Packager Guidelines  
Section 6: Cylinder and Packing Lubrication

6-1. GENERAL

1. For years, the lubrication requirements of reciprocating compressor cylinders were based on the operator's field experience. Typically, the unit would be set up to provide a generous amount of oil to each lube point, based on the operator's field experience. After a short run time, the cylinder was opened up and the bore was checked to confirm that sufficient oil remained on the cylinder bore. While this remains as the most accurate way to determine the lubrication requirements, the shortage of experienced operators, coupled with the wide range of compressor speeds and gas being compressed, has necessitated a more uniform approach for both break-in and normal operation.

   NOTE
   When shipped from Dresser-Rand High Speed Reciprocating Compressors the cylinder lubricators are set wide open to deliver the maximum amount of oil. These will need to be adjusted for break-in and normal operation in the field.

2. Start-up and break-in is the most critical time in the life of a compressor cylinder and packing. While cylinder bores, piston rings, piston rods, and packing have been manufactured to exacting tolerances and finishes, there still exist small irregularities between the mating parts. During start-up with new components, these regularities come into metal-to-metal contact and are gradually worn away. With a proper lubricant and adequate lubrication rates, this results in a polished or glazed surface. During break-in, the function of the lubricant is to fill these irregularities to reduce the rate of abrasion and to flush away the abraded particles. This glazing process may take anywhere from a few hours to two weeks, and should be monitored closely. Once the seating-in or glazing is complete, lubrication rates can be gradually reduced.

3. Due to increasing environmental concern and in the interest of economy, it is desirable to reduce oil consumption to a minimum. Operation at minimum oil flow rates also minimizes the buildup of carbon in the packing.

4. Many methods have been used to determine optimum lubrication rates. Most were based on the volume of oil required to cover the required surface area, with factors applied to compensate for the effect of pressure, speed, type of gas, differential pressure, etc. This standard has been developed empirically and is the result of input from several service and engineering sources.

6-2. Cylinder Lubrication System

A mechanical lubricator provides lubrication of the compressor cylinder bores, and pressure piston rod packings. For some applications, "pump-to-point" lubrication is supplied where each lubrication point is fed from an individual lubricator pumping unit. Normally, a metered "block-type" oil distribution system is furnished with the oil supply coming from the frame. With either method, a check valve is required at the cylinder connection of each oil line to prevent compressed gas from passing back through the lubrication system.

Recommendations are given to enable selection of suitable oil for a particular application and to determine an optimum feed rate. For external suction lubricator reservoirs, you must maintain a good grade of lubricant to lubricate internal components within the box. It must be a viscosity grade of ISO 680 compounded with acidless tallow AGMA-8. This provides a high degree of sliding motion under pressure and minimizes wear.
6-3. Cylinder Oil Recommendations

Four classifications of lubricating oil have been developed to cover the normal lubrication requirements of compressor cylinders. The physical and chemical properties of the four oil types generally recommended for these units are listed in Table 2-4. (This table is general in nature and covers conditions and pressures not necessarily applicable to all compressors.)

Selection of the proper type of oil for your particular application normally will be determined by the discharge pressure and also by the gas quality with respect to “wetness”. Consideration also must be given to the local operating conditions. Review this set of oil selection instructions with your oil supplier and compare your particular operating conditions with those listed in Table 2-4 for the various type cylinder oils.

In addition to the operating conditions given in Table 2-4, the following information also must be considered when selecting the type of oil to be used in a particular situation.

For Type 2 and 3 oils, the gases handled must be dry; that is, gases which do not carry suspended liquid, contain water vapor or other condensables which remain in the super-heated vapor state throughout the compression cycle. For Type 2X and 3X oils, the gases handled occasionally may carry small quantities of suspended liquid into the cylinder or may deposit some condensation in the cylinder. Type 2 oils are generally used when the operator wishes to use internal-combustion engine lubricating oil.

A. General Requirements

These oils are well refined petroleum products of the general types listed. They should be prepared from selected stacks of either naphthionic or paraffinic type, processed to minimize deposit formation. Superior rust-preventative properties also are desired. The pour point must be consistent with the lowest ambient gas intake and cylinder temperatures to be encountered. The pour point always must be sufficiently lower than ambient temperature to permit the proper rate of oil feed by the lubricator. In handling low-temperature gases, select oil of suitably low pour point, on the basis of intake and cylinder temperatures, to maintain a fluid of lubricant in the cylinder.

This oil must be capable of providing an improved state of boundary lubrication and must resist the washing effect of the particular condensate involved.

Type 2 - Internal-combustion engine lubricating oil of the following classes:

- Straight mineral oil.
- Additive-treated, non-detergent oil.
- Detergent engine oil.

Type 2X - Compounded compressor cylinder oil with 5% compounding is recommended. This oil must be capable of providing an improved state of boundary lubrication and must resist the washing effect of the particular condensate involved.

Type 3 - Rust and/or oxidation-inhibited oil or straight mineral oil is acceptable.

Type 3X - Compound compressor cylinder oil with 5 to 10% compounding is recommended.
### Table 2-4. Standard Cylinder Oil Recommendations

<table>
<thead>
<tr>
<th>Operating Conditions</th>
<th>Type 2</th>
<th>Type 2X</th>
<th>Type 3</th>
<th>Type 3X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge Temp. °F (°C)</td>
<td>Max. 350°</td>
<td>Max. 350°</td>
<td>&gt;350°</td>
<td>&gt;350°</td>
</tr>
<tr>
<td></td>
<td>Max. 177°</td>
<td>Max. 177°</td>
<td>&gt;177°</td>
<td>&gt;177°</td>
</tr>
<tr>
<td>Condensed water vapor present</td>
<td>NO</td>
<td>POSSIBLE</td>
<td>NO</td>
<td>POSSIBLE</td>
</tr>
<tr>
<td>Suspended liquid present</td>
<td>NO</td>
<td>POSSIBLE</td>
<td>NO</td>
<td>POSSIBLE</td>
</tr>
<tr>
<td>Special Requirements:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder with discharge pressure of</td>
<td>NO</td>
<td>NO</td>
<td>REQUIRED</td>
<td>REQUIRED</td>
</tr>
<tr>
<td>2000 to 7000 PSIG (13.8 to 48.27 Mpa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash Point (°F) (Open Cup) (°C)</td>
<td>380° Min.</td>
<td>380° Min.</td>
<td>410° Min.</td>
<td>410° Min.</td>
</tr>
<tr>
<td></td>
<td>193° Min.</td>
<td>193° Min.</td>
<td>210° Min.</td>
<td>210° Min.</td>
</tr>
<tr>
<td>Viscosity @ 100°F (38°C) Sayvolt</td>
<td>---</td>
<td>780 Max.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Universal SSU</td>
<td>---</td>
<td>168.4 Max.</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Kinematic Viscosity cSt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity @ 219°F Sayvolt</td>
<td>60 Min.</td>
<td>72 Min.</td>
<td>105 Min.</td>
<td>105 Min.</td>
</tr>
<tr>
<td>Universal SSU</td>
<td>10.2 Min.</td>
<td>13.3 Min.</td>
<td>21.5 Min.</td>
<td>21.5 Min.</td>
</tr>
<tr>
<td>Kinematic Viscosity cSt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfated Ash</td>
<td>0.50 Max.</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Neutralization Valve (color):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Acid Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong Acid Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Residue Conradson</td>
<td>0.45 Max¹</td>
<td>0.45 Max¹</td>
<td>0.45 Max¹</td>
<td>0.45 Max¹</td>
</tr>
</tbody>
</table>

**NOTES:**

1. 1 = Ash-free basis

### B. Service Considerations

1. On multi-stage compressors, or other applications involving high cylinder discharge temperatures, it is necessary to use higher viscosity oil than is normal.

2. When a gas being compressed is saturated with water or hydrocarbons, it is mandatory that a 3X oil can be used.

3. Certain lubricating oil additives will cloud the glycerin-water often used in lubricator sight feeds, necessitating frequent changes of the mixture. Compressing air and/or using synthetic oils for cylinder lubrication poses other concerns. See GFP15 for additional criteria that must be met.

4. On services that are compressing air, it is recommended that a synthetic type lubricant is used.

**CAUTION**
The continuous or intermittent carry-over of liquid to compressor cylinders requires the installation of efficient separators.

C. Inspection

All tests of cylinder lubricants should be conducted in accordance with the Standard Methods (latest edition) of the American Society for Testing Materials (ASTM).

D. Synthetic Lubricants

In recent years many synthetic lubricants that enhance cylinder lubrication have been developed. Synthetic lubricants are essentially pure which means that the tendency to oxidize and react with gas constituents is greatly reduced. Synthetics have also been developed that resist particular lubrication problems such as condensation, absorption in the gas stream and downstream contamination. Synthetics are more expensive than petroleum oils, but can often be used in less quantity and can be more easily recovered, reconditioned and reused. Synthetics can also lead to reduced maintenance requirements on valves, unloaders, piston rings and packing rings.

Synthetic lubricants are classified into several general types that have specific properties that can minimize the effect of the undesirable factors that have a negative effect on cylinder lubrication.

**Synthesized Hydrocarbons (Polyalphaolefins-PAO):** Recommended for applications requiring low pour points, in the presence of liquid water, where constituents of the gas cause deposits with petroleum oils, where downstream contamination is a problem, and where lubricant absorption is a problem. Synthetic hydrocarbons are susceptible to washing by hydrocarbon condensates and should not be used where these are of concern.

**Diesters:** Diesters have low pour points and readily accept additives which enhance their use. They are not compatible with petroleum based oils. They are effective in reducing deposits due to break-down of petroleum based oil oils in air compressors. They are not available in higher viscosities which makes them suspect in higher pressure applications.

**Polyglycols (Polyalkalineglycol-PAG):** These lubricants are particularly resistant to washing by hydrocarbon liquids and dilution by high pressure hydrocarbon gases. They also have low pour points. They are not compatible with petroleum based oils. They are water soluble which is a problem where liquid water is present. This can be reduced by blending with propylene oxide based polyglycols which are water insoluble but hydrocarbon soluble.

**Food Grade Lubricants:** These lubricants are Food & Drug Administration (FDA) approved and are not judged to be harmful to man nor animal. They are only used in processes where the end product is either intended for or comes in contact with materials that will be consumed by man or animal. Most applications for food grade lubricants are in high pressure polyethylene production.

The best choice of lubricant for a particular application depends on both pressure and temperature, as well as gas composition. Dresser-Rand has classified recommended lubricant properties by viscosity requirement in Table 2-4. Use of this table and the gas composition will assist in selecting a suitable lubricant. For particular brands of lubricants that meet the requirements, work with your lubricant supplier. Dresser-Rand does not recommend specific brands of lubricants.
6-4. Cylinder Lubrication Rate

1. Under start-up and break-in conditions, the amount of cylinder oil required for various cylinder sizes and discharge pressures is shown in Curve 2. These feed rates are approximate and are empirically derived. They are the suggested "break-in" feed rates when the gas is clean. Dirty gas will require increased feed rates as conditions dictate. Since the vast majority of field gas is water saturated, the rates have been adjusted to include the additional oil required for this condition.

5. Correction factors must be applied to the rates obtained from Curve 2 to account for the effects of speed and stroke, and for the specific gravity of the gas stream. These correction factors are shown in Curves 3 and 4.

3. Entrained liquids in the gas stream also will affect the amount of lubrication required to the cylinder bore. Curve 2 is based on the gas being water saturated at inlet conditions. Additional water in the form of entrained liquid, or if one suspects that liquids will be present, the lubrication flow rate may need to be increased by up to 60%.

4. Once you have completed the initial (break-in) period, you may begin to turn down the lubrication rates by adjusting the pump on the lubricator. This must be accompanied by a routine bore inspection to be sure you maintain a reasonable level of bore lubricant. We would expect the final rate to be somewhere between 67% to 50% of the original "break-in" rates.
5. The best way to insure proper lubrication is the paper test method. To check the cylinders for proper lubrication rates with paper, the following is a good guideline:

Relieve and vent all pressure from all cylinders and the system. Lock out the system so the compressor cannot be rotated or started. Remove the head and position the piston at the innermost stroke. Use two layers of regular unwaxed commercial cigarette papers together. Wipe the cylinder bore at the top with both papers using light pressure in a circular motion through about 20°. The paper next to the bore should be stained or wetted with oil, but the second paper should not be soaked through.
Repeat the test at both sides of the bore 90° from the top using two new clean papers for each side. If the paper next to the bore is not stained through, it may be an indication of under lubrication. This test should be performed on all cylinders. If both papers are stained through, it may be an indication of over lubrication. Either way, it is recommended that the lubrication rate be changed accordingly and the cigarette paper test be repeated until passed. If an increase or reduction of the lubrication rate is indicated for a cylinder, change in 5% increments by adjusting the cycle time of the lubricator pumps as outlined in the service manual. Let the machine run 24 hours and repeat the film test for all affected cylinders.

NOTE

The cigarette paper test only gives an indication of oil film quantity. It does not give an indication of viscosity quality. Oils diluted with water, hydrocarbons or other constituents may produce what appears to be an adequate film but the oil may not have the required load-carrying capability due to dilution.

6-5. Cylinder Lubricant Distribution

1. The number of lubrication points will vary depending on cylinder type, bore size and pressure rating. Cylinders have from one to four points for lubrication as follows:

   VIP Cylinders:
   - Two Points - Always on top
   - Four Points - Two on top, two on bottom

   Conventional Cylinders:
   - One Point - Always on top
   - Two Points - One on top and one on bottom
   - DDV Cylinders - Four points - always on top

   When top feeds only are required, the total amount of lubricant is supplied to the top point(s), evenly divided between inner and outer points of VIP cylinders. When both top and bottom feeds are required, the total amount of lubricant is split, with two thirds to the top point(s) and one third to the bottom point(s).

2. In cases of extremely wet or corrosive gases, lubrication atomizers are sometimes placed in the inlet nozzle to lubricate the valves. To be effective, the valves must be flooded with oil, so a generous rate of 20 drops per minute (2.0 PPD or .041 cu. in./min.) per point should be used when sizing the distribution system. This amount of oil should supplement the oil fed to the cylinder bore.

3. When the cylinder lube system includes suction port oilers, the outlet connection is capped at the factory for shipment and the Packager is required to tube it from the divider block or bulkhead to the connection point, which is usually in the suction bottle flange.
6-6. Packing Lubrication Rate

1. Lubrication rate to the packing is established in much the same way as for the cylinder. The following formula is used to size for the normal packing lubrication flow rate:

\[ Q = 0.002 \left[ 0.75 \times \text{Rod Diam.} + 0.0015 \times \text{Stroke} \times \text{RPM} + 0.00075 \times \text{Discharge Pressure} \right] \]

- \( Q \) is quantity of oil in Cu. In./Min.
- Rod Diam. is in inches
- Discharge Pressure in PSIG

Calculations for the various frames in the Separable line-up reveal that the rod size has very little impact on the lube rate to the rod, therefore, in the interest of simplicity, Curve 5 has been developed to determine the packing lubrication rate for various stroke compressors. Multiplying the stroke by the operating speed, and then following the vertical line to the operating pressure will provide the required base lube rate.
2. The gas density correction from Curve 4 must be applied for heavy molecular weight gases. The presence of entrained liquids may require increasing the lube rate by the same factor as for the cylinder bore. If corrosive gases are being pumped, the lube rate to the packing should be increased by 50%.

3. Minimum lube rate at "break-in" to each packing should be 1 pint per day = 0.02 Cu. In./Min.

4. As with cylinder lubrication, the rates are approximate and must be confirmed by examining the rod after operation.

6-7. Packing Lubricant Distribution

1. The number of lubrication points will vary depending on compressor type and pressure rating. Cylinder packing will have from none to two points as follows:

   VIP Cylinders:
   - Below 800 PSIG (56 kg/cm²) - None required
   - 800 PSIG (56 kg/cm²) and above - One Point

   MOS, HOS, HOSS and BOS Cylinders:
   - Below 3000 PSIG (211 kg/cm²) - One Point
   - 3000 PSIG (211 kg/cm²) and above - Two Points

For two point lubrication, two thirds of the lubrication is to be supplied to the point closest to the cylinder pressure and is usually marked H.P. or Inner Lube on packing cases; and one third is to the L.P. or Outer Lube point.

6-8. Points on Lubrication

1. Ensure the proper lubricant is being used for the gas being compressed.

2. No matter what lubricant is being used, at any flow rate, it cannot overcome dirt and foreign particles in the gas. Assure the gas, piping and bottles are clean and proper inlet filters and/or screens have been installed for start-up.

3. Injection pumps become erratic in operation at very low flow rates. Pumps should not be set to pump at less than 0.003 cu. in. Displacement.

4. Ensure all lubrication tubing is tight and free from leaks. Just because the pump is pumping does not mean it is getting to the cylinder or packing. In cases of apparent lack of lubrication, especially on low pressure cylinders, check the internal lubrication piping located inside the gas inlet and discharge piping connections.

6. When using TFE rings and packing in lubricated service, black, gummy deposits on pistons, heads and valves usually indicate marginal lubrication.

6. When reducing lubrication rates, after break-in, reduce in small incremental steps, usually not more than 5 to 10% at a time. The unit should be allowed to operate a minimum of 3 weeks at the reduced rate and then inspected before reducing the rate again. If the cylinder bore, piston rings, rods or packing begin to lose their polish or glaze and are beginning to turn dull, the lubrication rate is low and should be increased to the last acceptable rate.
7. With block lubrication systems, any change in rate affects all points. When attempting to reduce rates with a block system, all points lubricated by the block system must be inspected. To change the rate to one point, the block must be changed.

8. Excessive lubrication will not damage a compressor cylinder, but it can cause packing failure. Excessive packing lubrication can result in what is known as "hydraulicing". It lifts the packing off the rod causing blow-by and unequal pressure distribution across the packing rings. It usually results in packing overheating and extruding (TFE), or turning a blue color (bronze), while lubrication appears adequate.

9. While this Standard compensates for liquids present in the gas, it is recommended that every attempt be made to remove the liquids before the cylinder inlet as they contribute to excessive cylinder wear and in many cases cause valve failures.