

ARIEL Heavy Duty Balanced Opposed Compressors

TECHNICAL MANUAL
For Models:

JGM, JGN, JGP and JGQ;
and JGI (Vertical Non-Balanced)



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.

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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 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 JGI, JGM, JGN, JGP or JGQ 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 plate 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.

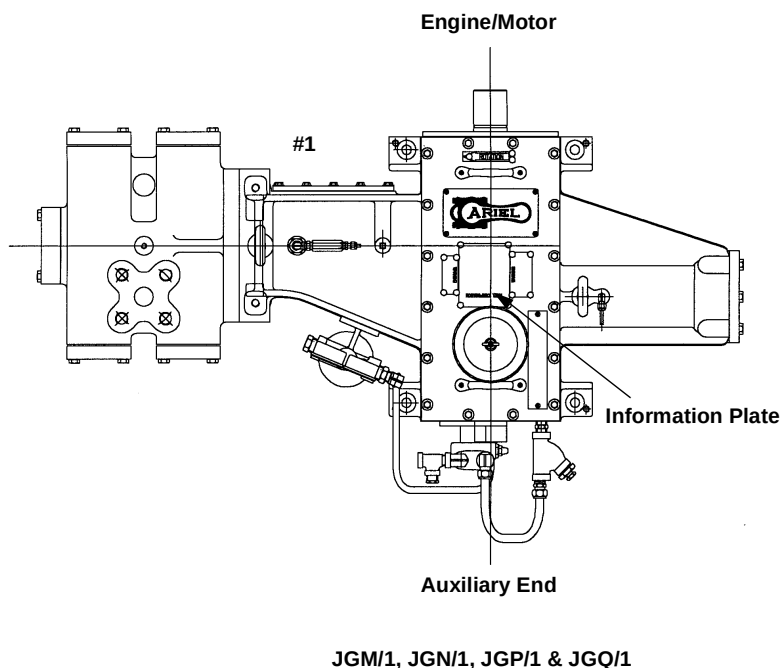


FIGURE 1-1: TYPICAL COMPRESSOR THROW NUMBERING AND INFORMATION PLATE LOCATION - 1/THROW

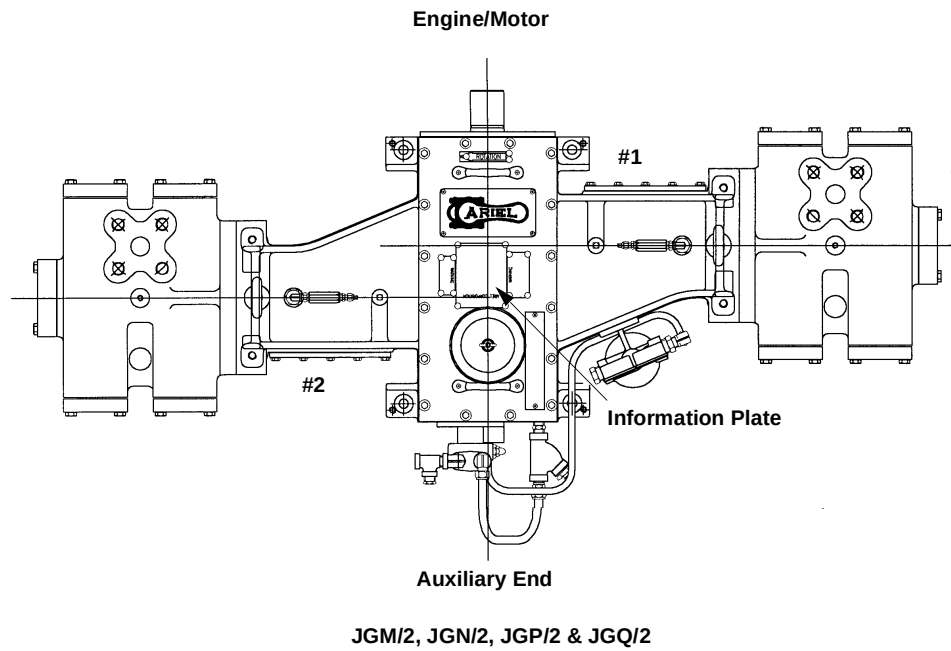


FIGURE 1-2: TYPICAL COMPRESSOR THROW NUMBERING AND INFORMATION PLATE LOCATION - 2/THROW

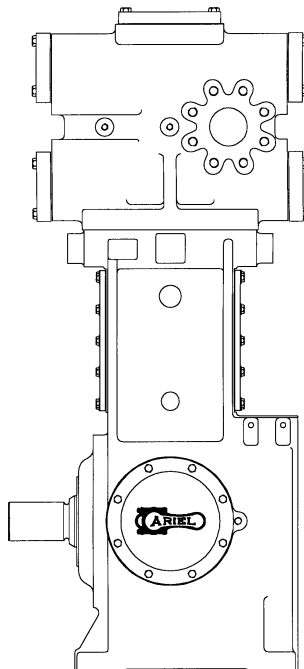


FIGURE 1-3: JGI - VERTICAL NON-BALANCED COMPRESSOR (SIDE VIEW)

Specifications

TABLE 1-1: JGI, JGM & JGP FRAME SPECIFICATIONS

MODEL	JGI/1	JGM/1	JGM/2	JGP/1	JGP/2
Stroke, inches (mm)	3-1/2 (89)	3-1/2 (89)	3-1/2 (89)	3 (76)	3 (76)
Speed, RPM	To 800	To 1500	To 1500	To 1800	To 1800
Piston Speed, FPM (m/s)	To 467 (2.37)	To 875 (4.45)	To 875 (4.45)	To 900 (4.57)	To 900 (4.57)
Number of Throws	1	1	2	1	2
Horsepower (kW)	To 55 (41)	To 84 (63)	To 167 (125)	To 85 (63)	To 170 (127)
Height - Bottom to Crankshaft Φ , in. (mm)	10.250 (260.35)	9.250 (234.95)	9.250 (234.95)	9.250 (234.95)	9.250 (234.95)
Connecting Rod Φ To Φ , in. (mm)	8.250 (209.55)	8.250 (209.55)	8.250 (209.55)	8.250 (209.55)	8.250 (209.55)
Maximum Width, in. (m)	25 (6.35)	62 (1.58)	83 (2.11)	62 (1.58)	83 (2.11)
Maximum Length, in. (m)	25 (6.35)	35 (0.89)	35 (0.89)	35 (0.89)	35 (0.89)
Approximate Weight with Cylinders, lb. (kg)	1100 (455)	1400 (640)	2000 (900)	1400 (640)	2000 (900)
Oil Pump Capacity, GPM (L/s)	3 (0.19)	4 (0.25)	4 (0.25)	4 (0.25)	4 (0.25)
Oil Heat Rejection, BTU/hr. (J/s)	3000 (879)	4000 (1172)	4000 (1172)	5000 (1465)	5000 (1465)
Sump Capacity, US gallons (L)	4 (15)	2.5 (9.5)	2.5 (9.5)	2.5 (9.5)	2.5 (9.5)
Piston Rod Diameter, in. (mm)	1.125 (28.63)	1.125 (28.63)	1.125 (28.63)	1.125 (28.63)	1.125 (28.63)
Internal Rod Load - Double Acting:					
Compression + Tension, lbf. (kN)	12,000 (53)	12,000 (53)	12,000 (53)	12,000 (53)	12,000 (53)
Tension, lbf. (kN)	6000 (26)	6000 (26)	6000 (26)	6000 (26)	6000 (26)
Compression, lbf. (kN)	7000 (31)	7000 (31)	7000 (31)	7000 (31)	7000 (31)
Internal Rod Load - Single Acting:					
Tension, lbf. (kN)	6000 (26)	6000 (26)	6000 (26)	6000 (26)	6000 (26)

TABLE 1-2: JGN & JGQ FRAME SPECIFICATIONS

MODEL	JGN/1	JGN/2	JGQ/1	JGQ/2
Stroke, inches (mm)	3-1/2 (89)	3-1/2 (89)	3 (76)	3 (76)
Speed, RPM	To 1500	To 1500	To 1800	To 1800
Piston Speed, FPM (m/s)	To 875 (4.45)	To 875 (4.45)	To 900 (4.57)	To 900 (4.57)
Number of Throws	1	2	1	2
Horsepower (kW)	To 126 (94)	To 252 (188)	To 140 (104)	To 280 (209)
Height - Bottom to Crankshaft $\varnothing$, in. (mm)	9.250 (234.95)	9.250 (234.95)	9.250 (234.95)	9.250 (234.95)
Connecting Rod $\varnothing$ To $\varnothing$, in. (mm)	8.250 (209.55)	8.250 (209.55)	8.250 (209.55)	8.250 (209.55)
Maximum Width, in. (m)	62 (1.58)	83 (2.11)	62 (1.58)	83 (2.11)
Maximum Length, in. (m)	35 (0.89)	35 (0.89)	35 (0.89)	35 (0.89)
Approximate Weight with Cylinders, lb. (kg)	1400 (640)	2000 (900)	1400 (640)	2000 (900)
Oil Pump Capacity, GPM (L/s)	4 (0.25)	4 (0.25)	4 (0.25)	4 (0.25)
Oil Heat Rejection, BTU/hr. (J/s)	4000 (1172)	4000 (1172)	5000 (1465)	5000 (1465)
Sump Capacity, US gallons (L)	2.5 (9.5)	2.5 (9.5)	2.5 (9.5)	2.5 (9.5)
Piston Rod Diameter, in. (mm)	1.125 (28.63)	1.125 (28.63)	1.125 (28.63)	1.125 (28.63)
Internal Rod Load - Double Acting:				
Compression + Tension, lbf. (kN)	18,000 (80)	18,000 (80)	20,000 (89)	20,000 (89)
Tension, lbf. (kN)	9000 (40)	9000 (40)	10,000 (44)	10,000 (44)
Compression, lbf. (kN)	10,000 (44)	10,000 (44)	11,000 (49)	11,000 (49)
Internal Rod Load - Single Acting:				
Tension, lbf. (kN)	9000 (40)	9000 (40)	10,000 (44)	10,000 (44)

Product Information and Safety Plates

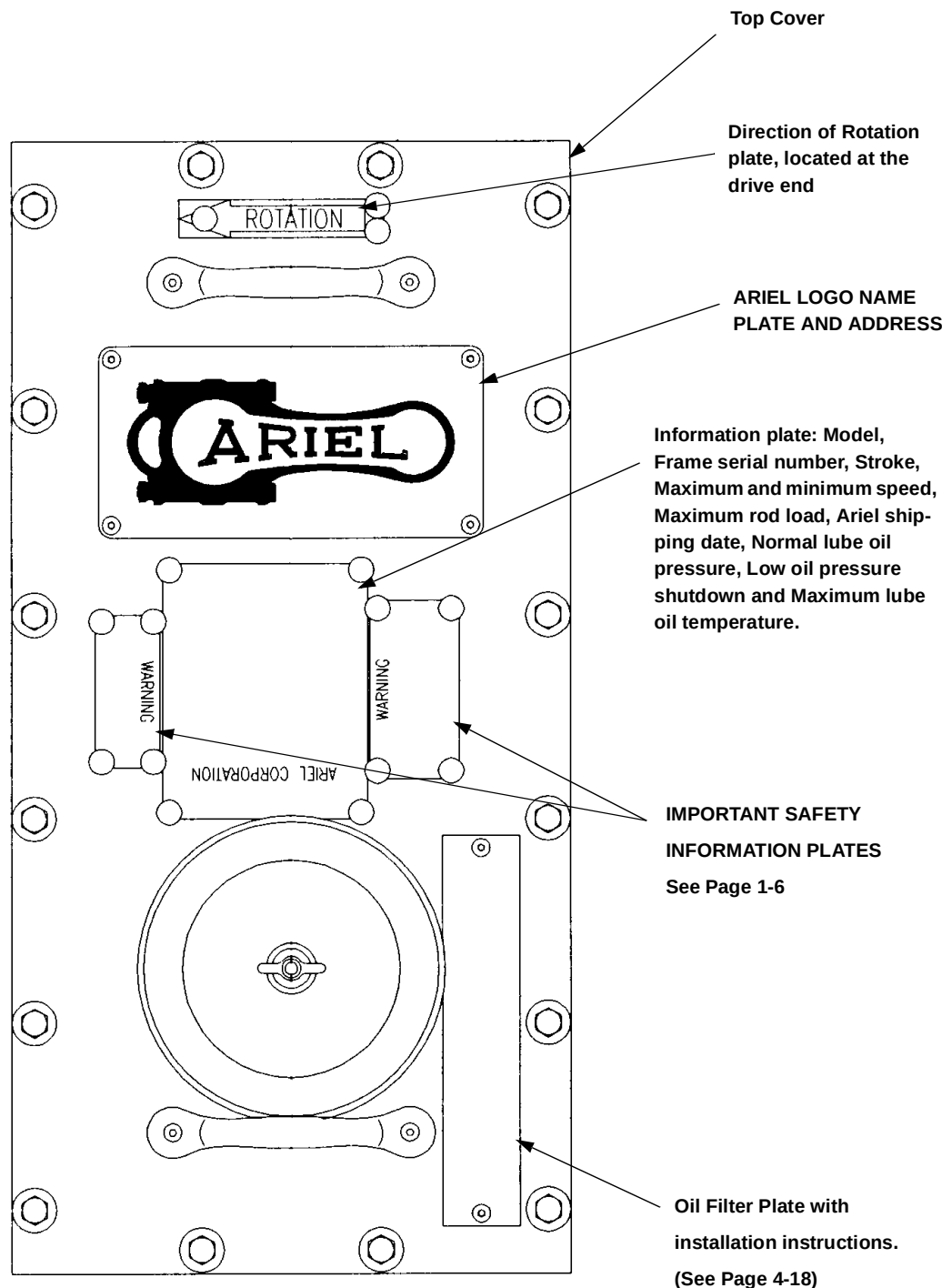


FIGURE 1-4: TOP COVER

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

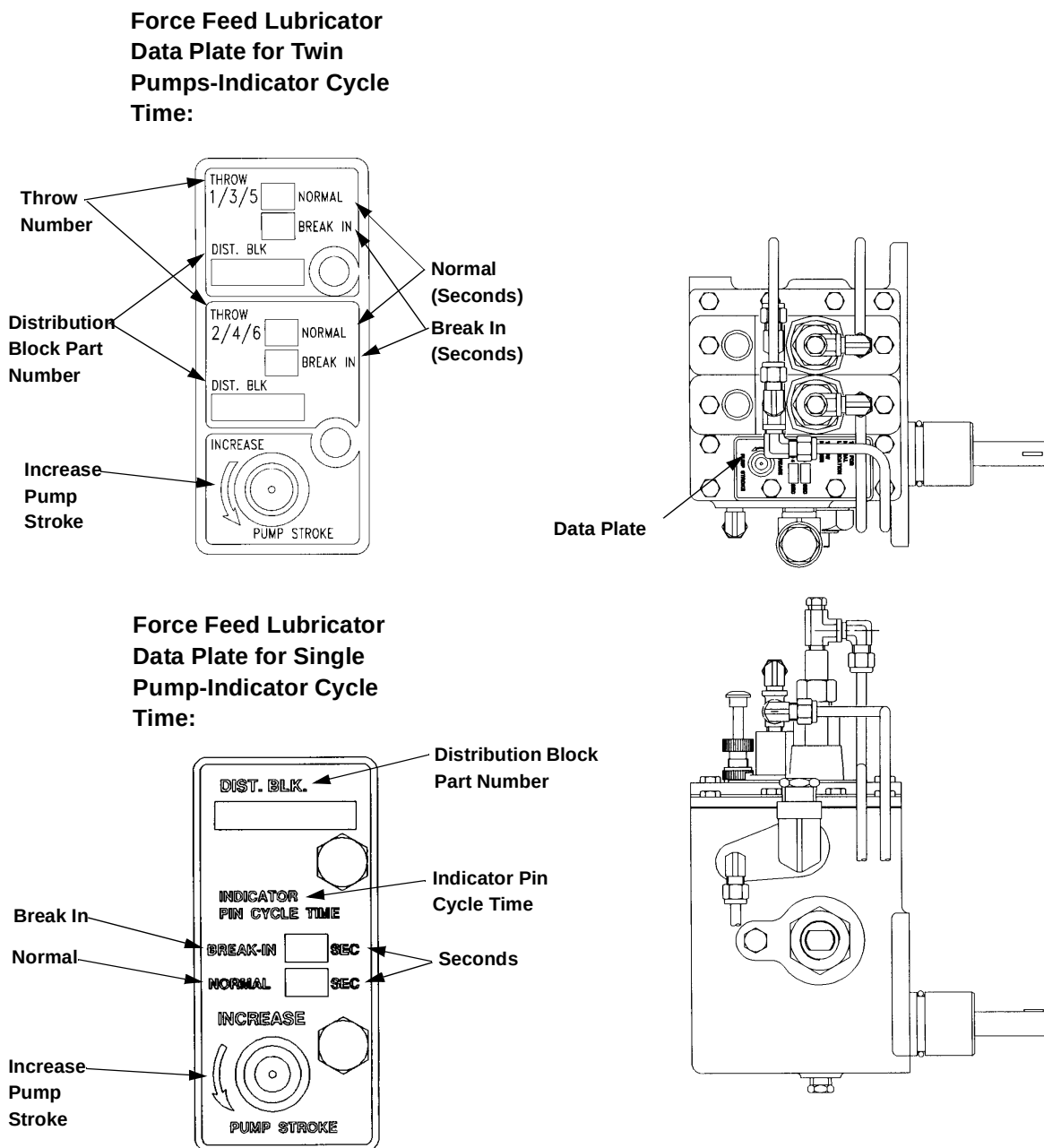
SEVERE PERSONAL INJURY AND PROPERTY DAMAGE WILL RESULT IF SUCTION AND DISCHARGE VALVES ARE NOT INSTALLED IN THEIR PROPER LOCATION.

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.



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 specific directions.

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

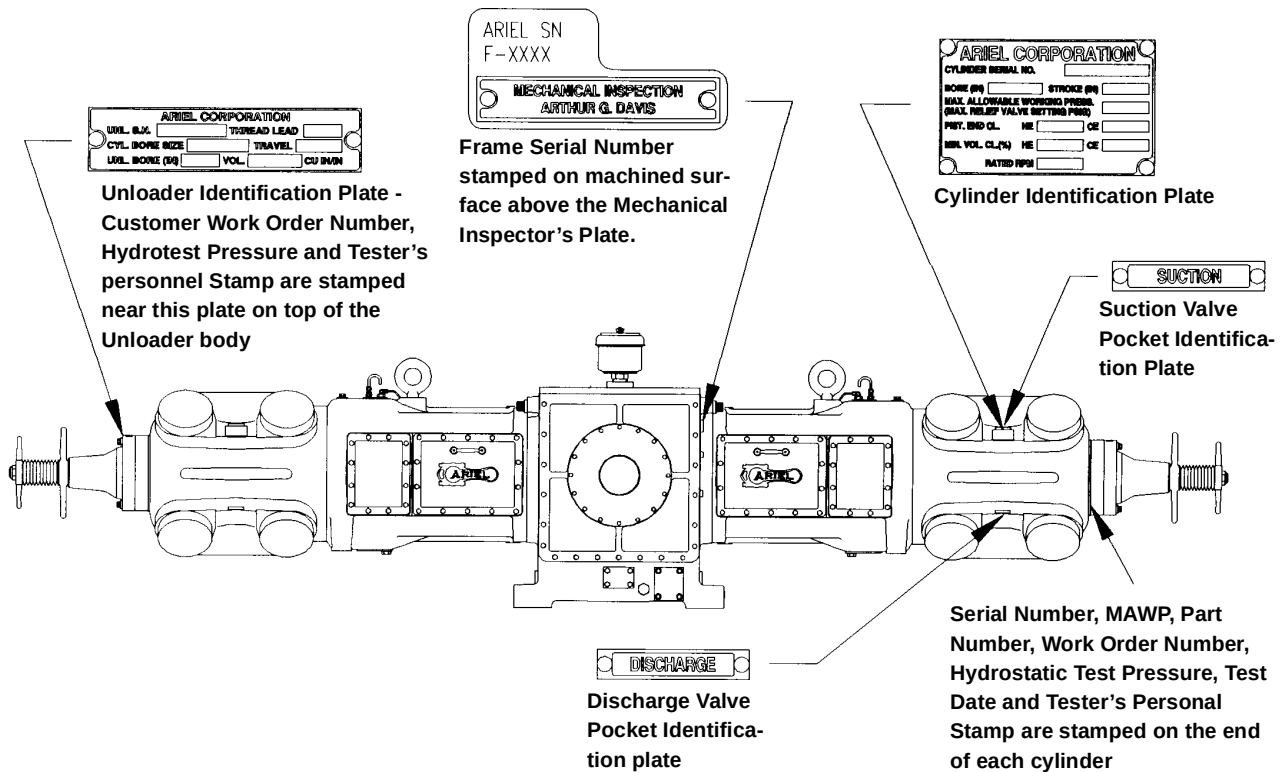


FIGURE 1-6: IDENTIFICATION PLATES - TYPICAL

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:**

The diagram shows a rectangular plate with the text "ARIEL CORPORATION" at the top. Below this are several fields for identification data, each with a label and an arrow pointing to it:

- Nominal Bore Diameter Inches:** Points to the "BORE(IN)" field.
- Stroke Inches:** Points to the "STROKE (IN)" field.
- Maximum Allowable Working Pressure (Maximum Relief Valve Setting PSIG - Pounds per Square Inch Gauge):** Points to the "MAX.ALLOWABLE WORKING PRESS. (MAX.RELIEF VALVE SETTING PSIG)" field.
- Piston End Clearance Inches:** Points to the "PIST.END CL. HE" field.
- Minimum Volumetric Clearance Percentage:** Points to the "MIN.VOL. CL.(%) HE" field.
- Class:** Points to the "CLASS" field.
- Rated Revolutions per Minute:** Points to the "RATED RPM" field.
- Crank End:** Points to the "CE" field.
- Head End:** Points to the "HE" field.
- Cylinder Serial Number:** Points to the "CYLINDER SERIAL NO." field.

The plate contains the following fields:

ARIEL CORPORATION

BORE(IN) [] CLASS []

STROKE (IN) [] RATED RPM []

MAX.ALLOWABLE WORKING PRESS. (MAX.RELIEF VALVE SETTING PSIG) []

PIST.END CL. HE [] CE []

MIN.VOL. CL.(%) HE [] CE []

CYLINDER SERIAL NO. []

**UNLOADER IDENTIFICATION
PLATE:**

The diagram shows a rectangular plate with the text "ARIEL CORPORATION" at the top. Below this are several fields for identification data, each with a label and an arrow pointing to it:

- Unloader Serial Number:** Points to the "UNL. S.N." field.
- Nominal Cylinder Bore Diameter Inches:** Points to the "CYL. BORE (IN)" field.
- Nominal Unloader Bore Diameter Inches:** Points to the "UNL.BORE (IN)" field.
- Thread Lead - Threads Per Inch:** Points to the "THD. LEAD (TPI)" field.
- Travel Inches:** Points to the "TRAV. (IN)" field.
- Volume:** Points to the "VOL." field.
- Cubic Inches Per Inch:** Points to the "CU IN/IN" field.

The plate contains the following fields:

ARIEL CORPORATION

UNL. S.N. [] THD. LEAD (TPI) []

CYL. BORE (IN) [] TRAV. (IN) []

UNL.BORE (IN) [] VOL. [] CU IN/IN []

FIGURE 1-7: CYLINDER AND UNLOADER IDENTIFICATION PLATES

Clearances

TABLE 1-3: CLEARANCES

DESCRIPTION	CLEARANCE, IN.	(CLEARANCE, mm)
Crankshaft Dust Seal (Feeler Gauge - Centered) N/A to JGI	0.008 to 0.010	(0.20 to 0.25)
Crankshaft Thrust (End) JGM, JGN, JGP & JGQ	0.0035 to 0.011	(0.09 to 0.26)
Crankshaft Thrust (End) JGI	0.009 to 0.025	(0.23 to 0.64)
Crankshaft Journal Bearing (Jack) N/A to JGI	0.0005 to 0.0035	(0.01 to 0.09)
Crankshaft Pin to Connecting Rod Bearing (Jack) N/A to JGI	0.0015 to 0.0040	(0.04 to 0.10)
Connecting Rod Thrust (Side) JGM, JGN, JGP & JGQ	0.007 to 0.016	(0.18 to 0.41)
Connecting Rod Thrust (Side) JGI	0.009 to 0.015	(0.23 to 0.38)
Connecting Rod Bushing to Crosshead Pin	0.0014 to 0.0031	(0.04 to 0.08)
Crosshead Bushing to Crosshead Pin - JGN/JGQ	0.0014 to 0.0036	(0.04 to 0.09)
Crosshead (Bronze) to Crosshead Pin	0.0015 to 0.0025	(0.04 to 0.07)
Crosshead (Gray Iron) to Crosshead Pin - JGI/JGM/JGP	0.0015 to 0.0025	(0.04 to 0.07)
Crosshead (Babbitted Ductile Iron) to Guide - JGN/JGQ (Feeler Gauge ^a)	0.004 to 0.008	(0.10 to 0.20)
Crosshead (Babbitted Bronze) to Guide (Feeler Gauge ^a)	0.006 to 0.010	(0.15 to 0.25)
Crosshead (Gray Iron) to Guide - JGI/JGM/JGP (Feeler Gauge ^a)	0.006 to 0.010	(0.15 to 0.25)
Total Piston End Clearance - Double Acting ^b	0.090 to 0.145	(2.29 to 3.68)
Piston End Clearance - Crank End (Double Acting) ^b	0.035	(0.89)
Piston End Clearance - Head End (Double Acting) ^b	0.055 to 0.110	(1.40 to 2.79)
Total Piston End Clearance - Tandem ^b	0.090 to 0.180	(2.29 to 4.57)
Piston End Clearance - Crank End (Tandem) ^b	0.035	(0.89)
Piston End Clearance - Head End (Tandem) ^b	0.055 to 0.145	(1.40 to 3.68)

a. Crosshead guide to crosshead clearance at the top is to be checked by inserting a standard 0.500 inch (13 mm) wide feeler stock from one side edge of the crosshead across to the opposite side. This is to be done at both ends. The bottom clearance is to be checked with 0.0015 inch (0.038 mm) feeler stock at the 4 corners. If the feeler can be inserted more than 0.500 inches (14 mm), the assembly is not acceptable.

b. If 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 and Packing Ring Side Clearance, Inches (mm)

The standard side clearance in inches (mm) for JG, M, P and SP class cylinders - piston rings and packing rings, when new, are as follows:

TABLE 1-4: NEW CONVENTIONAL 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)	0.005 to 0.009 (0.13 to 0.23)	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 0.009 (0.13 to 0.23)	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 0.011 (0.18 to 0.28)	0.004 to 0.008 (0.10 to 0.20)
3/4 (19.05)	0.750 to 0.752 (19.05 to 19.10)	0.014 to 0.019 (0.36 to 0.48)	0.006 to 0.010 (0.15 to 0.25)

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

NOMINAL WIDTH	ACTUAL GROOVE WIDTH	TWO-PIECE
3/16 (4.76)	0.187 to 0.189 (4.75 to 4.80)	0.007 to 0.012 (0.18 to 0.30)
1/4 (6.35)	0.250 to 0.252 (6.35 to 6.40)	0.008 to 0.013 (0.20 to 0.33)
3/8 (9.53)	0.375 to 0.377 (9.53 to 9.58)	0.008 to 0.013 (0.20 to 0.33)
1/2 (12.70)	0.500 to 0.502 (12.70 to 12.75)	0.008 to 0.013 (0.20 to 0.33)
3/4 (19.05)	0.750 to 0.752 (19.05 to 19.10)	0.008 to 0.013 (0.20 to 0.33)

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

ACTUAL GROOVE WIDTH	1 · RING/GROOVE NON-METAL OR CI	2 · RINGS/GROOVE NON-METAL OR CI	3 · RINGS/GROOVE NON-METAL & CI	BRONZE
0.375 to 0.377 (9.53 to 9.58)	0.011 to 0.014 (0.28 to 0.36)	0.011 to 0.015 (0.28 to 0.38)	N/A	0.006 to 0.008 (0.15 to 0.20)
0.447 to 0.449 (11.35 to 11.41)	N/A	N/A	0.013 to 0.018 (0.33 to 0.46)	
0.562 to 0.564 (14.28 to 14.33)	N/A	N/A	0.017 to 0.022 (0.43 to 0.56)	
0.936 to 0.938 (23.77 to 23.82)	N/A	Zero (0) ^a		N/A

a. Side loaded “AL” (5) ring type

TABLE 1-7: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP, IN. (mm) - M, P & SP CLASS CYLINDERS

BORE DIAMETER ^a	PISTON TO BORE CLEARANCE	PISTON RING END GAP - TFE	
		NEW	MAXIMUM
2.0625 (52)	0.007 to 0.011 (0.18 to 0.28)	0.025 to 0.030 (0.64 to 0.76)	0.120 (3.05)
2.25 (57)	0.007 to 0.011 (0.18 to 0.28)	0.027 to 0.032 (0.69 to 0.81)	0.128 (3.18)
2.5 (64)	0.007 to 0.011 (0.18 to 0.28)	0.030 to 0.036 (0.76 to 0.91)	0.144 (3.66)
2.75 (70)	0.007 to 0.011 (0.18 to 0.28)	0.033 to 0.040 (0.84 to 1.02)	0.160 (3.71)
3 (76)	0.007 to 0.011 (0.18 to 0.28)	0.036 to 0.044 (0.91 to 1.12)	0.176 (4.47)
3.25 (83))	0.009 to 0.013 (0.23 to 0.33)	0.039 to 0.047 (0.99 to 1.19)	0.188 (4.76)
3.5 (89)	0.009 to 0.013 (0.23 to 0.33)	0.042 to 0.052 (1.07 to 1.30)	0.208 (5.28)
3.75 (95)	0.010 to 0.014 (0.25 to 0.36)	0.046 to 0.056 (0.17 to 1.42)	0.224 (5.69)
3.875 (98)	0.010 to 0.014 (0.25 to 0.36)	0.047 to 0.057 (0.19 to 1.45)	0.228 (5.79)
4.125 (105)	0.010 to 0.014 (0.25 to 0.36)	0.049 to 0.060 (1.24 to 1.52)	0.240 (6.10)
4.375 (111)	0.011 to 0.015 (0.28 to 0.38)	0.052 to 0.064 (1.32 to 1.63)	0.255 (6.48)
4.75 (121)	0.012 to 0.017 (0.30 to 0.43)	0.057 to 0.077 (1.45 to 1.96)	0.308 (7.82)
5.125 (130)	0.012 to 0.017 (0.30 to 0.43)	0.061 to 0.081 (1.55 to 2.06)	0.324 (8.23)
5.5 (140)	0.013 to 0.018 (0.33 to 0.46)	0.065 to 0.085 (1.65 to 2.16)	0.340 (8.64)
5.75 (146)	0.013 to 0.018 (0.33 to 0.46)	0.068 to 0.088 (1.73 to 2.24)	0.352 (8.94)
6.125 (156)	0.014 to 0.020 (0.36 to 0.51)	0.073 to 0.093 (1.85 to 2.36)	0.372 (9.45)
6.5 (165)	0.014 to 0.020 (0.36 to 0.51)	0.077 to 0.097 (1.96 to 2.46)	0.388 (9.86)
7.5 (191)	0.016 to 0.022 (0.41 to 0.56)	0.089 to 0.109 (2.26 to 2.77)	0.430 (10.92)
8 (203)	0.016 to 0.022 (0.41 to 0.56)	0.095 to 0.115 (2.41 to 2.87)	0.460 (11.68)
8.5 (216)	0.017 to 0.023 (0.43 to 0.58)	0.102 to 0.122 (2.59 to 3.10)	0.488 (12.40)
8.875 (225)	0.018 to 0.024 (0.46 to 0.61)	0.106 to 0.126 (2.69 to 3.20)	0.504 (12.80)
10.5 (267)	0.021 to 0.027 (0.53 to 0.69)	0.125 to 0.145 (3.18 to 3.68)	0.580 (14.73)
11 (279)	0.022 to 0.028 (0.56 to 0.71)	0.131 to 0.151 (3.33 to 3.84)	0.604 (15.34)
13 (330)	0.026 to 0.032 (0.66 to 0.81)	0.155 to 0.175 (3.94 to 4.45)	0.700 (17.78)
13.5 (343)	0.027 to 0.033 (0.69 to 0.84)	0.162 to 0.182 (4.12 to 4.63)	0.728 (18.49)

- a. Conventional piston rings are standard for all M, P and SP Class Cylinders, except for 1-3/4M-FS Class Cylinder with bore diameters of 1.625" (41mm) and 1.75" (44) where piston/rider rings are standard. Piston/rider rings are optional for all other M, P and SP Class Cylinders.

TABLE 1-8: PISTON TO BORE CLEARANCE AND PISTON/RIDER RING END GAP, IN. (mm) - M, P & SP CLASS CYLINDERS

BORE DIAMETER ^a	PISTON TO BORE CLEARANCE	PISTON/RIDER RING END GAP	
		NEW	MAXIMUM
1.625 (41)	0.090 to 0.096 (2.29 to 2.44)		
1.75 (44)	0.090 to 0.096 (2.29 to 2.44)	0.016 to 0.032 (0.41 to 0.81)	0.128 (3.25)
2.0625 (52)	0.090 to 0.096 (2.29 to 2.44)	0.020 to 0.036 (0.51 to 0.91)	0.144 (3.66)
2.25 (57)	0.090 to 0.096 (2.29 to 2.44)		
2.5 (64)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
2.75 (70)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3 (76)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.25 (83))	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.5 (89)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.75 (95)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.875 (98)	0.090 to 0.096 (2.29 to 2.44)	0.045 to 0.061 (1.14 to 1.55)	0.244 (6.20)
4.125 (105)	0.090 to 0.096 (2.29 to 2.44)	0.049 to 0.065 (1.24 to 1.65)	0.260 (6.60)
4.375 (111)	0.090 to 0.096 (2.29 to 2.44)	0.052 to 0.068 (1.32 to 1.73)	0.272 (6.91)
4.75 (121)	0.090 to 0.096 (2.29 to 2.44)	0.057 to 0.073 (1.45 to 1.85)	0.292 (7.42)
5.125 (130)	0.090 to 0.096 (2.29 to 2.44)	0.062 to 0.078 (1.57 to 1.98)	0.312 (7.93)
5.5 (140)	0.090 to 0.096 (2.29 to 2.44)	0.068 to 0.084 (1.73 to 2.13)	0.336 (8.53)
5.75 (146)	0.090 to 0.096 (2.29 to 2.44)	0.071 to 0.087 (1.80 to 2.21)	0.348 (8.84)
6.125 (156)	0.090 to 0.096 (2.29 to 2.44)	0.069 to 0.099 (1.75 to 2.51)	0.396 (10.06)
6.5 (165)	0.090 to 0.096 (2.29 to 2.44)	0.074 to 0.104 (1.88 to 2.64)	0.416 (10.57)
7.5 (191)	0.090 to 0.096 (2.29 to 2.44)	b	b
8 (203)	0.090 to 0.096 (2.29 to 2.44)	b	b
8.5 (216)	0.090 to 0.096 (2.29 to 2.44)	0.114 to 0.144 (2.90 to 3.66)	0.576 (14.63)
8.875 (225)	0.090 to 0.096 (2.29 to 2.44)	0.120 to 0.150 (3.05 to 3.81)	0.600 (15.24)
10.5 (267)	0.090 to 0.096 (2.29 to 2.44)	0.144 to 0.174 (3.66 to 4.42)	0.696 (17.68)
11 (279)	0.090 to 0.096 (2.29 to 2.44)	0.152 to 0.182 (3.86 to 4.62)	0.728 (18.49)
13 (330)	0.090 to 0.096 (2.29 to 2.44)	0.182 to 0.212 (4.62 to 5.39)	0.848 (21.54)
13.5 (343)	0.090 to 0.096 (2.29 to 2.44)	0.190 to 0.220 (4.83 to 5.59)	0.880 (22.35)

- a. Conventional piston rings are standard for all M, P and SP Class Cylinders, except for 1-3/4M-FS Class Cylinder with bore diameters of 1.625" (41mm) and 1.75" (44) where piston/rider rings are standard. Piston/rider rings are optional for all other M, P and SP Class Cylinders.
- b. 8M x 3-1/2" (88.9 mm) stroke & 8SP-HE class cylinders, w/ 7.5" (191) bore: end gap, new is 0.099" to 0.129" (2.51 to 3.53), maximum is 0.516" (13.11). 8M x 3" (76.2) stroke, w/ 7.5" (191) bore: new 0.088" to 0.118" (2.24 to 3.00), maximum 0.472" (11.99). 8M x 3-1/2" (88.9) & 8SP-HE, w/ 8" (203) bore: new 0.106" to 0.136" (2.69 to 3.43), maximum 0.544" (14.07). 8M x 3" (76.2) w/ 8" (203) bore: new 0.095" to 0.125" (2.41 to 3.18), maximum 0.500" (12.70).

TABLE 1-9: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP, IN. (mm) - JG CLASS CYLINDERS

BORE DIAMETER ^a	PISTON TO BORE CLEARANCE	PISTON RING END GAP - NON-METALLIC	
		NEW	MAXIMUM
1.25 (32) ^b	0.025 to 0.033 (0.64 to 0.84)	0.018 to 0.028 (0.46 to 0.71)	0.112 (2.85)
1.5 (38) ^b	0.030 to 0.038 (0.76 to 0.97)	0.021 to 0.031 (0.51 to 0.79)	0.124 (3.15)
1.625 (41) ^b	0.030 to 0.038 (0.76 to 0.97)	0.023 to 0.033 (0.58 to 0.84)	0.132 (3.35)
1.75 (44) ^b	0.030 to 0.038 (0.76 to 0.97)	0.025 to 0.035 (0.64 to 0.89)	0.140 (3.55)
2.75 (70)	0.009 to 0.014 (0.23 to 0.36)	0.027 to 0.033 (0.69 to 0.81)	0.132 (3.35)
3 (76)	0.009 to 0.014 (0.23 to 0.36)	0.030 to 0.036 (0.76 to 0.91)	0.144 (3.66)
3.375 (86)	0.010 to 0.015 (0.25 to 0.38)	0.034 to 0.041 (0.88 to 1.04)	0.164 (4.17)
3.625 (92)	0.010 to 0.015 (0.25 to 0.38)	0.036 to 0.044 (0.91 to 1.12)	0.176 (4.47)
3.875 (98)	0.011 to 0.016 (0.28 to 0.41)	0.039 to 0.047 (0.99 to 1.19)	0.188 (4.78)
4.125 (105)	0.011 to 0.016 (0.28 to 0.41)	0.041 to 0.050 (1.04 to 1.27)	0.200 (5.08)
4.75 (121)	0.012 to 0.018 (0.30 to 0.46)	0.057 to 0.077 (1.45 to 1.96)	0.308 (7.82)
5.125 (130)	0.012 to 0.018 (0.30 to 0.46)	0.061 to 0.081 (1.55 to 2.06)	0.324 (8.23)
6.125 (156)	0.013 to 0.019 (0.33 to 0.48)	0.073 to 0.093 (1.85 to 2.36)	0.372 (9.45)
6.5 (165)	0.014 to 0.020 (0.36 to 0.51)	0.077 to 0.097 (1.96 to 2.46)	0.388 (9.86)
7.125 (181)	0.015 to 0.021 (0.38 to 0.53)	0.085 to 0.105 (2.16 to 2.67)	0.409 (10.39)
7.5 (191)	0.015 to 0.021 (0.38 to 0.53)	0.089 to 0.109 (2.26 to 2.77)	0.430 (10.92)
8.5 (216)	0.017 to 0.023 (0.43 to 0.58)	0.102 to 0.122 (2.59 to 3.10)	0.488 (12.40)
8.875 (225)	0.018 to 0.024 (0.46 to 0.61)	0.106 to 0.126 (2.69 to 3.20)	0.504 (12.80)

a. Conventional piston rings are standard for JG Class Cylinders, except 2-1/2JG-FS-HE Class cylinders with bore diameters of 2.25" (57mm) & 2.5" (64); 3JG-CE, 2.75" (70) & 3" (76); and 3-5/8JG-CE, 3.375" (86) & 3.625" (92), which use piston/rider rings. Piston/rider rings are optional for other JG Cylinders, except for 1-3/4JG-FS-HE, which uses conventional rings and wear band.

b. These sizes use conventional piston rings and wear band, see Table 1-10 for wear band values.

TABLE 1-10: WEAR BAND END GAP & RADIAL PROJECTION (NEW) - 1-3/4JG-FS-HE CLASS, IN. (mm)

BORE DIAMETER ^a	END GAP MINIMUM	RADIAL PROJECTION
1.25 (32)	0.049 (1.24)	0.005 to 0.012 (0.13 to 0.30)
1.5 (38)	0.049 (1.24)	0.008 to 0.012 (0.20 to 0.30)
1.625 (41)	0.052 (1.32)	0.008 to 0.012 (0.20 to 0.30)
1.75 (44)	0.058 (1.47)	0.008 to 0.015 (0.20 to 0.38)

a. New wear band side clearance is 0.010 to 0.014" (0.25 to 0.36).

TABLE 1-11: PISTON TO BORE CLEARANCE AND PISTON/RIDER RING END GAP, IN. (mm) - JG CLASS CYLINDERS

BORE DIAMETER ^a	PISTON TO BORE CLEARANCE	PISTON/RIDER RING END GAP	
		NEW	MAXIMUM
2.25 (57)	0.090 to 0.096 (2.29 to 2.44)	0.023 to 0.039 (0.58 to 0.99)	0.156 (3.96)
2.5 (64)	0.090 to 0.096 (2.29 to 2.44)	0.030 to 0.046 (0.76 to 1.17)	0.184 (4.67)
2.75 (70)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3 (76)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.375 (86)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.625 (92)	0.090 to 0.096 (2.29 to 2.44)	0.047 to 0.063 (1.19 to 1.60)	0.252 (6.40)
3.875 (98)	0.090 to 0.096 (2.29 to 2.44)	0.051 to 0.067 (1.30 to 1.70)	0.268 (6.81)
4.125 (105)	0.090 to 0.096 (2.29 to 2.44)	0.055 to 0.071 (1.40 to 1.80)	0.284 (7.21)
4.75 (121)	0.090 to 0.096 (2.29 to 2.44)	0.057 to 0.073 (1.45 to 1.85)	0.292 (7.42)
5.125 (130)	0.090 to 0.096 (2.29 to 2.44)	0.062 to 0.078 (1.57 to 1.98)	0.312 (7.93)
6.125 (156)	0.090 to 0.096 (2.29 to 2.44)	0.069 to 0.099 (1.75 to 2.51)	0.396 (10.06)
6.5 (165)	0.090 to 0.096 (2.29 to 2.44)	0.074 to 0.104 (1.88 to 2.64)	0.416 (10.57)
7.125 (181)	0.090 to 0.096 (2.29 to 2.44)	0.083 to 0.113 (2.11 to 2.87)	0.452 (11.48)
7.5 (191)	0.090 to 0.096 (2.29 to 2.44)	0.088 to 0.118 (2.24 to 3.00)	0.472 (11.99)
8.5 (216)	0.090 to 0.096 (2.29 to 2.44)	0.114 to 0.144 (2.90 to 3.66)	0.576 (14.63)
8.875 (225)	0.090 to 0.096 (2.29 to 2.44)	0.120 to 0.150 (3.05 to 3.81)	0.600 (15.24)

- a. Conventional piston rings are standard for JG Class Cylinders, except 2-1/2JG-FS-HE Class cylinders with bore diameters of 2.25" (57mm) & 2.5" (64); 3JG-CE, 2.75" (70) & 3" (76); and 3-5/8JG-CE, 3.375" (86) & 3.625" (92), which use piston/rider rings. Piston/rider rings are optional for other JG Cylinders, except for 1-3/4JG-FS-HE, which uses conventional rings and wear band.

Fastener Tightening Torque

Listed in the following tables are fastener tightening torque values required for proper assembly of Ariel JGI, JGM, JGN, JGP and JGQ 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 otherwise to be used for fastener lubrication, unless specified, or excessive stresses can result with the listed values.

TABLE 1-12: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE, INCH · TPI	TYPE	TORQUE, LB X FT (N·m)
Main Bearing Cap - Cap Screw	1/2 - 13	12 Point - Grade 8	58 (79)
JGI Bearing Carrier to Frame - Cap Screw	1/2 - 13	12 Point - Grade 8	44 (60)
Connecting Rod Cap - Cap Screw	1/2 - 13	12 Point/Socket Head	58 (79)
Connecting Rod Cap - Cap Screw	1/2 - 20	12 Point - Grade 8	67 (91)
Crosshead Pin Thru Bolt - Lock Nut	3/8 - 24	Hex - Flexloc	25 (34)
Frame to Cylinder - Cap Screw	1/2 - 13	12 Point - Grade 8	48 (65)
Frame to Support - Cap Screw	5/8 - 11	Hex - Grade 8 or 9	88 (120)
Eccentric Vernier Cap - Cap Screw	5/16 - 18	Hex - Grade 8	144 lb x in. (16)
Idler Sprocket Thru Bolt - Lock Nut	1/2 - 20	Hex - Drill & Pin	41 (55)
Rod Packing - Cap Screw	1/2 - 13	12 Point - Grade 8	35 (48)
Piston Nut	7/8 - 12	Ariel Design	222 (300)
Crosshead Nut	1 - 12	Ariel Design	255 (345)
Rupture Disk - Blow-Out Fitting Cap	1/4 Nom. Tube	Hex - Tube Fitting	36 lb x in. (4.1)
Hold Down - Stud-Nut	5/8 - 11	Hex Stud-Nut	100 ^a (130)
Valve Cap/Cylinder Head/Gas Passage/ Unloader - Cap Screw ^b	3/8 - 16	Hex - Grade 8 or 9 or 12 Point - Grade B7M or 8	193 lb x in. (22)
	7/16 - 14		26 (35)
	1/2 - 13		40 (54)
	5/8 - 11		79 (105)
	3/4 - 10		140 (190)
	7/8 - 9		230 (310)
	7/8 - 14		260 (350)
	1 - 8		345 (465)

TABLE 1-12: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE, INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Tandem Cylinder to Cylinder - Cap Screw ^b	1/2 - 13	Hex - Grade 8 or 9 or 12 Point - Grade 8	44 (60)
	5/8 - 11		88 (120)
	3/4 - 10		160 (215)
Seating Studs in Cylinder	3/8 - 16	Dog Point	107 lb x in. (12)
	7/16 - 14		172 lb x in. (19)
	1/2 - 13		22 (30)
	9/16 - 12		32 (43)
	5/8 - 11		44 (60)
	3/4 - 10		79 (105)
	7/8 - 9		130 (170)
	1 - 8		190 (260)
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	1/4 - 20	Hex - Grade 5	46 lb x in. (5.4)
	1/4 - 28		54 lb x in. (6.1)
	5/16 - 18		96 lb x in. (11)
	3/8 - 16		171 lb x in. (19)
	3/8 - 24		17 (23)
	7/16 - 14		23 (31)
	1/2 - 20		41 (55)

- a. Minimum torque for recommended 5/8" - 11TPI 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 stud to about 55% of ultimate strength of stud material, as specified by packager.
- b. When studs are specified for cylinder applications, tighten stud-nuts to the same values as cap screws in similar applications. Reference Figure 1-8:

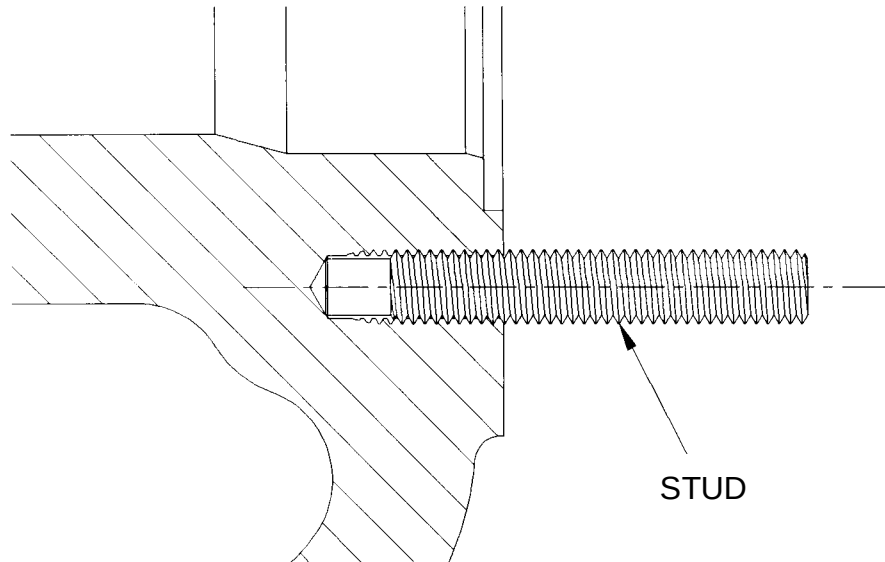


FIGURE 1-8: DOG POINT STUDS

TABLE 1-13: 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 8	26 (35)
	3/8 - 24		45 (61)
	7/16 - 20		62 (83)
	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 - Grade B8M - Stainless Steel	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 (49) ^c
		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 - 20		110 lb x in. (12.4)
	5/16 - 18		176 lb x in. (19.9)
	3/8 - 16		21 (28)

- a. 12 Point Cap Screw Center Fasteners in Valve Assemblies not marked SPL (Spirallock Threads), must be cleaned with Loctite Safety solvent and locked with one to two drops of Loctite #272. Do not use petroleum thread lubricants.
- b. 12 Point Cap Screws in Valve Assemblies with Spirallock Threads and marked SPL (see Figure 1-9:) 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 Lift-washer Type Valves.

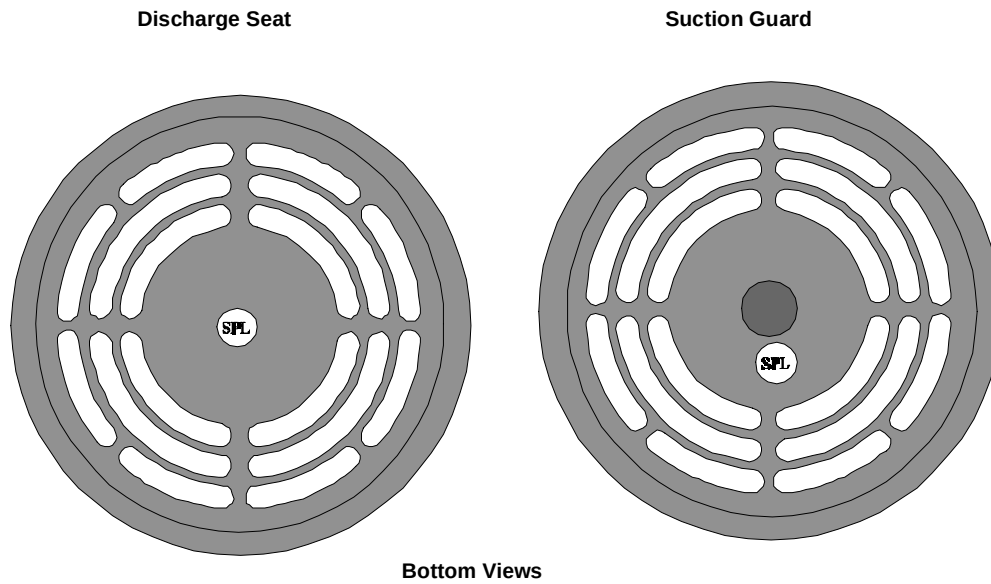


FIGURE 1-9: SPIRALOCK THREADED VALVE ASSEMBLY - MARKED SPL

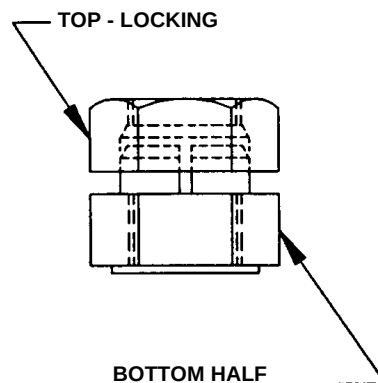


FIGURE 1-10: DRAKE LOCK NUT

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, except for 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. 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 but is jerked, 120 lb x ft torque can be applied.
4. 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.
5. 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.
6. 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.
7. Do not use a torque wrench to break fasteners loose as it may overload the torque wrench and/or cause loss of calibration.
8. 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
9. The ratio of actual torque at the fastener with that on the wrench scale is a function of the adapter's length and its position in relation to the torque wrench beam and the location on that at which the force is applied (see Figure 1-11:).

$$T_w = T_a \left(\frac{L}{L + A} \right)$$

T_w = Torque wrench setting, lb x ft

T_a = Torque required at fastener, lb x ft

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

A = Length of adapter, ft (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:).

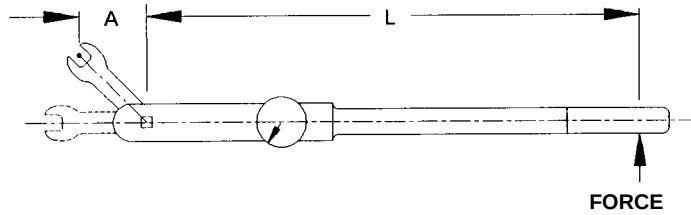


FIGURE 1-11: TORQUE WRENCH WITH ADAPTOR AT ANY ANGLE

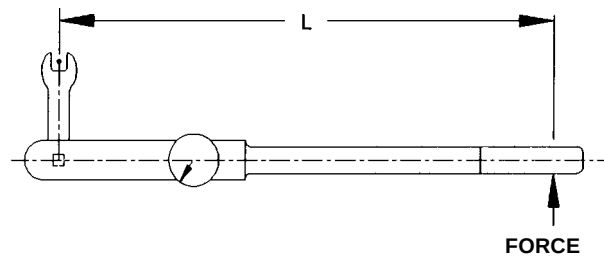
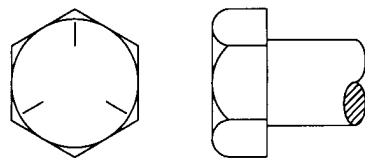


FIGURE 1-12: TORQUE WRENCH WITH ADAPTOR AT RIGHT ANGLE

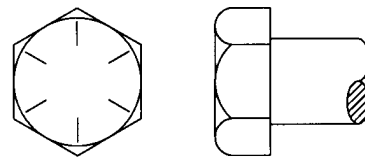
Ariel Bolting

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 1-12 on page 1-16. Figure 1-13: is provided to assist in the identification of bolts used in an Ariel compressor.

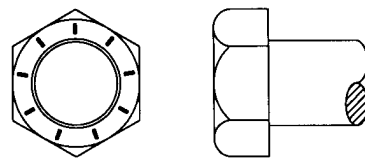
Connecting rod, valve cap and suction/discharge nozzle-Ariel supplied specialized companion flange-bolting is modified to prevent fatigue and cannot be replaced with standard bolts. If attempting to replace other bolting with standard bolts and there is any question, contact your packager or Ariel. Ariel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



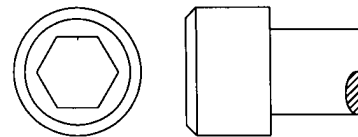
Hex head Grade 5



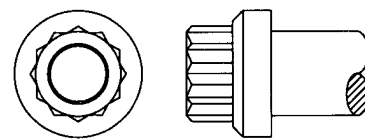
Hex head Grade 8



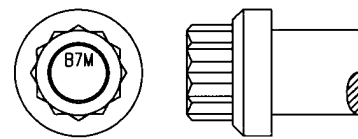
Hex head Grade 9



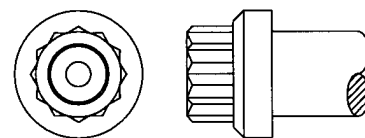
Hex Socket Head Grade 8



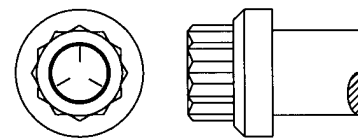
12 Point Grade 8



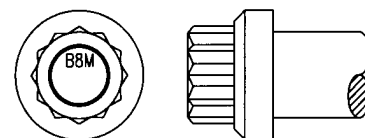
12 Point Grade B7M (NACE)



12 Point Interim Grade 5



12 Point Grade 5



12 Point Stainless
Steel Grade B8M

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 must 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 proper 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 position. The 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 movement 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 and 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
- Which way indicator moves (plus or minus)
- 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 requirements.

Vents and Drains¹

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 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.

1. Also see Section 4.

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 THROUGH 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 ON THE INFORMATION CONTAINED IN THIS SECTION. IT IS ALSO ESSENTIAL TO REFER TO THE PACKAGER'S OPERATING MANUAL.

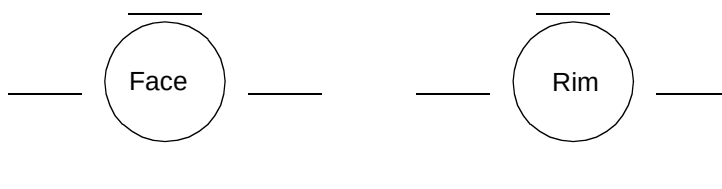
Start-Up Check List

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? _____
 Maximum 0.0015" (0.038 mm) feeler inserted to 1/2" (12.7 mm) maximum 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 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 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. Has the recommended oil filter element been installed?	_____	_____
19. Are the oil filter element 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 temperature 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 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 gauges working?	_____	_____
3. Oil filter diff. 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 PSIG (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?	_____	_____

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 1-8).



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 psig¹, 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 valve 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 DOWNSTREAM 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 CIRCUIT. THIS IS TO PROTECT AGAINST DISCHARGE-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.

JGI, JGM, JGN, JGP and JGQ frames should be 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.

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 1-7). An indicator pin 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:).

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 Application Data Book in the specification 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 Amot 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 4-8: Lube Oil System Schematic - Typical.
2. Ariel recommends installation of the Amot 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%.

Electric motor driven compressors must have a prelube pump to ensure oil flow prior to start-up. A start permissive should disable the start-up sequence if oil pressure is below 10 psig (0.7 bar_g). An automatic prelube cycle is strongly recommended for all electric drive systems, and required on those with unattended start sequences or frequent starts.

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 naphthenic.

Naphthenic - (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. Naphthenic 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, polyglycolethers, 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/cm²) 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.

JGI, JGM, JGN, JGP & JGQ compressors are equipped with simplex, spin-on, resin-impregnated cellulose 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) 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.

The proper lubrication rate may be determined several ways. The cigarette paper method utilizes two layers of un-waxed cigarette papers or equivalent. Place the layers together and lightly rub the cylinder bore. The first layer of paper should show oil and the second layer should be dry.

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 provided by Ariel, 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.

To set the proper force feed lubrication 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 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 twice the “normal” required lube rate for the break in period. Please contact Ariel for assistance if the existing pump is not capable of the 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 noted above, for serviceability.

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	< 1000 PSIG (< 70 BAR_g)	1000 TO 2000 PSIG (70 TO 140 BAR_g)	2000 TO 3500^a PSIG (140 TO 240 BAR_g)	3500 TO 5000^a PSIG (240 TO 345 BAR_g)	≥ 5000^a PSIG (≥ 345 BAR_g)
Pipeline Quality Natural Gas	SAE 40 weight ISO 150	SAE 40-50 weight ISO 150-220 1.25 x base rate	SAE 50 weight w/ compounding ISO 220-320 1.5 x base rate	Cylinder Oil ISO 320-460 2.0 x base rate or Synthetic - Diester/Polyglycol	Cylinder Oil w/ compounding ISO 460-680 3.0 x base rate or Synthetic - Polyglycol
Natural Gas w/ Water &/or heavy hydrocarbons ^b Methane < 90% SG > 0.7 Propane > 8%	SAE 40-50 weight ISO 150-220 1.25 x base rate	SAE 50-60 weight or SAE 40 weight w/ compounding ISO 220-320 1.5 x base rate	Cylinder Oil w/ compounding ISO 460-680 2.0 x base rate	Cylinder Oil w/ compounding ISO 680 3.0 x base rate or Synthetic - Diester/Polyglycol	Contact Lubricant Supplier
CNG	SAE 40 weight ISO 150	SAE 40-50 weight ISO 150-220	See Pipeline Quality Natural Gas or Synthetic - Polyglycol/Diester	See Pipeline Quality Natural Gas or Synthetic - Polyglycol/Diester	See Pipeline Quality Natural Gas or Synthetic - Polyglycol
Air	SAE 40 weight Air Compressor Oil ISO 150	SAE 50 weight Air Compressor Oil w/ compounding ISO 220 1.5 x base rate	Synthetic - Diester 1.5 x base rate	Contact Lubricant Supplier	Contact Lubricant Supplier
Wet Air	SAE 40-50 weight Air Compressor Oil w/compounding ISO 150-220	Synthetic - Diester 1.5 x base rate	Synthetic - Diester 2.0 x base rate	Contact Lubricant Supplier	Contact Lubricant Supplier

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

GAS STREAM	< 1000 PSIG (< 70 BAR_g)	1000 TO 2000 PSIG (70 TO 140 BAR_g)	2000 TO 3500^a PSIG (140 TO 240 BAR_g)	3500 TO 5000^a PSIG (240 TO 345 BAR_g)	≥ 5000^a PSIG (≥ 345 BAR_g)
Natural Gas w/ Carbon Dioxide >2% to 10%	SAE 40-50 weight ISO 150-220 1.25 x base rate	SAE 50-60 weight or SAE 40 weight w/compounding ISO 220-320 1.5 x base rate	Cylinder Oil w/ compounding ISO 460-680 2.0 x base rate or Synthetic PAG	Cylinder Oil w/ compounding ISO 680 3.0 x base rate or Synthetic PAG	Contact Lubricant Supplier
Natural Gas w/ Carbon Dioxide ≥ 10%	SAE 40-50 weight ISO 150-220 1.5 x base rate	SAE 50-60 weight or SAE 40 weight w/compounding ISO 220-320 2.0 x base rate	Cylinder Oil w/ compounding ISO 460-680 3.0 x base rate or Synthetic PAG	Cylinder Oil w/ compounding ISO 680 4.0 x base rate or Synthetic PAG	Contact Lubricant Supplier
Nitrogen	SAE 40 weight ISO 150	SAE 40-50 weight ISO 150-220	SAE 50 weight ISO 220	SAE 60 weight ISO 320	Cylinder Oil ISO 460-680
Natural Gas w/ H ₂ S >2% to 30%	SAE 40 weight w/ compounding 1.25 x base rate ISO 150	SAE 40-50 weight w/compounding 1.5 x base rate ISO 150-220	SAE 50 weight w/ compounding 2.0 x base rate ISO 220	SAE 60 weight w/ compounding 3.0 x base rate ISO 320	Cylinder Oil w/ compounding 4.0 x base rate ISO 460-680
Natural Gas w/ H ₂ S ≥ 30%	SAE 40 weight w/ compounding 1.5 x base rate ISO 150	SAE 40-50 weight w/ compounding 2.0 x base rate ISO 150-220	SAE 50 weight w/ compounding 2.5 x base rate ISO 220	SAE 60 weight w/ compounding 4.0 x base rate ISO 320	Cylinder Oil w/ compounding 6.0 x base rate ISO 460-680
Propane ^c (refrigerant)	SAE 40 weight or Refrigerant Oil 0.5 x base rate	SAE 40 weight or Refrigerant Oil 1.0 x 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:

0.3 PINTS/DAY/INCH BORE (0.0056 L/DAY/mm BORE) FOR JGI, JGM, JGN, JGP AND JGQ FRAMES - 1 (STD) OR 2 (OPT) LUBE POINTS PER CYLINDER.

ROD SIZE IS DOUBLED AND TREATED LIKE A CYLINDER.

BREAK IN RATE IS TWICE THE RECOMMENDED RATE. BREAK IN RATE SHOULD BE MAINTAINED FOR 200 HOURS OF OPERATION.

SPECIAL LUBRICANT FORMULATIONS ARE AVAILABLE FROM LUBRICANT SUPPLIERS FOR SPECIFIC APPLICATIONS. APPROPRIATE DOCUMENTATION SHOULD BE PROVIDED BY THE SUPPLIER WHICH CERTIFIES SUITABILITY OF THE FORMULATION FOR SITE CONDITIONS. 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.

All cylinders have both top and bottom lubrication injection points available as an order option.

Oil is supplied to 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.

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 lubricator reservoir.

There is a 1/8 inch NPT plug in the discharge line near the force feed lubricator pump through which the 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 fracture 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 apportioned 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.

From the distribution block, oil travels to the cylinders and packings.

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 "Force Feed Lubricator Adjustment" on page 3-7 and refer to Figure 5-10:.

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

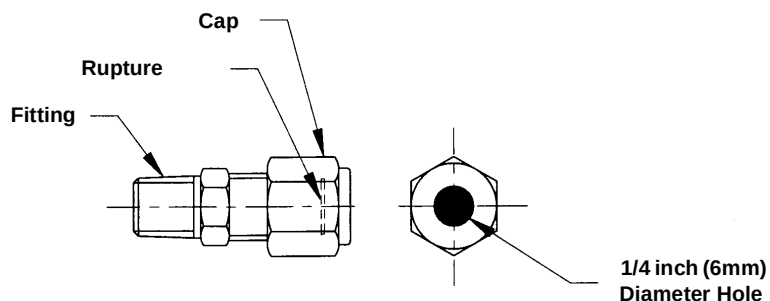
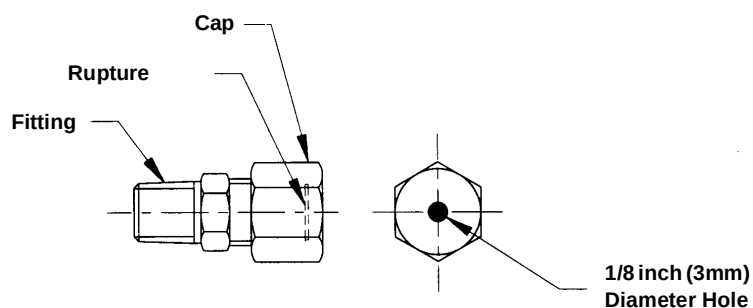
THE FORCE FEED SYSTEM MUST HAVE A WORKING NO-FLOW SHUTDOWN. THIS SHUTDOWN MUST BE SET TO ACTUATE WITHIN THREE TO FIVE MINUTES AFTER INTERRUPTION OF THE LUBRICATOR OIL FLOW.

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
Lubriquip	A-3531	3700	26	A-3536	Yellow	0.010	0.28
Lubriquip	A-3532	4600	32	A-3537	Red	0.012	0.30
Lubriquip	A-3533	5500	38	A-3538	Orange	0.014	0.36
Lubriquip	A-3534	6400	44	A-3539	Aluminum	0.016	0.41
Lubriquip	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 assembly, nor a Lubriquip disk in a Lincoln fitting. See Table 1-12 on page 1-16 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

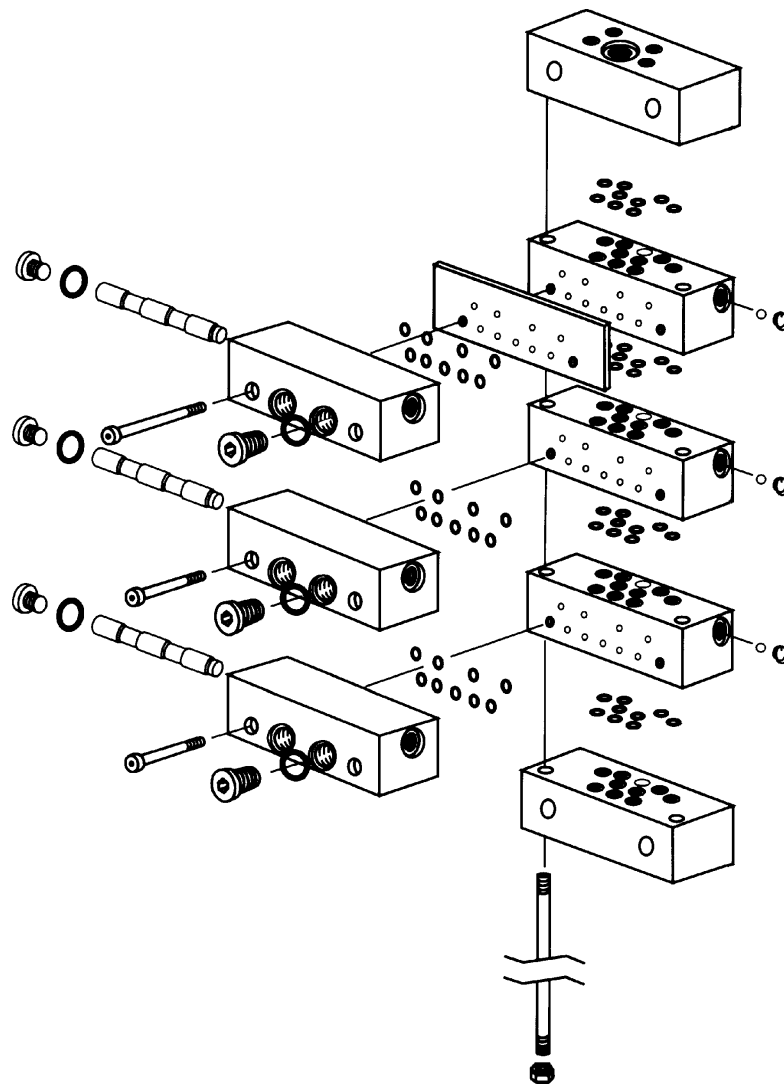


FIGURE 4-3: DIVIDER VALVE; DISTRIBUTION BLOCK - TYPICAL

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 normally supplied with Buna-N 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 cross-ported. 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 on a 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.

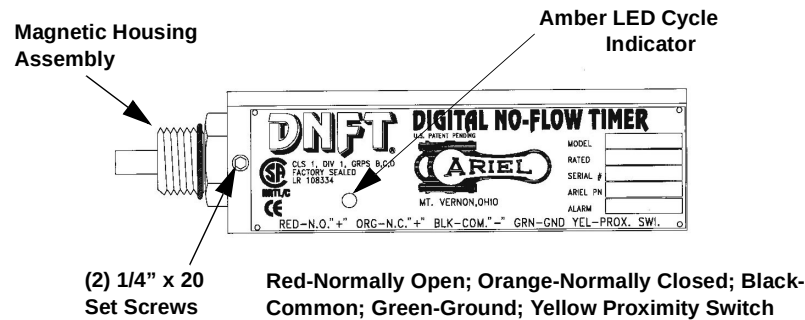


FIGURE 4-4: DIGITAL NO-FLOW TIMER SWITCH - (DNFT)

Assembly Instructions For Divider Valves

NOTE: THE CENTER TIE ROD IN THE BASEPLATE IS OFFSET SO THAT THE INTERMEDIATE 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.

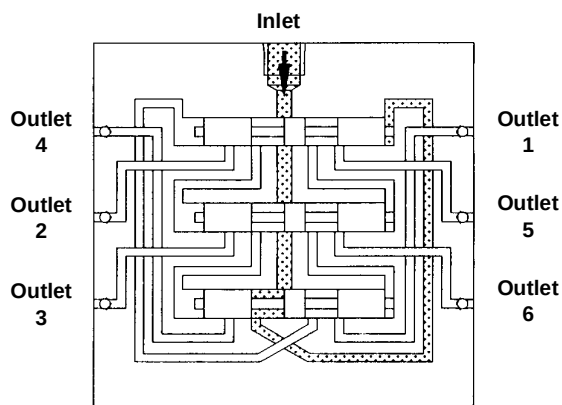


Illustration 1

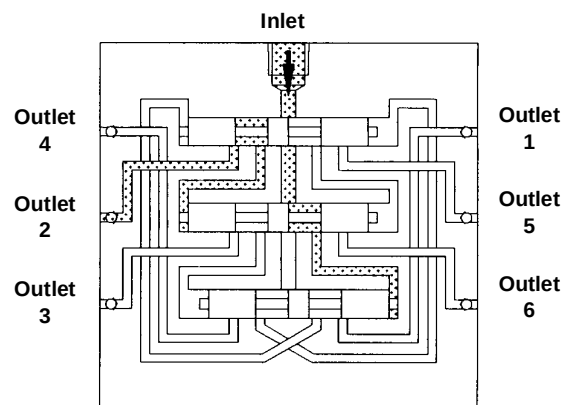


Illustration 3

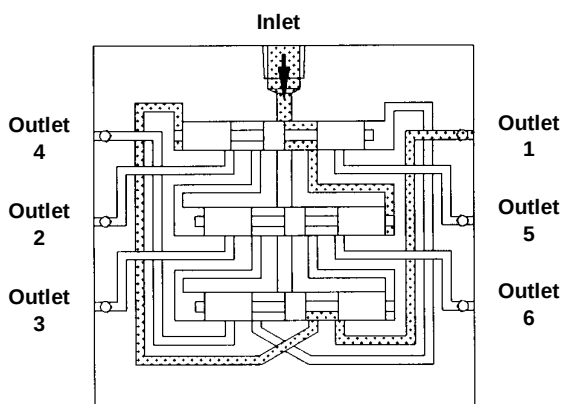


Illustration 2

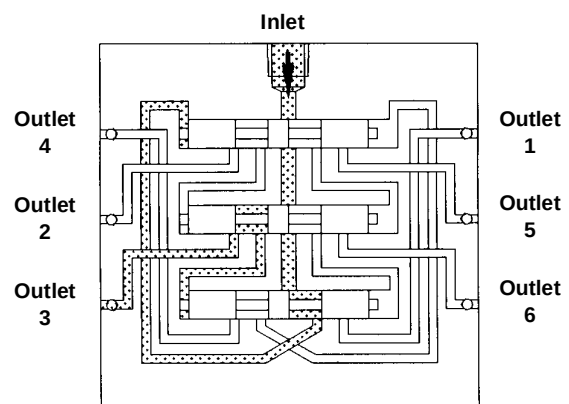


Illustration 4

FIGURE 4-5: DIVIDER VALVE OPERATION SCHEMATIC

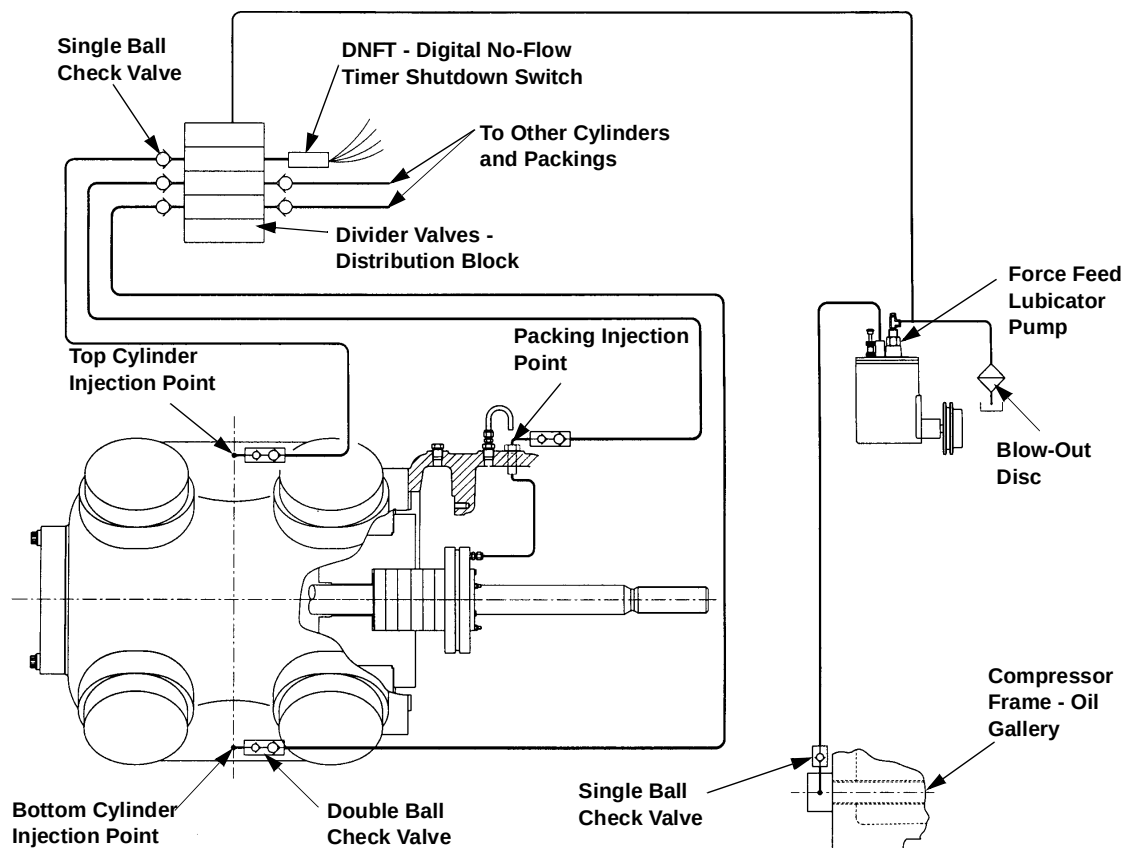


FIGURE 4-6: FORCE FEED LUBRICATION SYSTEM SCHEMATIC - TYPICAL

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. Refer to Figure 5-10:. 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.

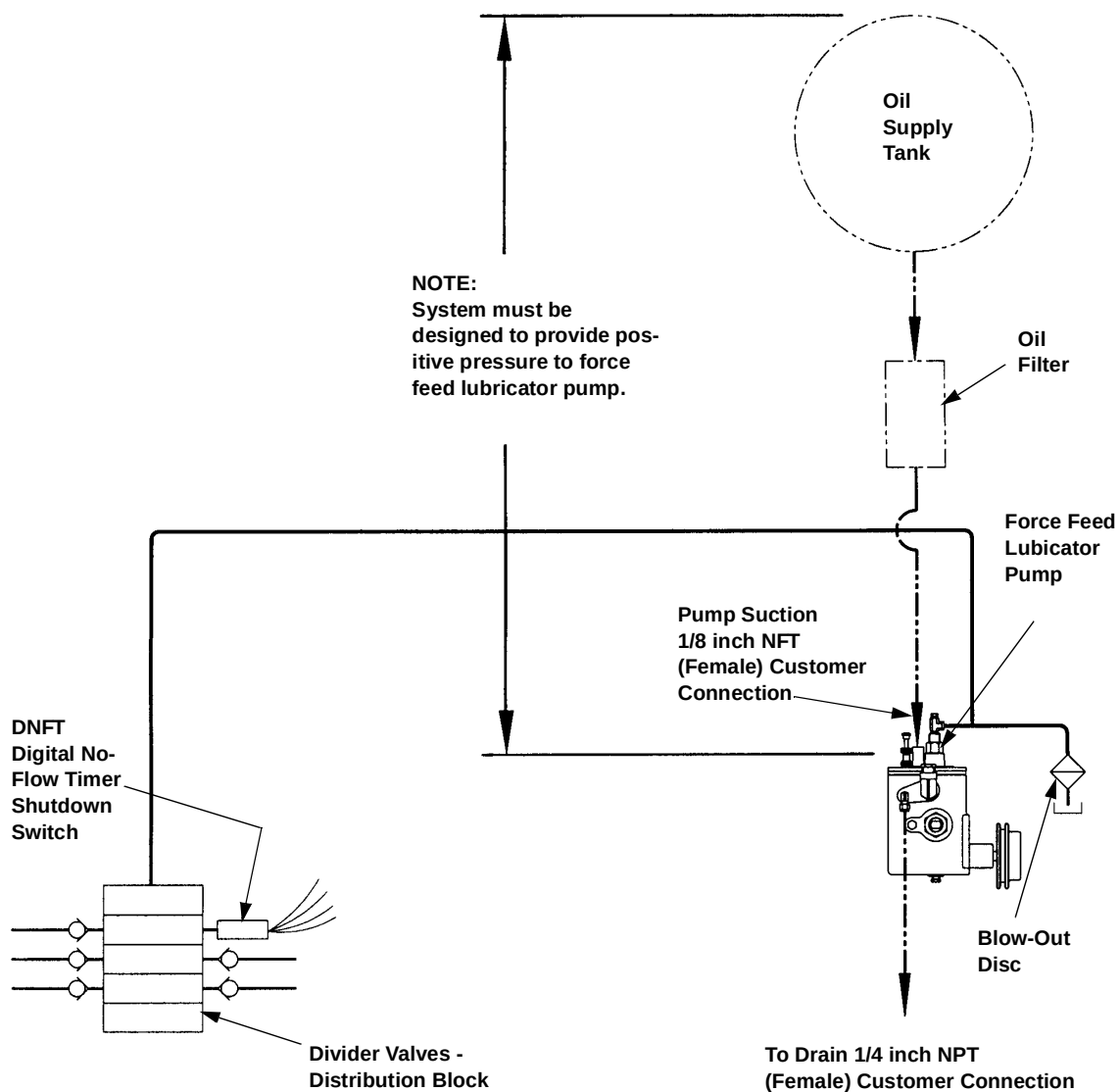


FIGURE 4-7: FORCE FEED LUBRICATION SYSTEM - INDEPENDENT OIL SUPPLY

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 4-8). An oil level regulator outside the crankcase should be used 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 4-8: Lube Oil System Schematic - Typical).

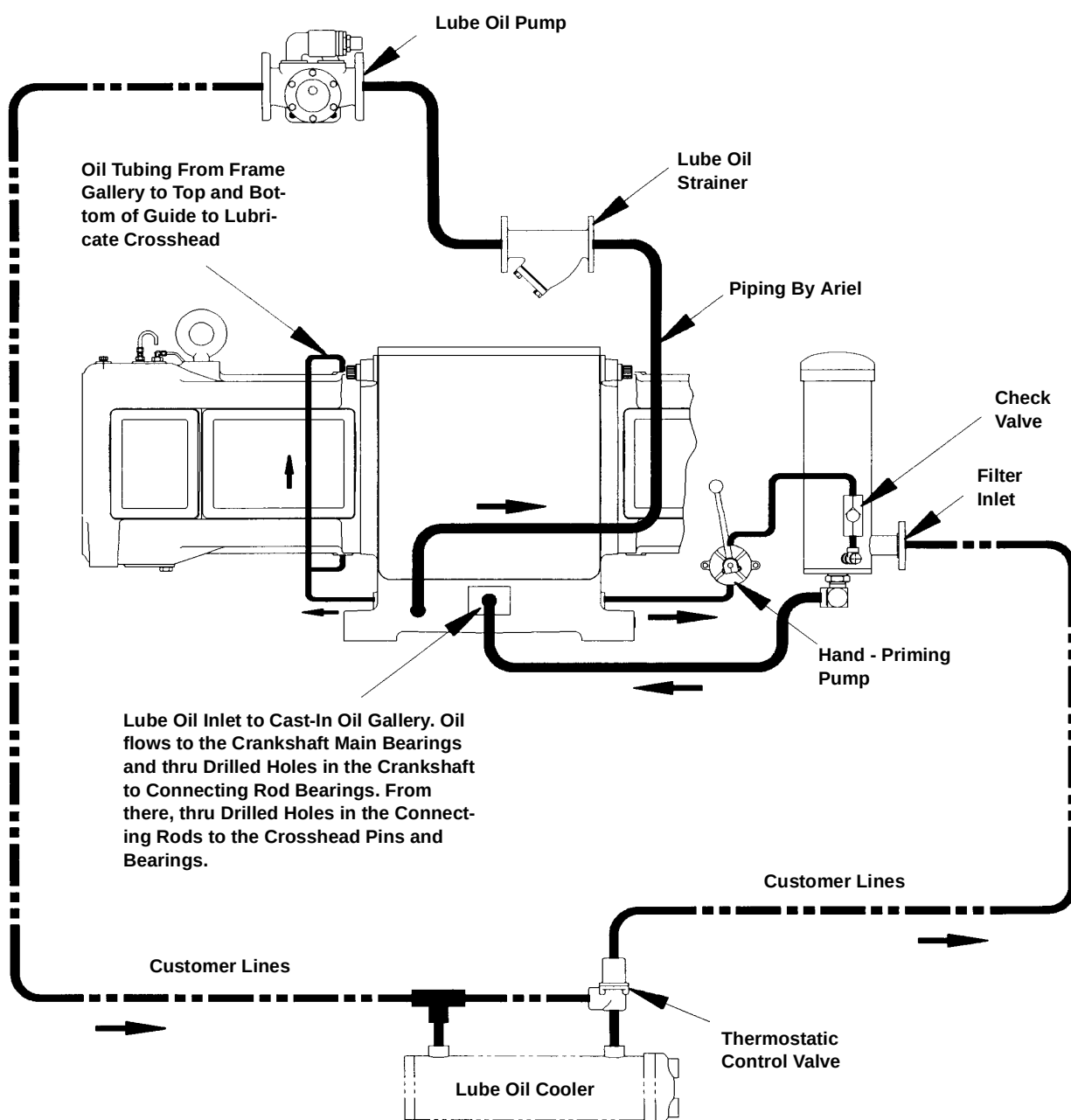


FIGURE 4-8: LUBE OIL SYSTEM SCHEMATIC - TYPICAL

Lube Oil Strainer, Filter & Filter Installation Instructions

Lube Oil Strainer

The 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

Ariel recommends replacing 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

1. Clean filter base surface, and be certain 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.

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

Lube Oil Pump & Lube Oil Pressure

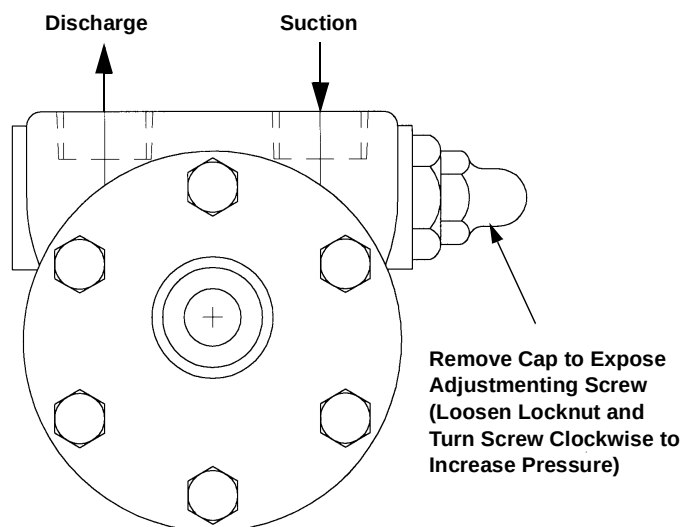


FIGURE 4-9: LUBE OIL PUMP

Description & Adjustment

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 4-9:).

Lube Oil Pressure

NOTE: NORMAL PRESSURE ON THE DISCHARGE SIDE OF THE LUBE OIL FILTER IS SET AT THE FACTORY AT 60 PSI (414 kPa) WHEN CRANKSHAFT SPEED EQUALS OR EXCEEDS 400 RPM FOR THE JGI; 750 RPM FOR THE JGM AND JGN, AND 900 RPM FOR THE JGP AND JGQ. IF OIL PRESSURE DROPS BELOW 50 PSI (350 kPa), THE CAUSE MUST BE FOUND AND CORRECTED.

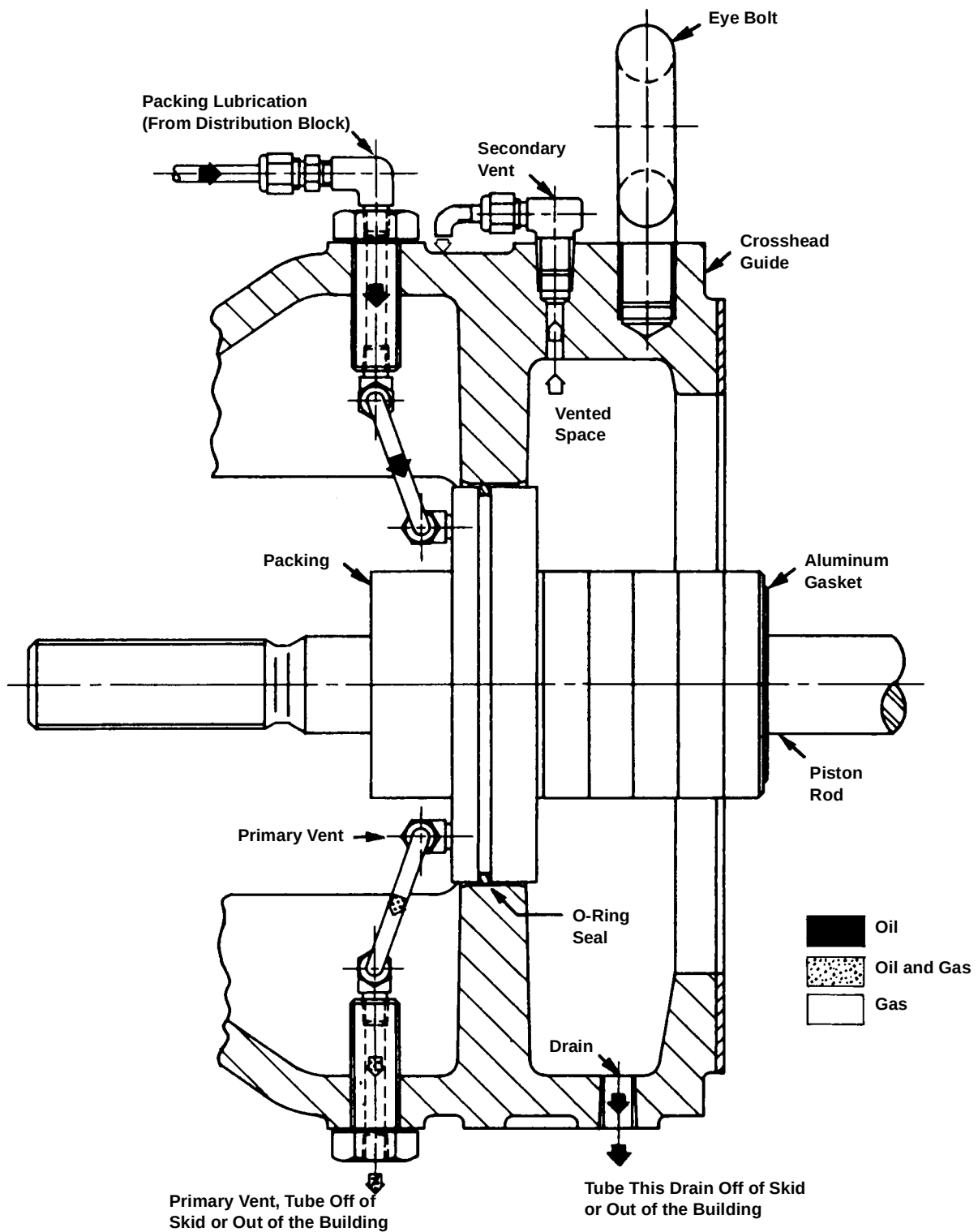
Low Oil Pressure Shutdown

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 SHUT-DOWN.**

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 TO FLOW INTO THE CRANKCASE FROM AN OVERHEAD TANK AT ALL AMBIENT TEMPERATURE CONDITIONS.

**FIGURE 4-10: PACKING, TUBING AND DISTANCE PIECE VENTING**

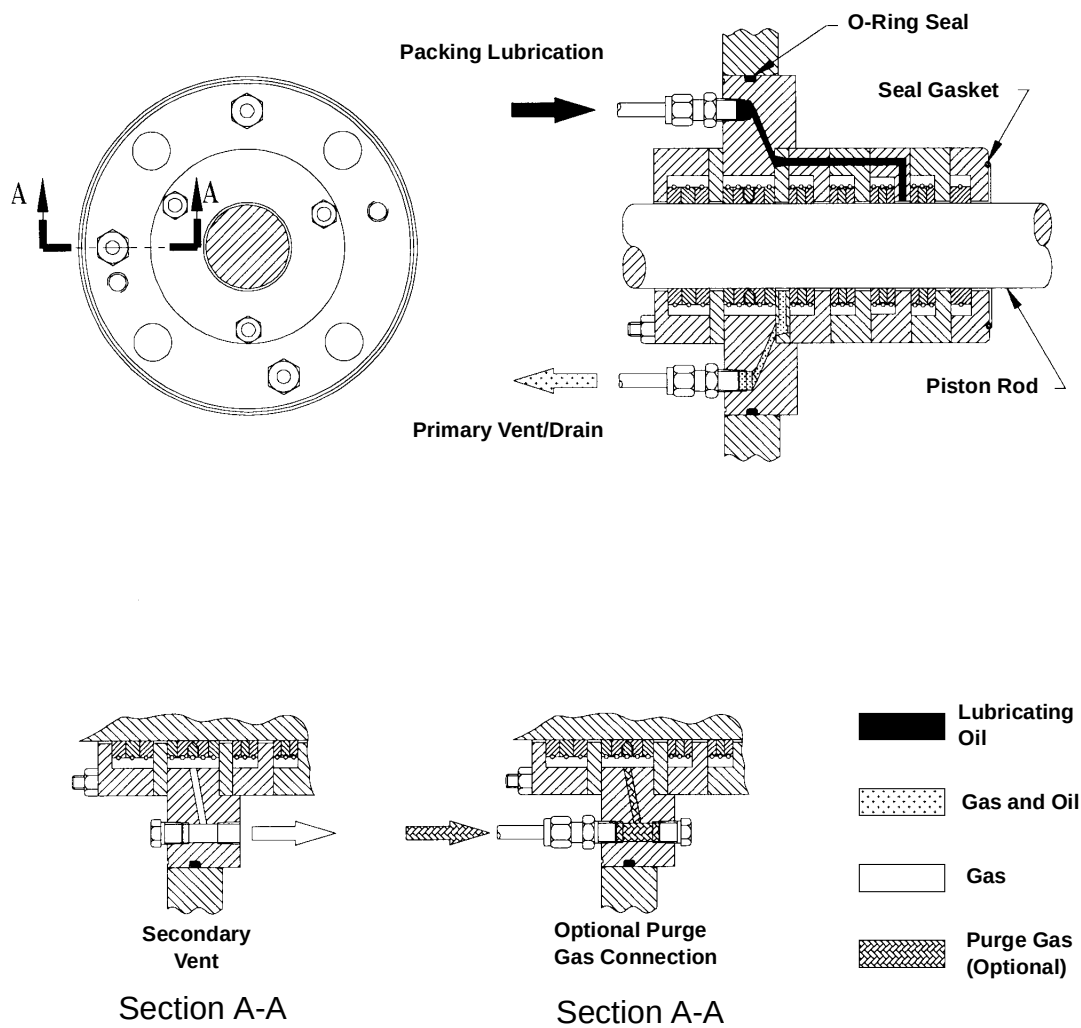


FIGURE 4-11: PACKING LUBRICATION AND VENTING

SECTION 5 - MAINTENANCE

General Introduction

The major components of the frame assembly are the crankcase or frame with integral crosshead guides, crankshaft and bearings, connecting rods, chain drive system and cross-heads.

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

A top cover on horizontally opposed models, and connecting rod and chain access covers on the JGI, 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 on the unit. 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. Damaged gaskets must 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.



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 (connecting rod and chain access covers on the JGI) and the side covers from the crosshead guides.
2. Move the throw to the outer dead center position.
3. Remove the crosshead as described in "Crosshead - Removal" on page 5-5. Turn the crankshaft until the throw is at its highest point. 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.
4. Half of the bearing shell will come out with the cap. The other half can be removed by sliding it out.
5. Turn the crankshaft until the rod can be taken out through the top opening of the crankcase (or connecting rod access hole on the JGI).
6. 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.

Connecting Rod Bushing

Check crosshead pin to bushing clearance (see Table 1-3 on page 1-10 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 hack-sawed 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 on 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 (OR TOWARD ACCESS HOLE IN THE JGI). 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 1-12 on page 1-16.
4. Tighten the connecting rod bolts in 25% increments to full torque to the values listed in Table 1-12 using a crisscross pattern.
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 1-10. 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

Note: Install Throw Marking and Joint Match Marks Up (or Toward Access opening for JGI)

Correct Orientation of the Rod is with Bearing Notches on Top Joint.

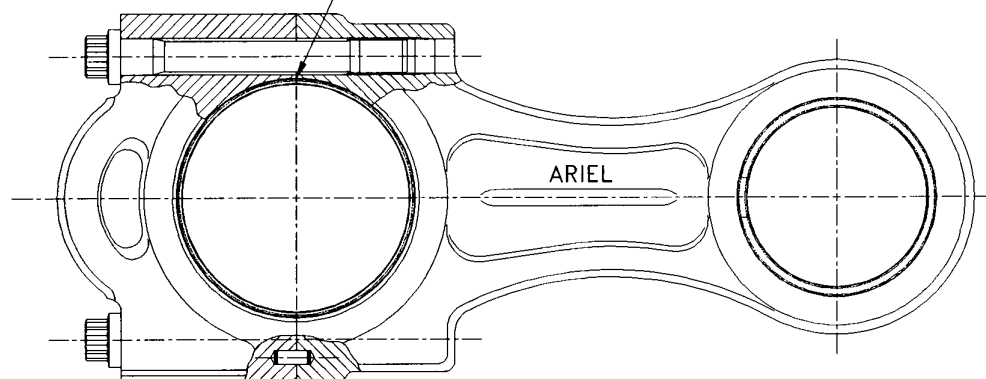


FIGURE 5-1: CONNECTING ROD - TYPICAL

6. Examine the removed top cover or access cover gaskets. If there is any doubt about their 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

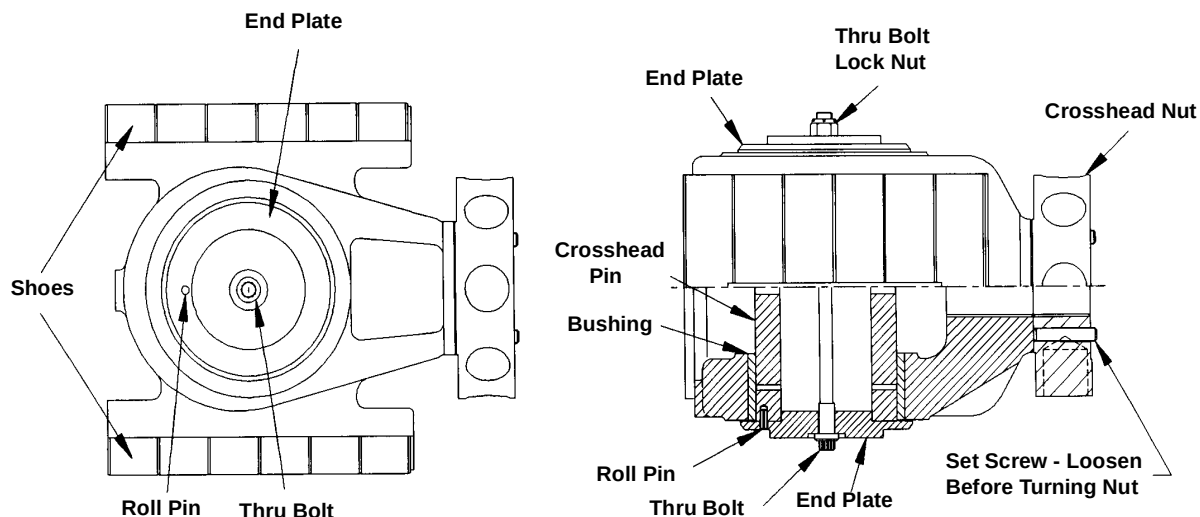


FIGURE 5-2: CROSSHEAD - TYPICAL

CAUTION

BEFORE REMOVING THE CYLINDER HEAD, BACK OFF ALL CAPSCREWS TO 1/8 INCHES (3 mm). MAKE SURE THAT THE HEAD IS LOOSE AND THE CYLINDER IS VENTED. SEE IMPORTANT SAFETY INFORMATION PLATES ON UNIT TOP COVER, (REFERENCE FIGURE 1-4: ON PAGE 1-5 FOR LOCATION.)

1. Remove crosshead guide side covers and cylinder head.
2. Move the 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 7-3, depending on nut style.
3. Use the Piston Nut Spanner (Torquing Adaptor) shown in Figure 7-1: 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. Crib JGI models so that crosshead does not fall down.

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. Roll the crosshead 90 degrees and remove it through the guide opening.
7. Check the crosshead pin to crosshead/bushing clearance. (See Table 1-3 on page 1-10.) 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.** Gray iron crossheads (JGI, JGM & JGP) and bronze crossheads do not have bushings; if the crosshead pin bearing area is worn, these crossheads should be replaced.

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 CROSSHEAD TO PREVENT DIRT FROM ACCUMULATING BETWEEN THE BUSHING AND CROSSHEAD BORE.

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

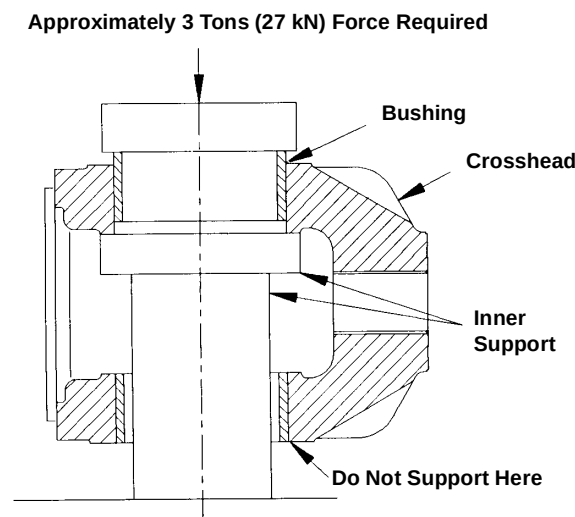


FIGURE 5-3: CROSSHEAD BUSHING REPLACEMENT

Crosshead - Installation

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

1. With the crosshead on its side, slip it in the crosshead guide. Once inside, it can be rolled upright. 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.
2. Turn the crankshaft to its outer dead center position to locate the connecting rod in position and insert the crosshead pin. Install the end plates, thru bolt and locknut. Tighten the locknut to the torque value listed in Table 1-12.
3. 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 assembly into the crosshead using the Piston Nut Torquing Adaptor. Make sure all threads are well lubricated with clean fresh oil to ensure smooth installation.

NOTE PISTON END CLEARANCE MUST NOW BE SET OR SERIOUS DAMAGE COULD OCCUR. REFER TO TABLE 1-3 ON PAGE 1-10 FOR PISTON END CLEARANCE SETTINGS.

4. Tighten the crosshead nut using the special slugging Peg Wrench or Open End Wrench shown in Figure 7-1: on page 7-3 and a slugging hammer.
5. Before installing the side covers, apply an anti-seize lubricant to the gaskets. This will aid to ease removal at a later date.
6. Replace the crosshead guide side covers; tighten all capscrews.

Crankshaft - Removal

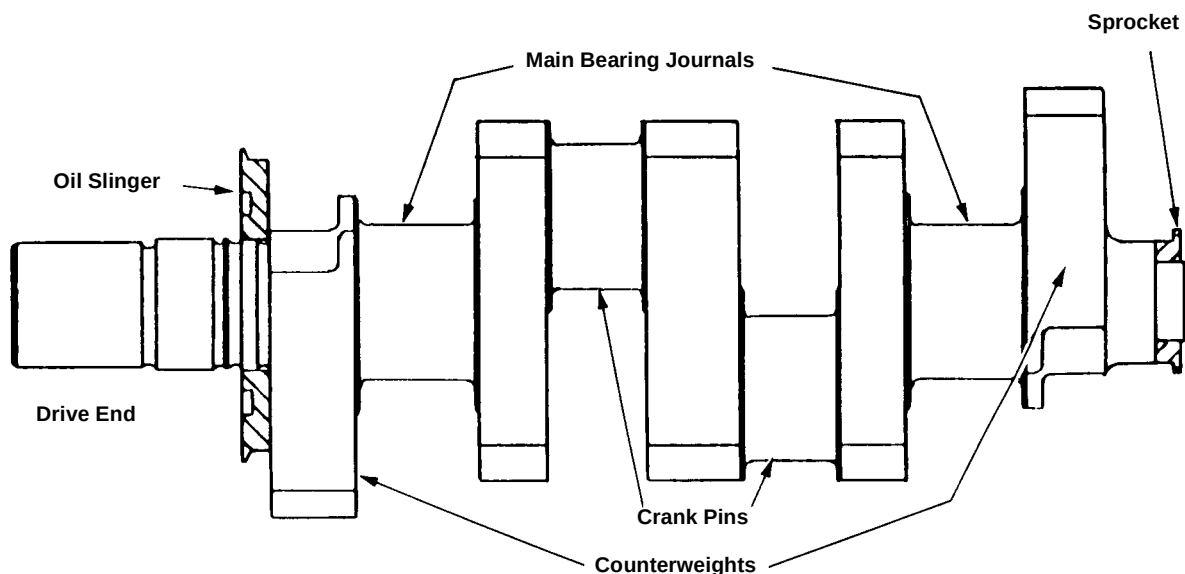


FIGURE 5-4: CRANKSHAFT WITH SLINGER AND SPROCKET - TYPICAL

1. Remove the coupling shim 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.)
2. Remove the top cover and crankshaft seal housing (or connecting rod, chain drive and crosshead access covers for a JGI).
3. Detach the connecting rods. (See "Connecting Rod - Removal" on page 5-2.) Move the rods to their full outer position. For the JGI, cribbing at the crosshead guide access hole is required to keep connecting rod up at the full outer position.
4. Remove the capscrews on the chain adjustment cap. Turn the cap to loosen the chain. Slip the chain off the crankshaft sprocket.
5. Remove the capscrews from the main 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 in Figure 5-5: For the JGI remove the capscrews in the bearing carrier, remove carrier and slide crankshaft out thru carrier hole to remove it.

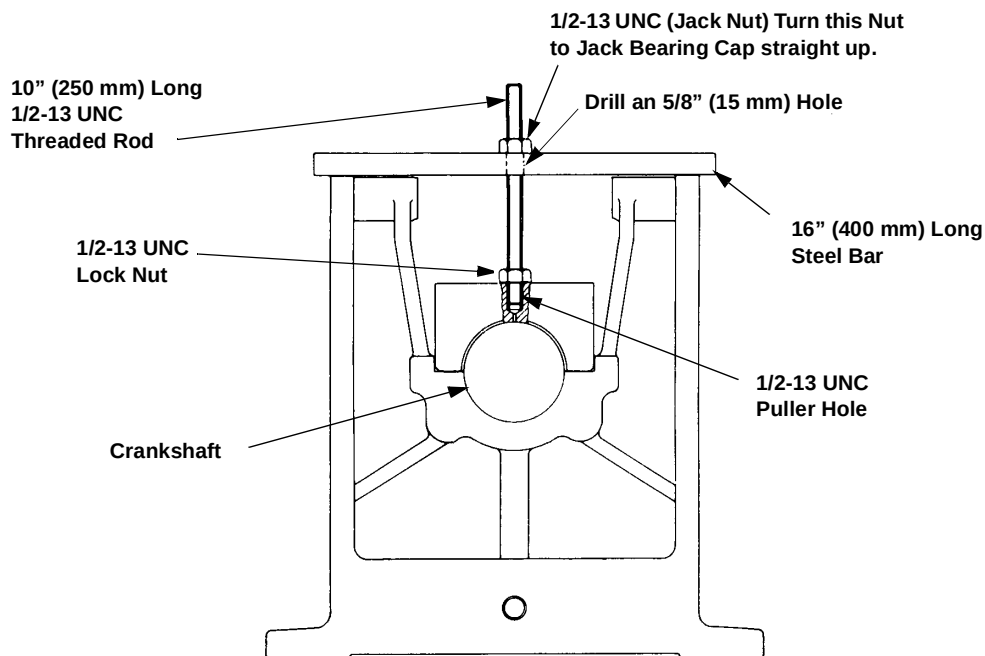


FIGURE 5-5: BEARING CAP PULLER

6. 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.
7. For horizontally opposed models, turn the crankshaft so that the drive end counterweight is straight up. The two throw crankshaft weighs about 100 lb (45 kg)

and can be lifted out by two persons or by using a crane and a clean nylon lifting sling at the second throw crank pin. The sling lifting point is to be above the center of gravity of the shaft, so that it does not want to rotate when lifted. Lift the crankshaft to tip up the chain drive end so that the crankshaft drive end will clear the frame seal housing opening and allow removal. Great care must be taken during this operation since the shaft could bind and become damaged. 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 of the running surface.)

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 6 mm, 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.

Crankshaft - Oil Slinger

Removal

Although the slinger should last indefinitely with proper care, it can become nicked. Should it need replacement, suspend the crankshaft on a sling with the drive end tipped down, 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 (13 mm) 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 5-6:) 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.

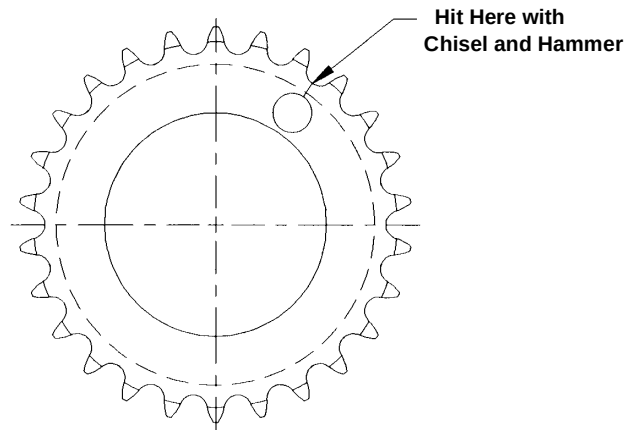


FIGURE 5-6: CRANKSHAFT - CHAIN SPROCKET

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.**

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 bearing 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.

On JGI models, remove the carrier bearing using a hydraulic press or jack. Remove the frame bearing using a hydraulic jack. A pushing tool with a shoulder is needed. Install new sleeve bearings by cooling bearings and using the hydraulic tools. Oil holes on bearing must

be aligned with holes in frame and carrier. The bearings must be pressed 3/16 in. (4.8 mm) below flush of the thrust faces, no more than 1/3 of the oil passage hole in the rod can be covered by the bushing. DO NOT TOUCH COLD SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

Crankshaft - Installation

1. Move the connecting rods to their full outer position. While the crankshaft is being lowered very slowly into the crankcase (if suspended by a crane with a nylon sling, use second throw crank pin), maneuver the drive end into the crankcase to clear the seal housing opening. Use clean gloves as during removal. Lower crankshaft into place so that both drive end and auxiliary end journals touch the bearing saddles at the same time. (For JGI models, slide crankshaft into position thru the bearing carrier opening and then replace bearing carrier).
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 1-12 on page 1-16. Bearing caps are match-marked to correspond with the throw position 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 1-10. 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 5-11).
7. Install new 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.
8. Reinstall covers, crankshaft seal housing and the top cover. Align crankshaft dust seal to clearance requirements in Table 1-3 on page 1-10

Chain Drive System

Description

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 5-7:, for the auxiliary end components and chain drive system.

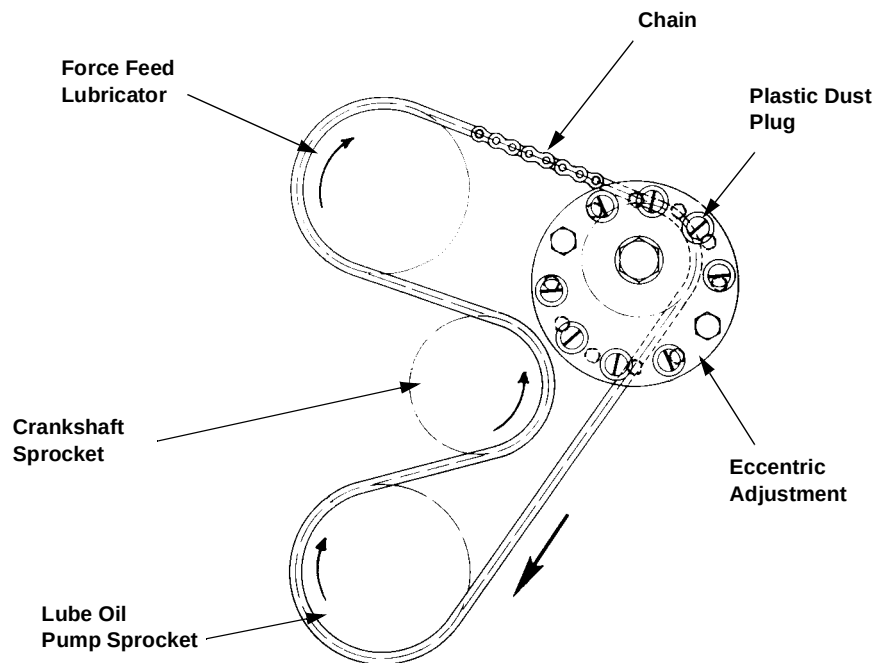


FIGURE 5-7: CHAIN DRIVE SYSTEM - TYPICAL

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 through its tightest position.
2. Remove the two capscrews and eight plugs from the eccentric adjustment cap. Rotate the cap 6 degrees clockwise facing cap from outside to line up 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 to the recommended torque shown in Table 1-12 on page 1-16, 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 of the most accessible span [4-3/4 inches (12cm)] is within 0.036 to 0.060 inches (0.91 to 1.51mm). This deflection is 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 chain.
4. Replace the dust plugs in the eccentric adjustment cap to keep dirt out of the unused holes in the end cover.

Chain and Sprocket Replacement

The chain 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 3.834 inches (97.38 mm) for 3/8 pitch, the chain should be replaced. Any sprocket showing any undercutting should be replaced.

Chain Idler Sprocket Replacement - (Eccentric Adjustment Caps)

1. Remove the frame top cover (or chain access cover for JGI). Remove the dust plugs and 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.
2. With a good machinist rule, measure the exact distance from the outer face of the chain sprocket to the closest face of the eccentric cap. Note the measurement for the proper positioning of the new sprocket.
3. Drift the roll pin from the idler nut. Remove the nut, 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.
4. Reassemble all parts using a new capscrew, Stat-O-Seal washer, sprocket, and nut. Compare the sprocket to cap measurement to the measurement previously taken. If necessary, shim between the cap and the idler spacer to make the measurements equal.
5. Install the assembly on the frame. Do not install the chain. First check the alignment to the crankshaft drive sprocket, with crankshaft centered in end play, using a straight edge.
6. If not in alignment within 1/32 inch (1 mm), shim as necessary, see Figure 5-8:. If the alignment is within 1/32 inch (1 mm), remove the entire assembly again. Tighten the idler nut to the recommended torque in Table 1-12 on page 1-16 and drill a 1/8 in. (3.175 mm) hole through the nut. Tap in a new roll pin.
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 5-12.

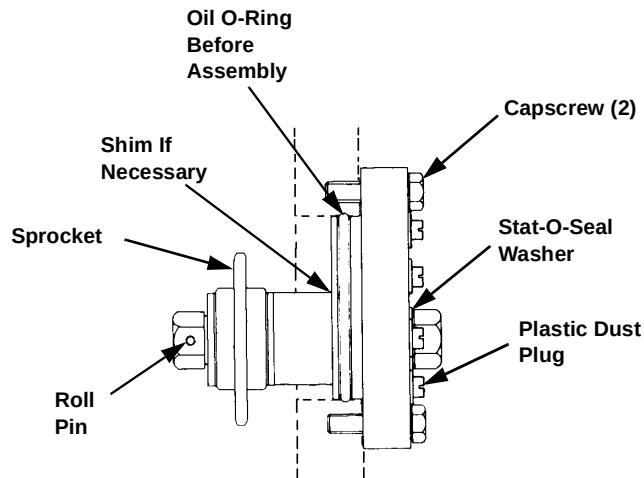
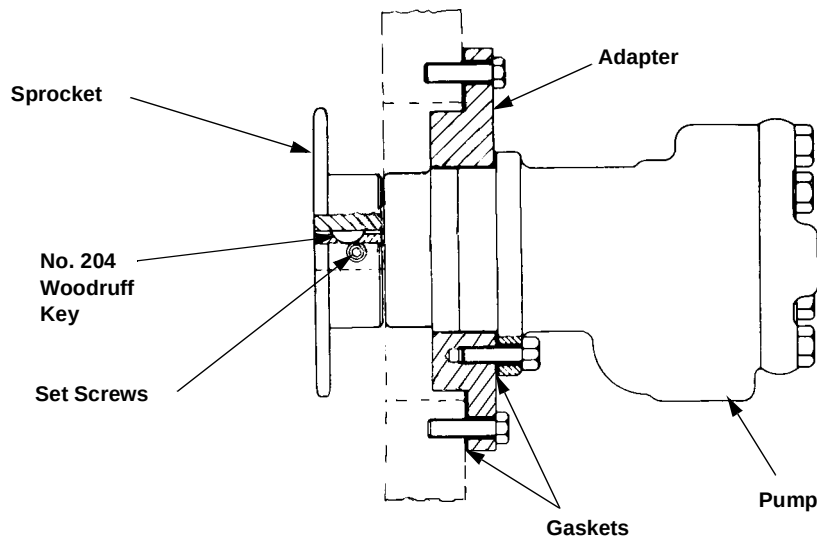


FIGURE 5-8: CHAIN IDLER SPROCKET (ECCENTRIC)

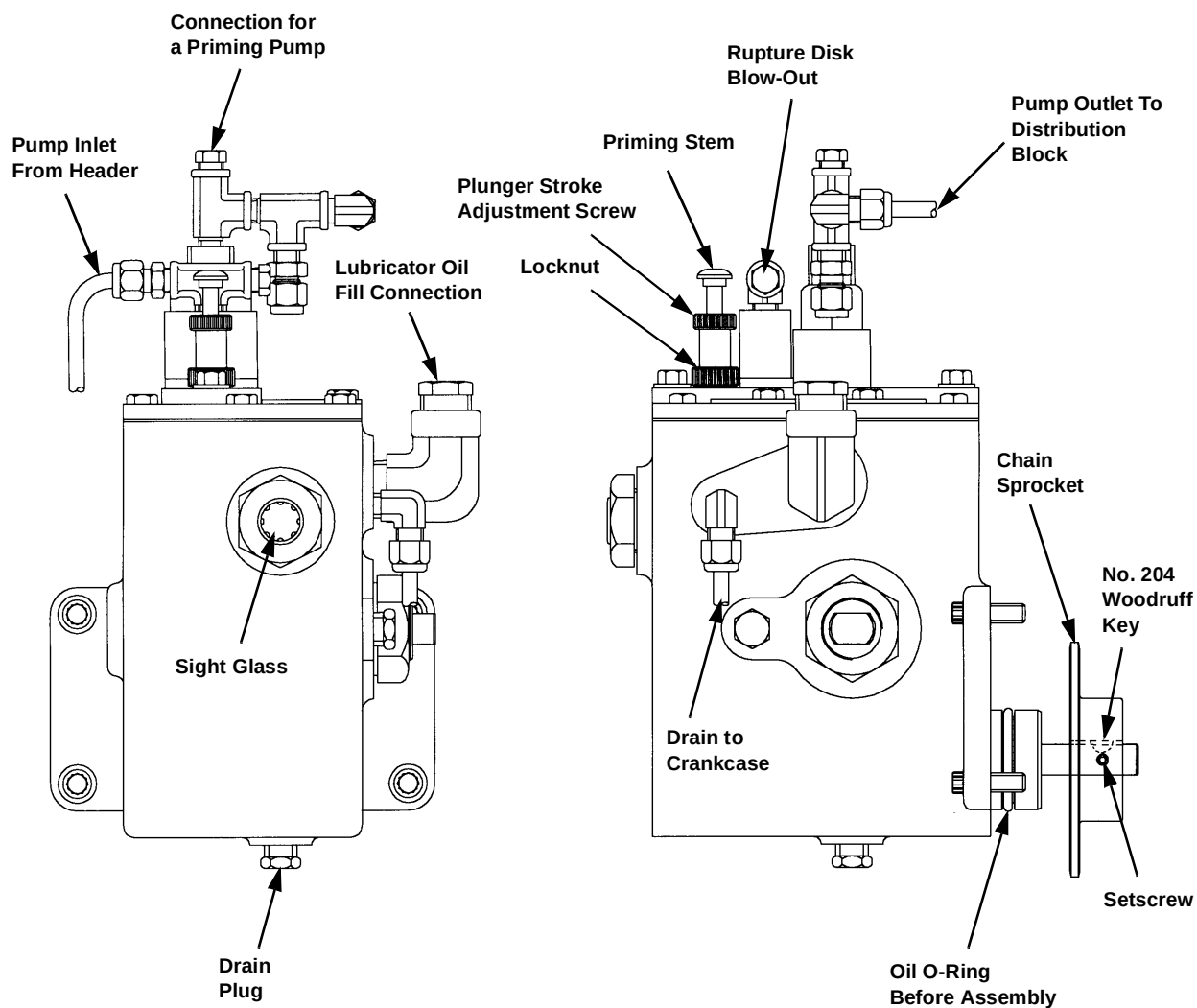
Lube Oil Pump Chain Sprocket Replacement

1. Refer to Figure 5-9:.
2. Remove all piping from the pump. Remove fasteners from pump mounting adaptor and the pump with sprocket will come free through the hole in the end cover after the removal of the chain.
3. With a good machinist rule, measure the exact distance from the sprocket drive face to the pump mounting adaptor face, in order to position the new sprocket. Note this measurement for future reference.
4. With the oil pump on a bench, use an Allen Wrench to remove the sprocket set screw; then, pull the sprocket from its shaft.
5. Remove the No. 204 Woodruff key.
6. Install a new No. 204 Woodruff, 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.
7. 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 screw.
8. 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.
9. Reinstall the pump onto the frame. Check the alignment to crankshaft drive sprocket, with crankshaft centered in end play, using a straight edge to within 1/32 inch (1 mm). If not in alignment, adjust sprocket position as necessary.
10. Re-install and adjust the chain according to the instructions in "Chain Adjustment" on page 5-12.
11. Reinstall all tubing to the pump.

**FIGURE 5-9: LUBE OIL PUMP AND SPROCKET**

Force Feed Lubricator Chain Sprocket Replacement

1. Refer to Figure 5-10: on page 5-16.
2. Remove the sprocket set screw and sprocket. Detach all tubing to the lubricator.
3. Remove the four mounting bracket capscrews and remove the lubricator.
4. 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.
5. 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.
6. 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 on the frame.
7. Put the new sprocket onto the shaft.
8. Check alignment to the crankshaft drive sprocket with crankshaft centered in end play, using a straight edge, to within 1/32 inch (1mm). Tighten the set screw.
9. Install chain and adjust using the instructions given in "Chain Adjustment" on page 5-12.
10. Re-attach all tubing to the lubricator.

**FIGURE 5-10: LUBRICATOR AND SPROCKET**

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" (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 is to be loosened first to the Caution! instructions 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 and slugging hammer, (see Figure 7-1: on page 7-3). 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, as to not put excessive weight on the piston and rod assembly which might cause bending.
4. Use the Piston Nut Spanner and a speed wrench to screw the piston and rod assembly out of the crosshead. The two dowels on the Piston Nut Spanner 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 1/8 inches (3 mm) smaller in diameter than the inside diameter of the packing. Using extreme care, slowly slide the piston rod through the packing to avoid damaging the rod threads or the packing rings.

Piston and Rod - Disassembly and Reassembly

Disassembly

The Piston and Rod Clamping Fixture shown in Figure 5-11: will be useful for the piston and rod disassembly and reassembly operations. This fixture may be purchased from Ariel.

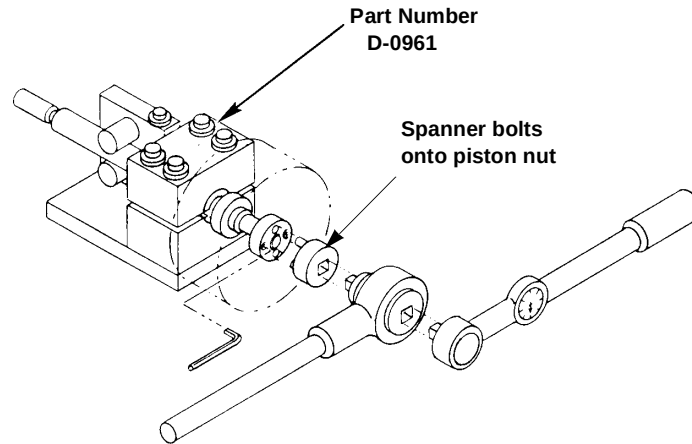


FIGURE 5-11: PISTON AND ROD CLAMPING FIXTURE

1. Clamp the piston and rod assembly in the special Clamping Fixture (D-0961), using the bushing for a 1-1/8" rod size (see Figure 5-11:). Tighten the four 12-point cap screws to prevent the rod from turning. The fixture will properly hold the piston rod to prevent damage to the parts and promote safety during disassembly and reassembly. The Clamping Fixture must be securely bolted down to prevent it from turning with the piston rod. It should be at a convenient height of approximately three feet or 0.9 meters. Remove the setscrews from the piston nut. Although the piston nut has been staked to lock the setscrews, they can be forced out, by turning with an Allen wrench, past the small lip that has been formed.
2. Remove piston nut using piston nut spanner (see Figure 7-1: on page 7-3).

NOTE: A SMALL AMOUNT OF GAS PRESSURE CAN BUILD UP WITHIN THE PISTON DURING OPERATION. THIS WILL VENT WHEN THE PISTON NUT IS LOOSENED.

3. After the piston nut has been removed, the piston and collar will slip off the end of the rod.

Reassembly

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

clean and dry.

2. Inspect each part 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 should be clean and free of burrs. Fit collar and nut into piston to verify the outside diameter fits, and turn freely by hand in the piston. 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 to determine wear (see "Determining Ring Wear:" on page 5-22). Replace piston rings as required.
5. Secure the piston rod in Torque Fixture D-0961.
6. Apply a thin coat of Never-Seez to piston rod shoulder and rod collar locating band, and collar face in contact with the piston, then slide collar onto rod.
7. Apply a thin coat of Never-Seez to the piston rod threads at the piston end, then slide piston onto rod and collar.

NOTE: ONE END OF SINGLE PIECE PISTONS ARE MACHINED 0.001" (0.03 MM) UNDERSIZE ACROSS A 3/4 INCH (20 MM) WIDE BAND FOR MANUFACTURING PURPOSES. THIS IS THE HEAD END OF THE PISTON.

8. Apply a thin coat of Never-Seez to the piston nut threads and piston mating face. Install nut and hand tighten to make up the piston and rod assembly.
9. Tighten the piston nut to the recommended torque in Table 1-12 on page 1-16.
10. After tightening nut, the piston rod should not protrude more than 0.010 in. (0.25mm) past the piston face.
11. Apply a thin coat 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 thru a 15° arc).
12. Prick-punch the piston nut, within 1/16 in. (1.5mm) of the set screw threads, to lock the set screws in place. Prick-punch marks should deform nut screw threads to lock the set screws in place.
13. Weigh the piston rod assembly with piston rings included. Stamp the weight on the piston' head end. Flatten and 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 into the cylinder. The threaded crosshead end of the rod is 1/8 inches (3 mm) 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 will help ensure that packing rings are not damaged.
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 1-10. Insert a feeler gage, equal to the required crank end clearance, thru the discharge valve pocket. Use the Piston Nut Spanner and a speed wrench 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 1-12 on page 1-16.
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 1-10. 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 1-12 on page 1-16.
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 1-12 on page 1-16.

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. Refer to "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 indicator¹ 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 movement, 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 5-1 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 5-1: PISTON ROD RUN OUT

THROW NUMBER:		1	2
VERTICAL	Piston @ CE	0	0
	Mid-Stroke		
	Piston @ HE		
HORIZONTAL	Piston @ CE	0	0
	Mid-Stroke		
	Piston @ HE		

Compare readings to Table 5-2.

TABLE 5-2: MAXIMUM ACCEPTABLE PISTON ROD RUN OUT READINGS

DIRECTION	JGM, JGN, JGP & JGQ		JGI
	INCHES	(mm)	
Vertical	0.0010	(0.025)	N/A
Horizontal	0.0005	(0.013)	

If a vertical reading is greater than the maximum acceptable reading, the following procedure is used to determine acceptability: With the piston at the head end, use feeler gages to determine clearance at the top of the piston. On rider ring pistons this clearance is over the band. Feeler top clearance is divided by ($\div$) 2 and then the following amount is subtracted: (-)0.003 inches (0.08 mm). Place a feeler of this calculated thickness under the bottom of the piston. Place the feeler under the wear band on wear band pistons. This feeler should 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 5-3 and record calculations and readings.

TABLE 5-3: FEELER THICKNESS TO CORRECT FOR PISTON WEIGHT

LINE	THROW NUMBER:	1	2
1	Top Feeler Clearance		
2	Line 1 ($\div$ 2)		
3	Line 2 - 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)
4	Bottom Feeler Thickness		
5	Vertical - Piston @ CE	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 JGM, JGP, JGN and JGQ cylinders use one-piece angle cut filled Teflon piston rings.

Determining Ring Wear:

Ariel recommends replacing rings when the end gap has increased three times the new dimension. To measure the end gaps, insert the rings in the cylinders without pistons. (See Table 1-7 or Table 1-9 for new end gap dimensions.)

Removal:

See paragraph 4 at “Piston and Rod - Removal” on page 5-17 for piston ring removal.

Wear Bands

1-3/4JG-FS-HE cylinder class pistons use a one-piece angle cut 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 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 5-19.

Wear Band - Installation

Install the wear band as if it was another piston ring as above. Wear bands are only used on 1-3/4JG-FS-HE cylinder class pistons.

Piston Rod Pressure Packing - Removal

1. Remove the piston and piston rod. See "Piston and Rod - Removal" on page 5-17.
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. Screw two short 3/8-16 UNC capscrews into the two tapped holes provided in the crankend face of the packing gland. A screwdriver or pry bar under the heads of the capscrews can be used to pull the entire pressure packing out into the crosshead guide. It will then come out through the 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 5-19.
12. After the crosshead nut has been tightened, tighten the rod packing bolts evenly to the recommended torque in Table 1-12 on page 1-16. 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 4-14 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 4-8 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 0.022 to 0.028 inches (0.56 to 0.71 mm) for PEEK rings and 0.011 to 0.017 inches (0.28 to 0.43 mm) for bronze and cast iron rings. 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 5-12:.

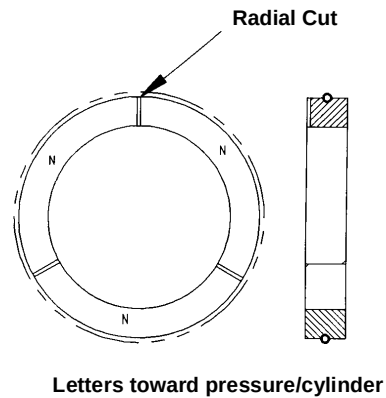


FIGURE 5-12: TYPE "P" PRESSURE BREAKER

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. The installed total end gap is 0.046 to 0.078 inches (1.17 to 1.98 mm) for Teflon and 0.093 to 0.125 inches (2.36 to 3.18 mm) for bronze and Polyimide. The second ring is a tangentially step cut ring. 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 5-13:

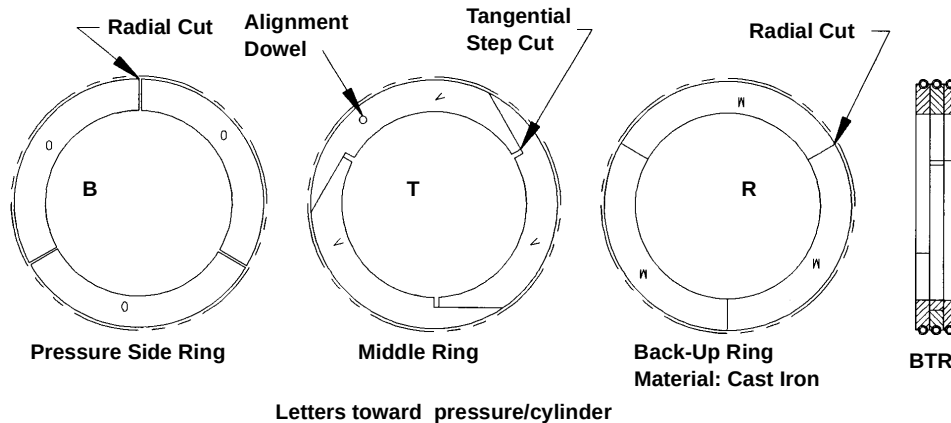


FIGURE 5-13: TYPE "BTR" SINGLE ACTING SEAL SET

Type "AL" Double Acting Seal Set

This set is made up of five rings. The center three are radial cut and the two outboard rings are step-tangent cut. The last two rings on each end are doweled together to stagger the cuts. The center ring, along with the two adjacent rings, form a wedge that overcomes rod friction and forces the set to have constant contact against both groove faces during either direction of rod travel. The installed total end gap is 0.062 to 0.093 (1.57 to 2.34 mm). This ring set is designed for gas purge applications. See Figure 5-14:

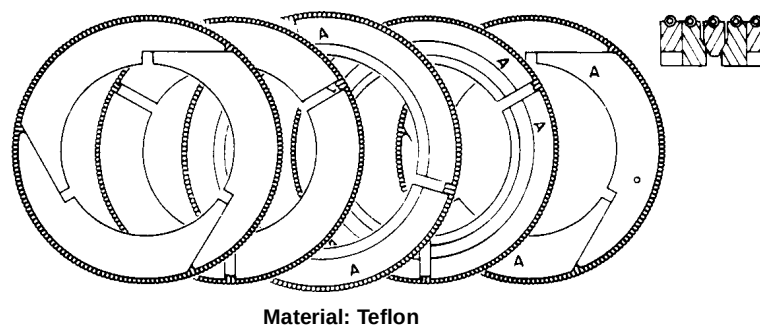


FIGURE 5-14: TYPE "AL" DOUBLE ACTING

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 0.046 to 0.078 inches (1.17 to 1.98 mm) for Teflon and 0.093 to 0.125 inches (2.36 to 3.18 mm) for bronze and Polyimide. 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 5-15:

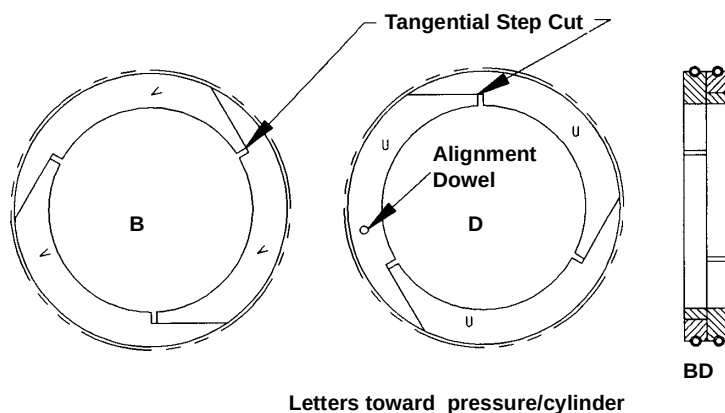


FIGURE 5-15: TYPE "BD" DOUBLE ACTING

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 5-16:

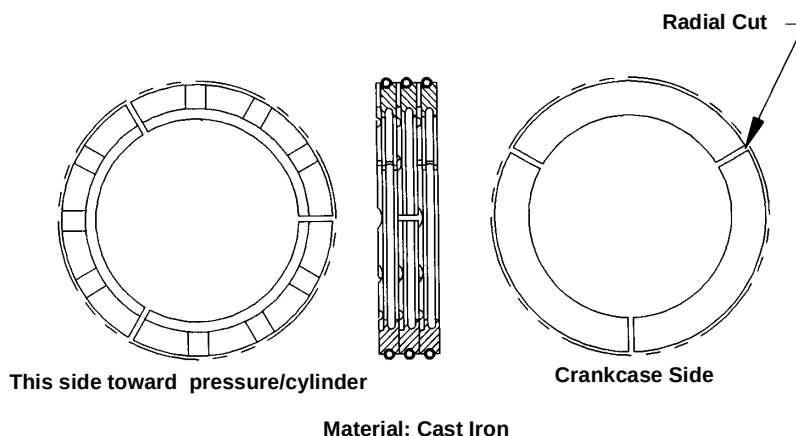
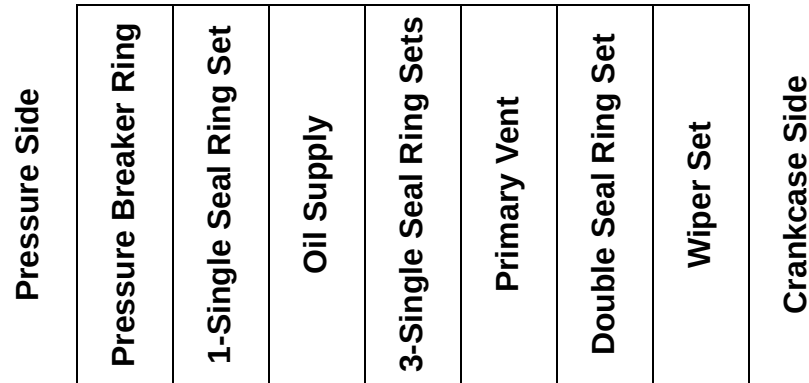


FIGURE 5-16: TYPE "3RWS" WIPER SET

Typical Arrangement of Piston Rod Packing Rings

The general arrangement of the oil supply, seal ring and vent locations is shown below:



The oil wiper rings and a seal ring set are carried on a separate diaphragm in the crosshead guide when a “two compartment distance piece” is supplied.

NOTE: REFER TO THE PACKING ASSEMBLY IN YOUR PARTS BOOK. SEE PAGE 4-21 FOR PACKING TUBING AND DISTANCE PIECE VENTING AND PAGE 4-22 FOR PACKING LUBRICATION AND VENTING.

Piston Rod Packing Ring Material

In the past, bronze was the standard material for Ariel packing rings. Bronze, however, is 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 the 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

CAUTION

BEFORE ATTEMPTING TO REMOVE ANY VALVE CAP, BE CERTAIN THAT 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 1-4: ON PAGE 1-5 FOR LOCATION OF IMPORTANT SAFETY INFORMATION PLATES.

Valves - Removal

1. Slightly loosen all of the bolts 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 5-17: on Page 5-31.
2. 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 7-3. Now the valve and retainer can be pulled out together. For cylinder class 1-3/4JG-FS-HE and 2-1/2JG-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 5-17.
3. 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 several uses.

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 springs may be required.

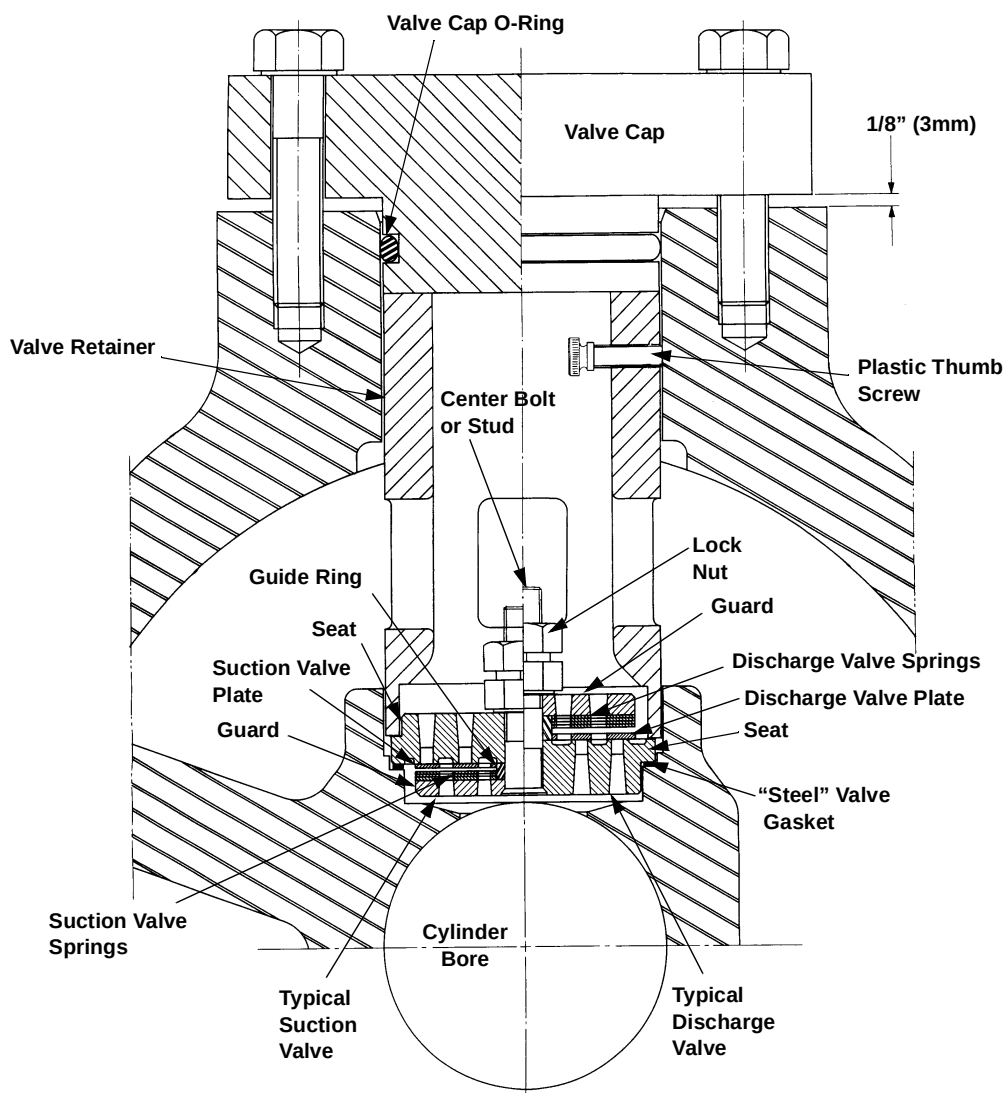
The suction valve must be selected on the basis of operating suction pressure and the discharge valve for operating discharge pressure. Proper valve spring selection is also based upon the operating speed (RPM), gas specific gravity and the suction temperature of the gas.

Contact Ariel in 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 onto 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 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 7-3, 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 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 1-12 on page 1-16. See "Bolt Tightening for Valve Caps" on page 5-31. If the assembly is correct, the distance from the underside of the cap to the valve boss surface on the cylinder will be 1/8 inches (3 mm).

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 5-17: 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 gas-kets(s) and valve retainer, in the valve pocket. See "Valves - Reassembly" on page 5-30.

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 5-18: 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.**

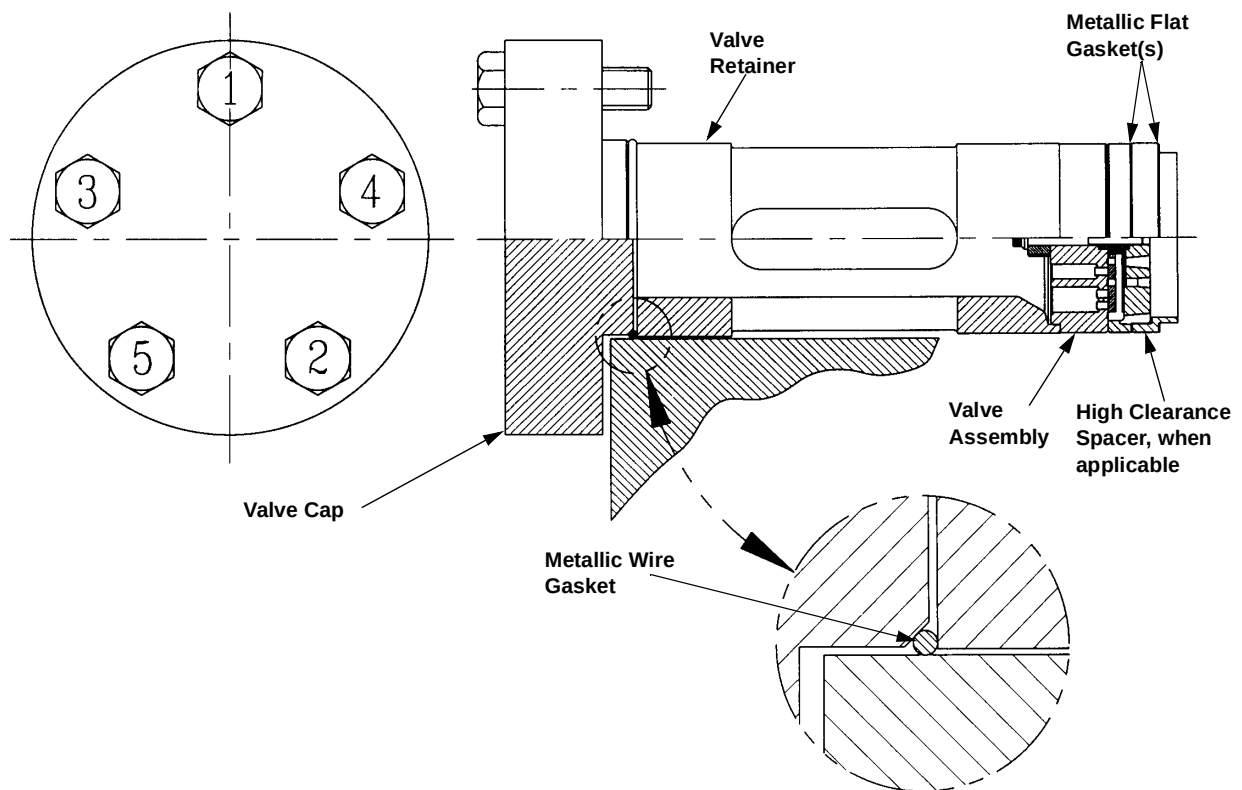


FIGURE 5-18: HIGH PRESSURE VALVE CAP ASSEMBLY

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, remove the bolts and flange that hold the packing in place and remove the packing. 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. While the torque used for the socket head bolting is not critical, these bolts must be sufficiently tight to prevent loosening during service. 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 1-12 on page 1-16 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 1-10 for clearances.

Adjustment

VVCP clearance volume may be changed with the compressor running or stopped. Consult the Packager's instructions regarding where to set the VVCP. 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.

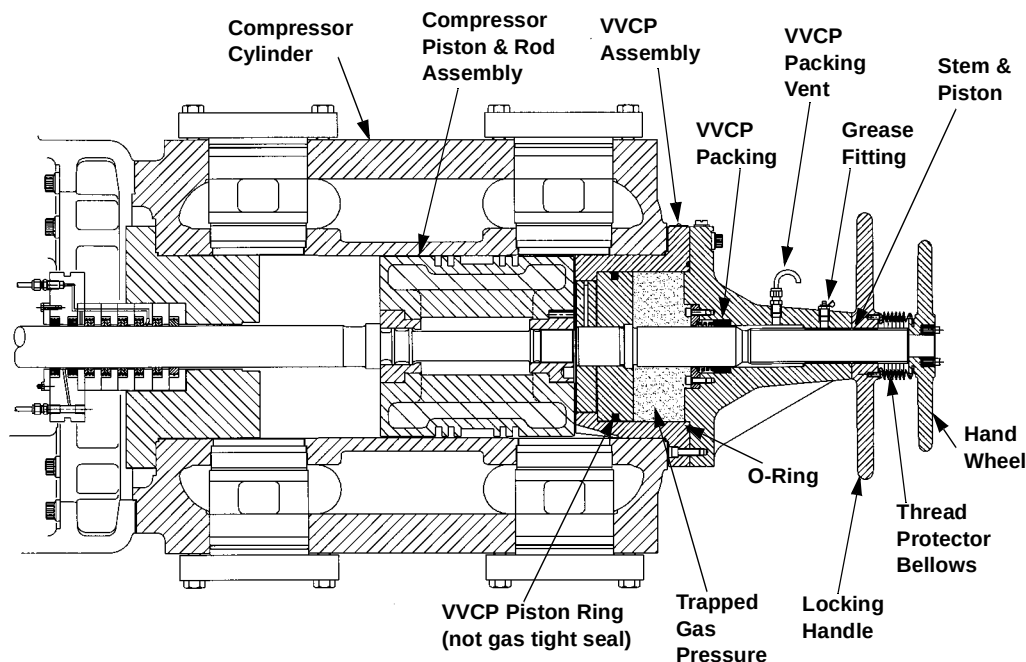


FIGURE 5-19: CYLINDER WITH VVCP

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 recommendation, 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 recorded with exacting detail in order that records will be available for tracking maintenance cost 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 in the sight glass and, if not, determine and correct cause. 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 is 35 psi (240 kPa) minimum.

10. High temperature shutdown to be set within 25°F (14C) 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).
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 strainer when oil is changed.
5. Open frame when oil is changed and visually inspect for foreign material. Disassembly is not recommended unless a reason for it is identified.
6. Check fluid level in damper (if applicable).
7. Re-tighten hold down stud-nuts to proper torque values and perform a soft foot check. More than 0.002 inches (0.05 mm) pull down requires re-shimming. If re-shimming is required, realign if necessary to hold coupling alignment within 0.005 inches (0.13 mm) TIR.
8. For cylinders rated greater than 3500 psi (24 000 kPa), inspect piston ring end gap. Replace rings that are outside the maximum limits listed in Table 1-7 and Table 1-9.

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

1. 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 1-10, replace the affected bearings.
2. Check crosshead guide clearance with feelers, and if outside the limits listed in Table 1-3 on page 1-10, replace the affected parts.
3. Inspect valves for broken plates and loose center bolts, replace broken parts and tighten center bolts to torque values listed in Table 1-13 on page 1-19.
4. 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 mm²/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.

5. Inspect piston ring end gap. Replace rings that are outside the maximum limit listed in Table 1-7 and Table 1-9.
6. 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 than 0.001 inches (0.03 mm), or tapered more than 0.002 inches (0.05 mm), replace the rod.
7. Rebuild cylinder packing cases.
8. Inspect for frame twist or bending by checking shimming of compressor feet.
9. Realign if necessary to hold coupling alignment within 0.005 inches (0.13 mm) TIR.
10. Check and re-calibrate all temperature and pressure gauges.
11. Check and record compressor rod run out.
12. Grease VVCP stem threads at grease fitting, with 2 to 3 pumps of multi-purpose grease using a standard hand pump grease gun.
13. Clean crankcase breather filter.
14. Adjust drive chains.
15. Pressure test distribution blocks.

Every 2 Years or 16,000 Hours (plus Daily/Monthly/6 months/yearly)

1. Check auxiliary and 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 an 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.
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 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.

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.

NOTES

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 3/4" Diameter (P/N A-0076)
- Open End Wrench for Hex Crosshead Nuts 2" (P/N B-0016)
- 1/4" x 3/8" UNF Valve Tool for Installing or Removing Valves (P/N A-0409)
- 5/16" x 1/2" UNF Valve Tool for Installing or Removing Valves (P/N A-0135)
- Piston Nut Spanner for 3/4" Square Drive Ratchet (P/N A-0279)
- Piston Turning Tool for 9/16" socket (P/N A-1678) provided with small tandem cylinders only
- Crank End Clearance Setting Tool 0.035" (0.89 mm), special tool provided for 2-3/4M, 3M, 2-14P-CE, 2-3/4P-CE and 3-1/4P-CE class cylinders only
- Torque Chart (D-2159)

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:

- Allen Wrenches: 3/32", 1/8", 9/64", 5/32", 3/16", 1/4", 5/16" & 3/8"

Ariel Optional Tools

- Piston and Rod Clamping Fixture (P/N D-0961) (see Figure 5-11: on page 5-18)
- Force Feed Lubricator Bearing Housing Spanner Wrench (P/N A-8158)

Standard Tools

The following standard tools are normally all that is required to work on Ariel JGI, JGM, JGN, JGP and JGQ compressors. These are in addition to the Ariel tools listed above. Please contact Ariel if you have any questions about tools for Ariel units.

- 3/8" Square Drive Ratchet Wrench
- 2" and 6" Extensions for above Ratchet
- 3/8" Square Drive Breaker Bar
- 1/2" Drive Speed Wrench
- 1/2" Female x 3/4" Male Adaptor
- 3/8" Square Drive Universal Joint
- 3/8" Square Drive Torque Wrenches (10 LB-IN to 250 LB-IN)
- 1/2" Square Drive Torque Wrench (15 LB-FT to 250 LB-FT)
- Set of 12 Point Sockets for a 3/8" Square Drive
- Set of 12 Point Sockets for a 1/2" Square Drive
- 3/8" 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
- 12" Adjustable Wrench
- 2 - Medium Size Screw Drivers
- Babbitt or Plastic Faced Slugging Hammer
- Feeler Gage Pack
- Awl

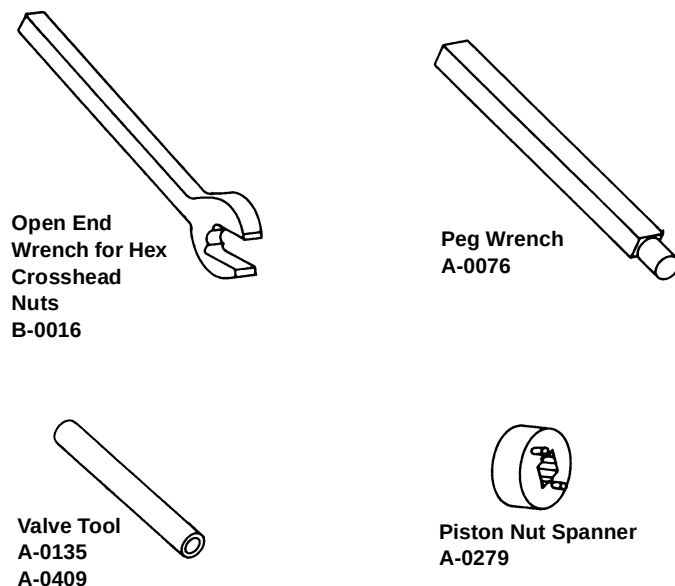


FIGURE 7-1: ARIEL TOOLS

Terms, Abbreviations¹ and Conversion to SI Metric²

Area

in² or square inch x 0.00064516 = meter², or m²

in² or square inch x 6.4516 = centimeter², or cm²

Flow - Gas

MMSCFD or million standard cubic feet per day (at 14.696 psia & 60°F) x 0.310 = normal meter³/second (at 1.01325 bar & 0°C), or m³/s_n

SCFM or standard cubic feet per minute (at 14.696 psia & 60°F) x 1.607 = normal meter³/hour (at 1.01325 bar & 0°C), or m³/h_n

1. US units of measure can appear abbreviated in upper or lower case.

2. Maintain upper and lower case letters in SI Metric as shown.

Flow - Liquid

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

GPM or US gallons per minute $\times 0.227125$ = $\text{meter}^3/\text{hour}$, or m^3/h

Force

lbf or pound (force) $\times 4.44822$ = Newton, or N

Heat

BTU or British Thermal Units $\times 1.05506$ = kilojoule, or kJ

Length

in. or " or inches $\times 25.4000$ = millimeters, or mm

ft or feet $\times 0.304800$ = meter, or m

Mass

lb or pound (mass) $\times 0.453592$ = kilogram, or kg

Moment or Torque

LB $\times$ FT or pound-foot (force) $\times 1.35583$ = Newton-meter, or N $\cdot$ m

LB $\times$ IN or pound-inch (force) $\times 0.112985$ = Newton-meter, or N $\cdot$ m

Power¹

HP or Horsepower $\times 0.745700$ = kilowatt, or kW

Pressure² or Stress

psi $\times 6894.757$ = Pascal, or Pa

Pa $\times 0.000145$ = psi

psi $\times 6.894757$ = kiloPascal, or kPa

kPa $\times 0.145$ = psi

1. Horsepower based on 550 ft-lb/sec

2. G suffix (PSIG) indicates gauge pressure, A indicates absolute

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. $(^{\circ}\text{F} - 32)/1.8$ = degrees Celsius, or °C

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) = mm²/s = centistoke, or cSt
(for a range of 33 thru 200,00 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

TABLE 7-1: 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	μ

a. Maintain upper and lower case letters as shown.

b. Not Recommended, but occasionally used.

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 Customer Technical Bulletins (Formerly Ariel Newsletters)

Ariel Customer Technical Bulletins provide important technical information including changes, corrections and/or additions to the 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.

