15

LUBRICATION, SEALING, AND CONTROL OIL SYSTEMS FOR TURBOMACHINERY*

15.1 CONSIDERATIONS COMMON TO ALL SYSTEMS

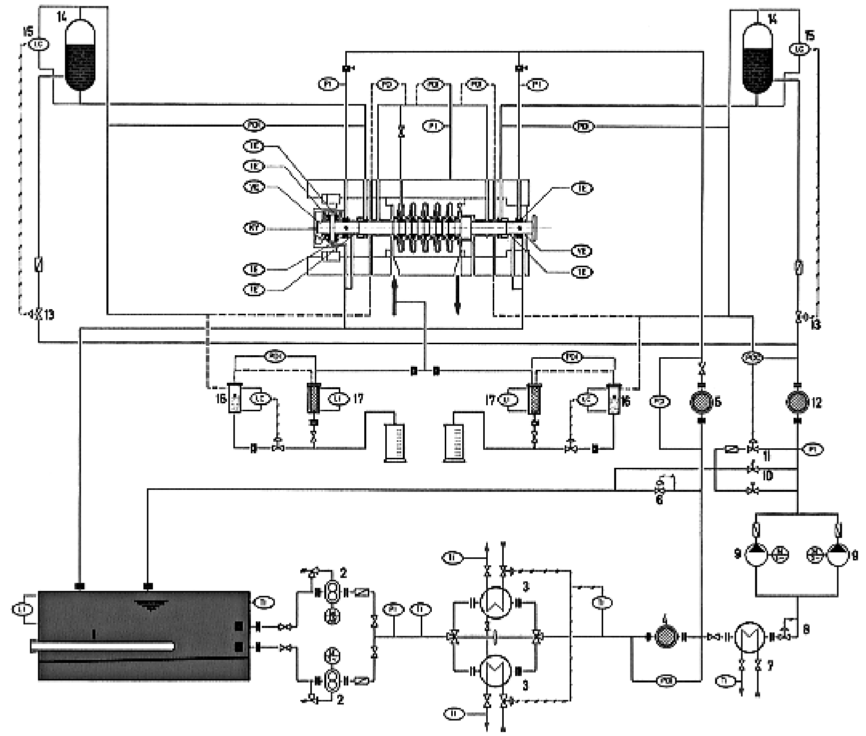
The primary function of an oil system is to provide the proper quantities of cooled and filtered oil at the required regulated pressure levels to the driven and driving equipment. This oil can be used for lubrication, shaft sealing, and/or control oil purposes. The oil system is designed to furnish the oil required at all operating conditions of the equipment. A basic combined lube and seal oil system is described and shown in Fig. 15.1.

A fabricated steel reservoir tank serves to store a volume of oil sufficient for typically 5 to 8 minutes at normal flow. The tank is fitted with both a dipstick and a sight glass level gauge. Removable heating elements, either steam or electric, are usually provided. These heaters are sized to heat the oil from the minimum site ambient temperature to the minimum required oil temperature required by the turbomachine (usually 70°F) within 12 hours. The tank is furnished with a temperature indicator and with a level switch that activates an alarm when the oil level is below the minimum operating level. The purge and vent connections on the tank provide a means to exhaust any gases that are released from the oil.

Oil is drawn from the bottom of the reservoir through suction strainers by motor- or steam turbine–driven pumps. The main and auxiliary pumps are identical and supply a constant flow of oil. Each pump discharge line has a relief valve that protects the equipment from any overpressure caused by a system malfunction. The relief valves are sized to pass full pump capacity. A pressure gauge and a check valve are furnished in each pump discharge line. A block valve is placed downstream of the check valve for maintenance purposes.

* Developed and contributed by Roy J. Salisbury, Manager, Customer Service Department, Imo Industries, Inc., DeLaval Turbine Division, Trenton, N.J. Portions derived from *Transamerica DeLaval Engineering Handbook*, copyright © 1947, by DeLaval Turbine Company.

A Practical Guide to Compressor Technology, Second Edition, By Heinz P. Bloch



1. Oil reservoir
2. LP oil pumps
3. Oil cooler
4. Prefilter
5. Fine filter
6. Pressure-regulating valve
7. Seal oil cooler
8. Pressure-reducing valve
9. HP seal oil pumps
10. Overflow valve
11. Bypass control valve
12. Fine filter
13. Throttle valve
14. Overhead tank
15. Level controller
16. Primary separator
17. Secondary separator

FIGURE 15.1 Basic lube and seal oil schematic: forward pressure control. *(Mannesmann-Demag, Duisburg, Germany)*

The flow of oil then passes through a transfer valve that can transfer the flow from one filter–cooler set to the other set without interrupting the flow. Out-of-service units can be opened for cleaning or maintenance while the other units are in service. Two identical coolers, each capable of handling the system's maximum flow and heat load, are furnished. Water flow to the coolers is regulated to maintain the desired oil outlet temperature of typically 120°F (49°C). Two identical filters are usually supplied; additional prefilters are sometimes used. One filter is placed downstream of each cooler to remove particulate material as small as 10 or 5 μm. Filters, with clean cartridges, are sized to handle the maximum system flow and pressure with a pressure drop no greater than approximately 5 psi. A differential-pressure indicator and a differential-pressure switch are placed across the filter–cooler combination to warn of the need to change the filter cartridges.

To avoid oil pressure surging and interruption of the oil supply, the out-of-service filter–cooler combination is filled with oil before it is put on the line. The vent valves on the filters and coolers are used to vent air from the units, while the oil cross-connect line is opened to fill them. This cross-connect line is left open to keep the out-of-service units pressurized. Thermometers are fitted upstream and downstream of the coolers to check unit performance.

A back-pressure regulator valve is supplied to establish and control the header pressure after the filter-cooler units. This valve can be either self- or pneumatically operated, whichever method is dictated by duty. Oil is taken from a point before the filter–cooler units and bypassed back to the reservoir. The valve is sized to control a wide range of flows, with either one pump or both pumps in operation. In the latter case, the valve would pass a maximum flow of the two pump capacities less the flow required by the system.

Several different pressure levels are often required to carry out the various functions of an oil system. A pressure-reducing valve is used to reduce the header pressure (established by the back-pressure regulator) to the required pressure level for lubricating oil, control oil, and so on. One valve is used for each required pressure level.

When oil seals are used on a compressor, the flow to the seals is set by a flow control valve. This valve is designed to maintain a constant volume of oil regardless of how the oil pressure may vary.

All control valves—flow, pressure, or differential-pressure—have bypass provisions. In case of malfunction, the control valve can be isolated and the flow or pressure adjusted manually through the bypass globe valve.

The unit lubricating oil line receives oil from the console and delivers it at approximately 20 psig to the various points to be lubricated. Except for modern machinery incorporating such componentry as magnetic bearings or nonlubricated couplings, or both, the oil supply is fed to the compressor thrust and journal bearings, to the coupling, and to the driving equipment bearings. The line is fitted with a pressure indicator and several pressure switches at the farthest extreme of the header to ensure an adequate oil supply at this outermost point. One switch is set to trigger an alarm, and a second switch starts the auxiliary oil pump when the lubricating oil pressure falls to, say, 12 psig. The third switch is set to trip the unit at typically 8 psig decreasing.

The lubricating oil drain system collects the oil used by the compressor, coupling, and driving equipment and returns it to the reservoir. Each atmospheric drain line from the bearings and seals is fitted with a sight flow indicator and a thermometer.

15.2 SEAL OIL CONSIDERATIONS

Seal oil would be needed for the various contacting face, mechanical or oil film seals on turbocompressors, but not, of course, for labyrinth or dry gas seals. Seal oil, if required, is supplied to each compressor through a separate header. The seal oil pressure is often controlled from the downstream side of the seal but on some applications is controlled upstream (forward pressure control). A differential back-pressure regulator valve is often used for mechanical seals; a head tank is typically used for oil film seals.

When mechanical seals are used, the oil-side pressure is set about 45 psi above the gas side. A differential back-pressure regulator senses compressor reference pressure or control gas and regulates the seal oil to maintain the proper differential pressure. The seal oil system is fitted with a differential-pressure indicator and several switches. These are connected between the seal oil return line and the control gas connection for back-pressure designs, or the seal oil supply line and the control gas for forward-pressure control. The switches activate an alarm and start the auxiliary pump when the seal–oil–gas differential falls to approximately 35 psi Δp.

Oil film seals usually have a head tank that is mounted above the compressor to maintain a 5-psi differential above the compressor reference pressure. Dual-head tanks are occasionally used, with a level control valve supplied downstream of the seal oil return lines to maintain the proper level in the head tank. For forward-pressure control the level control valve is on the seal oil supply line, as shown in Fig. 15.1. It is usually located approximately 14 ft (4 m) above the centerline of the compressor.

The overhead seal oil head tank arrangement is sized to have the proper capacity and rundown time for emergency operation, coastdown, and block-in. A pneumatic level transmitter sends a signal to a level-indicating controller that operates the level control valve. Level switches and gauges are furnished for monitoring, alarming, and trip functions.

Oil drainers or separators are supplied for both mechanical contact, oil film, and similar seals. They collect the contaminated seal oil and provide an automatic means of discharging this oil for reuse or disposal. An oil drainer is essentially a tank with a float-operated drain valve arranged so that the seal oil leakage can be drained without releasing any gas. Each drainer can be isolated for servicing by closing three valves. The nonoperational drainer is bypassed, and both seals are allowed to drain into the remaining drainer by opening the valves in the crossover lines. A level glass is fitted on the drainer to indicate the operating level.

The majority of the components in the oil system are usually mounted on a preassembled console such as that shown in Fig. 15.2. Consoles of this type are piped and tested prior to shipment; they can generally accommodate a wide selection of valves, flanges, fittings, and other components to meet various specifications. Piping can be entirely carbon steel, entirely stainless steel, or any combination of the two, depending mostly on user preference.

For compressors with gas turbine drivers, compressor oil is usually supplied by the turbine oil system. In such cases, a small seal console that contains seal booster pumps, filters, and the necessary seal oil controls and instrumentation is provided. On some units, the

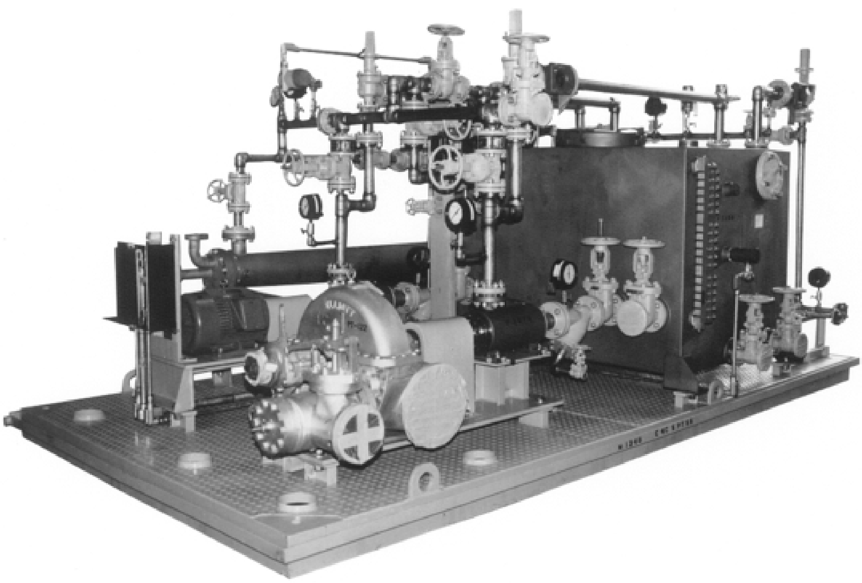


FIGURE 15.2 Lube oil console package for a modern compressor. *(Lubrication Systems Company, Houston, Tex.)*

main seal oil pump is driven from the compressor shaft with an auxiliary pump on the seal console. An emergency seal oil accumulator can be mounted directly on the seal oil console, with an external nitrogen supply providing the motive fluid to supply seal oil during plant power failures. These accumulators require special valving to avoid nitrogen ingestion into the system.

In most units the seal oil is combined with the lubricating oil in one system, but separate lubricating oil and seal oil systems can be provided if necessary because of potential contamination of the lubricating oil. Vacuum dehydrators, coalescers, centrifuges, air stripper, and nitrogen spargers are among the devices used to improve equipment reliability and reduce the cost of preventive maintenance. These units are typically designed for permanent installation on critical machinery oil systems for continuous, onstream purification.

A modern cost-effective lube oil reclaimer or onstream oil purifier schematic is shown in Fig. 15.3. Originally conceived by an Australian inventor, the principle is now employed in the Thermojet lube oil purifiers designed and manufactured by the Lubrication Systems Company of Houston, Texas.

In a typical configuration, the gear pump forces contaminated oil through a filter to remove particles and corrosion products. The pressurized oil is heated by steam or electric heaters and then enters the jet compressor or mixer where ambient air is induced. The air is humidified by the water in the oil and exits through a vent in the knockout vessel as the dehydrated oil returns to the reservoir. Process conditions are generally at temperatures of 140 to 190°F and atmospheric pressures. The higher the process temperature is, the greater the efficiency will be.

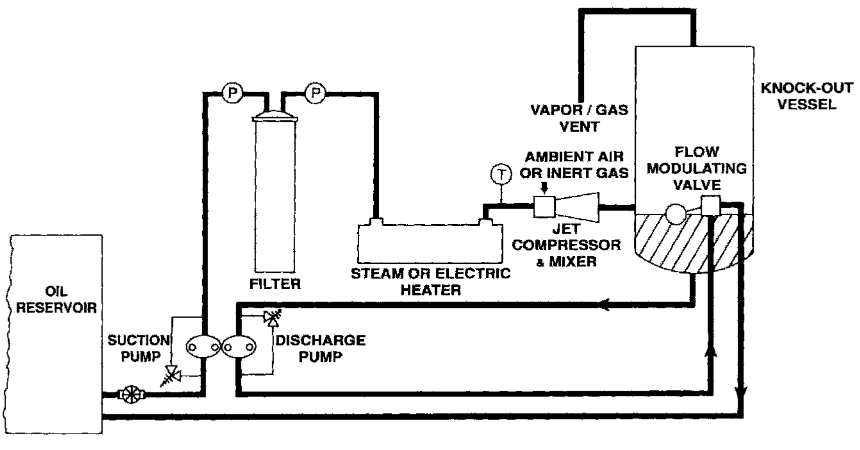


FIGURE 15.3 Onstream lube oil purifier using the air stripping principle. *(Ausdel, PTY, Ltd., Cheltenham, Victoria, Australia)*