been checked with feeler gauges? Record clearances below:	_____	_____
Throw #1 #2 #3 #4 #5 #6		
HE_____ _____ _____ _____ _____ _____		
CE_____ _____ _____ _____ _____ _____		
13. Has the crankcase been filled with oil to the proper level?	_____	_____
14. Has proper oil been installed if extreme ambient conditions exist or special gases are compressed?	_____	_____
15. Is the compressor crankcase oil level control working and set at the proper level?	_____	_____
16. Is the crankcase oil supply isolation valve open?	_____	_____
17. Does the crankcase low level shutdown work?	_____	_____
18. Have the recommended oil filter elements been installed?	_____	_____
19. Are the oil filter elements and all lube oil piping primed with oil?	_____	_____
20. Is the low oil pressure shutdown installed and tubed correctly to the downstream side of the oil filter?	_____	_____
21. Does the low oil pressure shutdown work?	_____	_____
22. Oil cooler? Compressor inlet oil temp. is 190°F (88°C) max.	_____	_____
23. Is the crankcase oil temperature shutdown installed, set and working?	_____	_____
24. If oil is cooled, is there a temperature control valve?	_____	_____
25. Is the crankcase breather element clean?	_____	_____
26. Is the force feed lubricator box filled with oil?	_____	_____
27. Is the force feed lubrication system primed?	_____	_____
28. Is the force feed lubrication system no flow shutdown installed and working?	_____	_____
29. Is the force feed blow out assembly installed? Check rupture disc for color? Purple is standard = 3250 PSIG (22 400 kPa).	_____	_____
30. Has the lubricator instruction plate or Technical Manual Cylinder Lubrication Sheet been checked for proper lube feed rate?	_____	_____
31. Is there a working vibration shutdown mounted on the compressor?	_____	_____
32. Are the primary and secondary packing vents and the distance piece vents open, and when necessary, tubed off of the skid or out of the building?	_____	_____
33. Is there some method of suction pressure control?	_____	_____
34. Are the suction pressure, interstage pressure and discharge pressure shutdowns set and working?	_____	_____
35. Are the safety relief valves installed and working to protect cylinders and piping for each stage of compression?	_____	_____

Compressor Model _____ Serial No. F-_____

	YES	NO
36. Are the gas discharge temperature shutdowns installed, set and working?	_____	_____
37. Have the gas suction lines been blown out to remove water, slag, dirt, etc.?	_____	_____
38. Have temporary screens been installed at cylinder suction?	_____	_____
39. Was compressor prelubed prior to starting? For electric motor driven units, compressor must have prelube pump.	_____	_____
40. For engine driven units, has the machine been rolled with the starter to make sure it is free? The oil pressure should come up noticeably while rolling on the starter.	_____	_____
41. For other drivers, has the machine been barred over by hand to ensure it is rolling free?	_____	_____
42. Does the driver rotation match the compressor rotation arrow?	_____	_____
43. For machines compressing a combustible gas, have the piping and compressor been purged to remove all air?	_____	_____
44. Have start-up instructions for other package equipment been followed?	_____	_____
45. Has the packager's representative done the required review of the packager's Start-Up and Operating Instructions for the unit with the unit operator?	_____	_____

Check List - After Starting

	YES	NO
1. Did the oil pressure come up immediately?	_____	_____
2. Are the oil filter pressure and force feed gauges working?	_____	_____
3. Oil filter differential pressure <10 psi (69 kPa), unless otherwise specified?	_____	_____
4. Any strange noises or shaking in the compressor or piping?	_____	_____
5. Is low oil pressure shutdown set at 35 psi (240 kPa)?	_____	_____
6. Are the high discharge gas temperature shutdowns set at approx 10% above normal discharge temperature? 375°F (190°C) max.	_____	_____
7. Is the distribution block indicator pin moving, and have you set lubricator for proper break-in flow rate?	_____	_____
8. Are there any oil leaks? If so, where?	_____	_____
9. Are the scrubber dumps and high level shutdowns working?	_____	_____
10. Are the scrubbers removing all liquids from the gas? How often do they dump? (___minutes)	_____	_____
11. Are there sands or oxides in the gas?	_____	_____
12. Is the overspeed shutdown set?	_____	_____
13. Are rod packings sealing properly?	_____	_____
14. Have all safety functions been tested to ensure shutdown of unit upon malfunction?	_____	_____

Compressor Model _____ Serial No. F-_____

	YES	NO
15. Has Ariel's "Compressor Warranty Notification and Installation List Data" form been completed and mailed or faxed to Ariel?	_____	_____
16. Has a copy of this completed initial "Start up Check List" been mailed or faxed to Ariel? Ariel mailing address: Ariel Corporation, 35 Blackjack Road, Mount Vernon, OH 43050 USA, Attention: Administrative Assistant-Sales or Ariel fax number 740-397-3856, Attention: Administrative Assistant-Sales.	_____	_____

Maximum Allowable Working Pressure

All Ariel Compressor Cylinders have a "Maximum Allowable Working Pressure (MAWP)." The MAWP, the hydrostatic test pressure, and the test date are stamped on the end of every Ariel Cylinder (see Figure 1-6: on page 1-7).

⚠ CAUTION

OPERATING CONDITIONS MUST NOT EXCEED CYLINDER DESIGN LIMITATIONS.

API Specification 11P, Second Edition, November 1989, Paragraph 1.10.4 defines "Maximum Allowable Working Pressure" as follows:

> "Maximum allowable working pressure (MAWP) is the maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred), when handling the specified fluid at the maximum specified temperature."

API SPEC 11P, paragraph 2.5.1.1 defines “Maximum Allowable Working Pressure” for Compressor Cylinders as follows:

> "The maximum allowable working pressure of the cylinder shall exceed the rated discharge pressure by at least 10 percent or 25 psig[1], whichever is greater."

API SPEC 11P, paragraph 1.10.5 defines the rated discharge pressure as follows:

> "Rated discharge pressure is the highest pressure required to meet the conditions specified by the purchaser for the intended service."

1. (172 kPa)

Relief Valve Settings

It is the responsibility of the packager to provide relief valves for every stage of compression in compliance with API SPEC 11P, paragraph 7.20.3, as follows:

"Relief valves setting shall take into consideration all possible types of equipment failure and the protection of the lowest pressure rated component in any continuous system. Relief valves shall be set to operate at not more than the maximum allowable working pressures but not less than the values following:

System Discharge Pressure psig (kPa)	Relief Valve Margin Above System Discharge Pressure
-14.7 to 150 (-101 to 1034)	15 PSI (100 kPa)
151 to 2500 (1035 to 17 237)	10%
2501 to 3500 (17 238 to 24 132)	8%
3501 to 5000 (24 133 to 34 474)	6%

NOTE: For rated discharge pressures above 5000 psig (34 474 kPa), the relief valve setting shall be agreed upon between the purchaser and the vendor."

⚠ CAUTION

WHEN A BYPASS IS FURNISHED, A RELIEF VALVE MUST BE INSTALLED IMMEDIATELY DOWNSTREAM OF THE BYPASS VALVE OR ON THE INLET SCRUBBER OF THE DOWN-STREAM CYLINDER. THIS RELIEF VALVE MUST BE SET FOR THE MAXIMUM ALLOWABLE WORKING PRESSURE OF THE CYLINDER WHICH HAS THE LOWEST MAWP OF THOSE IN THE BYPASS CIRCUT. THIS IS TO PROTECT AGAINST DIS-CHARGE-CHECK VALVE FAILURE WHEN OPERATING ON BYPASS. (SEE ARIEL PACKAGER'S STANDARDS, SECTION 4.4 "RELIEF VALVES").

Filling Sump & Priming a Main Oil Lube Oil System - Before Starting

Filling The Sump

1 Remove breather and fill compressor sump through top cover.

2 Check sight glass on auxiliary end. Oil level at start-up should be near the top of the glass. DO NOT OVERFILL SUMP. The crankshaft will dip into the oil, churn it, and make it difficult to pump and to control the proper level. (After the machine is running, it may be necessary to add oil to bring up oil level to one-half the height of the sight glass; but it must never exceed two-thirds height, while running.)

3 When the sump is filled to the proper level, replace and snug up the breather cap by hand, to facilitate later removal.

Priming - Main Lube Oil System

NOTE: BE SURE THE OIL SYSTEM FROM THE LUBE OIL PUMP THRU THE COOLER AND OIL FILTER IS FILLED WITH OIL.

JGH and JGE frames are equipped with a manual lube oil priming pump. It is important to prime the unit until the bearings receive oil. Five strokes of the pump, after the pressure gauge at the oil filter outlet indicates pressure, is sufficient. If the unit is equipped with a motor-driven pre-lube pump, the pump should run at pressure for a minimum of fifteen seconds before starting the unit.

All electric motor driven compressors and all unattended start compressors with any type driver must have a separate motor-driven prelube pump to ensure oil flow prior to start-up. The prelube pump flow rate should be 50% of the flow rate of the compressor frame lube oil pump. A start permissive for these applications is to be used to disable the startup sequence if oil pressure is below 15 psig (1.0 bar_g).

NOTE: IF THE CRANKSHAFT SPEED IS LESS THAN 50%, THERE WILL NOT BE ENOUGH FLOW THRU THE PUMP TO MAINTAIN PROPER LUBE OIL PRESSURE TO THE FRAME. AN AUXILIARY OR A LARGER LUBE OIL PUMP WILL BE REQUIRED.

Force Feed Lubricator Adjustment

Ensure that the force feed lubricator is set at the break-in rate shown on the force feed lubricator plate (see Figure 1-5: on page 1-6). The break-in and normal lube timing rates that are stamped on the lubricator box information plate are calculated according to the Ariel Lube Specifications to match the gas operation conditions as supplied to Ariel with the compressor order. The lube sheets supplied in the Ariel Parts Book state gas conditions and list the base rate multiplier at each lube point. When gas conditions are not supplied, the rates are calculated for clean, dry, 0.65 specific gravity, sweet gas at rated speed and discharge pres-

sures. An indicator on the distributor block shows the rate at which the block is cycling. To adjust, screw down the feed regulator until the indicator strokes at the proper rate. Run at this setting for 200 hours of operation. The lubricator adjustment may then be reduced to the normal operating rate (see Figure 1-5:).

When compressor location or operating conditions change, the lubrication rates should be changed according to the Ariel Lube Specifications shown in Table4 -1 on page4-7.

When two or more force-feed lubricator pumps are manifolded into one distribution block, the following procedure is recommended to adjust pump rates:

1. Start with each pump adjusted to full open.
2. Adjust the pumps in equal increments until the break-in cycle time is properly set. The pumps should be stroking at approximately the same rate.
3. After break-in, the pumps should be readjusted using the same technique until the prescribed cycle time is set. At this rate, the pumps should be operating with a stroke at least 20% of maximum. Pump stroke below 20% of maximum results in unreliable pump output. If necessary, stop one of the pumps and readjust the remaining pump(s) for desired cycle time.

Compressor Re-Application

NOTE: IF ANY OF THE CONDITIONS LISTED BELOW CHANGE, CONSULT YOUR PACKAGER AND/OR ARIEL FOR ANY HARDWARE AND/OR DOCUMENTATION CHANGES THAT ARE REQUIRED. PERFORMANCE, OPERATING PRESSURES AND LUBE RATE MUST BE RE-CALCULATED.

1. GAS PRESSURES, TEMPERATURES OR FLOW REQUIREMENTS
2. GAS PROPERTIES
3. DRIVER TYPE, SPEED OR TORQUE
4. RE-LOCATION OF COMPRESSOR TO A DIFFERENT SITE
5. CYLINDER RE-CONFIGURATION
6. CHANGE OF CYLINDER AND PACKING LUBRICANT TYPE

NOTES

SECTION 4 - LUBRICATION AND VENTING

General

Lubrication is vital for successful operation of a compressor and deserves special attention in the package design.

All compressors must have an oil cooler. Maximum allowable oil temperature into the compressor frame is 190°F (88°C). The packager is responsible for sizing a proper oil cooler. Operating conditions which must be taken into account are; the cooling medium, cooling medium temperature, cooling medium flow rate, lube oil temperature, and lube oil flow rate. Oil heat rejection data for each frame are shown in the Ariel Data Book in the Frame Details section (contact your Packager or Ariel when you need this information). The cooler should be mounted as close to the compressor as possible, with piping of adequate size to minimize pressure drop of both the lubricating oil and the cooling medium.

1 For proper operation of the thermostatic valve provided as an option by Ariel, the maximum differential pressure between the hot oil supply line (point B) and the cooled oil return line (point C) is 10 psi (0.7 bar). Refer to Figure 4-9: Lube Oil System Schematic.

2 Ariel recommends installation of the thermostatic valve in the mixing mode.

If a compressor is exposed to cold ambient temperatures, the oil system must be designed so the unit may be safely started with adequate oil flow to the main bearings. Temperature controlled cooler by-pass valves, oil heaters, cooler louvers and even buildings may be needed to ensure successful operation. Cold weather installations may use multi-viscosity oils in the compressor frame if the oil supplier can certify that the oil is shear stable. The viscosity of shear stable oil does not degrade through use. Multi-viscosity oils are subject to a shorter oil life than single grade oils by 30% to 50%.

All electric motor driven compressors and all unattended start compressors with any type of driver must have a prelube pump to ensure oil flow prior to start-up. A start permissive for these applications is to be used to disable the start-up sequence if oil pressure is below 15 psig (1.0 bar_g). Prelube is strongly recommended for all compressors to extend bearing life.

Lubrication performs at least six functions in a compressor:

1 Reduce friction - decreasing friction decreases energy requirement and heat buildup.

2 Reduce wear - decreasing wear increases equipment life expectancy and decreases maintenance costs.

3 Cool rubbing surfaces - cooling of rubbing parts maintains working tolerances, extends oil life, and removes heat from the system.

4 Prevent corrosion - minimization of surface corrosion decreases friction, heat, and component wear. Generally provided by additives rather than the base

lubricant.

5 Seal and reduce contaminant buildup - improves gas seal on piston rings and packing rings, and flushes away contaminants from moving parts.

6 Dampen shock - shock loads are cushioned, thereby reducing vibration and noise, and increasing component life.

Liquid lubricants commonly used in compressors include petroleum based oils and synthetic fluids. Lubricant additives are used to improve the viscosity index, inhibit oxidation, depress the lubricant pour point, inhibit rust formation, improve detergency, provide anti-wear protection, provide extreme pressure protection, improve “lubricity”, decrease effects of gas dilution, increase “wetability”, and resist “washing” of the lubricant due to water, wet or saturated gas, or diluent properties of the gas stream.

- *Viscosity index* is a measure of the ability of an oil to resist the thinning effect caused by increasing the oil temperature.
- *Lubricity* is the “slipperiness” or ability of a lubricant to decrease friction.
- *Wetability* is a measure of the ability of the lubricant to adhere to metal surfaces. An increase in wetability increases the lubricants’ resistance to “washing” effects.

Petroleum Based Oils - also referred to as mineral oils:

Paraffinic - higher wax content, better resistance to thinning at higher operating temperatures than napthenic.

Napthenic - (as compared to paraffinic) lower wax content, better flowability at low temperatures for cold start-ups, lower resistance to thinning at higher operating temperatures, better solvency, lower life/oxidation stability. Napthenic oils leave softer carbon deposits/residues on discharge valves, etc.

Animal Fats

Generally acidless tallow used as a compounding additive to petroleum lubricants to improve “slipperiness” at higher pressures and resist dilution in wet or saturated gases. They can solidify at low or high temperatures. Oils with these additives should not be used in the compressor frame.

Vegetable Oils

Rapeseed oil is an example. Used as a compounding additive in petroleum lubricants to improve “slipperiness” at higher pressures and resist dilution in wet or saturated gases. These additives are not high temperature oxidation stable and therefore additive life decreases rapidly above 170°F (77°C). Oils with these additives should not be used in the compressor frame.

Synthetic Lubricants

Man-made materials with more consistent, controlled chemical structures than petroleum lubricants. This improves predictability of viscosity and thermal stability. Synthetic lubricants can be designed with better oxidation resistance, better lubricity, better film strength, natural detergency, lower volatility, and results in decreased operating temperatures. These

attributes can help to decrease cylinder feed rate requirements. Justification for the use of synthetic lubricants is based on energy savings, reduced lubricant usage, increased component life, decreased equipment downtime, and reduced maintenance/labor. Some synthetic lubricants can be used in the compressor frame. Consult with the lubricant supplier before using these lubricants in the compressor frame.

- Synthesized Hydrocarbons - polyalphaolefins (PAO) can be used as compressor lubricants:
  1 Compatible with mineral oils.
  2 Requires additives to improve detergent action and improve seal compatibility.
  3 Soluble in some gases. Verify application with lubricant supplier.
- Organic Esters - diesters and polyolesters:
  1 Compatible with mineral oils
  2 Incompatible with some rubbers (O-rings), plastics, and paints. Compatible with Viton.
  3 Primarily used in air compressors.
- Polyglycols - polyalkylene glycols (PAG), polyethers, polygylcolethers, and polyalkylene glycol ethers:
  1 Poor inherent oxidation stability and corrosion protection - requires additives.
  2 Can be water soluble - must verify application with lubricant supplier.
  3 Not recommended for air compressors.
  4 Not compatible with mineral oils, some plastics and paints. Requires complete system flush when changing to or from polyglycols.
  5 Compatible with Viton and HNBR - Buna N (high end acrylonitrile-butadiene).
  6 Resistant to hydrocarbon gas dilution. Excellent wetability.

Cylinder oils are specially compounded lubricants designed for use in steam cylinders and/or compressor cylinders. Compounded lubricants can be petroleum or synthetic base. Additives can be animal, vegetable, or synthetic base. These lubricants are formulated to enhance oil film strength to counter the affects of water, wet gases, solvents, etc. present in the gas.

Compressor Frame Lubricants

Ariel recommends, for use in the compressor frame, a good quality mineral oil which provides proper lubrication and heat removal, as well as oxidation inhibition, rust and corrosion inhibition, and anti-wear properties.

For clean, dry, pipeline quality gas, the oil used in the natural gas fueled engine should be satisfactory. SAE 40 weight (ISO 150 grade) oil is recommended for normal operation.

The maximum viscosity of the lube oil for cold ambient temperature starting is 15,000 SUS (3300 cSt), typically 40°F (4°C) for SAE 30 weight (ISO 100 grade) oil, or 55°F (13°C) for SAE 40 weight (ISO 150 grade) oil.

The minimum viscosity at operating temperature is 60 SUS (10 cSt).

Low ash or no ash oils are recommended as high ash oils can increase maintenance requirements.

Additives must not be corrosive to lead or copper based bearing materials.

The compressor frame driven lube oil pumps maintain oil pressure with a spring loaded regulating valve within the pump head. Lube system pressure can be raised or lowered by adjusting this valve. Normal pressure on the discharge side of the lube oil filter is factory set for 60 psig (4.1 bar_g). If the lube oil pressure drops below 50 psig (3.4 bar_g), the cause should be found. A low lube oil pressure shutdown, set at 35 psig (2.4 bar_g), is required for protection of the compressor.

The minimum lube oil operating temperature is 150°F (66°C). This is the minimum temperature required to drive off water vapor.

When frame lube oil immersion heaters are used, the watt density of the heater element should not exceed 5 watts per square inch (0.8 W/cm^2) for systems without circulating pumps. Oil coking will occur at the element with higher wattage heaters if a circulating pump is not used. When high wattage heaters are required, the heaters must be interlocked with an oil circulation pump to ensure that coking of the oil will not occur. Coked oil will form deposits which can “insulate” the system and decrease heat removal. The deposits can also break loose and act as abrasives in the lubricating system.

JGE/6 compressors are equipped with simplex, cartridge style pleated synthetic type filters as standard.

All other JGH and JGE compressors are equipped with simplex, spin-on resin impregnated type filters as standard. Pressure gauges are provided for monitoring pressure drop across the filter

Compressor frame lubricating oil should be changed at regular maintenance intervals (6 months or 4,000 hours), when oil filter differential pressure exceeds 10 psi (0.7 bar) for spin-on filters (15 psi [1.0 bar_g] for cartridge type filters) or when oil sample results indicate the need. A more frequent oil change interval may be required if operating in an extremely dirty environment or if the oil supplier recommends it. Oil sampling should be performed on a regular basis to verify suitability of oil for continued service. Degradation to the next lower viscosity grade below the original viscosity or an increase in viscosity to the next higher grade requires a complete oil change. Viscosity testing should be performed at 212°F (100°C).

Cylinder And Packing Lubrication Requirements

Cylinder lubrication requirements will vary with the operating conditions and the composition of the gas to be compressed. Please refer to the following table for lubrication recommendations for various gas compositions and various operating conditions. Note that lubrication rates can change with operating conditions. Lubricating oil type will also vary with the composition of the gas which is to be compressed.

Separate force feed lube systems require oil with a viscosity below 5000 SUS (1100 cSt) at the lubricator pump inlet. Measures which may be necessary to make sure that the force feed pump is filled with oil during the suction stroke include; appropriate pipe and fitting size

from the tank to the force feed pump, heating the oil, and pressurizing the supply tank. An in-line oil filter or fine screen is required between the supply tank and the force feed lubricator pumps. Recommended filtration is 20 micron nominal.

Under lubrication results in a “mini-lube” condition. This condition results in extremely rapid breakdown of Teflon and PEEK piston and packing ring materials. Black, gummy deposits which can be found in the distance piece, packing case, cylinder and valves are indicators of under lubrication.

Over lubrication can result in excessive oil carryover into the gas stream, and increased quantities of deposits in the valves and gas passages. Valve plate breakage and packing failure are also symptoms of over lubrication. The packing case will “hydraulic”, which forces the packing rings to lift off of the rod enough to form a leak path. Increased gas leakage then results in packing and rod overheating. A rod and packing case can turn blue even though the lubrication appears sufficient.

Even when the proper rate and lubricating medium are in use, dirt and foreign matter in the gas will prevent the lubricant from performing properly. Inlet gas debris screens with a maximum 50 micron opening are recommended. Proper maintenance of the inlet screens is required.

To check cylinders for the proper lubrication rates, the cigarette paper test method can provide a practical indication. Relieve and vent all pressure from all cylinders. Remove a head end suction valve and position piston at inner center, for the cylinder to be checked. “Lock out” so that crankshaft cannot accidentally turn; see the caution in “General Introduction” on page 3-1 and refer to the Packager’s Operation Manual for details. Use two layers of regular unwaxed commercial cigarette paper, together. Wipe the cylinder bore at top with both papers using light pressure in circumferential motion through about 20°. The paper next to the bore should be stained (wetted with oil), but the second paper should not be soaked through.

Repeat the test at both sides of the bore at about 90° from the top, using two new clean papers for each side. When the paper next to the bore is not stained through, it may be an indication of under lubrication. When both papers are stained through, it may be an indication of over lubrication. In either case, it is normally recommended that the lubrication rate be changed accordingly and that all cigarette paper tests be repeated until passed. Repeat for all cylinders. If a reduction or increase of the lubrication rate is indicated for a cylinder, change in 5% increments by adjusting cycle time at the force feed lube pump as discussed in . Repeat oil film testing, for the cylinders affected, after 24 hours of operation.

NOTE: THE CIGARETTE PAPER TEST ONLY GIVES AN INDICATION OF OIL FILM QUANTITY. IT DOES NOT GIVE AN INDICATION OF VISCOSITY QUALITY. OILS DILUTED WITH WATER, HYDROCARBONS OR OTHER CONSTITUENTS MAY PRODUCE WHAT APPEARS TO BE AN ADEQUATE FILM. BUT THE OIL FILM MAY NOT HAVE THE REQUIRED LOAD-CARRYING CAPABILITY DUE TO THE DILUTION.

When observed symptoms indicate lack of lubrication; first verify that the force feed lubricator pumps are operating properly. Confirm that the distribution block cycle time matches the lube sheet or lubrication box information plate provided by Ariel, and double check that all tubing and fittings are tight and no leaks are present. Do not overlook the fittings inside the cylinder gas passages.

The lubricant flow rates are so low that all of the required flow to a lube point may be observed as a drip at a fitting. The break-in and normal lube timing rates which are stamped on the lubricator box information plate are calculated according to the Ariel Lube Specifications to match the gas operation conditions as supplied to Ariel with the compressor order. The lube sheets supplied in the Ariel Parts Book state gas conditions and list the base rate multiplier at each lube point. If gas conditions were not supplied, the rates are for clean, dry, 0.65 specific gravity, sweet gas at rated speed and discharge pressures. If the compressor operating conditions change (such as gas properties, gas pressures, temperatures or flow requirements or cylinder reconfiguration) the lubrication rates must be recalculated and hardware changes may be necessary to the force-feed lubrication system. Consult the following table and your Packager or Ariel.

To set the proper force-feed lubricator pump flow rate, the cycle time indicator on the distribution block is to be observed. Time the cycle from flash to flash for a digital no-flow timer switch (DNFT); or time the cycle from initial movement of the indicator pin at the fully retracted position, to the time when the pin returns to the fully retracted position and begins to move back out again for a magnetic cycle indicator assembly.

NOTE: WHEN ADJUSTING THE FORCE FEED LUBRICATION PUMP SETTING FOR THE APPROPRIATE CYCLE TIME, DO NOT SET THE PUMPS AT TOO LOW A FLOW RATE. THE PUMPS CAN BECOME INCONSISTENT WHEN SET TOO LOW.

The force feed lubrication pumps should be capable of delivering 150% minimum of the “normal” required lube rate for the break in period (set as close as possible to twice the “normal” rate for 200 hours). Please contact Ariel for assistance if the existing pump is not capable of the minimum flow rate required.

Used engine oil may be used as long as the new oil specifications meet the listed requirements, and the oil is appropriately filtered (i.e. 20 micron nominal). Oil viscosity must be monitored and tested, as follows, for serviceability. Oil should be changed at regular maintenance intervals (6 months or 4,000 hours), when oil filter differential pressure exceeds 10 psi (0.7 Bar) for spin-on filters or 15 psi (1.05 Bar) for cartridge type filters or when oil sample results indicate the need. A more frequent oil change interval may be required if operating in an extremely dirty environment or if the oil supplier recommends it. Oil sampling should be performed on a regular basis to verify suitability of oil for continued service. Degradation to the next lower viscosity grade below the original viscosity or an increase in viscosity to the next higher grade requires a complete oil change. Viscosity testing should be performed at 212°F (100°C).

The use of higher viscosity lubricants or specially compounded lubricants can compensate somewhat for the presence of liquids in the gas stream.

NOTE: WHEN THERE ARE LIQUIDS PRESENT IN THE GAS, THE MOST EFFECTIVE LUBRICATION OF CYLINDERS AND PACKING REQUIRES REMOVAL OF THE LIQUIDS BEFORE THE GAS ENTERS THE COMPRESSOR.

THESE LUBRICATION RECOMMENDATIONS ARE GENERAL GUIDELINES. IF THE RECOMMENDED LUBRICANTS OR FLOW RATES DO NOT APPEAR TO WORK ADEQUATELY, FLOW RATES AND/OR LUBRICANT TYPES MAY NEED TO BE CHANGED. PLEASE CONTACT THE LUBRICANT SUPPLIER FOR SPECIFIC LUBRICANT RECOMMENDATIONS.

WARRANTY OF COMPONENT FAILURES WHICH OCCUR WHILE USING LUBRICANTS WHICH DO NOT MEET THESE SPECIFICATIONS WILL BE SUBJECT TO REVIEW ON A CASE BY CASE BASIS.

TABLE 4-1: CYLINDER/PACKING LUBE OIL RECOMMENDATIONS FOR VARIOUS GAS STREAM COMPONENTS

GAS STREAM	CYLINDER DISCHARGE PRESSURE				
	< 1000 psig < (70 bar_g)	1000 to 2000 psig (70 to 140 bar_g)	2000 to 3500 psig (140 to 240 bar_g)[a]	3500 to 5000 psig (240 to 345 bar_g)[a]	> 5000 psig > (345 bar_g)[a]
Pipeline Quality Natural Gas Including CNG	SAE 40 wt. ISO 150 Base Rate or Various Synthetics Base Rate	SAE 40-50 wt. ISO 150 - 220 1.25 x Base Rate or Various Synthetics Base Rate	SAE 50 wt. ISO 220 w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 x Base Rate	Cylinder Oil ISO 320 - 460 w/ Compounding 2 x Base Rate or Synthetic - Diester/Polyglycol 1.5 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 3 x Base Rate or Synthetic - Polyglycol 2 x Base Rate
Natural Gas w/ Water and/or Heavy hydrocarbons[b] Methane < 90% Propane > 8% SG > 0.7	SAE 40 - 50 wt. ISO 150 - 220 1.25 x Base Rate or Various Synthetics Base Rate	SAE 50 - 60 wt. ISO 220 - 320 or SAE 40 wt. ISO 150 w/ Compounding 1.5 x Base Rate or Var. Synthetics 1.25 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 2 x Base Rate or Various Synthetics 1.5 x Base Rate	Cylinder Oil ISO 680 w/ Compounding 3 x Base Rate or Synthetic - Diester/Polyglycol 2 x Base Rate	Contact Lubricant Supplier
Natural Gas and Carbon Dioxide > 2% to 10%	SAE 40 - 50 wt. ISO 150 - 220 1.25 x Base Rate or Various Synthetics Base Rate	SAE 50 - 60 wt. ISO 220 - 320 or SAE 40 wt. ISO 150 w/ Compounding 1.5 x Base Rate or Var. Synthetics 1.25 x Base Rate	Cylinder Oil ISO 460-680 w/ Compounding 2 x Base Rate or Synthetic PAG 1.5 x Base Rate	Cylinder Oil ISO 680 w/ Compounding 3 x Base Rate or Synthetic PAG 2 x Base Rate	Contact Lubricant Supplier
Natural Gas w/ Carbon Dioxide ≥ 10%	SAE 40 - 50 wt. ISO 150 - 220 1.50 x Base Rate or Various Synthetics 1.25 Base Rate	SAE 50 - 60 wt. ISO 220 - 320 or SAE 40 weight ISO 150 w/ Compounding 2 x Base Rate or Var. Synthetics 1.5 x Base Rate	Cylinder Oil ISO 460-680 w/ Compounding 3 x Base Rate or Synthetic PAG 2 x Base Rate	Cylinder Oil ISO 680 w/ Compounding 4 x Base Rate or Synthetic PAG 3 x Base Rate	Contact Lubricant Supplier
Natural Gas w/ H_2S > 2% to 30%	SAE 40 wt. ISO 150 w/ Compounding 1.25 x Base Rate or Various Synthetics Base Rate	SAE 40 - 50 wt. ISO 150 - 220 w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 x Base Rate	SAE 50 wt. ISO 220 w/ Compounding 2 x Base Rate or Various Synthetics 1.5 x Base Rate	SAE 60 wt. ISO 320 w/ Compounding 3 x Base Rate or Various Synthetics 2 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 4 x Base Rate or Various Synthetics 3 x Base Rate

TABLE 4-1: CYLINDER/PACKING LUBE OIL RECOMMENDATIONS FOR VARIOUS GAS STREAM COMPONENTS

GAS STREAM	CYLINDER DISCHARGE PRESSURE				
	< 1000 psig < (70 bar_g)	1000 to 2000 psig (70 to 140 bar_g)	2000 to 3500 psig (140 to 240 bar_g)[a]	3500 to 5000 psig (240 to 345 bar_g)[a]	> 5000 psig > (345 bar_g)[a]
Natural Gas w/ H_2S ≥ 30%	SAE 40 wt. ISO 150 w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 Base Rate	SAE 40 - 50 wt. ISO 150 - 220 w/ Compounding 2 x Base Rate or Various Synthetics 1.5 x Base Rate	SAE 50 wt. ISO 220 w/ Compounding 2.5 x Base Rate or Various Synthetics 2 x Base Rate	SAE 60 wt. ISO 320 w/ Compounding 3.5 x Base Rate or Various Synthetics 2.5 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 5 x Base Rate or Various Synthetics 3 x Base Rate
Air	SAE 40 wt. ISO 150 Air Compressor Oil Base Rate or Various Synthetics Base Rate	SAE 50 wt. ISO 220 Air Compressor Oil w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 x Base Rate	Synthetic - Diester 1.5 x Base Rate	Contact Lubricant Supplier	Contact Lubricant Supplier
Wet Air	SAE 40 - 50 wt. ISO 150 - 220 Air Compressor Oil w/ Compounding Base Rate or Var. Synthetics Base Rate	Synthetic - Diester 1.5 x Base Rate	Synthetic - Diester 2 x Base Rate	Contact Lubricant Supplier	Contact Lubricant Supplier
Nitrogen (Bone Dry - Contact Ariel)	SAE 40 wt. ISO 150 Base Rate or Various Synthetics Base Rate	SAE 40 - 50 wt. ISO 150 - 220 Base Rate or Various Synthetics Base Rate	SAE 50 wt. ISO 220 Base Rate or Various Synthetics Base Rate	SAE 60 wt. ISO 320 Base Rate or Various Synthetics Base Rate	Cylinder Oil ISO 460 - 680 Base Rate or Various Synthetics Base Rate
Propane[C] (Refrigerant)	SAE 40 wt. ISO 150 or Refrigerant Oil 0.5 x Base Rate or Various Synthetics 0.5 x Base Rate	SAE 40 wt. ISO 150 or Refrigerant Oil Base Rate or Various Synthetics Base Rate	Refrigerant Oil Contact Lubricant Supplier	Refrigerant Oil Contact Lubricant Supplier	Refrigerant Oil Contact Lubricant Supplier

a. Also requires water cooled packing.
b. Lean burn engine oils contain detergents, dispersants and ash additives, which hold water in suspension. This suspension does not provide adequate lubrication in the cylinder and packings.
c. Verify oil pour point temperature is below inlet gas temperature.

NOTE: BASE RATE REFERRED TO ABOVE IS AS FOLLOWS:

0.4 PINTS/DAY/INCH BORE (0.0074L/DAY/mm BORE) FOR JGH AND JGE FRAMES

PISTON ROD DIAMETER IS DOUBLED AND TREATED LIKE A CYLINDER FOR CALCULATING PACKING LUBE RATE. FOR CYLINDERS WITH A TAIL ROD, THE LUBE RATE FOR EACH OF THE (TWO) PACKINGS IS TO BE CALCULATED SEPARATELY AND BOTH VALUES ADDED TOWARD THE RECOMMENDED TOTAL DAILY LUBE RATE.

BREAK-IN LUBE RATE SHOULD BE TWICE THE RECOMMENDED DAILY RATE (150% MINIMUM); I.E. THE BREAK-IN CYCLE TIME SHOULD BE APPROXIMATELY ONE-HALF THE NORMAL CYCLE TIME (67% MAXIMUM) TO INCREASE LUBE RATE. BREAK-IN RATE SHOULD BE MAINTAINED FOR 200 HOURS OF OPERATION.

CYLINDERS WITH BORE DIAMETERS LESS THAN 13 INCHES (330mm) HAVE ONE POINT BORE LUBE AS STANDARD; LARGER CYLINDERS HAVE MULTI-PORT LUBE AS STANDARD. TOP AND BOTTOM BORE LUBE IS AVAILABLE AS AN ORIGINAL PURCHASE OPTION (EXCEPT FOR T CLASS CYLINDERS WHICH HAVE MULTI-PORT LUBE FOR ALL SIZES AS STANDARD). PISTON ROD PACKINGS FOR HIGH-PRESSURE CYLINDERS HAVE TWO POINT LUBE. FOR MULTIPLE LUBE POINTS, THE REQUIRED LUBRICANT FOR THE CYLINDER OR PACKING IS DIVIDED EQUALLY AMONG THE LUBE POINTS.

THE RECOMMENDED LUBE RATES FOR BREAK-IN OR NORMAL OPERATION, IN CYCLES PER SECOND (AS STAMPED ON THE LUBRICATOR BOX INFORMATION PLATE), ARE CALCULATED AT MAXIMUM COMPRESSOR SPEED (AS STAMPED ON THE COMPRESSOR INFORMATION PLATE). THE LUBE RATE MAY BE REDUCED WITH SPEED, (AS COMPRESSOR SPEED IS REDUCED, CYCLE TIME INCREASES TO REDUCE LUBE RATE):

$$(RPM_{MAX} / RPM_{RUNNING}) \times CYCLE\ TIME\ SEC_{LUBE\ PLAT} = CYCLE\ TIME\ SEC_{RUNNING}$$

REFER TO THE LUBRICATION SHEETS IN THE ARIEL "PARTS BOOK" FOR THE CYCLE TIME (SECONDS) VS. RPM (COMPRESSOR SPEED) TABLE AT VARIOUS RUNNING SPEEDS FOR YOUR UNIT, AT THE STATED GAS OPERATING CONDITIONS AND LUBRICANT.

SPECIAL LUBRICANT FORMULATIONS ARE AVAILABLE FROM LUBRICANT SUPPLIERS FOR SPECIFIC APPLICATIONS. SUPPLIERS WHO WILL CERTIFY SUITABILITY OF THE FORMULATION FOR SITE CONDITIONS SHOULD PROVIDE APPROPRIATE DOCUMENTATION. CONTACT ARIEL FOR VERIFICATION OF WARRANTY COVERAGE.

Force Feed Lubrication System - Description

The force feed lubrication system provides oil to the compressor cylinders and the piston rod packings. Refer to Figure 4-7: on page 4-16.All cylinders have both top and bottom lubrication injection points available as an ordering option, excepting 13-1/2 thru 22-1/2 H&E and T cylinders where both top and bottom lubrication injection points are provided as standard.

Oil is supplied to the 150 micron sintered bronze filter on the suction side of the force feed lubricator pump directly from the pressure side of the frame lube oil system, or from an overhead tank. See Figure 4-8: on page 4-18. The filter, that is intended to prevent large particles from entering the pump, is mounted on the lubricator box using a bracket. The filter inlet is on the side of the filter housing and is provided with a 1/4 inch tube fitting connection.

The lubricator has its own oil reservoir to lubricate the worm gear and cam. The reservoir is self-contained and is not fed by the lube oil system. A sight glass on the lubricator will show the oil level in the lubicator reservoir. Refer to Figure 5-15: on page 5-21.

There are 1/4 inch tube fitting connections in the discharge line near the force feed lubricator pump(s) through which the force-feed lubrication system may be primed.

Next in the discharge line is a blow-out disc. If there is a blockage in the system, the pressure build-up will rupture the disc. Venting the system through the blow-out disc causes the no-flow shutdown switch to close.

The oil then travels to the distribution block. It is here that the lubricating oil is proportioned to provide the exact amounts to the cylinders and packings. The pistons in the intermediate sections of the distribution block move back and forth in a continuous cycle, forcing lubricant successively through the several outlets as long as lubricant is supplied under pressure at the inlet. Each outlet has a check valve to prevent oil from backing up in the block. An indicator on the block shows the rate at which the block is cycling. A pressure gauge is provided at each distribution block inlet to show system pressure.

From the distribution block, oil travels to the cylinders and packings. Check valves are located at each injection point where 1 inch minimum (25mm) of head is provided to ensure reliable check valve operation and to lengthen check valve life. At lube points where 1 inch of head is not feasible, an oil trap fitting is installed (see Figure 4-6: on page 4-16).

When cylinders served by the same force feed lube pump (or manifolded pumps) have a large differential pressure, pressure regulating valves are provided in each lube point line to ensure reliability and longer divider valve distribution block life. These valves are calibrated at the Ariel factory for a particular force feed pump system and lock-wired. Do not remove the lock wire or mix valves with another pump system.

Some of the oil to the packing travels through to the cylinders, but the bulk of it is drained out through the pressure vent/drain fitting on the bottom of the crosshead guide and through the atmospheric drain also in the bottom of the guide.

An oil level control valve, supplied by the packager and mounted on the skid, maintains proper level in the crankcase sump to replace oil used in cylinder lubrication.

Force Feed Lubricator Adjustment

See instructions under and refer to “Force Feed Lubricator Adjustment” on page 3-8.

NOTE: THE FORCE FEED SYSTEM MUST HAVE A BLOW-OUT DISC BETWEEN THE FORCE FEED LUBRICATOR PUMP AND THE NO-FLOW SHUTDOWN.

THE FORCE FEED SYSTEM MUST HAVE A WORKING NO-FLOW SHUTDOWN. THIS SHUTDOWN MUST BE SET TO ACTUATE WITHIN THREE TO FIVE MINUTES AFTER INTERRUPTION OF THE LUBRICATOR OIL FLOW

Blow-Out Fittings and Rupture Disks

TABLE 4-2: BLOW-OUT FITTING ASSEMBLIES AND REPLACEMENT RUPTURE DISKS

SUPPLIER	BLOW-OUT FITTING ASSEMBLY			REPLACEMENT RUPTURE DISK[a]			
				ARIEL P/N	COLOR	THICKNESS	
	ARIEL P/N	RATED PSI	RATED MPa			INCHES	MM
Lincoln	A-0080	3250	22.4	A-0124	Purple	0.0225	0.57
Lubriqui	A-3531	3700	26	A-3536	Yellow	0.010	0.28
Lubriqui	A-3532	4600	32	A-3537	Red	0.012	0.30
Lubriqui	A-3533	5500	38	A-3538	Orange	0.014	0.36
Lubriqui	A-3534	6400	44	A-3539	Aluminum	0.016	0.41
Lubriqui	A-3535	7300	50	A-3540	Blue	0.020	0.51

a. do not use a lincoln replacement rupture disk in a lubriquip blow-out fitting assembl , nor a lubriquip disk in a lincoln fitting. see table 1-14 on page 1-18 for blow-out fitting cap tightening torque. do not over tighten cap or blow-out pressure can be reduced.

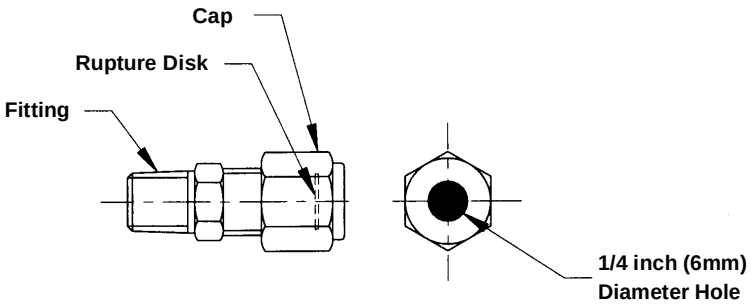


FIGURE 4-1: LINCOLN ST. LOUIS BLOW-OUT FITTING ASSEMBLY

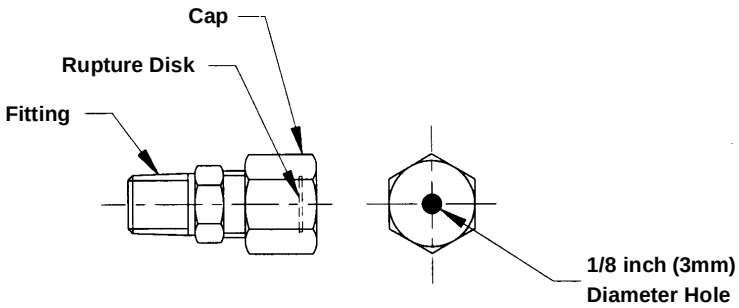


FIGURE 4-2: LUBRIQUIP BLOW-OUT FITTING ASSEMBLY

Divider Valves

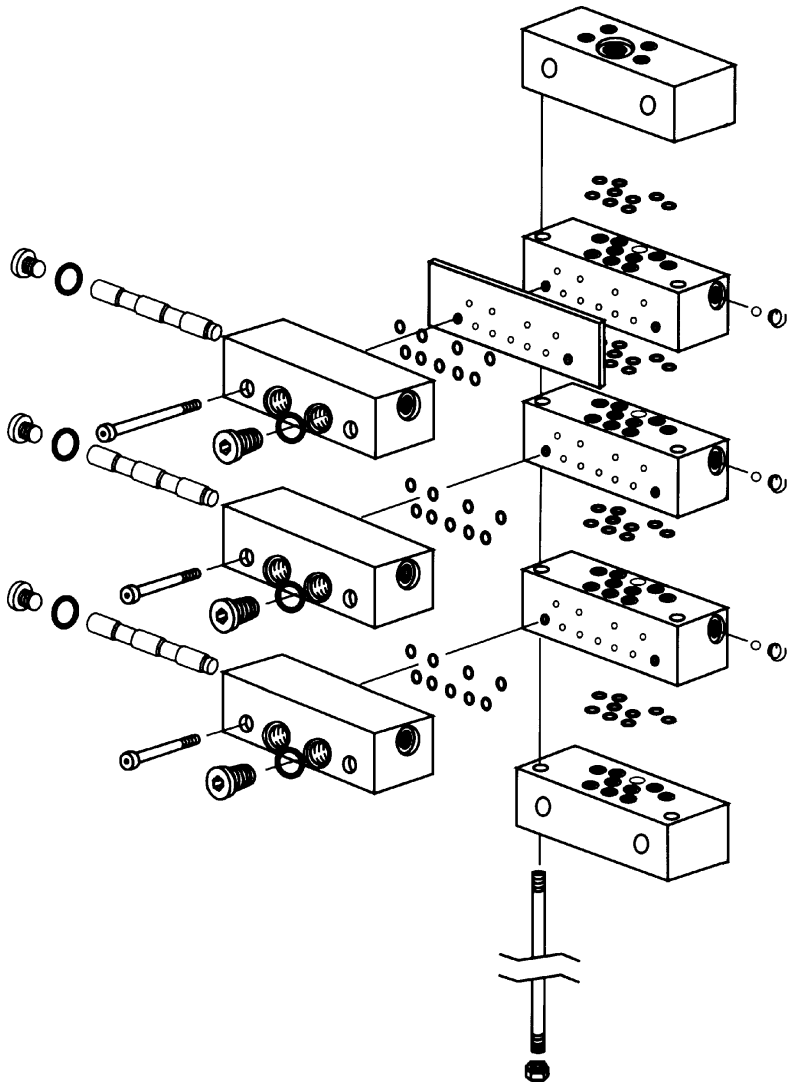


FIGURE 4-3: DIVIDER VALVES DISTRIBUTION BLOCK - TYPICAL

NOTE: REFER TO PARTS BOOK FOR THE FRAME BEING SERVICED FOR ASSEMBLY DRAWINGS, PARTS LIST AND REPAIR KITS THAT ARE AVAILABLE FOR DIVIDER VALVES.

Description

Divider valves are comprised of three to eight valve blocks fastened to a segmented baseplate. O-rings are used to seal between the valve blocks and the baseplate and between the baseplate segments. These divider valves are used in a single line, progressive lubrication system and can be used for dispensing oil or grease. Valves and baseplate segments are supplied with Viton O-rings.

Check valves are installed at the inlets of all lube points.

Valve blocks containing metering pistons discharge a predetermined amount of lubricant with each cycle. Valve blocks can be single or twin and can be externally singled or crossported. Outlets not to be used when singling or crossporting must be plugged.

A by-pass block can be used in any position on the baseplate. The use of a by-pass block allows the addition or deletion of lubrication points without disturbing existing tubing. Both outlets under a by-pass block must be plugged.

The valve blocks and by-pass blocks are fastened to a baseplate mounted on the machine to be lubricated. The baseplate contains the divider valve's inlet and outlet connections, interrelated passageways and built-in check valves. All piping of lubricant to and from the divider valve is connected to the baseplate.

The baseplate consists of one inlet block, three to eight intermediate blocks, one end block and three tie rods. Gasket plate seals are included with the baseplate segments. The valve block capacity of each baseplate is dependent upon the number of intermediate blocks in the baseplate. There must be a minimum of three working valves on each valve and baseplate assembly.

Standard Electronic-Lubricator Digital No-Flow Timer Switch - DNFT

The DNFT is a microprocessor-based switch used to sense no-flow or slow-flow conditions in the compressor cylinder lubrication system to facilitate alarm and/or shutdown. The DNFT also contains an amber light-emitting diode (LED) cycle indicator to provide a positive visual indication of system operation. The Ariel DNFT includes a proximity switch. The standard DNFT is factory set for (3) three minutes from no-flow to alarm/shutdown signal and is not adjustable. Optional programmable models are available. Introduced in September of 1996, the DNFT replaced the traditional mechanical no-flow switch and is standard on all new units. Since its introduction, the DNFT has undergone a series of design enhancements and several versions are in service. The current DNFT is shown in Figure 4-4:

The DNFT works thru a magnetic pin which cycles back and forth as the divider valve piston moves, flashing the amber LED and indicating a complete cycle of the divider valve. The DNFT operates on a non-replaceable sealed internal lithium battery, with an expected battery life of 6 to 10 years depending on cycle time. Optional models are available with a factory replaceable battery. Battery failure results in a fail safe DNFT no-flow output signal for shutdown. Battery failure requires replacement of the DNFT. Expired DNFT’s may be returned for partial credit.

While earlier versions of the DNFT required position adjustment on the magnet housing assembly, DNFT’s supplied after August 1997 no longer require such adjustment. To replace the DNFT, remove conduit and mark wiring connections. Remove wiring and the old DNFT.

Retain for partial credit return. Disassemble the magnetic housing from the switch body by loosening the (2) 1/4”-20 set screws ona new DNFT. Be sure magnet pin and spring are intact and working in the magnetic housing assembly. You should feel spring force when pushing on the magnet pin by hand. Screw the magnetic housing assembly into the end of the divider valve housing. Be sure set screws are loosened and slide the switch body all the way onto the nut of the magnetic assembly. Tighten set screws and re-attach wiring and conduit.

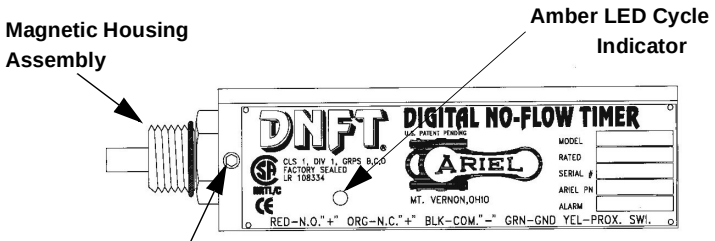


FIGURE 4-4: DIGITAL NO-FLOW TIMER SWITCH - (DNFT)

Assembly Instructions For Divider Valves

NOTE: THE CENTER TIE ROD IN THE BASEPLATE IS OFFSET SO THAT THE INTER-MEDIATE BLOCKS CANNOT BE ASSEMBLED BACKWARDS. IF EXCESSIVE FORCE IS ENCOUNTERED DURING ASSEMBLY, MAKE SURE BLOCK IS NOT BACKWARDS.

1. Screw three tie rods into inlet block until ends are flush with surface of block.
2. Slide inlet gasket onto tie rods.
3. Alternately slide an intermediate block and an intermediate gasket plate onto the tie rods until the last intermediate block is in place.
4. Discard remaining intermediate gasket plate.
5. Slide end gasket plate and end block onto tie rods.
6. Lay baseplate assembly on flat surface and tightening nuts to 72 lb-in. (8.1 N·m), torque.
7. Mount divider valves with gasket plates onto baseplate and tightening mounting screws to 108 lb-in. (12.2 N·m), torque.

Operation

The inlet passageway is connected to all piston chambers at all times with only one piston free to move at any one time. With all pistons at the far right, lubricant from the inlet flows against the right end of piston 1. (See Figure 4-5: illustration 1)

Lubricant flow shifts piston 1 from right to left dispensing piston lube through connecting passages to outlet 1. Piston 1 shift directs flow against right side of piston 2. (See Figure 4-5: illustration 2)

Lubricant flow shifts piston 2 from right to left dispensing lube through valve ports of piston 1 and through outlet 2. Piston 2 shift directs lubricant flow against right side of piston 3. (See Figure 4-5: illustration 3)

Lubricant flow shifts piston 3 from right to left dispensing lube through valve ports of piston 2 and through outlet 3. Piston 3 shift directs lubricant through connecting passage to the left side of piston 1. (See Figure 4-5: illustration 4)

Lubricant flow against left side of piston 1 begins the second half-cycle which shifts pistons from left to right dispensing lubricant through outlets 4, 5 and 6 of the divider valve.

If pistons refuse to move, check for air lock in one or more valve ports by manually shifting a piston from right to left.

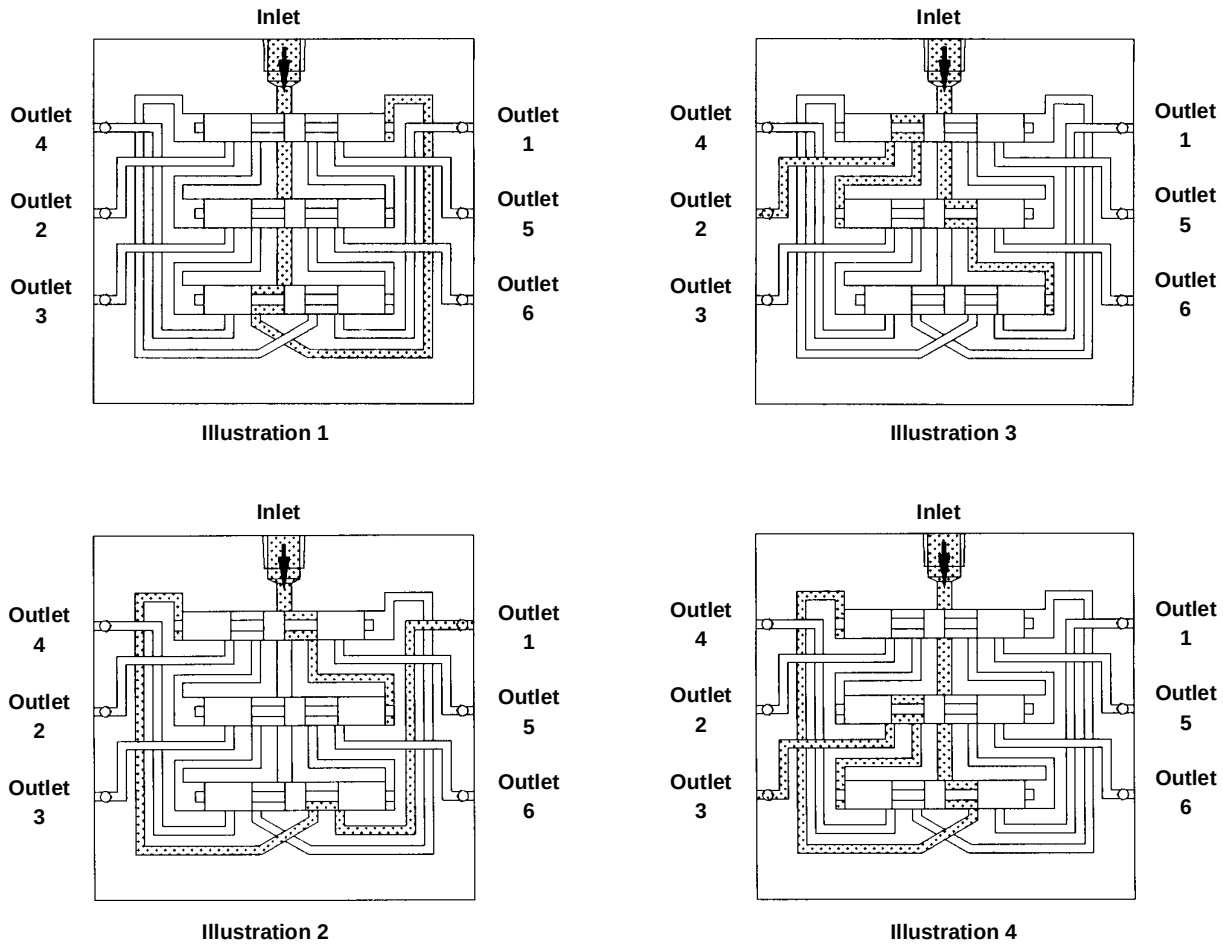


FIGURE 4-5: DIVIDER VALVE OPERATION SCHEMATIC

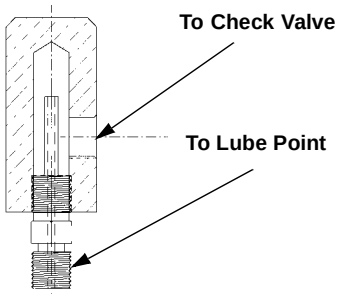


FIGURE 4-6: OIL HEAD TRAP FITTING

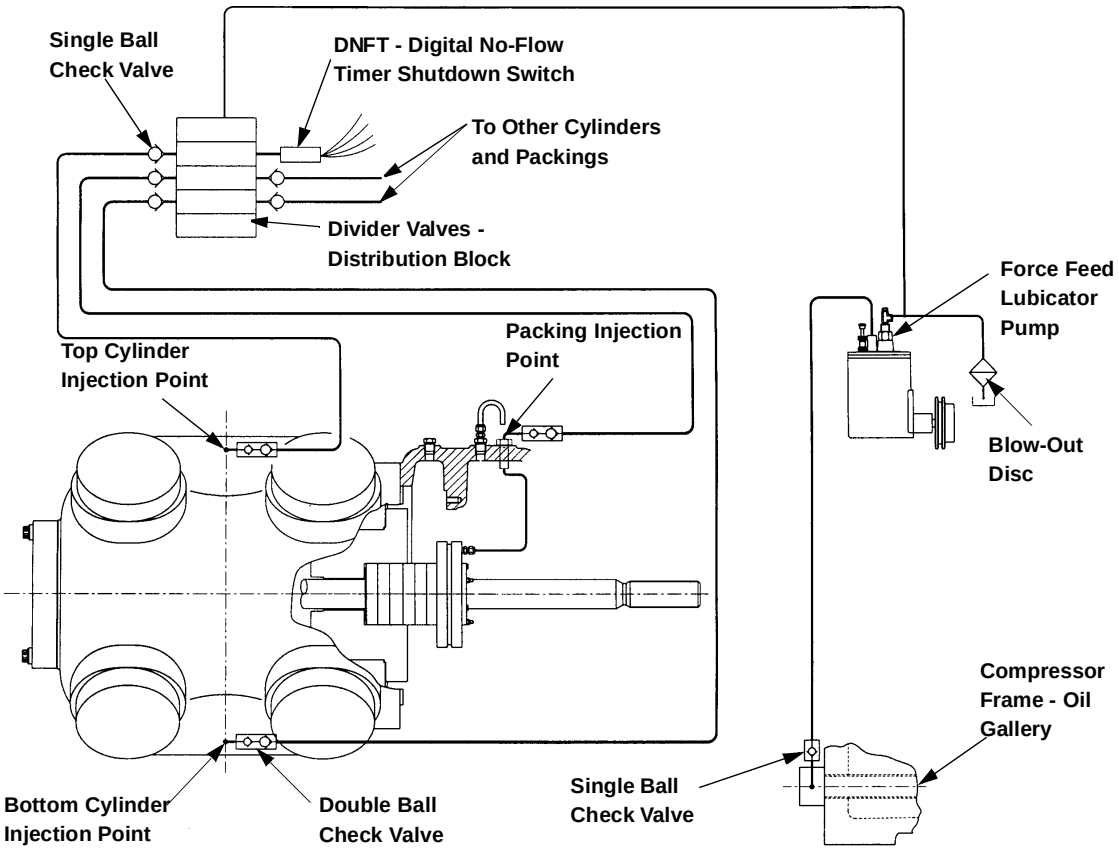


FIGURE 4-7: FORCE FEED LUBRICATION SYSTEM SCHEMATIC - TYPICAL

NOTE: PRESSURE IN FORCE FEED LUBE LINES IS, AS A MINIMUM, 110% OF THE CYLINDER SUCTION GAS PRESSURE.

Force Feed Lubrication System and Running Conditions

Force Feed Lubrication System

1 Check sight glass on lubricator reservoir to make sure it is properly filled with oil. The oil in the reservoir is used only to lubricate the worm gear and cam; it does not flow through the system. Oil is added only if it becomes necessary to raise the reservoir oil level.

2 The system has been filled with oil at the factory, and unless the piping has been disturbed, is ready for operation. If piping has been removed, or if the system has been drained, it can be filled and primed through a 1/8 inch plug on the discharge end of the lubricator pump. Priming the force feed lubrication system requires the use of a priming pump.

3 If the unit has been overhauled, adjust the lubricator for maximum delivery. Reference Figure 5-15: Loosen the adjusting screw locknut. Turn the plunger stroke adjustment screw to the full up position. Tighten the adjusting screw locknut. Proper feed rate may be set after the machine is started.

Running Conditions

When the machine is running, make sure that the oil level in the lubricator reservoir is at least one-half way up the sight level, but does not exceed two-thirds.

See your packager's specific data to determine the normal operating conditions, the cylinder working pressures, and the rated speed.

System Design Considerations and Operating Parameters

To optimize force-feed lubrication system operation, Ariel uses the following general guidelines:

1 Minimal use of “master/slave” distribution blocks in favor of lubricator pumps dedicated to an individual distribution block.

2 Maintain lube ratios within prescribed limits and cycle times as low as possible (10 sec minimum) to provide each point with lubrication as frequently as possible.

3 Multiple pumps with manifolding are used to ensure that 150% of the normal lubrication rate can be provided during break-in.

4 Pumps are not allowed to operate below 20% of full stroke, the point at which they become unreliable.

5 In some applications, to optimize operation of the lubrication system, a single divider output is used to deliver lubrication to both a packing and a cylinder.

6 In some applications, cross-porting of divider valves is used to deliver the proper proportion of lubricant to a given point.

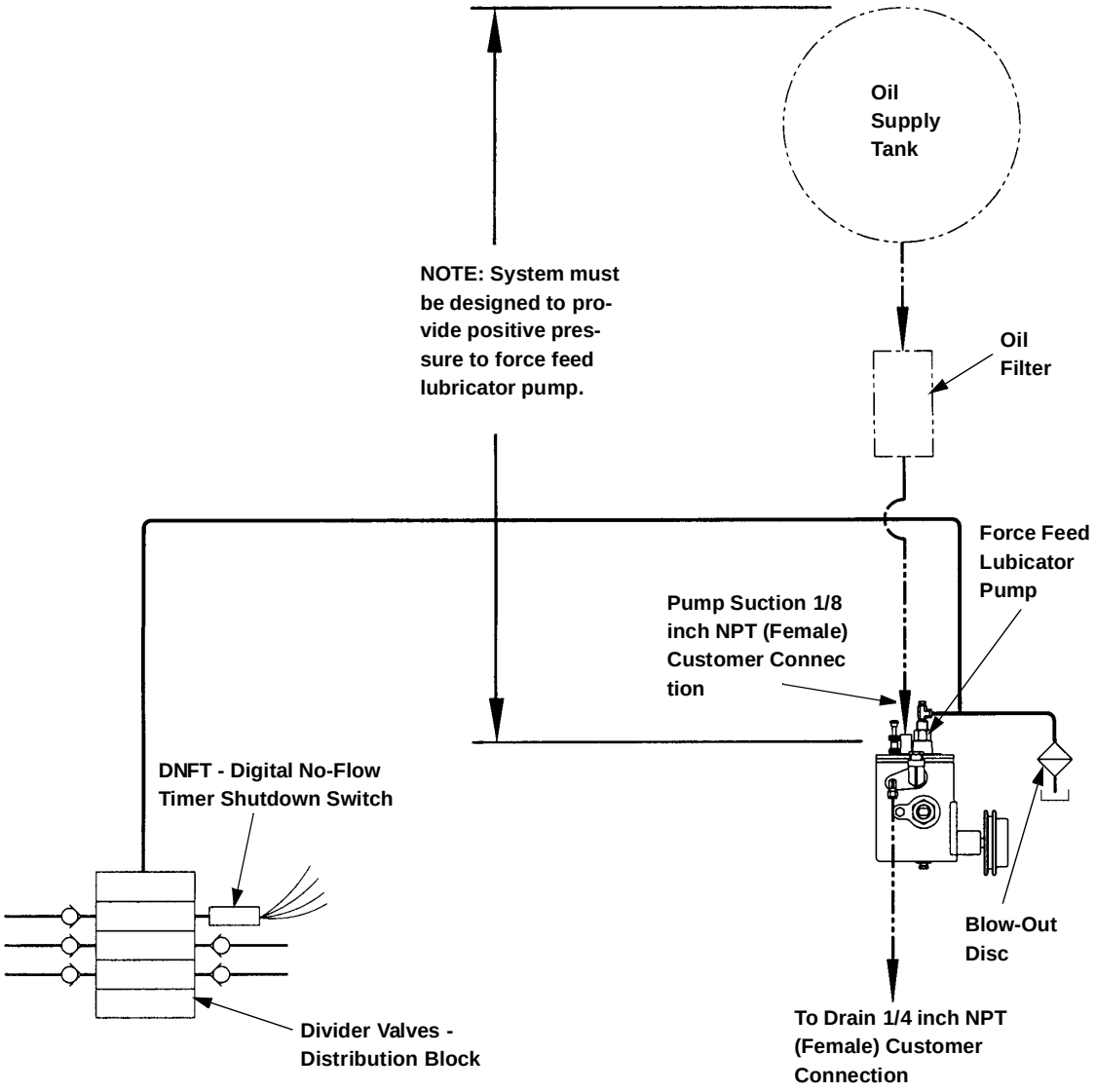


FIGURE 4-8: FORCE FEED LUBRICATION SYSTEM - INDEPENDENT OIL SUPPLY

Frame Lubricating System - Description

The frame lubricating system supplies oil to the internal frame running gear. The cylinders are supplied with lubrication by the force feed system (see “Force Feed Lubrication System - Description” on page 4-9). An oil level regulator outside the crankcase should be used to maintain the proper oil level in the sump.

Frame lubrication is drawn from the sump through the suction strainer into the oil pump that is mounted on the crankcase auxiliary end cover. The pump's discharge is piped to an oil cooler mounted on the compressor skid and is temperature controlled with a thermostatic control valve. Oil returns from the cooler to the oil filter mounted on the auxiliary end of the

crankcase. Pressure gauges are provided on the filter inlet and outlet. Normal pressure drop thru a clean filter is 2 to 6 PSI (15 to 40 kPa), at normal operating temperature.

From the filter, oil travels to an oil gallery cast in the crankcase and running the length of the crankcase.

Drilled holes from the gallery thru the bearing saddles deliver oil to the crankshaft bearings.

Passages drilled diagonally thru the crankshaft from the crank journals to the crank pins deliver oil to the connecting rod bearings.

Holes drilled through the length of the connecting rods deliver oil to the connecting rod bushing.

Oil travels from the bushings thru holes drilled in the middle of the crosshead pin to the hollow crosshead pins, and from there to the crosshead bushing.

Drilled passages from the oil gallery deliver oil at full system pressure thru the tubing to lubricate the top and bottom of each crosshead. Run-off from the shoes, crosshead, and connecting rod bushings collects in the crosshead guide and drains back to the sump (see Figure 4-9: Lube Oil System Schematic).

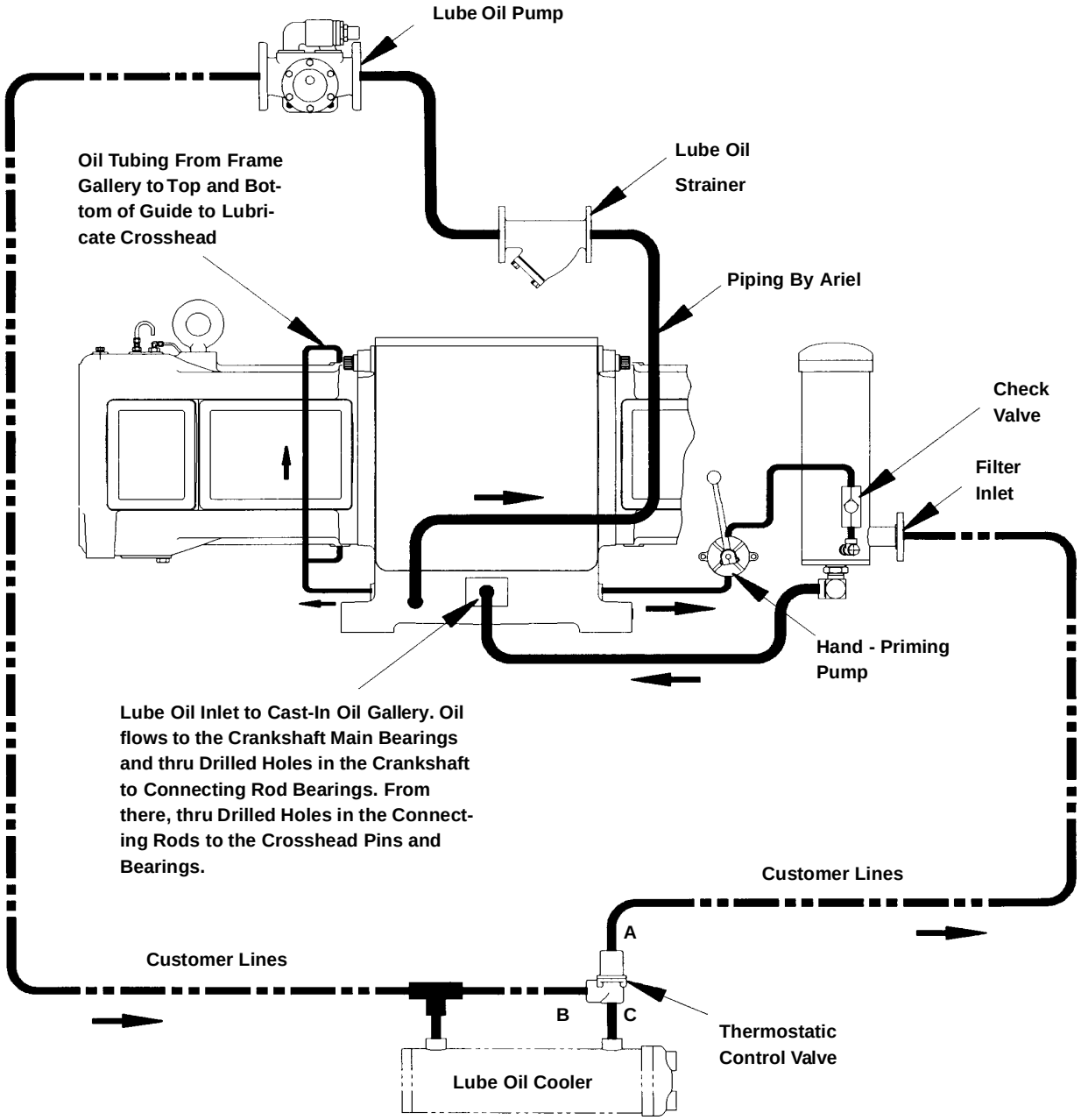


FIGURE 4-9: LUBE OIL SYSTEM SCHEMATIC

Lube Oil Strainer, Filter & Filter Installation Instructions

Lube Oil Strainer

A 595 micron (30 mesh) strainer is located on the auxiliary end of the crankcase below the oil level. The strainer basket should be taken out and washed in an appropriate solvent whenever the lubricating oil is changed.

Lube Oil Filter JGH/2/4 & JGE/2/4

Ariel recommends replacing the filter element when differential pressure reaches approximately 10 PSI (70 kPa) across the filter at normal operating temperatures or at six month intervals.

Filter Element Installation Instructions JGH/2/4 & JGE/2/4

1. Clean filter base surface, and be certain the old gasket is removed.
2. Fill filter with clean oil using the same grade oil as in the crankcase.
3. Apply clean lube oil to the filter gasket.
4. After the filter gasket contacts the base, tighten one turn.
5. After starting the unit, check for leaks, and retighten if necessary.
6. Do not run unit with a damaged filter can. It can fracture or leak. Replace only with an Ariel approved filter.

Lube Oil Filter JGE/6

Ariel recommends replacing the filter element when differential pressure reaches approximately 15 PSI (125 kPa) or after every 12 months of service at normal operating temperature.

Filter Element Installation Instructions JGE/6

1. Remove drain plug and drain completely.
2. During draining, remove flowing vent and top cover. Remove spring plate assembly and strainer tube.
3. After oil has drained completely, remove element and inspect the interior of the vessel.
4. Place a new element over the seat in the bottom of the vessel.
5. Insert the strainer tube and reinstall the spring plate assembly.
6. Inspect the cover O-ring. Install cover. Tighten nuts to a torque setting of 70-80 lb-ft (95-110 N·m).
7. When changing the oil filter, remove flowing vent line and 1/16 in. (2 mm) orifice fitting and blow out line with compressed air. Clean orifice with 1/32 in. (1 mm) diameter wire or standard paper clip (20/21 gage). Re-assemble vent line and orifice fitting.
8. Close the drain and fill the vessel with clean oil using the same grade oil as in the crankcase. Trapped air will be released through the vent.
9. Check for leaks.

NOTE: FAILURE TO FILL FILTER VESSEL WITH OIL, PRIOR TO STARTING, CAN CAUSE SEVERE DAMAGE TO THE COMPRESSOR.

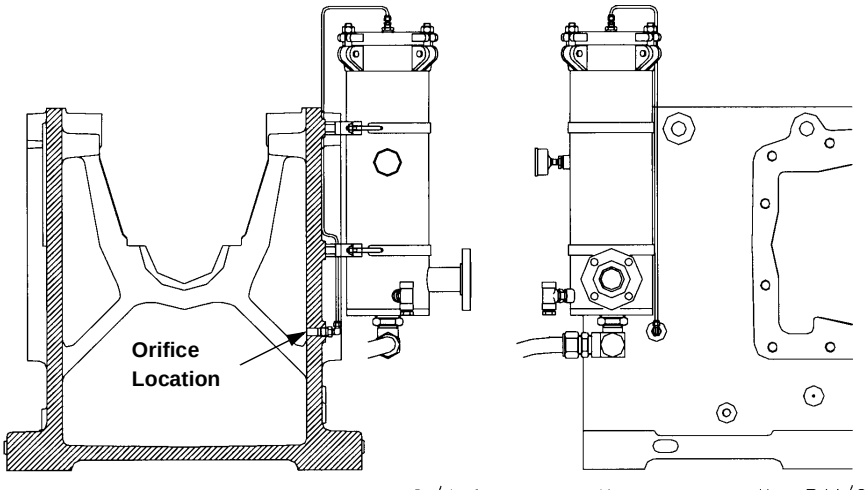


FIGURE 4-10: JGE/6 OIL FILTER FLOWING VENT TO PREVENT AIR ENTRAPMENT

Lube Oil Pump & Lube Oil Pressure - JGH/2/4 & JGE/2/4

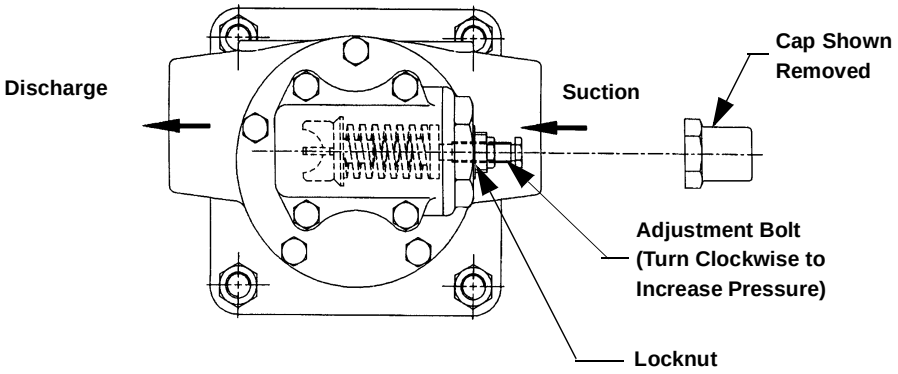


FIGURE 4-11: LUBE OIL PUMP - JGH/2/4 & JGE/2/4

Description & Adjustment - JGH/2/4 & JGE/2/4

Oil pump discharge pressure is held nearly constant by a spring loaded regulating valve within the pump head. Lube system pressure can be raised or lowered by adjusting this valve (see Figure 4-11: Lube Oil Pump - JGH/2/4 & JGE/2/4).

Lube Oil Pressure - JGH/2/4 & JGE/2/4

NOTE: NORMAL PRESSURE ON THE DISCHARGE SIDE OF THE LUBE OIL FILTER IS SET AT THE FACTORY AT 60 PSIG (414 kPa) WHEN CRANKSHAFT SPEED EQUALS OR EXCEEDS 600 RPM FOR JGH AND 750 RPM FOR JGE. IF OIL PRESSURE DROPS BELOW 50 PSIG (350 kPa), THE CAUSE MUST BE FOUND AND CORRECTED.

NOTE: IF THE CRANKSHAFT SPEED IS LESS THAN 50%, THERE WILL NOT BE ENOUGH FLOW THRU THE PUMP TO MAINTAIN PROPER OIL PRESSURE TO THE FRAME. AN AUXILIARY OR LARGER LUBE OIL PUMP WILL BE REQUIRED.

Lube Oil Pump & Lube Oil Pressure - JGE/6

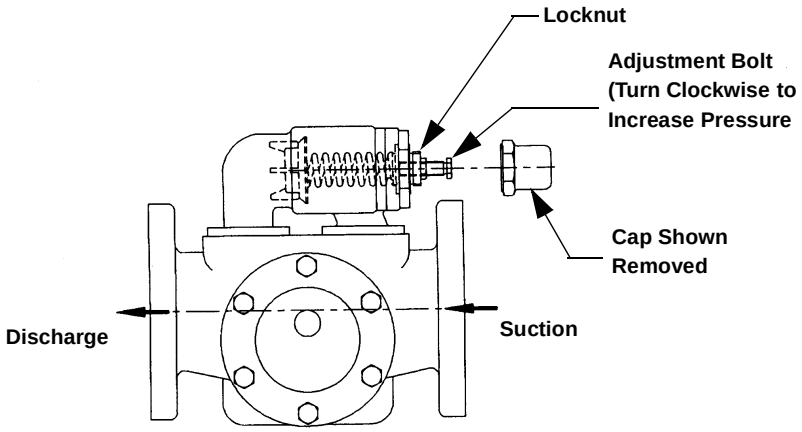


FIGURE 4-12: LUBE OIL PUMP - JGE/6

Description & Adjustment - JGE/6

Oil pump discharge pressure is held nearly constant by a spring loaded regulating valve within the pump head. Lube system pressure can be raised or lowered by adjusting this valve (see Figure 4-12:)

Lube Oil Pressure - JGE/6

NOTE: NORMAL PRESSURE ON THE DISCHARGE SIDE OF THE LUBE OIL FILTER IS SET AT THE FACTORY AT 60 PSIG (414 kPa) WHEN CRANKSHAFT SPEED EQUALS OR EXCEEDS 600 RPM FOR THE JGH AND 750 RPM FOR THE JGE. IF OIL PRESSURE DROPS BELOW 50 PSIG (350 kPa), THE CAUSE MUST BE FOUND AND CORRECTED.

Low Oil Pressure Shutdown

The low oil pressure shutdown is normally mounted by the packager and is supplied to customer specifications. Ariel provides an oil pressure pickup fitting on the oil gallery located after the cooler and filter. The electric or pneumatic oil pressure switch is to be set to actuate when oil pressure falls below 35 PSIG (240 kPa).

NOTE:

1. **THE COMPRESSOR MUST HAVE A WORKING LOW OIL PRESSURE SHUTDOWN.**
2. **DO NOT ATTEMPT TO ADD OIL TO THE CRANKCASE THROUGH THE BREATHER HOLE WHILE THE UNIT IS RUNNING. THIS WILL CAUSE OIL FOAMING AND UNNECESSARY NO FLOW SHUTDOWNS IN THE FORCE FEED LUBRICATION SYSTEM.**
3. **SINCE THE FORCE FEED LUBRICATION SYSTEM IS CONSTANTLY USING OIL FROM THE CRANKCASE, A WORKING CRANKCASE OIL LEVEL CONTROLLER IS NECESSARY. THIS MUST BE DESIGNED TO ALLOW OIL T FLOW INTO THE CRANKCASE FROM AN OVERHEAD TANK AT ALL AMBIENT TEMPERATURE CONDITIONS.**

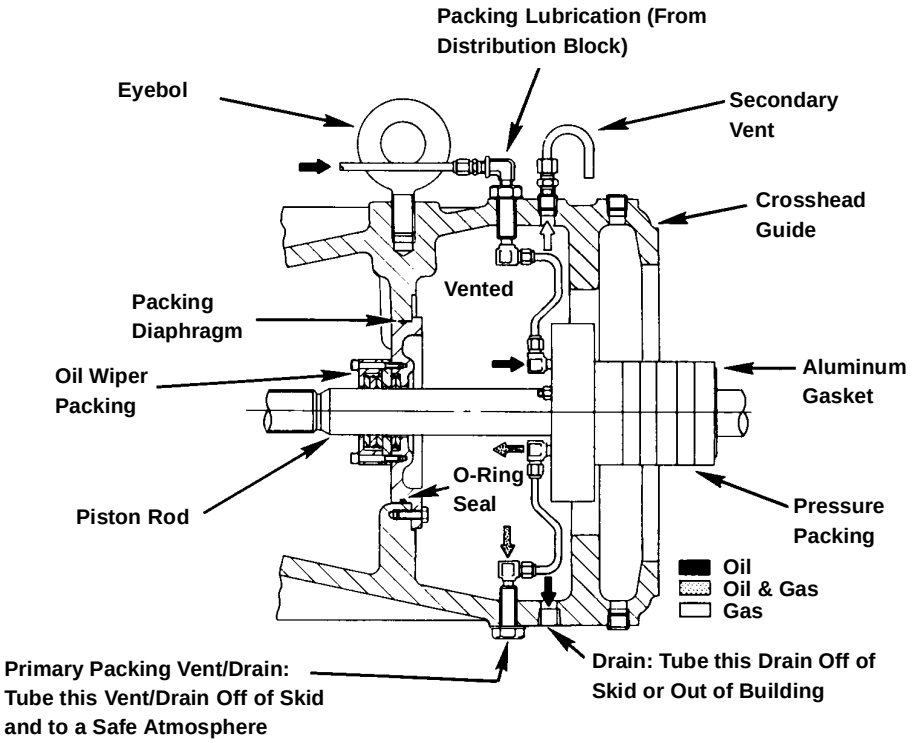


FIGURE 4-13: SINGLE COMPARTMENT DISTANCE PIECE - PACKING, TUBING & VENTING

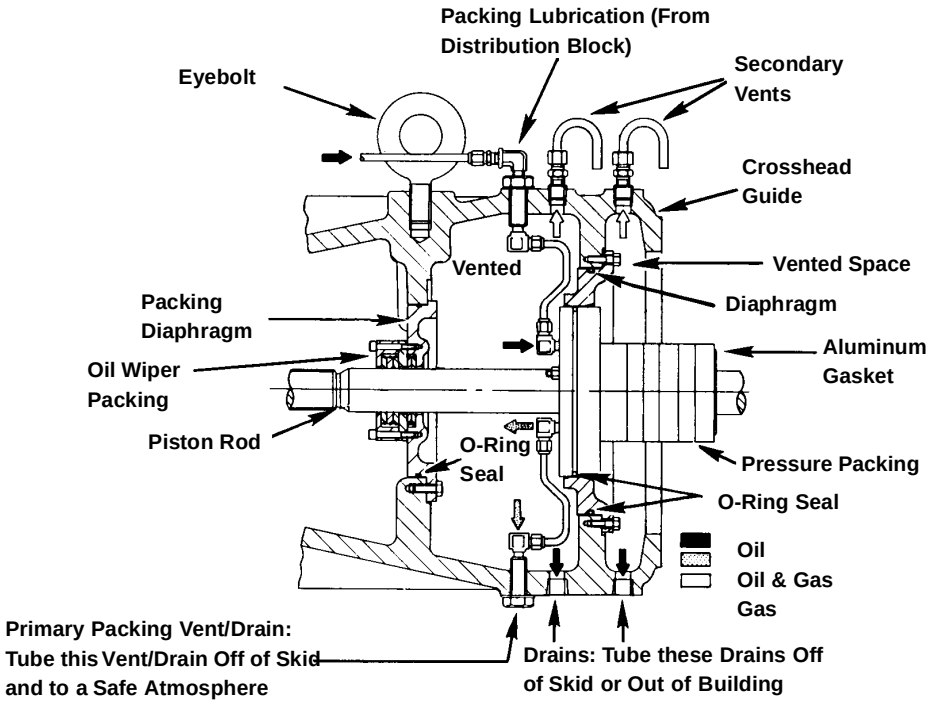


FIGURE 4-14: SHORT-TWO COMPARTMENT DISTANCE PIECE - PACKING, TUBING & VENTING

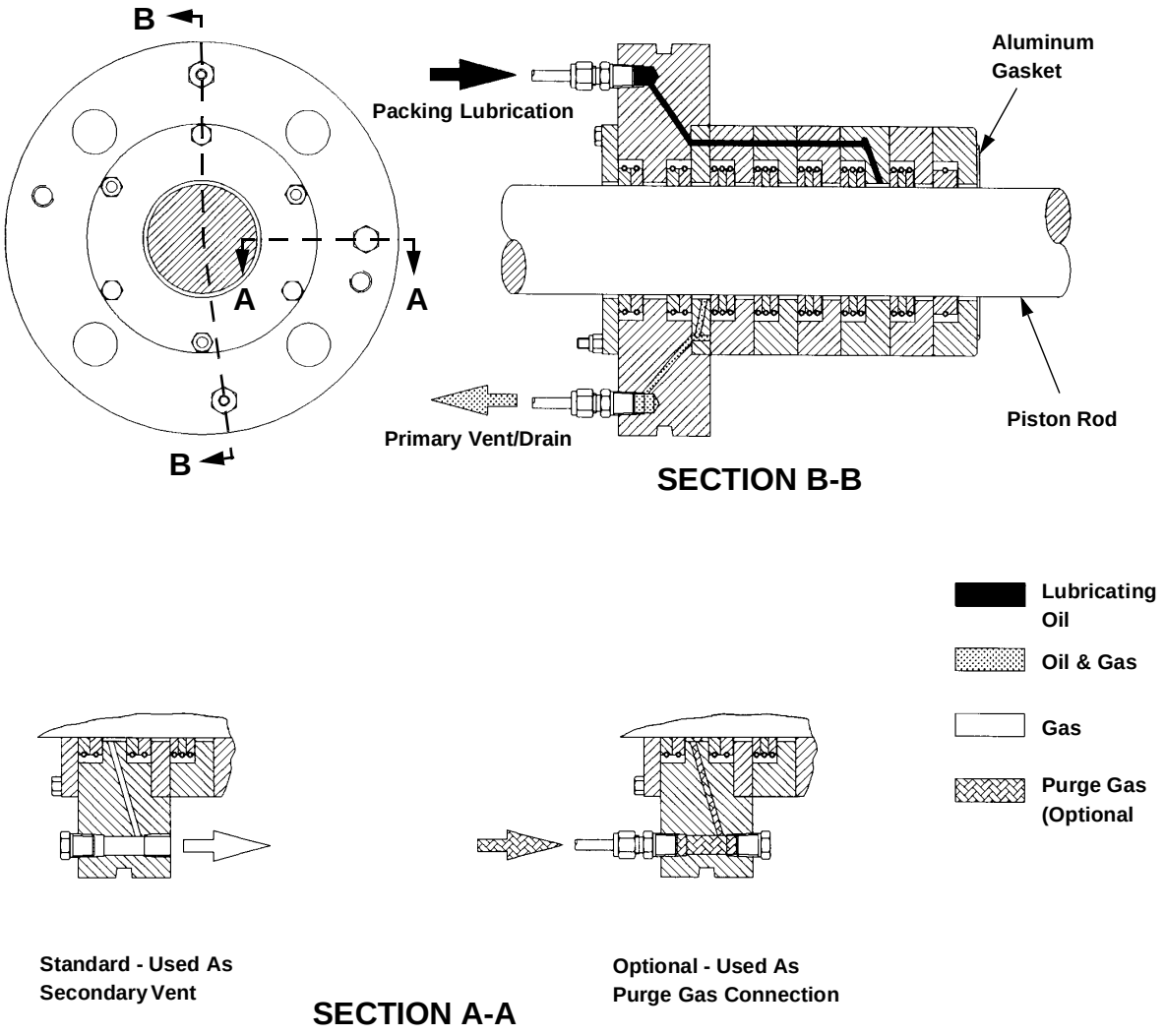


FIGURE 4-15: PACKING LUBRICATION AND VENTING - SINGLE COMPARTMENT DISTANCE PIECE

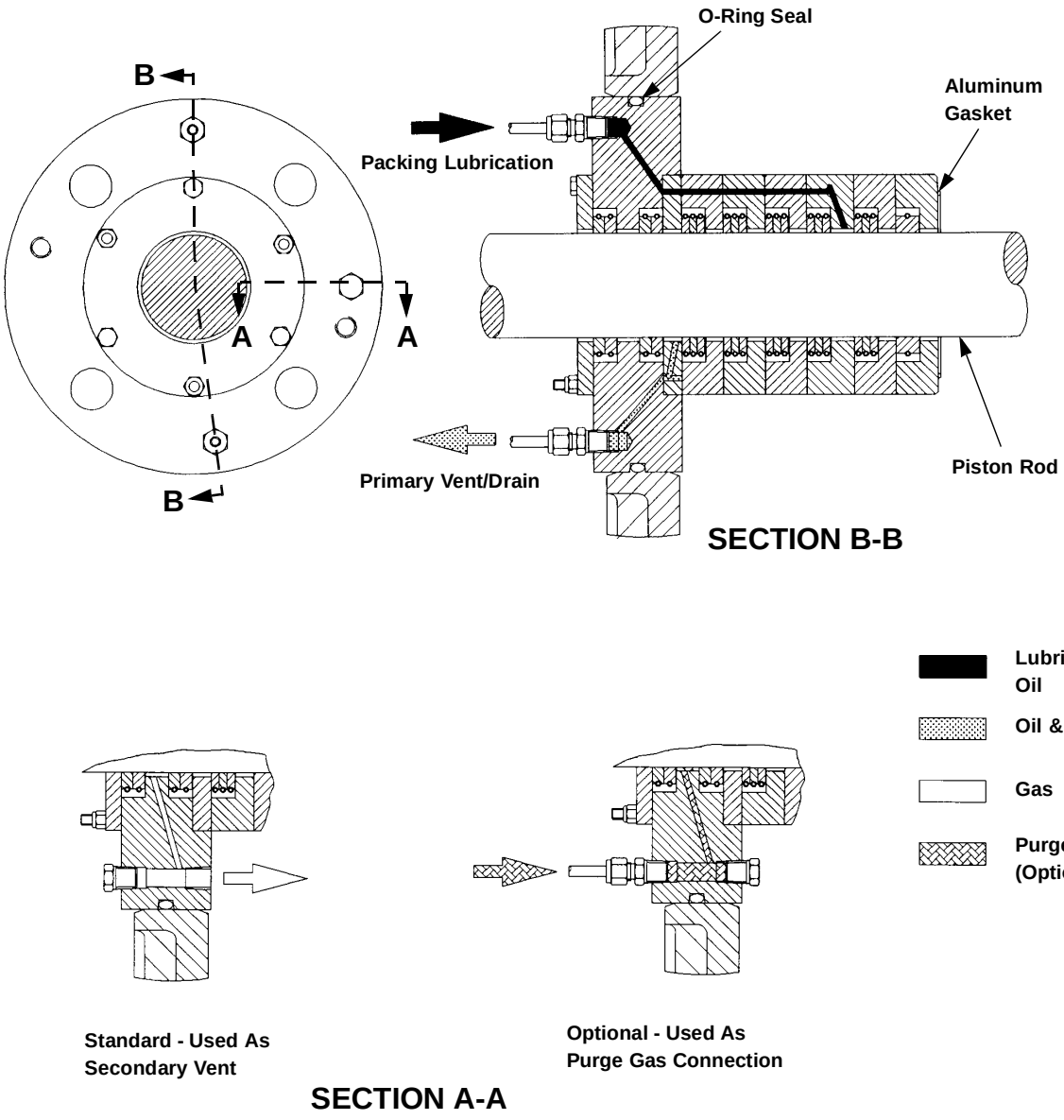


FIGURE 4-16: PACKING LUBRICATION AND VENTING - DOUBLE COMPARTMENT DISTANCE PIECE

NOTES

SECTION 5 - MAINTENANCE

General Introduction

The major components of the frame assembly are the crankcase, crankshaft and bearings, connecting rods, chain drive system, crossheads and guides, and distance pieces.

A cast-in oil gallery runs the length of the crankcase. Drilled oil passages feed lubricating oil to the running gear.

Removable end covers, a top cover, and crosshead guide side covers provide generous access for inspecting and removing internal components. The top cover is made of aluminum for easy handling.

Absolute cleanliness, including the use of lint-free wiping cloths, is a necessity during any maintenance on the compressor. When access covers have been removed, keep the frame covered to protect the interior from dust except when actually working within it. Any components that have been removed should be protected from falling objects that might mar or chip running surfaces.

Whenever the machine is dismantled, gaskets at non-pressure positions are to be carefully inspected before reuse, if damaged they should be replaced. Gaskets at pressure locations should be replaced. Always apply an anti-seize lubricant to both sides of the gaskets for easy removal at a later date. During major overhauls, drain and flush the crankcase

When opposed throw compressor cylinders are exchanged side to side on a given unit, all reciprocating components excepting the conn rods must be exchanged. When re-applying to a throw other than opposed or when reapplying to a different size or class cylinder, the weight balance must be re-calculated. Contact your packager and/or Ariel Field Service for more information.

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⚠ CAUTION

TO PREVENT PERSONAL INJURY, ENSURE THAT COMPRESSOR CRANKSHAFT CANNOT BE TURNED BY THE DRIVER OR COMPRESSOR CYLINDER GAS PRESSURE DURING MAINTENANCE: -- ON ENGINE-DRIVEN COMPRESSORS, REMOVE THE CENTER COUPLING OR LOCK THE FLYWHEEL. -- ON ELECTRIC MOTOR-DRIVEN COMPRESSORS, IF IT IS INCONVENIENT TO DETACH THE DRIVER FROM THE COMPRESSOR, THE DRIVER SWITCH GEAR MUST BE LOCKED OUT DURING MAINTENANCE.

BEFORE STARTING ANY MAINTENANCE OR REMOVING ANY COMPONENTS, RELIEVE ALL PRESSURE FROM THE COMPRESSOR CYLINDERS. (SEE PACKAGER'S INSTRUCTIONS FOR COMPLETELY VENTING THE SYSTEM.

⚠ CAUTION

AFTER PERFORMING ANY MAINTENANCE, THE ENTIRE SYSTEM MUST BE PURGED WITH GAS PRIOR TO OPERATION, TO AVOID A POTENTIALLY EXPLOSIVE AIR/GAS MIXTURE.

Connecting Rod - Removal

1 Remove the top cover from the crankcase and the side covers from the crosshead guides.

2 Remove the middle spacer bar on a 2-throw frame and the middle bar of each set of three on a 4- throw frame.

3 Move the throw to the outer dead center position and remove the locknut, bolt, end plates, and crosshead pin from the crosshead.

4 Remove the crosshead as described in "Crosshead - Removal" on Page 5-6. Before removing the crosshead, refer to the CAUTION on Page 5-5. (CAUTION: CROSSHEADS ARE HEAVY. CARE MUST BE TAKEN WHEN HANDLING TO AVOID PERSONAL INJURY. THE WEIGHT OF EACH CROSSHEAD IS LISTED IN THE BALANCE SHEET THAT COMES IN THE MANUAL WITH EACH COMPRESSOR.)

5 Turn the crankshaft until the throw is at its highest point. Loosen the connecting rod bolts. Using the connecting rod cap removal tool (see Figure 7-2: on Page 7-3), jack against the bolt heads to pull the cap free from the dowels. Be sure to support the connecting rod so that it will not slide off the crankshaft. Remove the top two connecting rod bolts and the rod bearing cap. The bottom two bolts remain in the cap while the cap is being removed.

6 Half of the bearing shell will come out with the cap. The other half can be removed by sliding it out.

7 Turn the crankshaft until the rod can be taken out through the side cover openings in the crosshead guide.

8 After the removal of the connecting rods, be sure to protect the crank pins from being nicked or scratched.

NOTE: IF ALL CONNECTING RODS ARE TO BE REMOVED, IT MAY BE MORE EXPEDIENT TO REMOVE THE CRANKSHAFT PRIOR TO REMOVING THE RODS.

Crank Pin Bearing & Connecting Rod Bushing Removal & Installation

Crank Pin Bearing

This is a tri-metal (steel, bronze, and babbitt with a tin flash) precision split bearing. A visual inspection should be sufficient to determine if the bearing is serviceable. Any appreciable wear of the babbitt would expose the bronze underneath. Such exposure indicates the need for bearing replacement.

There are notches in the rod and rod cap for the bearing tabs in order to position and maintain the position of the bearing halves.

NOTE: CRANK PIN BEARINGS AND MAIN BEARINGS ARE NO LONGER FUNCTIONALLY INTERCHANGABLE. CRANK PIN (CONNECTING ROD) BEARINGS HAVE A NARROWER GROOVE. DO NOT PUT A CRANK PIN BEARING IN A MAIN BEARING LOCATION.

Connecting Rod Bushing

Check crosshead pin to bushing clearance (see Table 1-3 on Page 1-9 for recommended clearance.) Wear on the pin can be determined by a visual inspection. Replace the pin if necessary.

If a replacement bushing is needed, the existing bushing should be filed or hacksawed to within 1/32 inches (1 mm) of its thickness. It can then be easily drifted out.

A press would be helpful to install the new bushing. Do not use a hammer to force the bushing into place as this will distort the bushing's bore. Lay the connecting rod on the press surface so that the chamfered edge of the rod bushing hole is on top. Be sure to locate the bushing oil hole at the connecting rod oil passage before pressing it in. The bushing has an annular groove around its outer surface in line with the oil hole; therefore, if the bushing should shift circumferentially during operation, oil can still travel to its inner surface and to

the crosshead pin. However, during installation of a new bushing, no more than 1/3 of the oil passage hole in the rod should be covered by the bushing.

The bushing must be installed into the connecting rod by cooling the bushing in a dry ice and alcohol solution. The bushing needs to be left in the solution long enough to reach the same temperature as the solution, about -120°F (-85°C). DO NOT TOUCH COLD SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

NOTE: ABSOLUTE CLEANLINESS IS REQUIRED OF BOTH THE BUSHING AND THE CONNECTING ROD TO PREVENT DIRT FROM ACCUMULATING BETWEEN THE BUSHING AND CONNECTING ROD.

Connecting Rod - Installation

1 Snap the half bearing shell into the rod with the bearing tab properly located in the notch in the rod. With the crankcase top cover off, turn the throw to the inner dead center position and slide the rod into the crosshead guide space.

NOTE: THE CAPS AND RODS ARE NUMBERED BY THROW BEGINNING WITH NUMBER ONE AT THE DRIVE END. ALWAYS INSTALL RODS WITH THE NUMBERS UP. BE SURE TO PROTECT CRANK PIN AT ALL TIMES.

2 Fit the connecting rod to the crank pin and turn to the highest position. Replace the cap, the half bearing shell properly located in the notch, and the bolts. Snug up all bolts. Do not tighten bolts to full torque at this point.

3 Reconnect the rod and the crosshead with the pin. Install the end plates, the thru bolt and lock nut. Tighten the lock nut to the value listed in Table 1-14 on Page 1-18.

4 Tighten JGH connecting rod bolts to the value given in Figure 1-14 on Page 1-18 using a crisscross pattern. Tighten JGE connecting rod bolts by pre-torquing the bolts to 90 lb-ft (122 N·m) using a crisscross pattern. Then tighten each bolt exactly one quarter turn, by using the turn indicator tool, as shown in Figure 5-1:

5 Measure each crankshaft to connecting rod bearing jack clearance, with a dial indicator and magnetic stand, to the values listed in Table 1-3 on Page 1-9. Turn the crankshaft pin up and mount the indicator stand on an adjacent web with the stem of the indicator on the rod above the centerline of the pin. Push down on the rod, set indicator to zero, then pry up on the head of the connecting rod bolt with a bar, observe and record reading.

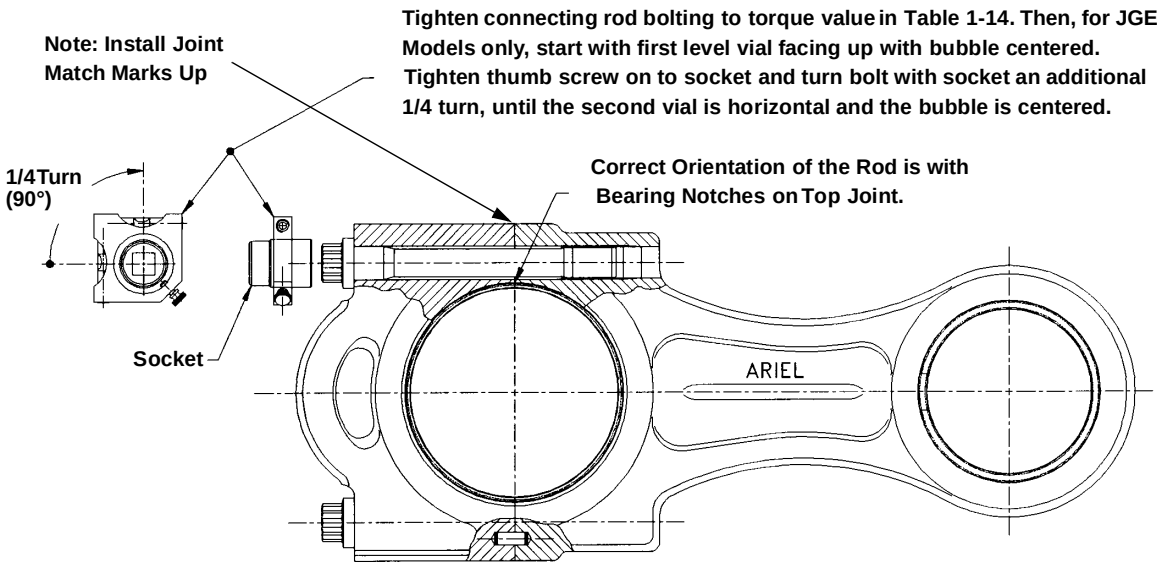


FIGURE 5-1: CONNECTING ROD -TYPICAL

6 Reinstall the spacer bars. All spacer bars are match-marked for proper location. They must be reinstalled in their original location. Tighten all spacer bar bolts to the value listed in Table 1-14 on Page 1-18.

7 Examine the removed top cover and side cover gaskets. If there is any doubt that they are not in a good usable condition, install new gaskets. Before installing old or new gaskets, apply an anti-seize lubricant to both sides to aid in their easy removal at a later date. Replace the top cover and crosshead guide cover. Tighten all capscrews.

Crosshead - Removal

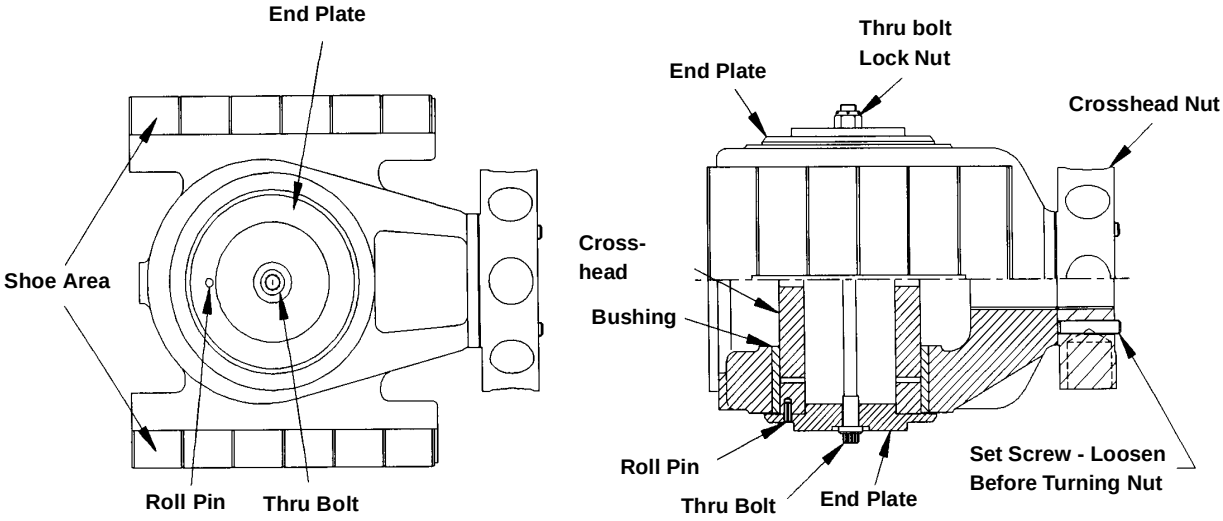


FIGURE 5-2: CROSSHEAD - TYPICAL

⚠ CAUTION

BEFORE REMOVING THE CYLINDER HEAD, BACK OFF ALL CAPSCREWS TO 1/8 INCHES (3mm). MAKE SURE THAT THE HEAD IS LOOSE AND THE CYLINDER IS VENTED. SEE IMPORTANT SAFETY INFORMATION PLATES ON UNIT TOP COVER, (REFERENCE FIGURE 1-3: ON PAGE 1-4 FOR LOCATION.)

⚠ CAUTION

CROSSHEADS ARE HEAVY. CARE MUST BE TAKEN WHEN HANDLING TO AVOID PERSONAL INJURY. THE WEIGHT OF EACH CROSSHEAD IS LISTED IN THE BALANCE SHEET THAT COMES IN THE MANUAL WITH EACH COMPRESSOR.

1 Remove crosshead guide side covers and cylinder head.

2 Move crosshead to its inner dead center position and back off, but do not remove, the crosshead nut set screws. Loosen the crosshead nut with the special slugging Peg or Open End Wrench shown in Figure 7-1: on Page 7-2 or the optional hydraulic crosshead nut torquing tool G-7583 shown in Figure 5-6: on

Page 5-10.

3 Use the Piston Nut Torquing Adaptor shown in Figure 7-1: on Page 7-2 to screw the piston rod out of the crosshead. The two dowels on the Adapter fit holes in the piston nut. Turn the crosshead nut off the piston rod. Push the rod end forward to the edge of the packing to provide a clearance for crosshead removal.

4 With the crosshead in its outer dead center position, remove the crosshead pin thru bolt, lock nut, end-plates and pin.

5 Turn the crankshaft to its inner dead center position. Move the crosshead to its outer dead center position to be free of the connecting rod. Make sure the connecting rod does not drop and damage the crosshead guide surface.

6 Remove the oil wiper packing from the crosshead guide diaphragm. Install the Crosshead Installation/RemovalTool as shown in Figure 5-3:.

7 Push the crosshead onto the Crosshead Installation Tool (see Figure 5-3:) and rotate the crosshead 90 degrees.

8 Slide a 3/16 inch (5 mm) thick plate into the gap between the crosshead and the crosshead guide (as shown in Figure 5-3:).

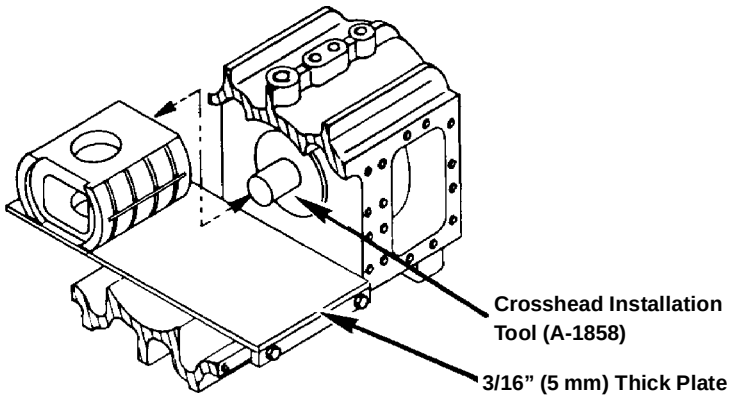


FIGURE 5-3: CROSSHEAD INSTALLATION

9 Remove the Diaphragm from the crosshead guide and slide the crosshead out of the crosshead guide on the plate.

10 Check the crosshead pin to bushing clearance.(See Table 1-3 on Page 1-9.) Wear on the pin can be determined by a visual inspection. Replace the pin if necessary. If the bushings need to be replaced, hacksaw or file to within 1/32 inches (1 mm) of their thickness. They can be easily drifted out. A press will be needed to install new bushings. The bushing can be installed in the crosshead by cooling the bushing in a dry ice and alcohol solution. The bushing needs to be left in the solution long enough to reach the same temperature as the solution, about -120°F (-85°C). DO NOT TOUCH COLD SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

NOTE: THE SIDE OF THE CROSSHEAD RECEIVING THE NEW BUSHING SHOULD BE SUPPORTED DIRECTLY TO PREVENT POSSIBLE CRUSHING OF THE CROSSHEAD BY THE PRESS. (SEE FIGURE 5-3.)

ABSOLUTE CLEANLINESS IS REQUIRED OF BOTH BUSHING AND CROSS-HEAD TO PREVENT DIRT FROM ACCUMULATING BETWEEN THE BUSHING AND CROSSHEAD BORE.

11 Visually inspect the shoe surfaces for scoring. Since they are constantly lubricated under pressure during operation, there should be virtually no wear.

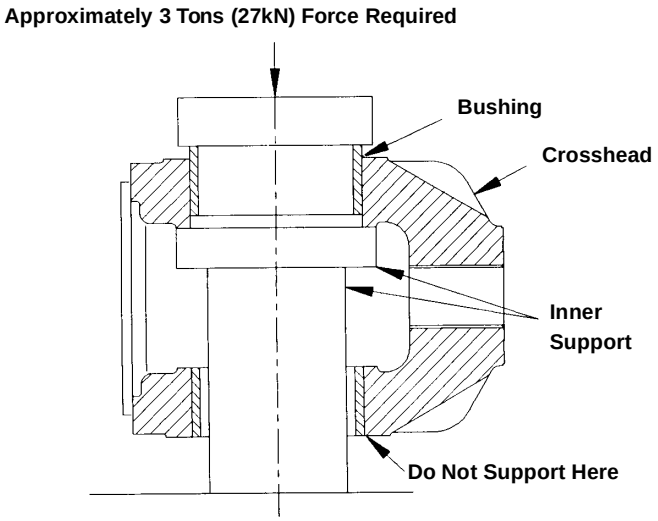


FIGURE 5-4: CROSSHEAD BUSHING REPLACEMENT

Crosshead - Installation

NOTE: BE SURE CROSSHEADS ARE RETURNED TO THEIR ORIGINAL THROW LOCATION.

1 Lay a 3/16 inch (5 mm) thick plate in the bottom of the crosshead guide and lay the crosshead on its side as shown in Figure 5-3: on Page 5-7.

2 Mount the Crosshead Installation Tool onto the crosshead guide diaphragm. Install the diaphragm with this tool mounted into the crosshead guide. Slide the crosshead onto the tool.

3 Remove the 3/16 inch (5 mm) thick plate. Rotate the crosshead 90° and push into the guide. Make sure it does not become cocked. Should the crosshead become wedged, do not force it. Ease it off and start again. Be careful not to damage the crosshead shoe surface during installation. Remove the crosshead installation tool and reinstall the wiper packing.

4 Turn the crankshaft to its outer dead center position to locate the connecting rod in position and insert the crosshead pin. Use B-1989 Alignment Tool (refer to Figure 5-5: on Page 5-9) on the opposite side of the crosshead to assist the

insertion of the pin. Install the crosshead pin thru bolt, lock nut and end-plates. Tighten the thru bolt and lock nut to the value listed in Table 1-14 on Page 1-18. (TIP: If difficult to insert, chill the pin.)

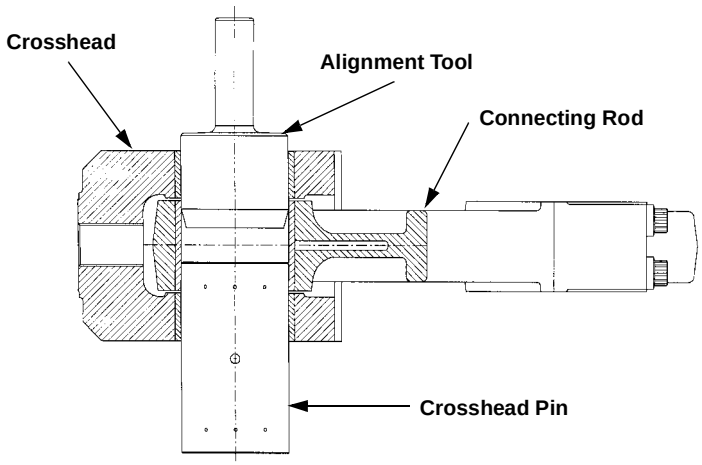


FIGURE 5-5: CROSSHEAD PIN ALIGNMENT TOOL (B-1989) - TYPICAL

5 Reinstall the crosshead nut on the piston rod. Be sure to have setscrew cup points on the crosshead side of the nut. Screw the piston rod in the crosshead using the Piston Nut Torquing Adaptor. Make sure all threads are well lubricated with clean, fresh oil to ensure a smooth installation. Ensure that the Piston Torquing Adaptor has been removed.

NOTE PISTON END CLEARANCE MUST NOW BE SET OR SERIOUS DAMAGE COULD OCCUR. (SEE TABLE 1-3 ON PAGE 1-9 FOR PISTON END CLEARANCE SETTINGS).

6 Tighten crosshead nut using the special slugging peg or open end wrench shown in Figure 7-1: on Page 7-2 or the optional hydraulic crosshead-nut torquing tool, Part Number G-7583, shown in Figure 5-6: on Page 5-10. In addition to the ram shown in the figure, the Ariel hydraulic pump kit (Part Number G-6520) is required. See “Using the Optional Hydraulic Torquing Tool” on Page 5-10.

7 Before installing the side covers, apply an anti-seize lubricant to the gaskets. This will aid to ease removal at a later date.

8 Replace the crosshead guide side covers; tighten all capscrews.

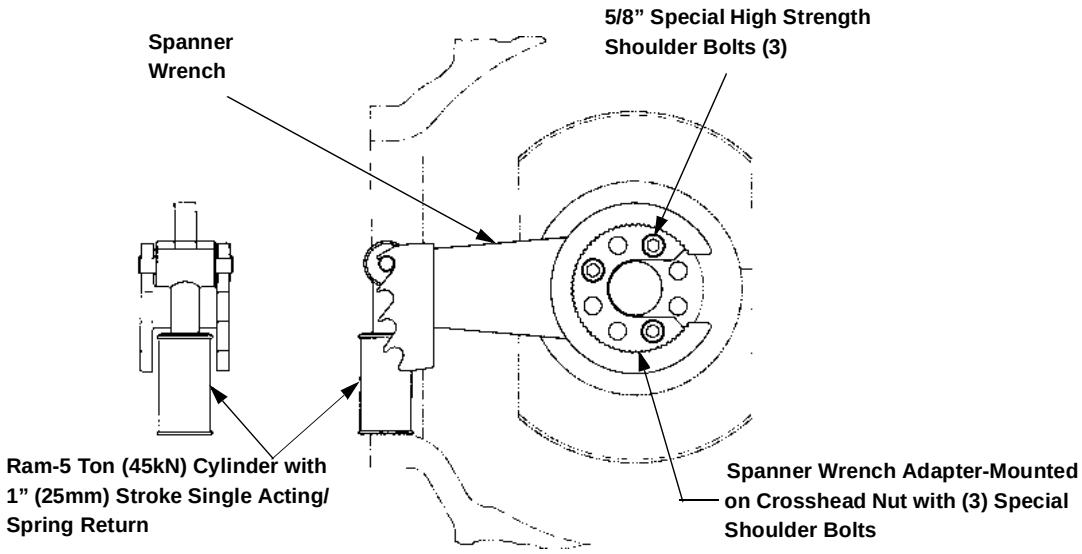


FIGURE 5-6: OPTIONAL HYDRAULIC CROSSHEAD-NUT TORQUING TOOL, G-7583

Using the Optional Hydraulic Torquing Tool

Use the following procedure to tighten the crosshead nut to the specified torque value (see Figure 1-14 on Page 1-18) using the hydraulic torquing tool, G-7583.

1. Bolt the spanner wrench adapter to the crosshead nut using the three special shoulder bolts, with the open side away from the spanner wrench moment arm.
2. Slide the spanner wrench onto the adapter spline.
3. Position the hydraulic ram in the crosshead guide window and in a notch of the spanner wrench moment arm.
4. Apply hydraulic pressure until the ram fully extends.
5. Release hydraulic pressure and re-set the ram into the next notch.
6. Repeat this procedure until the hydraulic pressure reaches 3500 psi (24 132 kPa), the nut does not move and the ram is not fully extended.
7. Remove all tool components.

Crankshaft - Removal

1. Remove the coupling disk pack. Remove the coupling hub. (In order to remove the coupling hub it may be necessary to heat it. Use insulated gloves to protect hands.) If the coupling hub is not removed, the drive end cover cannot be removed and will need to be lifted out with the crankshaft.
2. Remove the top cover, spacer bars. and drive end cover (if the coupling hub has

been removed). Tip: If the spacer bar bolts are difficult to remove, use a 12 point hammer wrench.

3 Be careful not to damage the sharp corners on each end of the top of the crankcase. These corners form the junction between the end covers, top cover, and base; thus they must be kept sharp and unmarred to prevent oil leaks.

4 Detach the connecting rods. (See “Connecting Rod - Removal” on Page 5-2.) Move the rods to their full outer position.

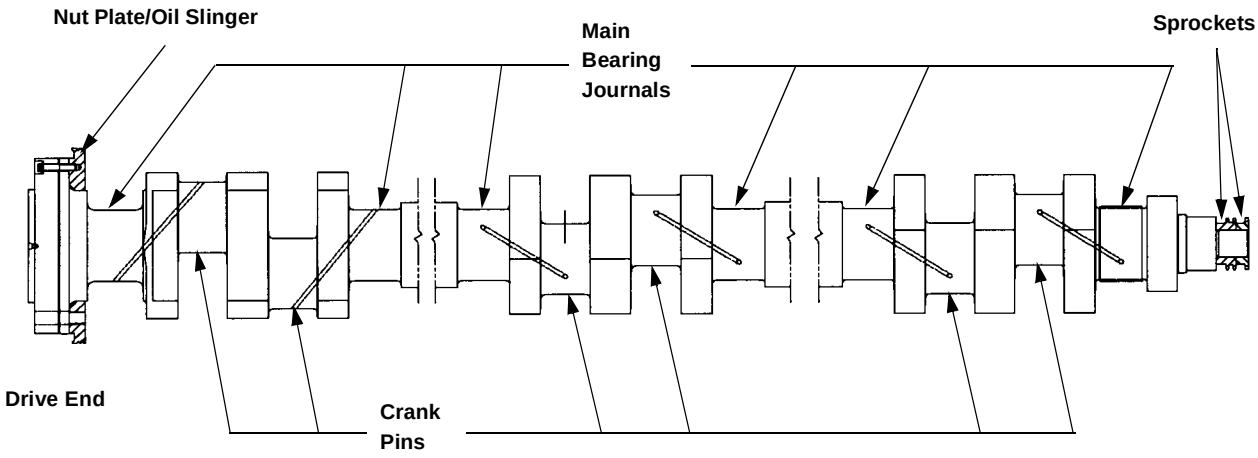


FIGURE 5-7: CRANKSHAFT - TYPICAL FLANGE (JGE/6)

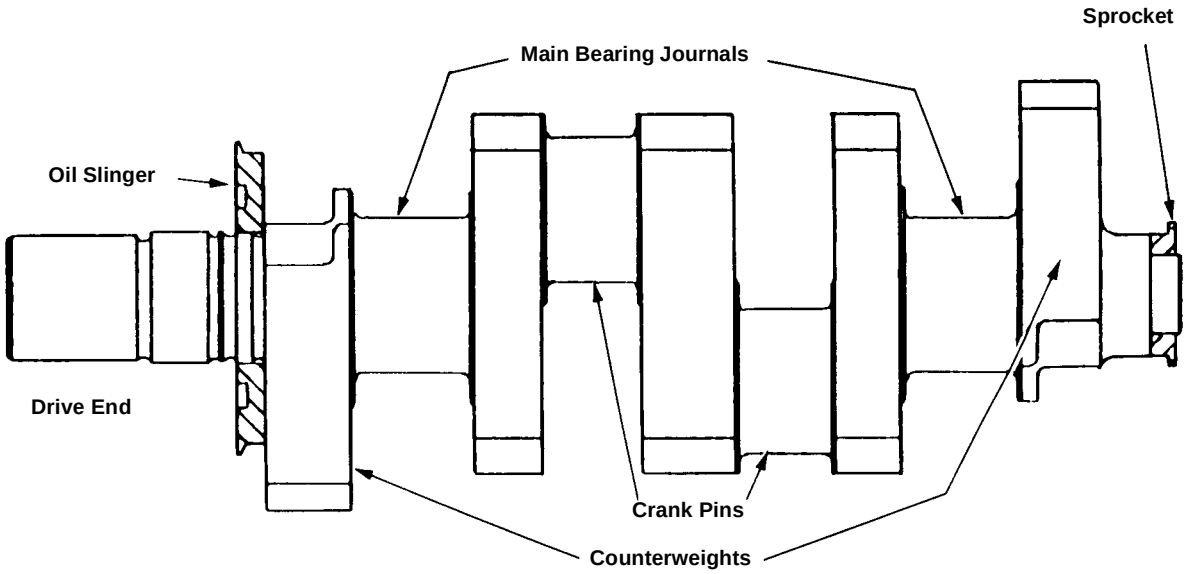


FIGURE 5-8: CRANKSHAFT - TYPICAL STUBSHAFT

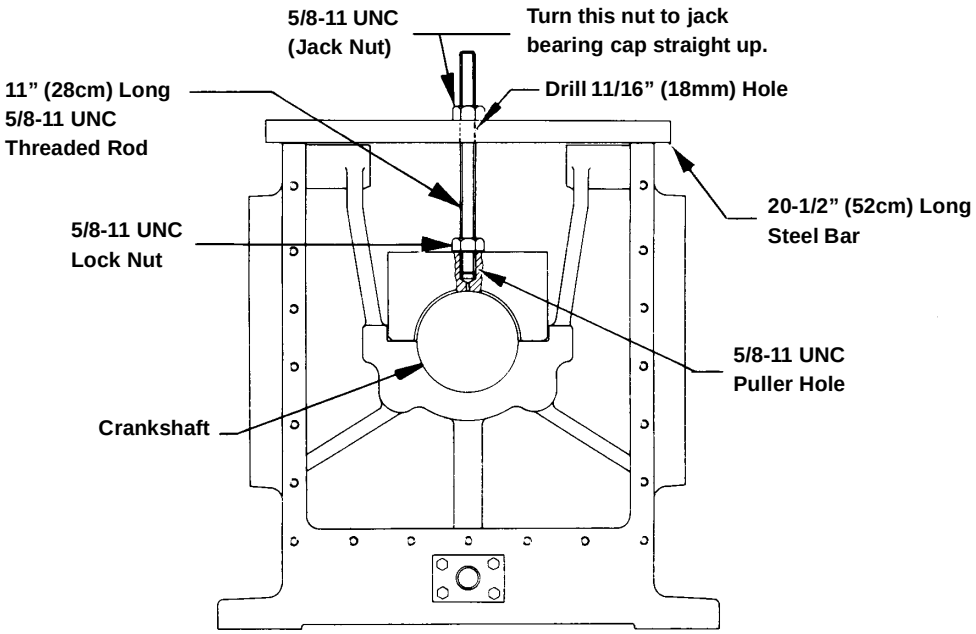


FIGURE 5-9: MAIN BEARING CAP PULLER

5 Remove the capscrews on the chain adjustment cap. Turn the cap to loosen the chain. Slip the chain off the crankshaft sprocket.

6 Remove the capscrews from the bearing caps. Pull the caps straight up to prevent damage to the dowel fit. If the cap is tight, use a Bearing Cap Puller as illustrated.

7 Before removing the crankshaft from the crankcase, wooden saddles or a notched wooden crate with sides high enough to prevent the webs or oil slinger from touching bottom should be prepared in order to store the crankshaft during maintenance - even though it may be out for only a short time. In addition, the crankshaft should be adequately protected from above so that dropped tools or equipment cannot mar the surface of pins and journals.

8 Turn the crankshaft so that sling lifting points are above the center of gravity of the shaft, so that it does not want to rotate when lifted. Lift straight up with the ends of the crankshaft parallel to the frame. Two men will be needed to safely remove the crankshaft as well as a crane or lift due to the weight of the crankshaft (listed below). Appropriate sized nylon slings should be used during this operation so as not to mar the running surface of the crankshaft. Great care must be taken during this operation since the shaft could bind and become damaged.

NOTE: THE LOWER HALF BEARING SHELLS SOMETIMES HAVE A TENDENCY TO STICK TO THE SHAFT JOURNALS BECAUSE OF THE CLOSE FITTING OILY SURFACES OF THE TWO PARTS. THEREFORE, WHEN THE SHAFT HAS BEEN LIFTED CLEAR OF THE SADDLES (APPROXIMATELY 1/4 inches OR 6mm) CHECK TO MAKE SURE THAT THE LOWER HALF BEARING SHELLS HAVE NOT COME OUT WITH THE SHAFT. IF SO, THE BEARING SHELLS

SHOULD BE TAPPED BACK ONTO THE SADDLES BEFORE LIFTING THE SHAFT ANY FURTHER.

9 While one person operates the crane, raising it very slowly, the second person must grasp the crankshaft at the drive end with one hand on the counterweight or one of the throws and the other hand on the end of the shaft to keep the crankshaft level. Wear gloves to avoid being cut by the slinger and to achieve a good grip. (As with each operation, the gloves should be clean to avoid marring the running surface.) As the shaft is being slowly raised, the drive and auxiliary ends should be lifted at the same rate. Again, care must be taken to avoid marring the crankshaft surfaces by carefully guiding the crankshaft.

TABLE 5-1: APPROXIMATE WEIGHTS OF BARE CRANKSHAFTS

NUMBER OF THROWS	POUNDS (kg)
2	450 (200)
4	900 (400)
6	1350 (600)

Crankshaft - Oil Slinger

Removal:

Although the slinger should last indefinitely with proper care, it can become nicked. Should it need replacing, suspend the crankshaft as in the CRANKSHAFT REMOVAL PROCEDURE and heat the slinger to 400°F (240°C), it will attain a yellow glow at this temperature. When it has expanded it should fall off by itself. DO NOT TOUCH HOT SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

Installation:

Put a rod at least 1/2 inches (13mm) in diameter through the slinger. (Special care should be exercised when handling the slinger, not only to keep its surfaces unmarred, but to avoid being cut by the outer sharp edge.) After the slinger is suspended heat it with a small torch. When it has attained a yellow glow, approximately 400°F (240°C) it can be slipped over the drive end of the crankshaft. Hold the slinger in position with high temperature gloves or two pieces of clean wood, rotating it slightly to make sure it is square, until it has cooled enough to shrink onto the crankshaft. DO NOT TOUCH HOT SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

Crankshaft - Chain Sprocket

Removal:

Examine the sprocket carefully for signs of wear. If it has been in operation for five years or more, it may be convenient to replace it if the crankshaft is removed from the frame.

Drill a hole in the sprocket hub. This hole should be parallel to the shaft centerline and big enough that it removes most of the hub cross section. (See Figure 5-10:) Be careful not to touch the shaft with the drill. Mark the drill with tape so you do not drill through the sprocket and into the crankshaft face.

The drilled hole will relieve most of the shrink, and a couple of good radial hits with a hammer and chisel will open the sprocket enough so it can be easily removed.

Installation:

Encircle the sprocket with wire. Suspend the sprocket from the wire and heat it with a small propane torch. When it has attained a yellow glow, approximately 400°F (240°C) it can be slipped over the auxiliary end of the crankshaft. Hold the sprocket in position with high temperature gloves or two pieces of clean wood, rotating it slightly to make sure it is square, until it has cooled enough to shrink on the crankshaft. DO NOT TOUCH HOT SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

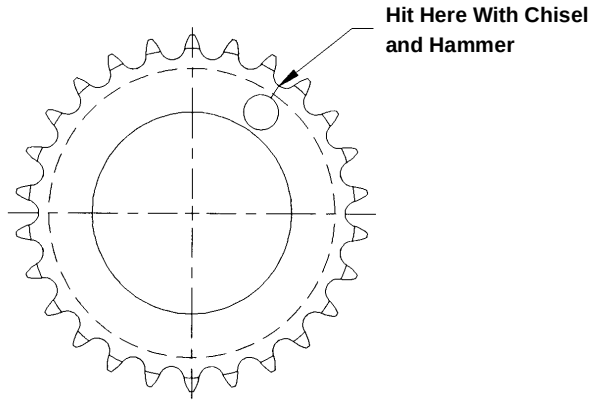


FIGURE 5-10: CRANKSHAFT CHAIN SPROCKET - TYPICAL

Main Bearings - Removal and Installation

Bearings must be replaced if they show signs of wear or scoring. Wear will be indicated by the bronze showing through the babbitted surface.

If replacement bearings are needed, the old bearings halves can easily be slid out, new bearings slid in (untabbed end first), and snapped into place. Locate tabs in the notches in the bearing saddles and bearing caps.

NOTE: CRANK PIN BEARINGS AND MAIN BEARINGS ARE NO LONGER FUNCTIONALLY INTERCHANGABLE. CRANK PIN (CONNECTING ROD) BEARINGS HAVE A NARROWER GROOVE. DO NOT PUT A CRANK PIN BEARING IN A MAIN BEARING LOCATION.

Crankshaft - Installation

1. Move the connecting rods to their full outer position. While the crankshaft is being lowered very slowly into the crankcase (suspended by a crane with a nylon sling), one man should grasp the drive end and slowly maneuver the drive end and auxiliary end straight down into the crankcase, wearing clean gloves as during removal. Both drive end and auxiliary end journals should touch the bearing saddles at the same time.
2. When the crankshaft is resting on the bearing saddles, attach the bearing caps with the capscrews lightly snugged. Then, starting at the thrust end, tighten the bolts in a crisscross pattern in 25% increments to the recommended torque value in Table 1-14 on Page 1-18. Bearing caps are match-marked to correspond with the spacer bar and spacer bar bosses on the frame.
3. Be sure the dowels in the bearing caps are aligned with the holes in the crankcase base. A set screw on top of each dowel prevents it from backing out.
4. Measure each crankshaft journal bearing jack clearance, with a dial indicator and magnetic stand to Table 1-3 on Page 1-9. To measure main bearing clearance, turn the adjacent crankshaft pin up and mount the indicator stand on the main bearing cap, with the indicator stem touching the web of the crank adjacent to the bearing cap. Push down on the crank, set indicator to zero, pry up, observe and record reading. This is best done before the connecting rods are installed by pulling a clean lifting strap around the adjacent pin and pulling up on the crankshaft with a crane or bar on the strap.
5. Reattach the connecting rods (See “Connecting Rod - Installation” on Page 5-4), packing diaphragms, and unloaders/head end heads.
6. Reinstall the chain drive. (See “Chain Drive System” on Page 5-16).
7. Replace the spacer bars. Locate the match mark on the spacer bar. Install the spacer bar so that the match mark is up and next to the spacer bar boss with the same marking.
8. Install new end cover gaskets. Examine the top cover gasket. If there is any doubt that it is not in good usable condition, install a new gasket. Before installing gaskets, apply an antiseize lubricant to all gaskets or to the metal surfaces on which they will seat. This will aid in their easy removal at a later date. Trim the excess from the new end cover gaskets flush to the base with a knife after end covers have been re-bolted.
9. Reinstall the drive end cover and the top cover.

Chain Drive System

Description - JGH/2/4 & JGE/2/4

The chain drive system is crankshaft-driven at the auxiliary end of the frame. The chain runs the lube oil pump and force feed lubricator. Chain tightness is controlled by an idler sprocket attached to the eccentric adjustment cap. The chain dips into the crankcase oil and, as a result, is constantly lubricated. See Figure 5-11: for the auxiliary end components and chain drive system for the JGH/2/4 & JGE/2/4 Models.

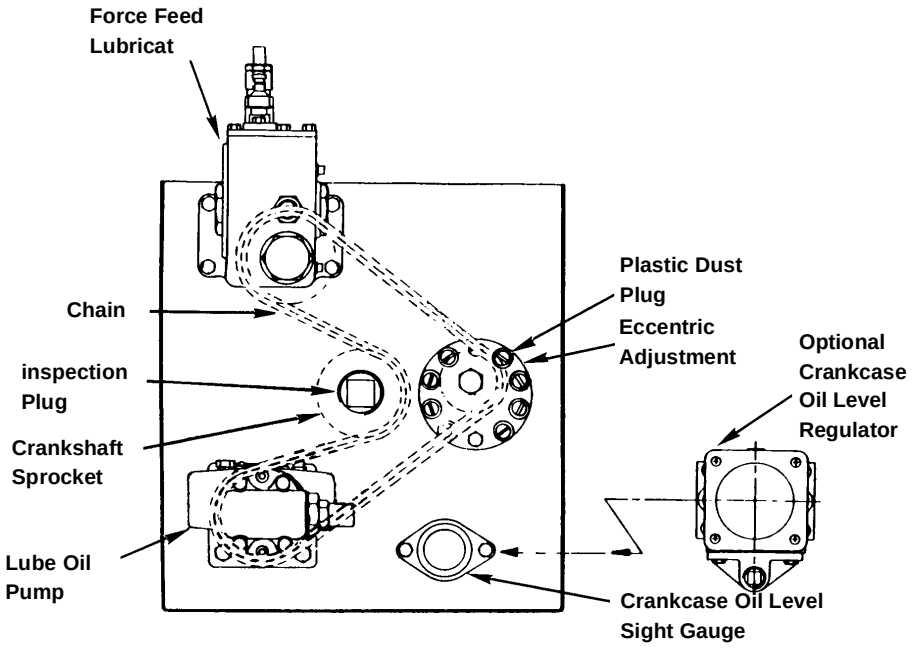


FIGURE 5-11: CHAIN DRIVE SYSTEM JGH/2/4 & JGE/2/4

Description - JGE/6

The chain drive system is crankshaft-driven at the auxiliary end of the frame. Two chains run the lube oil pump and force feed lubricator, respectively. Chain tightness is controlled by idler sprockets attached to the eccentric adjustment caps. The lube oil drive chain dips into the crankcase oil and the splash action provides oil to the force feed lubricator chain, as a result, both are constantly lubricated. See Figure 5-12: for the auxiliary end components and chain drive system for JGE/6 Models.

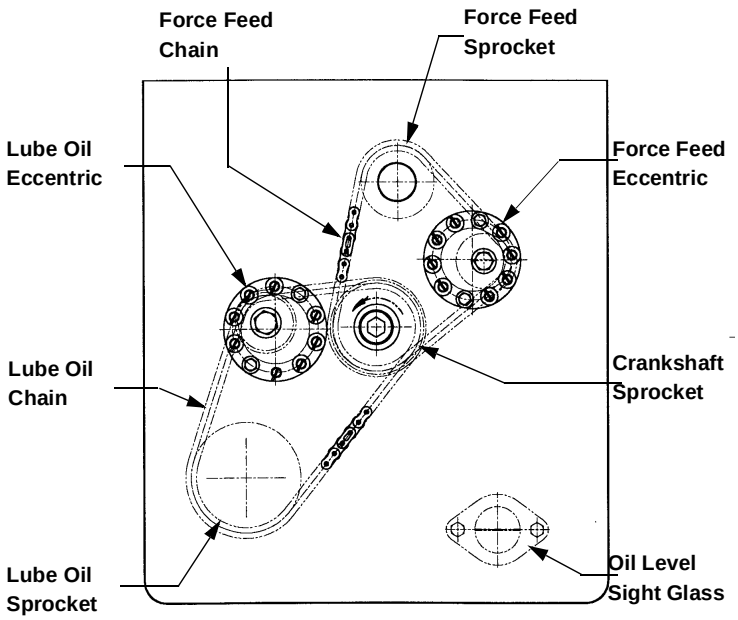


FIGURE 5-12: CHAIN DRIVE SYSTEM JGE/6 - TYPICAL (STANDARD ROTATION)

Replacement of any parts that can change the position of the drive sprocket on the crankshaft (i.e. crankshaft, drive sprocket, thrust plates), and/or loss of the as built sprocket position on driven components, can require repositioning the lube oil pump and force feed lubricator sprockets. Center crankshaft in end play. With a good straight edge, check to see that sprockets are aligned within 1/32 inch (1mm). Or measure the distance between the inside face of the auxiliary end cover to the near faces of the drive sprockets on the crankshaft with a good machinist rule. Check the driven sprockets in the chain drive system against the measured dimensions at crankshaft drive sprockets. Adjust the driven sprockets to the drive sprocket measurements to be aligned within 1/32 inch (1mm). If not in alignment, disassembly and shimming the eccentrics may be required.

Chain Adjustment

1. Roll machine to the tightest position of the chain. This prevents snugging up on the chain at a slack position and breaking rollers or ruining the pump and lubricator bearings when the chain goes thru its tightest position.
2. Remove the two capscrews and eight plugs from the eccentric cap. Rotate the cap 6 degrees clockwise facing cap from outside to line up the two new capscrew holes. If this makes the chain too tight, try turning the cap around in a counterclockwise direction for a different hole lineup.
3. Tighten the two capscrews (for recommended torque see Table 1-14 on Page 1-18) and roll the machine to check the tightness in a number of positions. At its tightest position, the chain should be adjusted so that the deflection from a straight line is within the chain deflection limits shown in Table 5-2 between the

idler and force feed lubricator sprockets and also between the crankshaft and idler or lube oil pump sprockets. For the 6-throw compressor (JGE/6), be sure to identify the direction of rotation (standard or reverse) to be certain that the correct deflection values are used (the most accessible span). This deflection can be measured from a straight edge held on the chain wrapped over the two sprockets. The allowable deflection is measured at the center of the span, while a force of 2 to 10 lb (9 to 45 N) finger pressure is applied to the chain.

TABLE 5-2: CHAIN DEFLECTION LIMITS

COMPRESSOR MODEL AND ROTATION[a]	DEFLECTION LIMITS	
	FORCE FEED LUBRICATOR TO IDLER IN. (mm)	LUBE OIL PUMP OR IDLER TO CRANKSHAFT IN. (mm)
JGH/2/4 & JGE/2/4 Standard Rotation	0.060 to 0.100 (1.52 to 2.54)	N/A
JGH/2/4 & JGE/2/4 Reverse Rotation	0.066 to 0.110 (1.68 to 2.80)	N/A
JGE/6 Standard Rotation	0.024 to 0.041 (0.61 to 1.04)	0.034 to 0.056 (0.86 to 1.42)
JGE/6 Reverse Rotation	0.032 to 0.054 (0.81 to 1.37)	0.043 to 0.072 (1.09 to 1.83)

a. Standard rotation is clockwise, when facing the compressor at the drive end (i. e. standing at the coupling); reverse is counter-clockwise.

4 Replace the plugs in the eccentric adjustment cap to keep dirt out of the unused holes in the end cover.

Chain and Sprocket Replacement

The chain(s) should be replaced if the elongation exceeds 0.084 inches (2.13 mm) over a 10 pitch length. The section of chain to be measured should be stretched tight, in place, in the compressor and measured with vernier calipers. A reading made outside of the rollers at 10 pitches should be added to a reading between the inside of the same rollers and then be divided by two. If this calculation exceeds 5.084 inches (129.1 mm) for 1/2 pitch, the chain should be replaced. Any sprocket showing any undercutting should be replaced.

Eccentric Vernier - Chain Idler Sprockets Replacement (Self-Aligning Sprocket)

1 A typical chain idler sprocket is shown in Figure 5-13: on Page 5-19. Note that the location of the chain idler sprockets will vary for standard rotation versus reverse rotation with standard rotation defined as clockwise when viewed at the drive end (standing at the coupling).

2 The procedure for sprocket replacement is similar for the single chain (JGH/2/4 & JGE/2/4) and the 2-chain (JGE/6) configurations. One exception is that the force feed lubricator idler sprocket is thinner than the other sprockets and care must be taken when realigning the sprockets after sprocket replacement.

3 Remove the frame top cover. Remove the two capscrews that hold the eccentric adjustment cap to the end cover. Rotate the eccentric cap to loosen the chain for removal. After dropping the chain off the idler sprocket, the entire assembly can be removed from the end cover.

4 Remove the locknut, hex capscrew, sprocket and Stat-O-Seal washer. Discard

all four items since they must be replaced with new parts. Remove and discard the cap o-ring.

5 Reassemble all parts using a new capscrew, Stat-O-Seal washer, sprocket, and locknut. Tighten the idler locknut to the recommended torque shown in Table 1-14 on Page 1-18.

6 Install the assembly on the end cover.

7 Apply oil and install a new o-ring. Install the assembly and adjust the chain according to the instructions given in “Chain Adjustment” on Page 5-17.

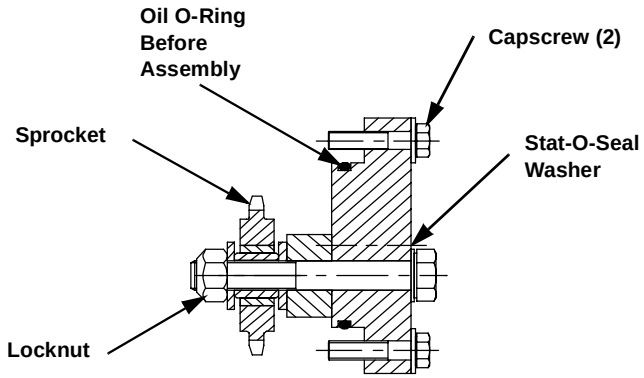


FIGURE 5-13: ECCENTRIC VERNIER - CHAIN IDLER SPROCKET (SELF-ALIGNING SPROCKET)

Lube Oil Pump Chain Sprocket Replacement

1 Remove all piping from the pump. Remove fasteners from pump mounting flange and the pump with sprocket will come free through the hole in the end cover after the removal of the chain.

2 With a good machinist rule, measure the exact distance from the sprocket drive face to the pump mounting flange face, in order to position the new sprocket. Note this measurement for future reference.

3 With the oil pump on a bench, use an Allen Wrench to remove the sprocket set screws; then, pull the sprocket from its shaft.

4 Remove the square key, 3/16 x 1 inches (4.8 x 25 mm) long, from the shaft and file the shaft to smooth out any burrs raised by the cup point of the set screw.

5 Install a new square key, 3/16 x 1 inches (4.8 x 25 mm) long, after first checking to make sure the key will fit into the new sprocket. If the key is too thick, it can be polished with an emery cloth on a flat surface until it can easily slide into the notch. It may also be a little high and require filing of the top edge.

6 Install a new sprocket to the original measurement between the sprocket drive

face and the pump mounting flange face. When it is in position, tighten the set screws.

7 Install new gaskets. Before reinstalling the pump, apply an anti-seize lubricant to the gasket surfaces. This will aid in easy removal at a later date.

8 Reinstall the pump onto the end cover. Check the alignment to crankshaft drive sprocket, with crankshaft centered in end play, using a straight edge to within 1/32 inch (1mm). If not in alignment, adjust sprocket position as necessary.

9 Adjust the chain according to the instructions in “Chain Adjustment” on Page 5-17.

10 Reinstall all tubing to the pump.

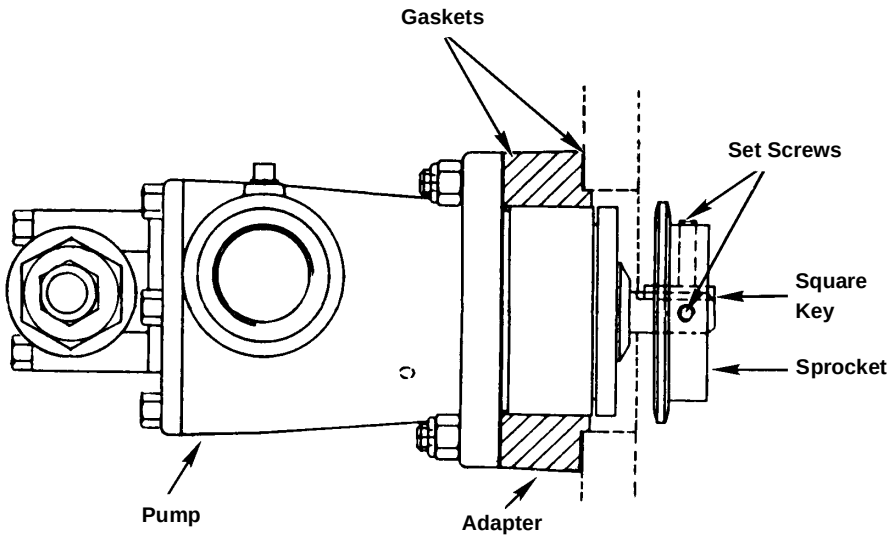


FIGURE 5-14: LUBE OIL PUMP CHAIN SPROCKET - TYPICAL

Force Feed Lubricator Chain Sprocket Replacement - JGH/2/4 & JGE/2/4 (Set Screw & Key)

1 For the following steps, refer to Figure 5-15:.

2 With a good machinist rule, measure the exact distance from the inside face of the auxiliary end cover to the near face of the lubricator sprocket. Note the measurement for proper positioning of the new sprocket. Remove chain.

3 Remove the sprocket set screw and sprocket. Detach all tubing to the lubricator.

4 Remove the four mounting bracket capscrews and remove the lubricator.

5 With the lubricator on the bench, remove the Woodruff Key from the shaft and file the shaft to remove any burrs raised by the cup point of the set screw. Install a new O-ring.

6 Install a new No. 204 Woodruff Key after first checking to make sure the key will fit into the new sprocket. If it is too thick, it can be polished with an emery cloth on a flat surface until it can easily slide into the notch. It may also be a little high and require filing of the top edge.

7 After the new key has been installed and it has been determined that the new

sprocket will fit, oil the new O-ring and remount the lubricator to the end cover.

8 Put the new sprocket onto the shaft and set to measured dimension. Tighten the set screw.

9 Check alignment to the crankshaft drive sprocket with crankshaft centered in end play, using a straight edge, to within 1/32 inch (mm). When aligning this sprocket with the idler sprocket, be sure to take into account that the idler sprocket is thinner than the other sprockets. If not in alignment, adjust sprocket position as necessary.

10 Install chain and adjust using the instructions given in “Chain Adjustment” on Page 5-17.

11 Re-attach all tubing to the lubricator.

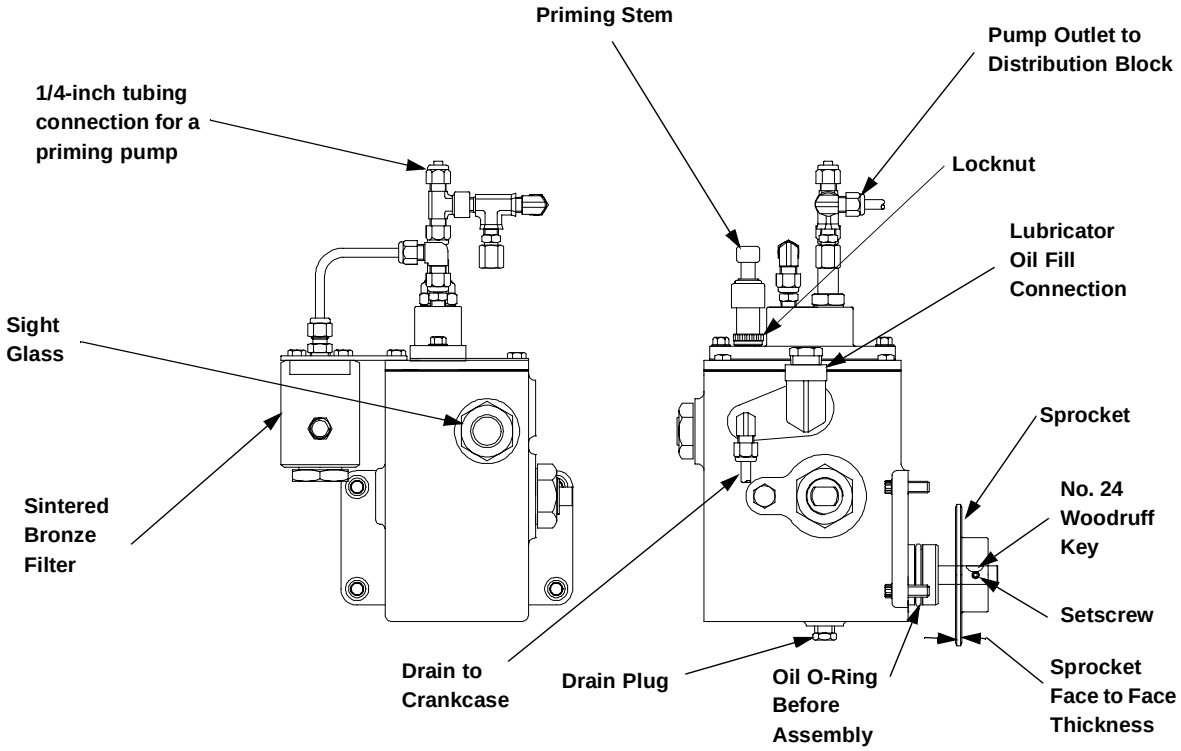


FIGURE 5-15: FORCE FEED LUBRICATOR PUMP W/ CHAIN SPROCKET - TYPICAL

Force Feed Lubricator Chain Sprocket Replacement - JGE/6 (Fenner Coupling)

1 On the JGE/6 Models, the sprocket on the force feed lubricator is secured by a Fenner drive coupling instead of set screws and a Woodruff key. A Fenner drive coupling is shown in Figure 5-16:.

2 With a good machinist rule, measure the exact distance from the inside of the auxiliary end cover to the near edge face of the chain sprocket. Note the measurement for the proper positioning of the new sprocket. Remove chain.

3 Loosen the hex on the Fenner coupling. Remove the sprocket and Fenner drive coupling. Detach all tubing to the lubricator.

4 Remove the four mounting bracket capscrews and remove the lubricator.

5 With the lubricator on the bench, install and oil a new O-ring.

6 Disassemble, clean and inspect the Fenner drive coupling. Oil threads and reassemble Fenner drive coupling.

7 Remount the lubricator to the end cover.

8 Mount the Fenner drive coupling and new sprocket onto the shaft.

9 Set the lubricator sprocket to the measured dimension.

10 Tighten the Fenner drive coupling hex. Note that the tightening action may cause the sprocket to move toward the cover slightly. After tightening, recheck the sprocket to auxiliary end cover dimension, adjust as required until the new measurement equals the original measurement.

11 Check alignment to crankshaft drive sprocket, with crankshaft centered in end play, using a straight edge to within 1/32 inch (1mm). If not in alignment, adjust sprocket position as necessary.

12 Install chain and adjust using the instructions given in “Chain Adjustment” on Page 5-17.

13 Re-attach all tubing to the lubricator.

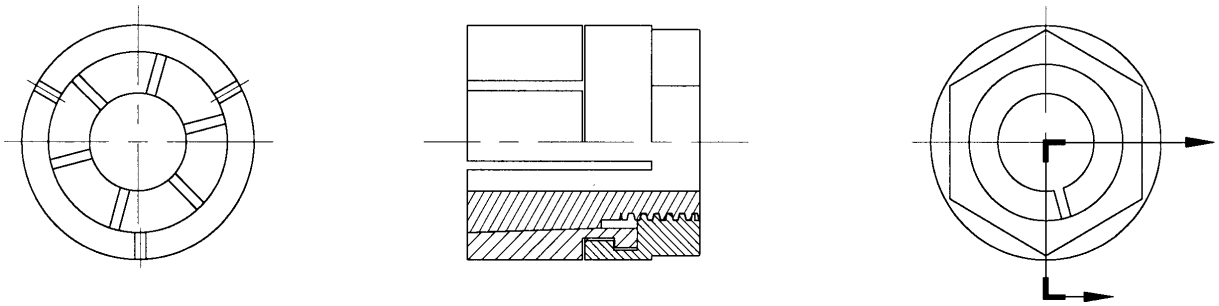


FIGURE 5-16: FENNER DRIVE COUPLING

Piston And Rod - Removal

⚠ CAUTION

TO PREVENT PERSONAL INJURY, ENSURE THAT COMPRESSOR CRANKSHAFT CANNOT BE TURNED BY THE DRIVER OR COMPRESSOR CYLINDER GAS PRESSURE DURING MAINTENANCE: -- ON ENGINE-DRIVEN COMPRESSORS, REMOVE THE CENTER COUPLING OR LOCK THE FLYWHEEL. -- ON ELECTRIC MOTOR-DRIVEN COMPRESSORS, IF IT IS INCONVENIENT TO DETACH THE DRIVER FROM THE COMPRESSOR, THE DRIVER SWITCH GEAR MUST BE LOCKED OUT DURING MAINTENANCE.

BEFORE PERFORMING ANY MAINTENANCE, COMPLETELY VENT SYSTEM. BEFORE REMOVING A CYLINDER HEAD, BACK OFF ALL CAPSCREWS 1/8 INCHES (3 mm). MAKE SURE THE HEAD IS LOOSE AND THE CYLINDER IS COMPLETELY VENTED.

1 Remove the crosshead guide side covers and the cylinder head. The cylinder head should be loosened first to the Caution above.

2 Move the crosshead to its inner dead center position. Back off, but do not remove, the crosshead nut set screws. Loosen the crosshead nut with the special slugging wrench. (See Figure 7-1: on Page 7-2.) Use the open end wrench for hex nuts and the peg wrench for round nuts.

3 Remove the cylinder head. In the case of tandem cylinders where the outboard cylinder bore is smaller than the inboard bore, it is necessary to remove the outboard cylinder. Support such cylinders during removal and installation. Excessive weight on the piston and rod assembly will cause the rod to bend.

4 Use the Piston Nut Spanner or Turning Tool to screw the piston and rod assembly out of the crosshead. (See Figure 5-19: on Page 5-28.) The two dowels on the tool fit the holes in the piston nut. Turn the crosshead nut off the piston rod.

5 As the piston leaves the cylinder, be careful in handling the piston rings. Despite their toughness in service, rings are fragile with regard to removal. Always handle them with clean tools and hands protecting the rings from nicks, marring, and bending. Move the piston out of the cylinder until a fraction of the first ring clears the cylinder. Encircle the ring by hand (use a band for larger sizes) until it is clear and remove it. Use this same procedure to remove the succeeding rings and wear band.

6 Slide the piston rod out of the head end. The threaded crosshead end of the rod is 1/4 inches (6 mm) smaller in diameter than the inside diameter of the packing. Using extreme care, slowly slide the piston rod through the packing so as not to damage the rod threads or the packing rings.

Piston And Rod - Disassembly and Reassembly

Disassembly

Older rods not drilled and threaded for the G-5266 torquing tool (see Figure 5-18:), require a clamping fixture and special tools for proper piston and rod disassembly/reassembly. They are best done by a qualified service center. Rods which do not have the threaded hole may be reworked by a qualified machine shop. Contact your distributor or Ariel for details.

NOTE: DO NOT USE THE G-5266 TORQUING TOOL ON 4-5/8-INCH (117mm) CYLINDER CLASS.

Reassembly

1 Clean all piston and rod assembly parts thoroughly. Be sure piston is internally clean and dry.

NOTE: NON-LUBE COMPRESSOR CYLINDER COMPONENTS HAVE SPECIAL CLEANING REQUIREMENTS. COMPLETE N0N-LUBE CYLINDERS, ORDERED AND SHIPPED FROM ARIEL, ARE PROVIDED CLEANED AND PROTECTED TO NON-LUBE SERVICE REQUIREMENTS. INTERNAL PARTS SHIPPED LOOSE, CONTAMINATED INTERNAL SURFACES AND ALL REPAIR PARTS MUST BE CLEANED TO SPECIAL ARIEL NON-LUBE SERVICE REQUIREMENTS. REFER TO "Cleaning Non-Lube Compressor Cylinder Components" on Page 5-46.

2 Inspect parts for nicks, burrs or scratches and dress surfaces with a fine grit stone as required.

3 Inspect the piston rod threads and collar shoulder. Threads are to be clean and free of burrs. Install the collar and nut onto the piston rod to verify that the inside diameter fits and rotates freely. Run the piston nut down by hand until the rod threads protrude to verify freedom of thread engagement. Remove nut and collar.

4 Check piston rings and wear band to determine wear (see "Determining Ring Wear:" on Page 5-30 and "Determining Wear Band Wear:" on Page 5-30). Replace piston rings and wear bands as required.

5 If the piston rod is not drilled and threaded for G-5266 torquing tool (see Figure 5-18:), clamp the piston rod in Torque Fixture D-0961, using clean and oil free PVC liners (see Figure 5-17:). Clamp the piston rod as close to the collar as possible, but where holding device will not interfere with the piston. Older rods not drilled and threaded for the G-5266 torquing tool are best done by a qualified service center.

6 Apply a thin coating of "Never-Seez" (anti-seize and lubricating compound) to the piston rod shoulder and rod collar locating bands, and collar face in contact with the piston, then slide collar onto rod. "Never-Seez" is manufactured by Bostick, Boston Street, Middleton, MA 01949 USA, Telephone: 508-777-0100.

7 Apply a thin coating of "Never-Seez" to piston rod threads at the piston end, then slide piston in place onto rod and collar.

NOTE: ONE END OF SINGLE PIECE PISTONS ARE MACHINED 0.002 INCHES (0.05 mm) UNDERSIZE ACROSS A 3/4 INCH (20mm) WIDE BAND FOR MANUFAC-

TURING PURPOSES. IF THE PISTON IS SYMMETRICAL AND CAN BE INSTALLED IN EITHER DIRECTION, ASSEMBLE WITH THE UNDERSIZE BAND TOWARD THE HEAD END.

8 Apply a thin coating of “Never-Seez” to the piston nut threads and piston mating face. Install nut and hand tighten.

9 For piston rods not drilled and threaded for the G-5266 torquing tool, tighten the piston nut to the recommended torque found in Table 1-14 on Page 1-18, using the piston nut spanner (see Figure 7-1: on Page 7-2) and piston torquing fixture (see Figure 5-17:). It may be necessary to use a hydraulic torque wrench to achieve the required torque. For piston rods drilled and threaded for the G-5266 torquing tool (see Figure 5-18:), put the optional torquing tool in place, with the two dowels placed into the piston rod nut. Tighten the puller head, until torquing tool is tight against the piston rod assembly (minimum of 8 turns), then back off 1/4 turn. Note that the puller head is provided with barring holes to insert a 3/8” (9.5 mm) rod, to assist in tightening or loosening the puller, if necessary. A hydraulic pressure of 3,500 psi (24.1 MPa) is to be applied to the torquing tool to stretch the piston rod. Then 50 lb-ft (68 N·m) of torque is to be applied to the 9/16 inch hex pinion gear drive. The hydraulic pressure is then released and the torquing tool removed. The G-5266 torquing tool is also used and pressurized to disassemble a piston and rod.

⚠ CAUTION

DO NOT OVERPRESSURE THE HYDRAULIC TORQUING TOOL. OVERPRESSURE CAN CAUSE THE TORQUING TOOL TO FAIL AND/OR RESULT IN EXCESSIVE PRE-LOAD OF THE PISTON ROD. PISTON ROD FAILURE CAN OCCUR DUE TO EXCESSIVE PRE-LOAD. SUCH FAILURES CAN RESULT IN PERSONAL INJURY

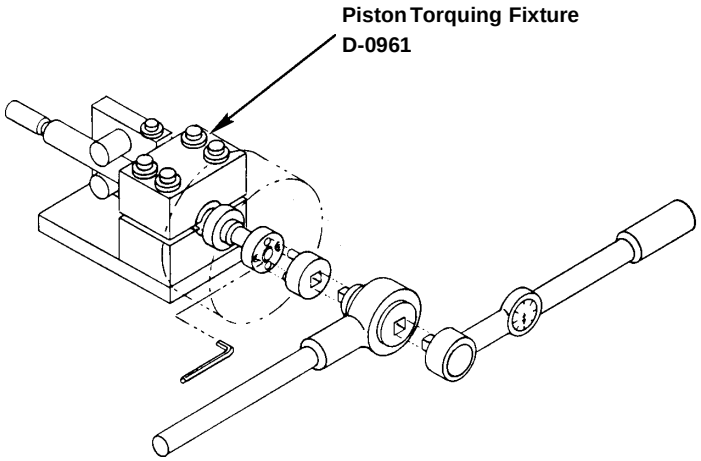


FIGURE 5-17: PISTON AND ROD CLAMPING REQUIREMENTS

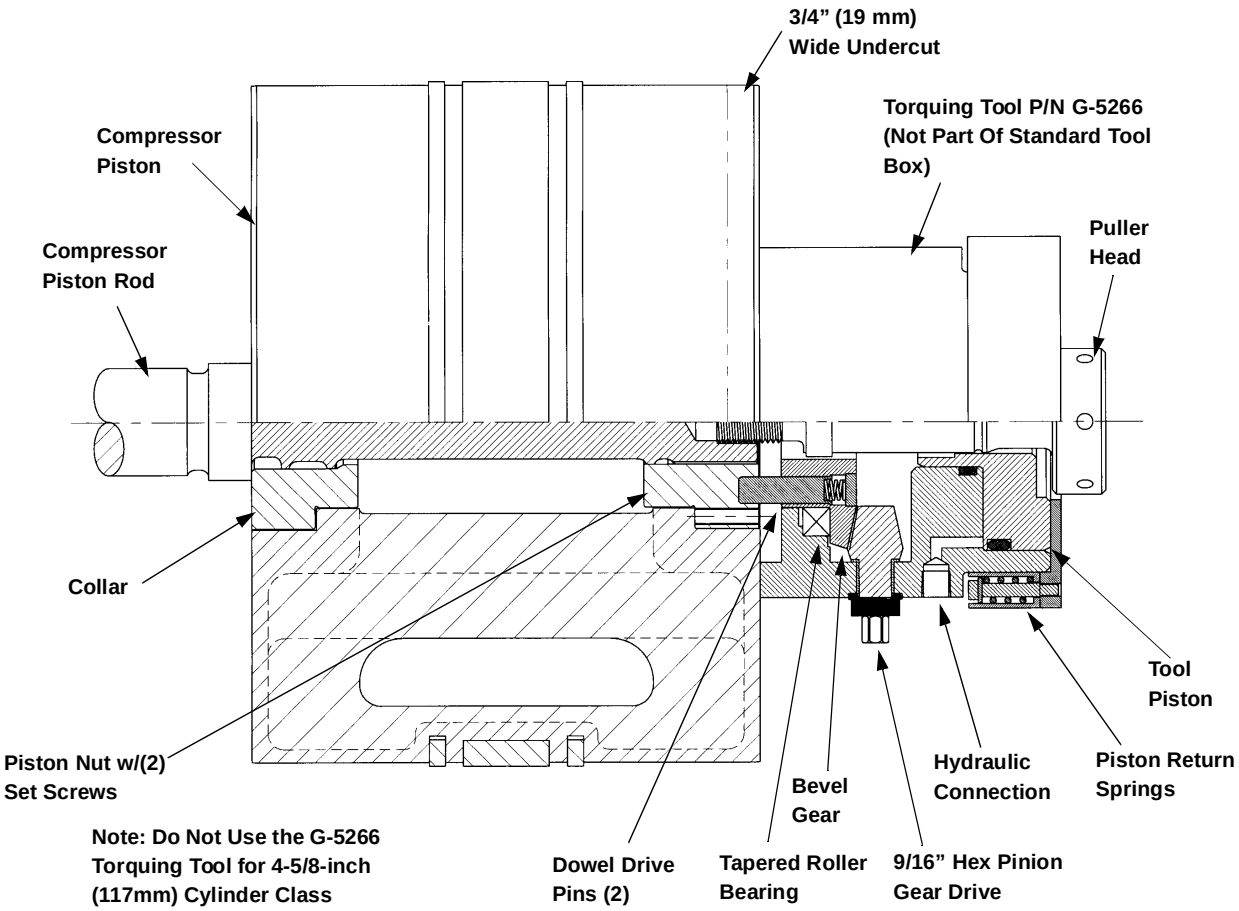


FIGURE 5-18: PISTON NUT TORQUING TOOL (P/N G-5266)

10 After tightening, the piston rod should not protrude more than .010 inches (0.25 mm) past the piston face.

11 Apply a thin coating of “Never-Seez” to two new Allen set screws. Two new Allen wrenches are also required per nut at each tightening and are discarded after their one time destructive use. Install the set screws and tighten so that the Allen wrench is permanently deformed by tightening past its yield point (twisted through a 15 degree arc).

12 Prick-punch the piston nut, within 1/16 inches (1.5 mm) of the set screw threads, to lock the set screws in place.

13 Weigh the piston rod assembly with the piston rings and wear bands included. Stamp the weight on the piston’s head end. Flatten any raised lips to avoid clearance measurement errors. Record this weight for future reference.

Piston and Rod - Installation

1 Install the piston/rod assembly with piston rings and wear band into the cylinder. The threaded crosshead end of the rod is 1/4 inches (6mm) smaller than the inside diameter of the packing. It is not necessary to use an entering sleeve if reasonable care is taken, but a sleeve may be helpful. Using a non-metallic sleeve from the crosshead side will help ensure that packing rings are not damaged. An optional tool, Part Number A-8559, is available from Ariel (refer to Figure 7-3: on Page 7-3).

2 Screw the crosshead nut onto the piston rod. Make sure all threads and nut seating surfaces are well lubricated with clean, fresh oil to ensure proper assembly. Position the crankshaft in the inner dead center position. Remove a crank end discharge valve. Determine the required piston crank end clearance as shown on the cylinder identification plate. Refer to Table 1-3 on Page 1-9. Insert a feeler gage, equal to the required crank end clearance, thru the discharge valve pocket. Use the tools illustrated in Figure 5-19: on Page 5-28 to screw the piston rod into the crosshead until piston is snug against the feeler gage. Snug the crosshead nut, but do not tighten. Remove the feeler gage.

3 Ensure that the Piston Turning Tool has been removed. Replace the cylinder head and gasket. Tighten all cylinder head bolts evenly to the proper torque value listed in Table 1-14 on Page 1-18.

4 Remove a head end suction valve. Determine the required piston head end clearance as shown on the cylinder identification plate. Refer to Table 1-3 on Page 1-9. Rotate the crankshaft 180° to the outer dead center position, and using the feeler gages thru the valve pocket, check the head end clearance. Determine that measured clearance is within the required clearance limits.

5 Tighten the crosshead nut to the proper torque value listed in Table 1-14 on Page 1-18.

6 Tighten set screws in the crosshead nut.

7 Before installing the side covers, apply an anti-seize lubricant to the gaskets. This will aid removal at a later date.

8 Replace the crosshead guide side covers; tighten all capscrews.

9 Replace the valve assemblies, tighten all valve cap bolts evenly to the proper torque value listed in Table 1-14 on Page 1-18.

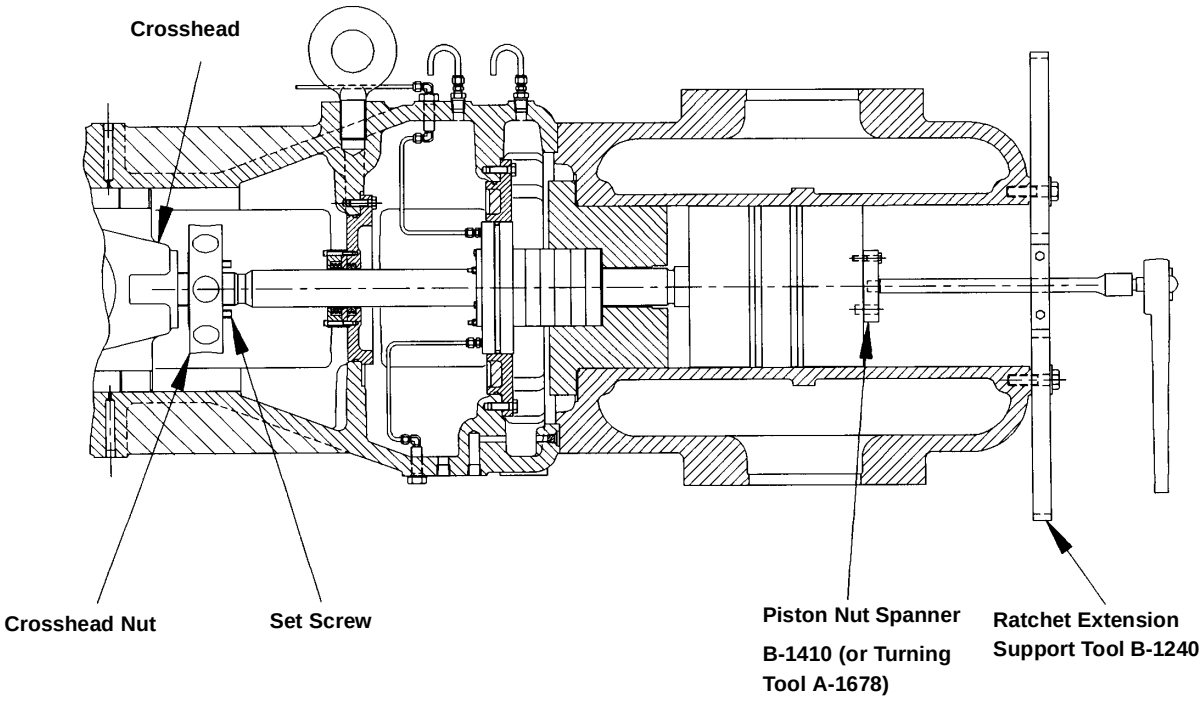


FIGURE 5-19: PISTON AND ROD INSTALLATION - TYPICAL

Piston Rod Run Out

Check piston rod run out after installing a new unit, after relocating a unit or after any maintenance that could affect rod run out.

Verify that the crosshead guides are properly shimmed to level. See “Procedure For Setting and Aligning” on Page 2-1. Verify that the crossheads are in direct contact with the bottom guide. A 0.0015 inches (0.04 mm) feeler stock should not be able to be inserted more than 1/2 inches (13 mm) at all four corners of the crosshead.

Position the dial indicator[1] stem against the piston rod, close to the packing case. Set the indicator to zero with the piston toward the crank end. Readings are to be taken in both the vertical and horizontal directions. When measuring vertical rod moment, upward movement will be recorded as positive, downward movement will be recorded as negative. When measuring horizontal rod movement, rod movement toward the auxiliary end of the frame, will be recorded as a positive reading, movement toward the drive end of the frame will be recorded as a negative reading. Copy Table 5-3 to record readings. Bar over crankshaft by hand and record readings at mid-stroke and with piston at the head end.

1. Use a 0.0001 inches (0.001 mm) increment dial indicator.

TABLE 5-3: PISTON ROD RUN OUT

THROW NUMBER:		1	2	3	4	5	6
VERTICAL	Piston @ CE	0	0	0	0	0	0
	Mid-Stroke						
	Piston @ HE						
HORIZONAL	Piston @ CE	0	0	0	0	0	0
	Mid-Stroke						
	Piston @ HE						

Compare readings to Table 5-4.

TABLE 5-4: MAXIMUM ACCEPTABLE PISTON ROD RUN OUT READINGS

DIRECTION	INCHES	(mm)
Vertical	0.0020	(0.051)
Horizontal	0.0010	(0.025)

If a vertical reading is greater than the maximum acceptable reading, the following procedure is to be used to determine acceptability: With the piston at the head end, use feeler gages to determine clearance at the top of the piston. On wear band or rider ring pistons, this clearance is over the rings or band. Feeler top clearance is to be divided by (÷) 2 and then subtract, (-) 0.005 inches (0.13 mm). Place a feeler of this calculated thickness under the bottom of the piston. Place the feeler under the wear band or rider ring on wear band or rider ring pistons. This feeler is to be long enough to stay under the piston as the piston is moved throughout its stroke. Re-measure vertical run out and compare to acceptable limits in the table above. The horizontal readings, taken without the use of feelers are to be used for acceptance. Copy Table 5-5 and record calculations and readings.

TABLE 5-5: FEELER THICKNESS TO CORRECT FOR PISTON WEIGHT

LINE	THROW NUMBER:	1	2	3	4	5	6
1	Top Feeler Clearance						
2	Line 1 (÷2)						
3	Line 2 - 0.005 inches (-0.13mm)	- 0.005” (-0.13mm)	- 0.005” (-0.13mm)	- 0.005” (-0.13mm)	- 0.005” (-0.13mm)	- 0.005” (-0.13mm)	- 0.005” (-0.13mm)
4	Bottom Feeler Thickness						
5	Vertical~Piston @ CE	0	0	0	0	0	0
6	Vertical~Piston @ HE						

If readings are not within acceptable limits after replacing worn parts and correcting any piping misalignment, the piston rod assembly should be replaced.

Piston Rings

All JGH and JGE double acting cylinders use one-piece angle cutfilled Teflon piston rings as standard.

Seal-Joint Rings

Seal-joint piston rings are standard for tandem compressor cylinders and are available for double acting cylinders. Refer to Figure 5-20:.

Seal-joint piston rings are directional and must be installed properly.

To utilize the seal-joint rings in double acting cylinders, contact Ariel for the new part numbers.

FIGURE 5-20: SEAL-JOINT RINGS

Determining Ring Wear:

Ariel recommends replacing rings when the end gap has increased to three times the new dimension.To measure the end gaps, insert the rings in the cylinders without pistons. (See Table 1-8 on Page 1-12 for new end gap dimensions.)

Removal:

See paragraph 4. at “Piston And Rod - Removal” on Page 5-23 for piston ring removal.

Wear Bands

22-1/2H, 22-1/2E and all T cylinder class pistons use one one-piece angle cut filled Teflon wear band.

Determining Wear Band Wear:

Since the wear band does not work as a sealing ring, end gap is not critical. The amount of wear band projection beyond the outer diameter of the piston is important. Wear band projection can be checked by measuring piston to cylinder bore clearance at the bottom of the bore. This can be done without removing the piston from the cylinder. Replace the wear band before it has worn enough to allow the piston to touch the cylinder bore.

Piston Rings - Installation

1 Place the rings over the grooves in the piston. Compress the Teflon one-piece rings by hand.

2 With the rings fully compressed in the grooves, insert the rod and piston into the cylinder. Make sure the one-piece rings stay in place while inserting the piston and rod.

NOTE: RING GAPS ARE TO BE STAGGERED AROUND THE PISTON, RATHER THAN IN LINE.

3 Follow the steps under “Piston and Rod - Installation” on Page 5-27.

Wear Band - Installation

Install the wear band as if it was another piston ring as above.

Piston Rod Pressure Packing - Removal

1 Remove the piston and piston rod. See “Piston And Rod - Removal” on Page 5-23.

2 Remove packing diaphragm and oil wiper packing.

3 Disconnect the lube oil tube and/or coolant connections from the top of the packing gland and the primary vent tube from the bottom of the gland. Remove the twelve point capscrews that hold the pressure packing gland to the cylinder.

4 At this point do not remove the small nuts from the studs. These studs hold the entire packing case together so it can be removed as an assembly.

5 Pull the entire pressure packing out into the crosshead guide. It will then come out through the large side opening of the guide. The pressure packing may now be taken to a clean place for disassembly.

6 Set the pressure packing on a clean surface on its nose cup or cylinder end. Three long tie studs hold the pressure packing together. The stud holes are not equally spaced. This prevents the stack of parts from being aligned incorrectly. Remove the stud nuts and the pressure packing can be unstacked. Replace these nuts each time the pressure packing is serviced.

7 Ring wear can be determined by placing the assembled rings, (note match-marks), on the piston rod. Check end gap clearance. If the ends butt, or nearly butt, they should be replaced by new rings.

8 Fins or wire edges on the rings due to wear should be carefully filed off so that all matching edges will be square.

9 The metal gasket on the end cup can be pried loose with a sharp awl. Be careful not to scratch the sides of the gasket groove.

10 Before reassembly be certain all parts are perfectly clean.

Piston Rod Packing - Reassembly

1 Be sure to refer to the pressure packing assembly in your parts book. Ariel supplies four parts books with each unit. Please contact your distributor if you do not have a parts book. A pressure packing assembly drawing also is packaged with each pressure packing re-build kit.

2 If installing a new set of rod rings in an existing packing case, the case parts need to be inspected for wear. Cups should be smooth and flat on the back side where the rod rings must seal. If the cups or grooves have worn concave or tapered, they should be reground or relapped. It is rarely necessary to alter the crosshead side of the cups, however, if this is found necessary, care must be taken so that the correct side clearance for the renewal rings is not destroyed.

NOTE: IF PREMATURE WEAR IS SUSPECTED, REFER TO THE ARIEL "Cylinder And Packing Lubrication Requirements" on Page 4-4.

3 Before a packing case is installed, it should always be disassembled and thoroughly cleaned in an appropriate solvent for the intended service.

4 Make sure that each rod ring and cup is properly positioned and that rings are liberally coated with a clean lubricant before reassembly. Examine all parts for unusual nicks or burrs which might interfere with the free floating of the rod ring in the cups. Particular care should be taken with rod rings made of soft materials, such as bronze or TFE, and it is extremely important that wiper rings be handled and installed so as to prevent damage to the scraping edges.

5 Parts should be laid out on a work bench so that they can be installed progressively with each in its correct position and the rod rings with their proper faces toward the pressure. Note that all rod ring segments are carefully lettered and must be assembled accordingly. This is most important in order to ensure proper sealing. After the tie stud nuts are tightened, all rings should be free to "float" radially in each cup.

6 For new installations, care must be given to the cleaning of all accumulated dirt in the lines and compressor because foreign material will lodge in the packing to become destructively abrasive.

7 Prior to installing the packing case into the cylinder, the end cup gasket must be inspected for nicks and damage that would cause it to leak in service. When in doubt, replace the gasket with a new one.

8 Before installing the packing case into the cylinder, be sure the gasket surface in the packing counter bore on the crank end of the cylinder is clean and not scratched.

9 Reinstall the complete packing case assembly with the oil supply point on top. Using the rod packing bolts, pull the packing into place.

10 Reinstall the packing diaphragm and wiper packing.

11 Reinstall the piston and rod. Follow the steps under "Piston and Rod - Installation" on Page 5-27.

12 After the crosshead nut has been tightened, tighten the rod packing bolts evenly to the recommended torque in Table 1-14 on Page 1-18. This procedure will ensure that the pressure packing comes up square on its nose gasket. Alignment is readily accomplished by the use of feelers to maintain a uniform clearance all around between the case bore and the rod.

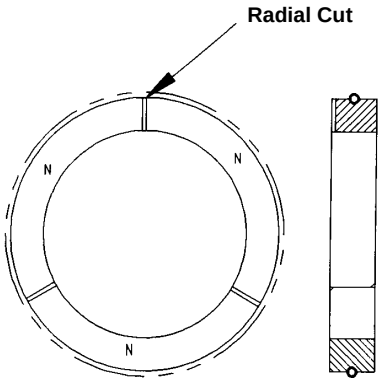
13 Retighten the small tie stud nuts. Reinstall the tubing connections for the oil supply, primary vent and/or coolant. Take care not to cross-thread the tubing nuts. Tubing nuts must be tight.

NOTE: AFTER INSTALLING THE NEW PRESSURE PACKING RINGS, REFER TO "Force Feed Lubrication System" on Page 4-17 FOR INSTRUCTIONS FOR PRIMING THE FORCE FEED LUBE SYSTEM. PRIMING SHOULD BE REPEATED EACH TIME A COMPRESSOR IS STARTED BECAUSE OIL LINES MAY HAVE BEEN BLED DURING DOWN TIME. FOLLOW INSTRUCTIONS IN "Force Feed Lubricator Adjustment" ON PAGE 3-8 FOR LUBRICATION RATES THAT ARE RECOMMENDED FOR BREAK-IN OF A NEW MACHINE. BREAK-IN LUBE RATES ARE TWICE THE NORMAL RATES - OR ONE-HALF THE NORMAL INDICATOR PIN CYCLE TIME.

Types of Piston Rod Packing Rings

Type "P" Pressure Breaker

This is a single ring. It is cut radially into three equal segments. Total end clearance for the ring is 0.040 to 0.046 inches (1.02 to 1.17mm) for PEEK material and 0.020 to 0.026 inches (0.51 to 0.66mm) for cast iron. This ring breaks down or slows the gas flow without sealing it completely. This end gap should be maintained by adjusting the ring gap or replacing the ring. See Figure 5-21:



Material: PEEK

Letters toward pressure/cylinder

FIGURE 5-21: TYPE "P" PRESSURE BREAKER

Type "BTR" Single Acting Seal Set

This set is made up of three rings. It seals in one direction only. The first ring (pressure side) is radially cut with an installed total end gap of 0.93 to 0.125 inches (2.36 to 3.18mm) for

teflon and 0.107 to 0.125 inches (2.72 to 3.18mm) for bronze, polyimide and PEEK. Material for this ring is Teflon. The second ring is a tangentially step cut ring and is also made of Teflon. The first two rings are doweled so the cuts are staggered from one ring to the other. The third ring is called a back-up ring and is radially cut. The bore in this ring is larger than the rod diameter. This allows the radial joints to be tight together forming a gas seal. No dowel is necessary for this ring. See Figure 5-22:

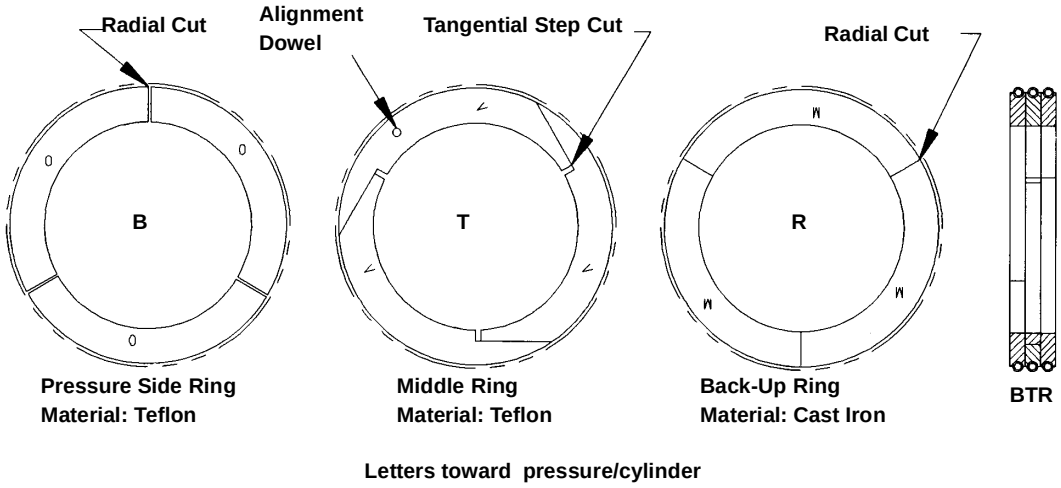


FIGURE 5-22: TYPE "BTR" SINGLE ACTING SEAL SET

Type "BD" Double Acting Seal Set

This set consists of two tangentially step cut rings. The rings are doweled so the tangential cuts are staggered from one ring to the other. The installed total end gap is 0.93 to 0.125 inches (2.36 to 3.18mm) for teflon and 0.107 to 0.125 inches (2.72 to 3.18mm) for bronze, polyimide and PEEK. The set is double acting in that it will seal in either direction. It is used in cylinders operating near atmospheric pressure to prevent air from entering the cylinder. Install with the match mark letters facing the pressure. See Figure 5-23:

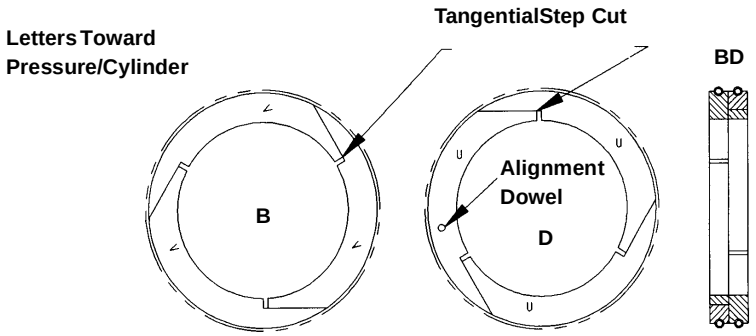


FIGURE 5-23: TYPE "BD" DOUBLE ACTING

Type "3RWS" Oil Wiper Set

This set uses three radial cut rings. They are doweled to provide a staggered arrangement. Their purpose is to keep crankcase oil out of the packing and cylinder. Assemble with the blank face towards the oil (crankcase) and the slotted side towards the pressure packing. See Figure 5-24:

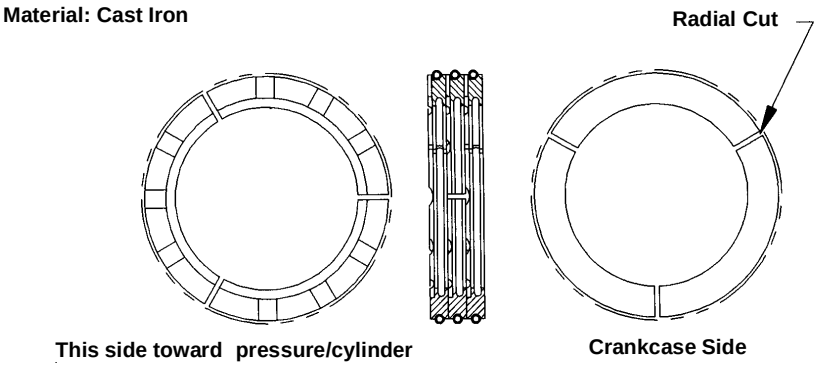


FIGURE 5-24: TYPE "3RWS" WIPER SET

Type "WAT" Double Acting Seal Set

This set is made up of three rings. The first two rings (pressure side) are radially cut. The third ring is a tangentially step cut ring. The last two rings are doweled so the cuts are staggered from one ring to the other. The first ring, along with the center ring, forms a wedge that overcomes rod friction and holds the ring set against both groove faces during either direction of rod travel. The installed total end clearance is 0.093 to 0.125 inches (2.36 to 3.18mm). This ring set is intended primarily for low pressure application. Install with the match mark letters facing the pressure. See Figure 5-25:

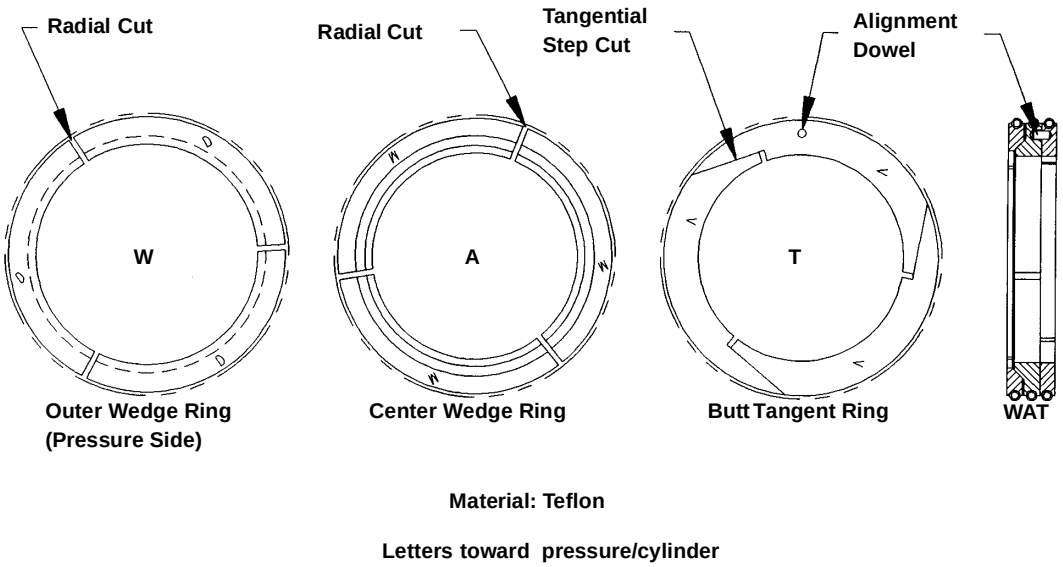
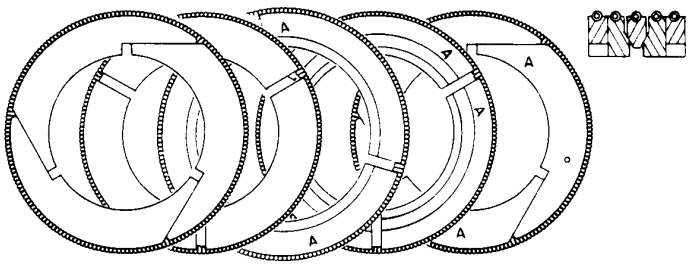


FIGURE 5-25: TYPE "WAT" DOUBLE ACTING

Type "AL" Double Acting Seal Set

This set is made up of five rings which function like a double ended "WAT" design ring set. The installed total end clearance is 0.093 to 0.125 inches (2.36 to 3.18mm). It is meant to be used in a groove into which low-pressure fluid is supplied which serves to totally block leakage.



Material: Teflon

FIGURE 5-26: TYPE "AL" DOUBLE ACTING

Arrangement of Piston Rod Packing Rings

Ariel supplies JGH and JGE packings in five pressure ranges. The general arrangement of the oil supply, seal ring and vent locations is shown below:

The type of rings used will depend upon the pressure application.

The oil wiper rings and one seal ring set are carried on a separate diaphragm in the crosshead guide.

NOTE: Refer to the packing assembly in your parts book. See Figure 4-13: and Figure 4-14: for Packing Tubing and Distance Piece Venting; and Figure 4-15: and Figure 4-16: for Packing Lubrication and Venting.

Piston Rod Packing Ring Material

Some years ago bronze was the standard material for all Ariel packings. Bronze, however, is totally unsatisfactory for sour gas service, (hydrogen sulfide in the gas). PEEK, cast iron and Teflon provide outstanding service with sour gas, and since they perform equally well with sweet gas, they are now standard materials.

A typical packing will have a PEEK pressure breaker, Teflon/cast iron single acting rings, all Teflon double acting rings, and a cast iron wiper set. The Teflon is glass reinforced and impregnated with molybdenum disulfide. This provides a strong, slick material to reduce friction and wear.

Valves

Most valves in JGH and JGE cylinders use non-metallic plates.

⚠ CAUTION

BEFORE ATTEMPTING TO REMOVE ANY VALVE CAP, BE CERTAIN THA ALL PRESSURE HAS BEEN VENTED FROM THE COMPRESSOR CYLINDER. THE PRESSURE MUST BE COMPLETELY VENTED FROM BOTH THE SUCTION AND DISCHARGE PASSAGES OF THE CYLINDER. SEE FIGURE 1-3: ON PAGE 1-4 FOR LOCATION OF IMPORTANT SAFETY INFORMATION PLATES.

Valves - Removal

1 Loosen all of the bolts slightly, on each valve cap. With all the bolts loose, the cap should stay in its original position. If it pushes out on its own accord-stop! Take steps to completely vent the cylinder. See Caution above. A typical valve assembly is shown in Figure 5-27: on Page 5-40.

After all the above safety checks, remove the valve cap bolts. A pair of prybars (or screwdrivers), one on each side of the cap, will help pry it loose. With the retainer still in place, screw a valve tool over the valve center bolt. (See Figure 7-1: on Page 7-2.) Now the valve and retainer can be pulled out together.
For cylinder class 2-1/4E-FS-HE, 2-1/4H-FS-HE, 3E-FS-HE and 3H-FS-HE tandem cylinders, the suction and discharge piping and cylinder head must be removed to gain access to the concentric valve. A concentric valve combines the suction and discharge valves in one assembly. See Caution at "Piston And Rod - Removal" on Page 5-23

2 In most cases the flat metal gasket will remain in the pocket. It is difficult to see. A flashlight and a small mirror on an adjustable rod are the best tools to see the gasket clearly. On cylinders with horizontal valves, the gasket may fall into the gas passage. A small magnet on a flexible extension rod will help fish it out. This gasket should be replaced after every other use.

Valves - Maintenance

Ariel uses valves manufactured by Hoerbiger Corporation. Before servicing any valve refer to the correct valve assembly drawing and parts list and Hoerbiger's literature in the Parts Book. On the valve assembly drawing you will notice that valves have different springing for different pressure levels. The cylinder cover sheet in the Parts Book lists the valve originally supplied with each cylinder. If different operating pressures are encountered, then different springing may be required.

The suction valve must be selected on the basis of operating suction pressure and the discharge valve for operating discharge pressure. Proper valve spring selection is also based upon the operating speed (RPM), gas specific gravity and the suction temperature of the gas.

Contact Ariel, Mount Vernon, for assistance in valve selection.

Valves - Reassembly

1 The 1/32 inches (0.8 mm) thick soft metallic flat gasket should be coated with an anti-seize lubricant. It can then be either inserted into the valve pocket or stuck on the valve. In either case, care must be taken to keep this gasket from falling into the gas passage.

2 The retainer keeper is a thermo-plastic thumb screw in a threaded hole in the bottom valve retainers. This should be screwed through just far enough to provide friction so that bottom retainers will not fall out while the cap is being installed.

3 Using the Valve Tool, illustrated in Figure 7-1: on Page 7-2, the valve and the retainer may be inserted into the pocket together. When installed correctly, the distance from the outer retainer face to the surface of the valve boss on the cylinder will be approximately 1/8 inches (3 mm) shorter than the length of the nose on the valve cap.

4 Inspect the valve cap o-ring for cuts or gashes and replace it if necessary. Lubricate the o-ring and the nose of the valve cap. Some high pressure cylinders use a soft metallic wire gasket in lieu of the o-ring design. Insert the cap and tighten the bolts evenly to the recommended torque in Table 1-14 on Page 1-18. See “Bolt Tightening for Valve Caps” on Page 5-41. If the assembly is correct, the distance from the underside of the cap to the valve boss surface on the cylinder will be approximately 1/8 inches (3 mm) when valve and gaskets are new. This dimension will vary as a result of valve maintenance and gasket thickness.

NOTE: BE CERTAIN ALL PARTS, GASKET FACES, AND MATING SURFACES ARE ABSOLUTELY CLEAN AND ALWAYS USE CLEAN, FRESH OIL ON THE THREADS BEFORE REINSTALLING BOLTS.

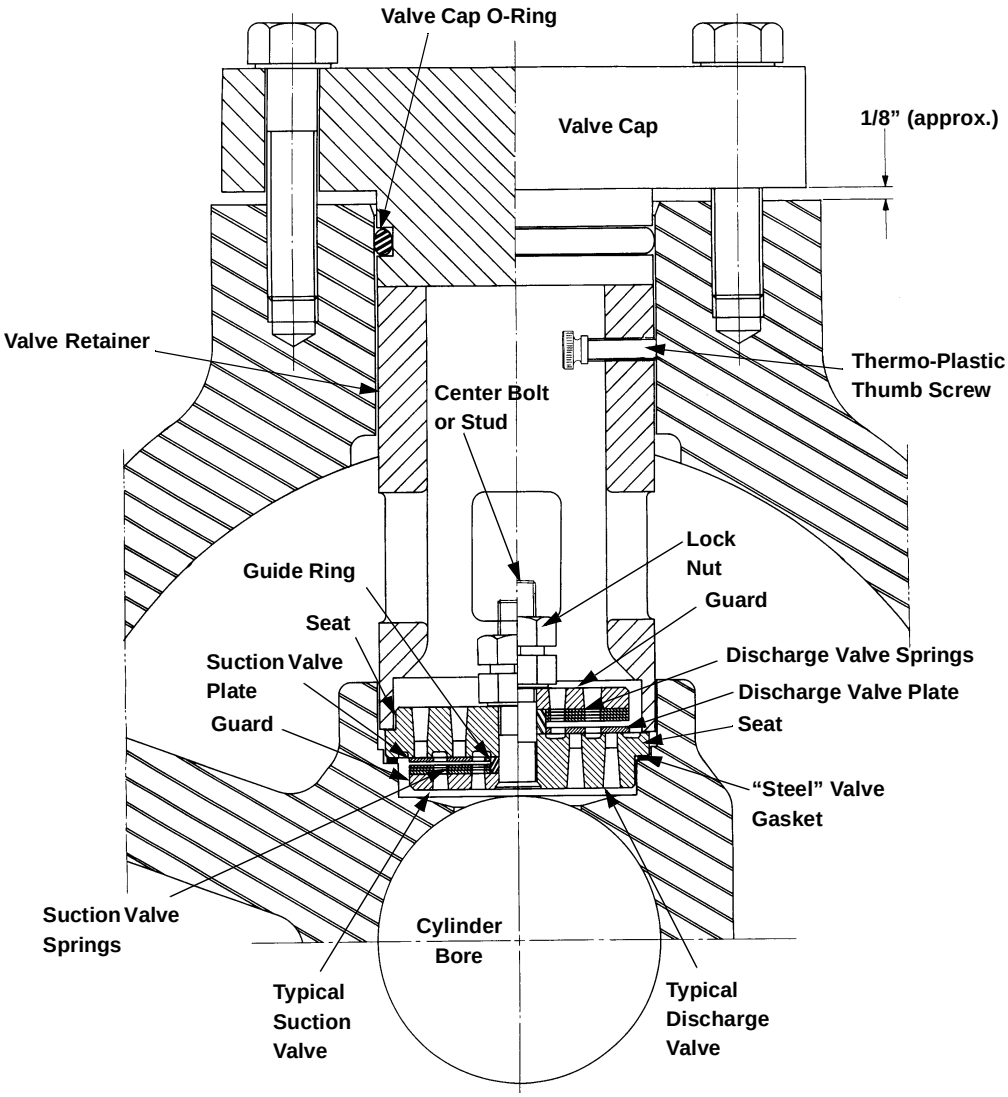


FIGURE 5-27: TYPICAL VALVE ASSEMBLIES

Bolt Tightening for Valve Caps

Proper fastener tightening technique is essential for sealing of valve caps with soft metallic wire gaskets used in some high pressure cylinders. It is important to draw up bolting to full torque in even and gradual steps. Do not allow the valve cap to be tightened with bias on one bolt or to become cocked in the bore. Such bias or cocking can cause uneven crush of the gasket, which could cause a leak and could also cause bolt failure. This step tightening procedure is also recommended for all valve caps.

Install the valve assembly (and high clearance spacer, when applicable), with the flat gaskets) and valve retainer, in the valve pocket. See “Valves - Reassembly” on Page 5-39. For high pressure applications, place a new, proper, soft metallic wire gasket on the retainer and install the valve cap. Be careful not to gouge the bore, distort or damage the wire gasket. Always use a new metallic wire gasket; wire gaskets are not reusable.

Lubricate threads and bolt seating surfaces with petroleum type lubricant, and install bolts. Do not use anti-seize compounds on valve cap bolting. Tighten each bolt until snug using a criss-cross pattern. Next, tighten each bolt to 25% of full torque, moving across from bolt to bolt, in a criss-cross pattern. See Figure 5-28: 1-2-3-4-5. Repeat this step for 50%, 75% and 100% of full torque.

Proper tightening and torquing is important for all valve caps, but is especially important for high pressure valve cap assemblies. High pressure applications have caution plates on the cylinder which are stamped with proper torque values:

⚠ CAUTION

SEVERE PERSONAL INJURY AND PROPERTY DAMAGE CAN RESULT IF VALVE CAP BOLTING IS NOT INSTALLED TO PROPER TORQUE OF _____FT. LBS. _____N·m.

REFER TO TECHNICAL MANUAL FOR PROPER TORQUING PROCEDURE.

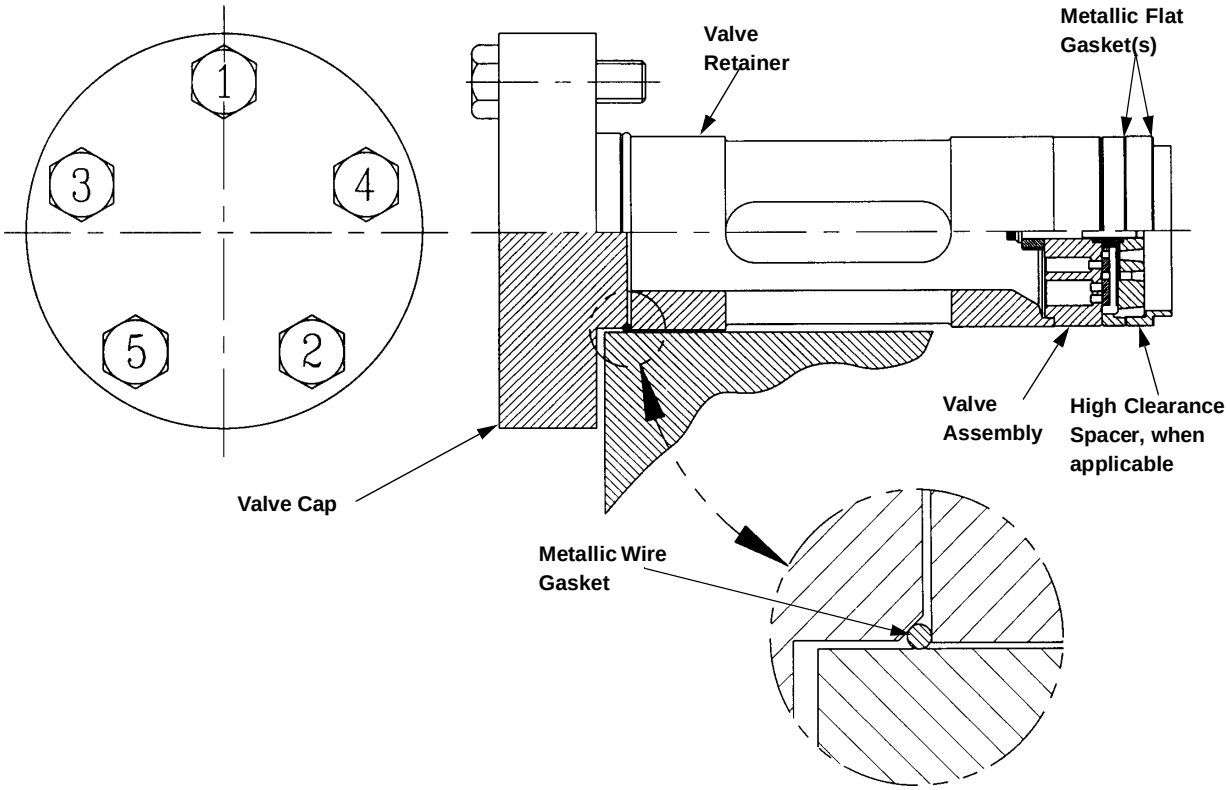


FIGURE 5-28: HIGH PRESSURE VALVE CAP ASSEMBLY

VVCP - Variable Volume Clearance Pocket Head End Unloader

Removal

Disconnect the VVCP packing vent. Remove the VVCP from the cylinder using similar procedures as when removing a cylinder head. The approximate weights of VVCP's for handling purposes can be found in the Ariel Data Book.

Disassembly

Unsnap the thread protector bellows from the slot in the hand wheel. With the locking handle locked, remove locknut and hand wheel. A hammer or puller may be required to break hand wheel to stem tapered fit. Loosen locking handle and unscrew to remove handle. Remove

socket head screws at inside of bolt flange and separate the halves of the VVCP. Unscrew the VVCP stem and piston assembly to remove.

⚠ CAUTION

TRAPPED GAS PRESSURE CAN PRESENT A PERSONAL SAFETY HAZARD WHEN SERVICING THE VVCP. WORK IN A WELL VENTILATED, NON SPARKING AREA. DO NOT BREATHE GAS OMMITTED FROM VVCP WHEN VENTING TRAPPED GAS.

Maintenance

To replace or clean the VVCP packing, mechanically depress the packing assembly spring and remove the snap ring. A piece of all thread rod, two hex nuts and two heavy washers may be used to compress the packing assembly. The inner washer must be large enough to catch the packing assembly, and small enough to allow the snap ring to be compressed and removed. Use proper snap ring pliers. Replace the VVCP packing when excessive leakage is noted at the vent. Remove the VVCP piston ring; replace as necessary.

Clean all parts to remove all debris, rust, etc. The stem and piston are permanently pinned, do not attempt to disassemble.

Reassemble the VVCP in reverse order, using a new o-ring at the bolt flange. Be sure that thread protector bellows are properly aligned when installing hand wheel. Lubricate stem with 3-4 pumps of all-purpose petroleum grease with a hand pump grease gun at the grease fitting.

To re-install the VVCP on the cylinder, use a new head gasket. Lubricate threads and bolting seating surfaces with petroleum type lubricant and install bolting. Tighten each cap screw until snug using a criss-cross pattern. Next tighten each cap screw to 25% of full torque, moving from cap screw to cap screw in a criss-cross pattern. Repeat this step for 50%, 75% and 100% of full torque. See Table 1-14 on Page 1-18 for tightening torque value. Reconnect VVCP packing vent. When installing a new VVCP, check total piston end clearance and re-set crank end/head end feeler clearances with VVCP completely closed. See Table 1-3 on Page 1-9 for clearances.

Adjustment

VVCP clearance volume may be changed with the compressor running or stopped. Consult the Packager's instructions regarding where to set theVVCP. Also reference the VVCP data sheet in the Ariel Technical Manual Parts Book.

The VVCP piston ring is designed not to be gas tight, to allow a nearly balanced gas pressure for ease of VVCP adjustment with the cylinder pressurized. Gas pressure behind the

VVCP piston normally vents when cylinder is vented. Process debris or rust around the piston ring can make a seal that takes some time to vent. If gas is trapped behind the piston, the VVCP can be adjusted when the cylinder is pressurized, but difficult to turn when the cylinder is vented. This problem is corrected by disassembling the VVCP and cleaning.

To adjust the volume, loosen the stem locking handle, so that stem is free to turn. Turn the stem by use of the hand wheel on the outboard end of the shaft. Turn hand wheel clockwise to load; counterclockwise to unload. Re-tighten the stem locking handle to 150 lbs-ft (203 Nm) torque.

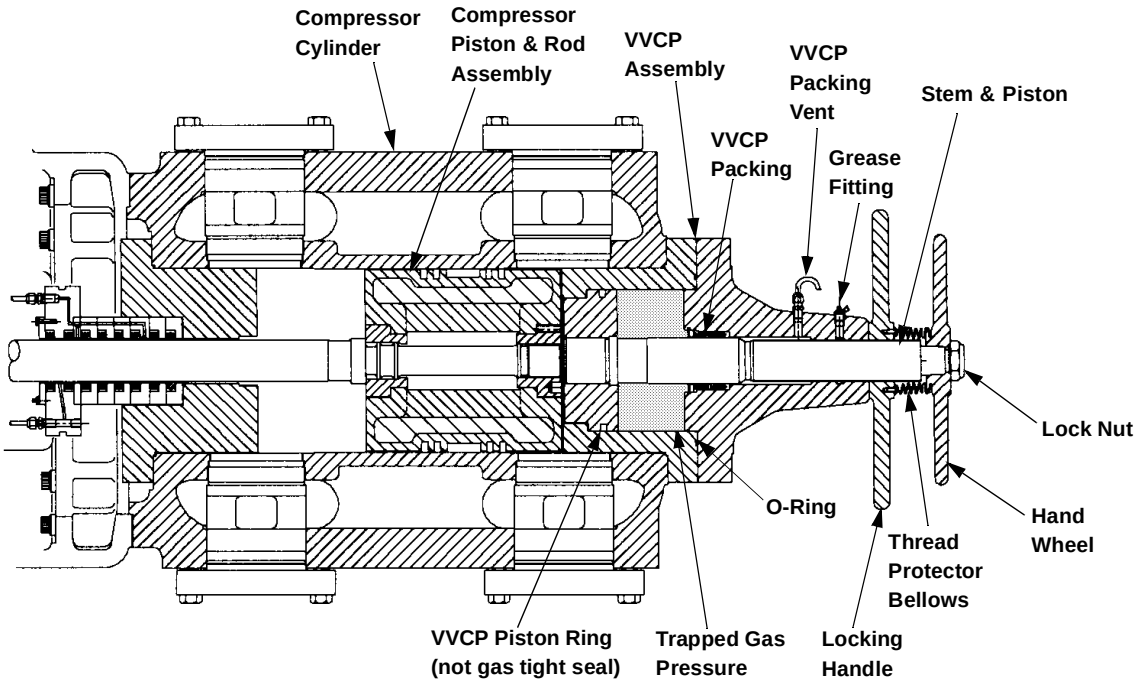


FIGURE 5-29: CYLINDER WITH VVCP - TYPICAL

Water-Cooled Compressor Rod Packing

When any disassembly of (optional) water-cooled rod packing cases is required from the as supplied - as received condition from the manufacturer, proper re-assembly and testing is required. This is to ensure that the cases do not leak.

Re-assembly

Cases are lapped, and care must be taken to prevent scratching of the mating surfaces of the cups. Scratches can cause significant leakage problems.

The cups are numbered on the outside diameter and are to be assembled in consecutive order, starting with the end cup. The studs are offset so the cups will only fit one way.

Make sure the tie studs are completely screwed into the end cup. Put the proper ring in the groove and facing the proper direction. Be careful when sliding parts onto the tie studs to ensure that no scratching occurs to the lapped faces.

Install second cup next, put the rings into place, and make sure the two (2) small o-rings are in place around the coolant holes.

Continue assembling the remaining parts in the proper configuration to the packing case drawing. In consecutive order, by repeating the above step.

Install tie stud-nuts and tighten to the values given in Table 1-14 on Page 1-18. Using fingers, make sure that all rings move freely, radially, in their grooves. Side loaded WAT and AL rings will be snug, but should still move using fingers.

Testing

100% verification of function is required for all internal passages.

The passages are to be checked by blowing compressed air thru the connection taps on the flange and verifying that air is exiting at the proper holes. When air is applied to the connection tap stamped “Coolant In”, air should be exiting the connection tap stamped “Coolant Out”, or if air is applied to the tap stamped “Lube”, air should be exiting at the appropriate cup on the inside diameter of the case.

Pressure leak test packing cases as follows:

1 Plug the “Coolant Out” connection>
2 Apply 60 to 100 psi (400 to 700 kPa) compressed air pressure to the “Coolant In” connection>
3 Submerse the pressurized case in a tank of oil (use water for non-lube cylinders).
4 After the air trapped in the ring grooves has been released, there should be no continuous stream of bubbles coming from the pressurized case.
5 Cases which fail this testing procedure are to be disassembled, inspected, repaired, re-assembled and re-tested.

All cylinders with water-cooled packing must be connected to a circulating water cooling system that will provide the required flow, pressure drop, inlet temperature and heat rejection, unless prior approval is obtained from Ariel to leave it unconnected.

Ethylene Glycol Contamination

Ethylene glycol contamination of a compressor can result from water-cooled compressor rod packing or oil cooler.

Ethylene glycol anti-freeze coolant mixture leaking into the compressor frame crankcase oil can cause crankshaft seizure due to lack of adequate lubrication. Crankcase oil should be changed as recommended in “Recommended Maintenance Intervals” on Page 6-1. Also, crankcase oil should be routinely sampled and analyzed by a qualified laboratory to verify suitability for continued use, including checking for ethylene glycol contamination.

Even small quantities of ethylene glycol in the oil can be detrimental. If contamination is less than 5%, drain oil, replace filters and flush oil system with a 50-50 mixture of butoxyethanol (Dow Chemical Company Dowanol EB or equivalent) and 10W oil using a motor driven pump. Flushing should be done on a warm compressor. Bearings should be continuously flushed for 1/2 hour while barring over compressor. All surfaces that come in contact with crankcase oil are to be flushed, including spraying all interior surfaces in the crankcase. Completely drain cleaning mixture, being sure to drain all components of the oil system. Repeat flushing operation using a 60/40 mixture of 10W oil and kerosene or fuel oil. Completely drain the system, install new filters and fill the crankcase with proper oil. The source of the coolant leak must be found and repaired.

If sampling indicates ethylene glycol contamination greater than 5% or if the compressor has seized due to contamination, the unit must be disassembled, cleaned with 100% butoxyethanol, flushed with kerosene or fuel oil and repaired as required. All surfaces that come in contact with crankcase oil must be cleaned with butoxyethanol, including all passages and piping, and then flushed with kerosene or fuel oil. Oil and filters must be changed. The source of the coolant leak must be found and repaired.

Butoxyethanol presents health and safety hazards. Use proper eye and shin protection and adequate ventilation. Do not use near open flame or sparks. See manufacturer's Material Safety Data Sheet for complete details.

Ethylene glycol, butoxyethanol, contaminated oils and solvents must be properly disposed. A qualified chemical disposal service should be used.

Cleaning Non-Lube Compressor Cylinder Components

Complete non-lube cylinders ordered and shipped from Ariel are provided cleaned and protected to non-lube service requirements. Internal parts shipped loose, contaminated internal surfaces and all repair parts are to be cleaned prior to installation, thus providing long life of non-lube compressors and extending life of rings.

Clean the cylinder bore thoroughly with denatured alcohol until a clean, alcohol soaked, white "Bounty" paper towel does not remove any more debris. This includes all surfaces of the bore, counter bore, valve pockets, etc.... Do not use Never-Seize on the crank-end-head steel gasket. If the cylinder in an o-ring seal, apply only a very light film of oil to the cylinder seating surface to seal the o-ring.

Denatured alcohol presents health and safety hazards. Keep away from heat, sparks, flame and all other ignition sources. Use adequate ventilation, neoprene or butyl gloves, mono-goggles or face-mask and impermeable apron. Denatured alcohol contains methyl alcohol which is poisonous if ingested. Avoid eye contact. Materials resulting from clean-up are to be handled and disposed in a proper manner. See manufacturer's Material Safety Data Sheet for more information.

Use very small amounts of Never-Seize on the nut and collar when assembling the piston assembly.

Thoroughly clean the piston with denatured alcohol until a clean, alcohol soaked towel does not remove any more debris. This includes cleaning the ring grooves exceptionally well.

Disassemble the packing case, wipe all surfaces clean with denatured alcohol and re-assemble. When the packing case is water-cooled, re-assemble and test to “Types of Piston Rod Packing Rings” on Page 5-33, using water instead of oil for testing. Thoroughly dry packing case with warm air, such as with a hair dryer. Handle cleaned parts with new or clean “rubber” or new white cotton gloves.

Before installing the piston rod into the unit, wipe the piston rod with denatured alcohol. Be careful not to leave any fingerprints on the rod before it contacts the packing case rings.

Make sure the piston rod is wiped down with denatured alcohol after the rod is installed.

Clean the head end head or unloader components with denatured alcohol. Use small amounts of oil for the bolt holes to make sure the oil does not run down into the cylinder. Also install the head end steel gasket without Never-Seize.

The valves should be disassembled, cleaned with denatured alcohol, re-assembled, wiped down again, and installed. Clean the retainers and high clearance assemblies with denatured alcohol. Use only a thin film of oil for the valve cap o-rings and bolt holes.

Cleaned parts are to be assembled immediately to avoid contamination and corrosion. If cylinder is not to be put into immediate service, contact Ariel (see “Ariel Telephone and Fax Numbers” on Page 7-11) for preservation instructions to ER-34.

NOTES

SECTION 6 - TECHNICAL ASSISTANCE

Recommended Maintenance Intervals

Like all equipment, Ariel compressors do require maintenance. The frequency of maintenance is dictated by the environment in which the compressor is placed, the loads the user imposes on the compressor and the cleanliness of the gas.

First and foremost on the preventative maintenance list is the completion and compliance with the Ariel Corporation Packagers Standard and Compressor Start Up Check List. All items must be adhered to, both before and after start up.

The following is a guide only and, as stated above, may vary due to operating conditions. The time intervals start from the start up date of the unit. If your oil supplier's recommended oil service changes are more frequent than the Ariel recommendations, the supplier's intervals should be followed. Regular oil analysis is recommended. If problems develop the oil should be changed immediately and the cause of the problem determined and corrected.

A log book should be kept with each unit. Every maintenance item can be entered with exacting detail in order that records will be available for tracking maintenance costs per unit and for trouble-shooting.

Operator logs should be reviewed by qualified personnel to determine trends in compressor performance and/or maintenance.

Daily

1. Check frame oil pressure. It should be 50-60 PSIG (350-420 kPa) when at operating temperature. Compressor inlet oil temperature is 190°F (88°C) maximum.
2. Check frame oil level. It should be visible in the sight glass approximately mid-level when running. If oil is not visible in the sight glass, determine and correct the problem. Do not overfill. Check oil makeup tank for sufficient oil supply.
3. Check lubricator block cycle movement indicator. Refer to information plate on top of lubricator box for correct cycle time. Very dirty or wet gas may require a more frequent cycle time than normal.
4. Check primary and secondary packing vents for blowing. If blowing, determine cause and, if necessary, replace packing internal parts.
5. Check and correct any gas leaks.
6. Check and correct any oil leaks.
7. Check operating pressure and temperatures. If not normal, determine cause of abnormality. It is recommended that a daily log of operating temperatures and pressure be kept for reference.
8. Check shutdown set points.

9 Low oil pressure shutdown 35 psi (240 kPa) minimum.

10 High temperature shutdown to be set within 25° F (14°C) of actual operating temperature.

11 High-low pressure shutdowns set as close as practical. Consideration should be given to rod load capacity of machine.

12 Check lubricator box oil level.

13 Check for unusual noises or vibrations.

Monthly (in addition to Daily Requirements)

1 Check and confirm safety shutdown functions.

2 For cylinders rated greater than 3500 psi (24 000 kPa) remove cylinder heads and check cylinder for oil presence to verify lubrication is adequate.

Every 6 Months or 4,000 Hours (plus Daily/Monthly)

1 Drain and replace lubricator box oil.

2 Change oil filter or when differential pressure exceeds 10 psi (70 kPa) for the JGH/2/4 & JGE/2/4.

3 Change oil. A more frequent oil change interval may be required if operating in an extremely dirty environment or if the oil supplier recommends it or if an oil analysis dictates it. A less frequent oil change interval may be allowed if the oil is replenished on a regular basis due to force feed lubricator usage.

4 Clean sintered element in small oil filter supplied on the force-feed lubrication system every time the main oil filter is changed.

5 Clean strainer when oil is changed.

6 Open frame when oil is changed and visually inspect for foreign material. Disassembly is not recommended unless a reason for it found.

7 Check fluid level in damper (if applicable).

8 Re-tighten hold down stud-nuts to proper torque values and perform a soft foot check. More than 0.002 inch (0.05 mm) pull down requires re-shimming. If re-shimming is required, realign if necessary to hold coupling alignment within 0.005 inch (0.13mm) TIR.

9 For cylinders rated greater than 3500 (24 000 kPa), inspect piston ring end gap. Replace rings that are outside the maximum limits listed in Table 1-8 on page 1-12 or Table 1-9 on page 1-13.

Yearly or 8,000 Hours (plus Daily/Monthly/6 Months)

1 Change oil filter when differential pressure exceeds 15 psi (105 kPa) for the JGE/6.

2 Check main bearing clearance, connecting rod bearing clearance, and crank thrust clearance with a bar and indicator. If outside the limits listed in Table 1-3 on page 1-9, replace the affected bearings.

3 Check crosshead guide clearance with feelers, and if outside the limits listed in

Table 1-3 on page 1-9, replace the affected parts.

4 Inspect valves for broken plates and loose center bolts, replace broken parts and tighten center bolts to torque values listed in Table 1-15 on page 1-21.

5 Inspect cylinder bores for damage or wear. If gouged, so that the total cross sectional area of the gouges is greater than 0.001 square inches per inch of cylinder circumference (0.025 mm^2/mm of cylinder circumference), cylinder should be replaced or re-bored to a maximum of 0.020 inches (0.50 mm) oversize. The cylinder should also be replaced or re-bored if the bore is more than 0.001 inches per inch of cylinder diameter (0.001m/m of cylinder diameter) out of round or tapered.

NOTE: REBORING REMOVES NITRIDED SURFACE OF CYLINDER BORE. CONTACT ARIEL FOR RE-NITRIDING.

6 Inspect piston ring end gap. Replace rings that are outside the maximum limit listed in Table 1-8 on page 1-12 thru Table 1-13 on page 1-17.

7 Inspect piston rods for damage and excessive wear. If gouged or scratched, replace the rod. If the rod is more than 0.005 inches (0.13 mm) under size, out of round more that 0.001 inches (0.03 mm), or tapered more than 0.002 inches (0.05 mm) replace the rod.

8 Rebuild cylinder packing cases.

9 Inspect for frame twist or bending by checking shimming of compressor feet.

10 Realign if necessary to hold coupling alignment within 0.005 inches (0.13 mm) TIR.

11 Check and re-calibrate all temperature and pressure gauges.

12 Check and record compressor rod run out.

13 Grease VVCP stem threads at grease fitting, with 2 to 3 pumps of multi-purpose grease using a standard hand pump grease gun.

14 Clean crankcase breather filter.

15 Adjust drive chains.

16 Pressure test distribution blocks.

Every 2 Years or 16,000 Hours (plus Daily/Monthly/6 Months/Yearly)

1 Check auxiliary end chain drive for sprocket teeth undercutting and chain for excessive stretching.

2 Rebuild oil wiper cases.

Every 4 Years or 32,000 Hours (plus Daily/Monthly/6 Months/1/2 Years)

1 Check main and connecting rod bearing clearances by using a dial indicator and a pry bar. Disassembly to check clearances is not recommended. Disassembly should be performed if the pry bar check indicates excessive clearance.

2 Check crosshead guide clearances with feeler gauges. Re-shim crosshead guide to support, if required, and re-tighten fasteners to proper torque.

3 Check crosshead pin to crosshead pin bore and connecting rod bushing bore by removing crosshead pins.

4 Check for excessive wear in the auxiliary end drive chain tightener.
5 Check for excessive ring groove wear in pistons.

Every 6 Years or 48,000 hours (plus Daily/Monthly/6 Months/1/2/4 Years)

1 Replace main and connecting rod bearing shells and bushings.
2 Replace lubricator distribution blocks.
3 Replace crosshead bushings.
4 Replace the DNFT.

Trouble Shooting

Minor problems can be expected during the routine operation of an Ariel compressor. These troubles are most often traced to liquid, dirt, improper adjustment or to operating personnel being unfamiliar with Ariel compressors. Difficulties of this type can usually be corrected by cleaning, proper adjustment, elimination of an adverse condition, replacement of a relatively minor part or proper training of the operating personnel.

Major problems can usually be traced to long periods of operation with unsuitable lubrication, careless operation, lack of routine maintenance or the use of the compressor for purposes for which it was not intended.

For trouble shooting of the force-feed lubrication system and for testing the pump, distribution block(s) and check valves in the force-feed system, a hand purge pump (Ariel Part Number G-7162) will be useful.

Recording of the interstage pressures and temperatures on multistage units is valuable because any variation, when operating at a given load point, indicates trouble in one of the stages. Normally, if the interstage pressure drops the trouble is in the lower pressure cylinder. If it rises, the problem is normally in the higher pressure cylinder.

While it would be impossible to compile a complete list of every possible problem, listed below are some of the more common ones with their possible causes.

Problem	Possible Causes
Low Oil Pressure	Oil pump failure. Oil foaming from counterweights striking oil surface (oil level too high). Cold oil. Dirty oil filter. Interior frame oil leaks. Excessive leakage at bearings. Improper low oil pressure switch setting. Oil pump relief valve set too low. Defective pressure gauge. Plugged oil sump strainer. Improper end clearance in oil pump.
Noise in Cylinder	Loose piston. Piston hitting cylinder head end head or crank end head. Loose crosshead balance nut. Broken or leaking valve(s). Worn or broken piston rings or wear bands. Valve improperly seated or damaged seat gasket. Liquids in cylinder.

Problem	Possible Causes
Excessive Packing Leakage	Worn packing rings. Improper lube oil and or insufficient lube rate. Dirt in packing. Packing rings assembled incorrectly. Improper ring side or end gap clearance. Plugged packing vent system. Scored, tapered or out of round piston rod. Excessive piston rod run-out. Packing not seated or properly run in.
Packing Over Heating	Lubrication failure. Improper lube oil and/or insufficient lube rate. Worn packing rings. Dirt in packing. Improper ring side or end gap clearance. Scored, tapered or out of round piston rod. Excessive piston rod runout.
Excessive Carbon on Valves	Excessive lube oil. Improper lube oil. Oil carry-over from inlet system or previous stage. Broken or leaking valves causing high temperature. Excessive temperature due to high pressure ratio across cylinders.
Relief Valve Popping	Faulty relief valve. Leaking suction valves or rings on next higher stage. Obstruction, bind or valve closed in discharge line.
High Discharge Temperature	Excessive ratio across cylinder due to leaking inlet valves or rings on next higher stage. Fouled intercooler piping. Leaking discharge valves or piston rings. High inlet temperature. Improper lube oil and or lube rate.
Frame Knocks	Loose crosshead pin or pin caps. Loose or worn main, crankpin or crosshead bearings. Low oil pressure. Cold oil. Incorrect oil. Knock is actually from cylinder end. Low fluid level in damper.
Drive End of Crankshaft Oil Leak	Clogged vent or vent piping. Excessive cylinder packing leakage.
Piston Rod Oil Wiper Leaks	Worn wiper rings. Wipers incorrectly assembled. Worn/scored rod. Improper fit of rings to rod/side clearance.

SECTION 7 - APPENDICES

Ariel Tools

Ariel Furnished Tools

Ariel provides one tool box with each unit with tools included in the box as listed below (see Figure 7-1:).

- Peg Wrench for Round Crosshead Nuts (A-4996)
- Open End Wrench[a] for Hex Crosshead Nuts 4" (C-0618)
- Ratchet Extension Support (B-1240)
- 5/16" x 1/2" UNF Valve Tool for Installing or Removing Valves (A-0135)
- 1/4" x 3/8" UNF Valve Tool for Installing or Removing Valves (A-0409)
- 5/8" x 3/4" UNF Valve Tool for Installing or Removing Valves (A-0626)
- 3/4" x 1" UNC Valve Tool for Installing or Removing 'CT' Type Valves (A-2289)
- Connecting Rod Bolt Turn Indicator Tool (B-1495) (JGE only)
- Piston Nut Spanner for 1" Square Drive Ratchet (B-1410)
- Piston Turning Tool for 9/16" Socket (A-1678) provided with small tandem cylinders only (not illustrated).
- Cylinder Bolt Torque Adapter (A-6393)
- Crosshead Installation Tool (A-1858)
- Torque Chart (D-2159)
- Connecting Rod Cap Removal Tool (C-2106) (see Figure 7-2:)
- Crosshead Pin Alignment Tool (B-1989)

Ariel provides these tools with every compressor. Please contact your Distributor if you do not have these tools.

These tools are specifically designed for use on Ariel units. Clean all tools before use. Ensure that the tool and the part being removed or installed are fully engaged during the process. If a tool is missing, worn or broken, please call your distributor for a replacement. Do not use substitute, worn or broken tools.

Also included in the tool box are standard commercial tools as follows:

- Forged Eyebolts: 3/8" - 16, UNC and 1/2" - 13 UNC
- Allen Wrenches: 5/32", 3/16", 3/8", 1/2" & 3/4"
- (6) Hex Capscrews, Grade 5, 1/4 - 20 x 1 (A-1858 to Crosshead Guide Diaphragm)
- Force-Feed Lubricator Bearing Housing Spanner Wrench (A-8158)

a. Provided only when original equipment compressor is provided with any Hex crosshead nuts.

Ariel Optional Tools

- Piston Nut Torquing Tool (G-5266) (see Figure 5-18: on page 5-26)
- Hydraulic Pump Kit to power G-5266 (G-6362) (hand pump, hose, coupler and gauge)
- Piston Torquing Fixture (D-0961) (see Figure 5-17: on page 5-26)
- Force-Feed Lubrication Hand Purge Pump (G-7162)
- Piston Rod Entering Sleeve (A-8559)
- Hydraulic Crosshead Nut Torquing Tool (G-7583) (see Figure 5-6: on page 5-10)
- Hydraulic Pump Kit to Power G-7583 (G-6520)

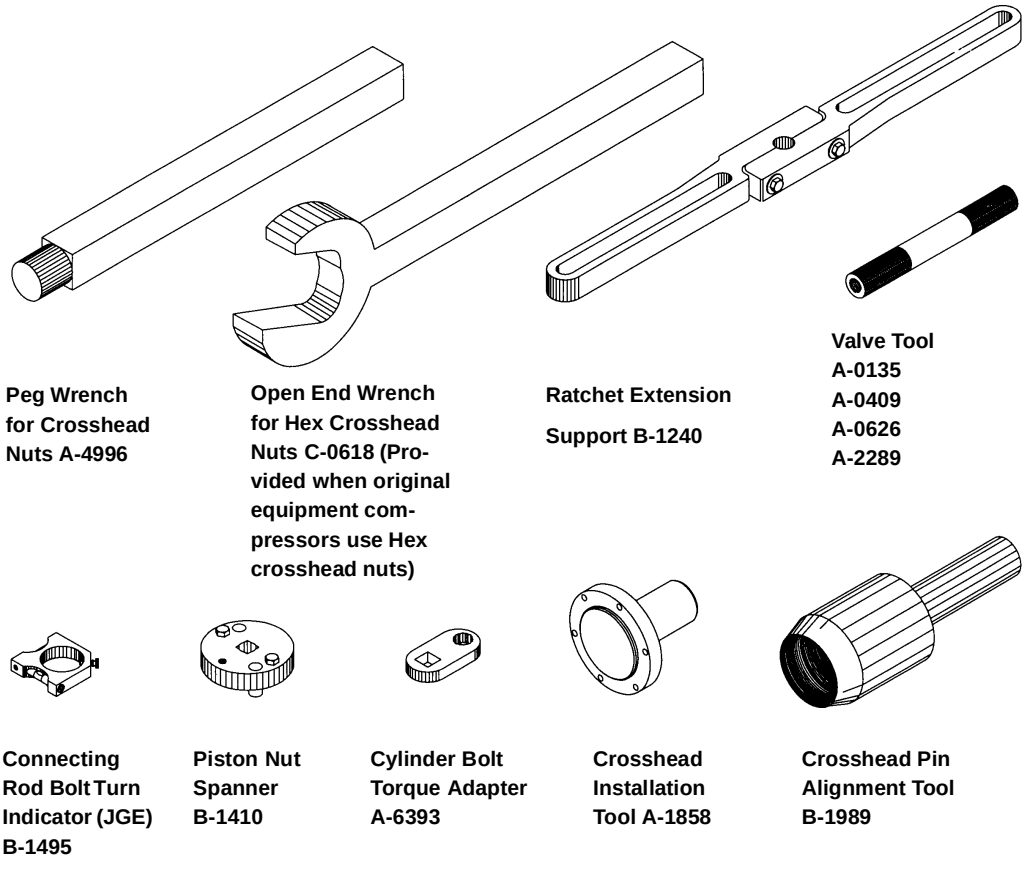


FIGURE 7-1: ARIEL TOOLS

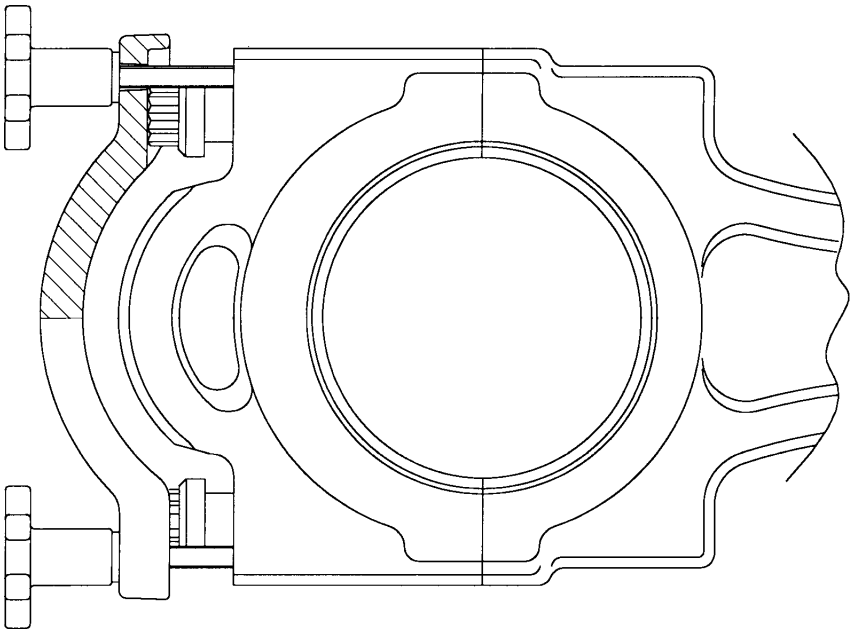


FIGURE 7-2: CONNECTING ROD CAP REMOVAL TOOL - TYPICAL (C-2106)

FIGURE 7-3: PISTON ROD ENTERING SLEEVE (A-8559)

Minimum Hand Tools Required

The following hand tools are normally all that is required to work on Ariel compressors. These are in addition to the Ariel furnished and optional tools listed above. Please contact Ariel if you have questions about tools on Ariel units.

- 1/2" Square Drive Ratchet Wrench
- 2" and 6" Extensions for above Ratchet
- 1/2" Square Drive Breaker Bar
- 1/2" Drive Speed Wrench
- 1/2" Female x 3/4" Male Adaptors
- 1/2" Square Drive Universal Joint
- 3/8" Square Drive Torque Wrenches (10 LB-IN to 250 LB-IN)
- 1/2" Square Drive Torque Wrenches (15 LB-FT to 250 LB-FT)
- 3/4" Square Drive Torque Wrench (to 1590 LB-FT)
- 7/16", 1/2", 9/16", 3/4", and 15/16" Sockets for a 1/2" Square Drive Ratchet Wrench
- 1/2" Hex Key and 1/4" Hex Key (Allen) Sockets for a Square Drive Ratchet Wrench
- 5/16" - 12 Point Box Wrench
- 1/2" x 9/16" Open End Wrench
- 3/8" x 7/16" Open End Wrench
- 7/8" x 15/16" Open End Wrench
- 2 - Medium Size Screw Drivers
- Babbitt or Plastic-Faced Slugging Hammer
- Set of 3/8" Drive Sockets
- 3/8" Square Drive Ratchet Wrench
- 7/8", 1", 1-1/8"and 1-3/8", 3/4" Drive, 12 Point Sockets
- 1-5/16" and 1-1/2", 3/4" Drive, Sockets
- 3/4" Square Drive Ratchet Wrench
- 3/4" Female to 1" Male Adaptor

Terms, Abbreviations[a] and Conversion to SI Metric[b]

Area

in^2 or square inch x 0.00064516 = $meter^2$, or m^2

in^2 or square inch x 6.4516 = $centimeter^2$, or cm^2

Flow - Gas

MMSCFD or million standard cubic feet per day (at 14.696 psia & 60°F) x 0.310 = normal $meter^3$/second (at 1.01325 bar & 0°C), or m_n^3/s

SCFM or standard cubic feet per minute (at 14.696 psia & 60°F) x 1.607 = normal $meter^3$/ hour (at 1.01325 bar & 0°C), or m_n^3/h

Flow - Liquid

GPM or US gallons per minute x 0.0630902 = liter/second, or L/s = dm^3/s

GPM or US gallons per minute x 0.227125 = $meter^3$/hour, or m^3/h

Force

lbf or pound (force) x 4.44822 = Newton, or N

Heat

BTU or British Thermal Units x 1.05506 = kilojoule, or kJ

Length

in. or " or inches x 25.4000 = millimeters, or mm

ft or feet x 0.304800 = meter, or m

Mass

lb or pound (mass) x 0.453592 = kilogram, or kg

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a. US units of measure can appear abbreviated in upper or lower case.
b. Maintain upper and lower case letters in SI Metric as shown.

Moment or Torque

LB x FT or pound-foot (force) x 1.35583 = Newton-meter, or N· m

LB x IN or pound-inch (force) x 0.112985 = Newton-meter, or N· m

Power[a]

HP or Horsepower x 0.745700 = kilowatt, or kW

Pressure[b] or Stress

psi x 6894.757 = Pascal, or Pa

Pa x 0.000145 = psi

psi x 6.894757 = kiloPascal, or kPa

kPa x 0.145 = psi

bar x 100 000 = Pascal, or Pa

Pa x 0.00001 = bar

bar x 100 = kPa

kPa x 0.01 = bar

psi x 68.94757 = mbar or millibar

mbar x 0.0145 = psi

psi x 0.06894757 = bar

bar x 14.5 = psi

Speed

FPM or feet per minute x 0.005080 = meter per second, or m/s

RPM or r/min or revolutions per minute x 60 = revolutions per second, or rev/s

Temperature

°F or degrees Fahrenheit. (°F - 32)/1.8 = degrees Celsius, or °C

a. Horsepower based on 550 ft-lb/sec
b. G suffix (PSIG) indicates gauge pressure, A indicates absolute

Time

sec = second, or s

min or minute x 60 = second, or s

hr or h or hour x 3600 = second, or s

Viscosity

SSU, SUS or Saybolt Universal seconds x 0.22 - (180/SSU) = mm^2/s = centistoke, or cSt
(for a range of 33 thru 200,000 SUS)

Volume

gal or gallons (US liquid) x 3.78541 = liter, or L

Other Abbreviations

CE = Crank End

CI = Cast Iron

CL. = Clearance

CU = Cubic

CYL = Cylinder

℄ = Centerline

DNFT = Digital No-Flow Timer Switch

ESNA = Registered Trade Mark of Elastic Stop Nut Division, Harvard Industries

HE = Head End

HEX = Hexagon

MAWP = Maximum Allowable Working Pressure

MAX. = Maximum

MIN. = Minimum

N/A = Not Applicable

NO. = Number

NPT = National Pipe Thread

PEEK = Poly-Ether-Ether-Ketone plastic material

% = Percent

PIST = Piston

SAE = Society of Automotive Engineers

SG = Specific Gravity

SI = International System, as applied to the modern metric system

S. N. or S/N = Serial Number

TFE = Teflon

THD = Thread

TIR = Total Indicator Reading

TPI = Threads Per Inch

TRAV = Travel

UNC = Unified (Inch) National Coarse Screw Threads

UNF = Unified (Inch) National Fine Screw Threads

UNL = Unloader

VOL = Volume

W/ = With

Wt = Weight

Gas Analysis Common Abbreviations

TABLE 7-1: GAS ANALYSIS COMMON ABBREVIATIONS

COMMON ABBREVIATION	COMPONENT NAME (SYNONYM)	CHEMICAL FORMULA
C1	Methane	CH4
C2	Ethane	C2H6
C3	Propane	C3H8
IC4	Iso-Butane (2-Methyl Propane)	C4H10
NC4	N-Butane	C4H10
IC5	Iso-Pentane (2-Methyl Butane)	C5H12
NC5	N-Pentane	C5H12
NEOC5	Neopentane	C5H12
NC6	Hexane	C6H14
NC7	Heptane	C7H16
NC8	Octane	C8H18
NC9	Nonane	C9H20
NC10	N-Decane	C10H22
NC11	N-Undecane (Hendecane)	C11H24
NC12	N-Dodecane	C12H26
C2-	Ethylene (Ethene)	C2H4
C3-	Propane (Propylene)	C3H6
BENZ	Benzene	C6H6
TOL	Toluene	C7H8
EBNZ	Ethylbenzene	C8H10
CO	Carbon Monoxide	CO
CO2	Carbon Dioxide	CO2
H2S	Hydrogen Sulfide	H2S
H2	Hydrogen	H2
O2	Oxygen	O2
N2	Nitrogen	N2
H2O	Water	H2O
He	Helium	He
Ar	Argon	Ar
---	Air	---

TABLE 7-2: USEFUL SI METRIC MULTIPLE AND SUBMULTIPLE FACTORS

MULTIPLICATION FACTOR	PREFIX	SI SYMBOL[a]
1 000 000= 10^6	mega	M
1 000 = 10^3	kilo	k
100 = 10^2	hecto[b]	h
10 = 10^1	deka[b]	da
.1 = 10^{-1}	deci[b]	d
.01 = 10^{-2}	centi[b]	c
.001 = 10^{-3}	milli	m
.000 001 = 10^{-6}	micro	:

a. Maintain upper and lower case letters as shown.
b. Not Recommended, but occasionally used.

Ariel Customer Technical Bulletins (Formerly Ariel Newsletters)

Ariel Customer Technical Bulletins provide important technical information including changes, corrections and/or additions tothe Technical Manual for Packagers and End Users. Be sure to refer to this material before operating or servicing the equipment.

A complete listing of these Bulletins is available at the Ariel Website, and copies may be obtained from the Packager or from Ariel.

Technical and Service Schools on Ariel Compressors

Ariel schedules several in plant schools each year, which include classroom and hands on training. Ariel can also arrange to send a representative to provide a customized training school at your location. Contact Ariel for details.

Ariel Telephone and Fax Numbers

Switchboard	740-397-0311	Weekdays 8 am - 5 pm Eastern Time, except holidays
General Fax	740-397-3856	
Field Service	740-393-5052	**Emergency** from 5 pm - 8 am, weekends and holidays
Spare Parts[a]	740-397-3602	For all calls to Spare Parts Group, day or night
Spare Parts Fax	740-393-5054	

The after hours system works as follows:

1. Dial number.
2. Calls are answered by voice mail.
3. Leave message: caller's name, telephone number, serial number of equipment in question (frame, cylinder, unloader) and brief description of emergency.
4. The call will be immediately forwarded to a responsible individual, who will return the call as soon as possible.

a. Users must order all parts thru Authorized Distributors.

NOTES