

MECHANICAL CONTACT SHAFT SEAL

by

Richard A. Lewis

Senior Application Engineer — Compressors

Elliott Company

Jeannette, Pennsylvania



Richard A. Lewis graduated from Pennsylvania State University in 1970 and has been involved in turbomachinery since that time. He spent two years in Test Engineering, conducting aerodynamic performance tests on compressors, and five years in Application Engineering, overseeing machinery selections. He is presently senior application engineer-compressors, and in that capacity serves as a leader of the Application Group.

ABSTRACT

Various aspects of the mechanical contact type shaft seal are discussed, including theory of operation, features, and applications. Limits are discussed so that the paper should be of interest to both the operator and specifier.

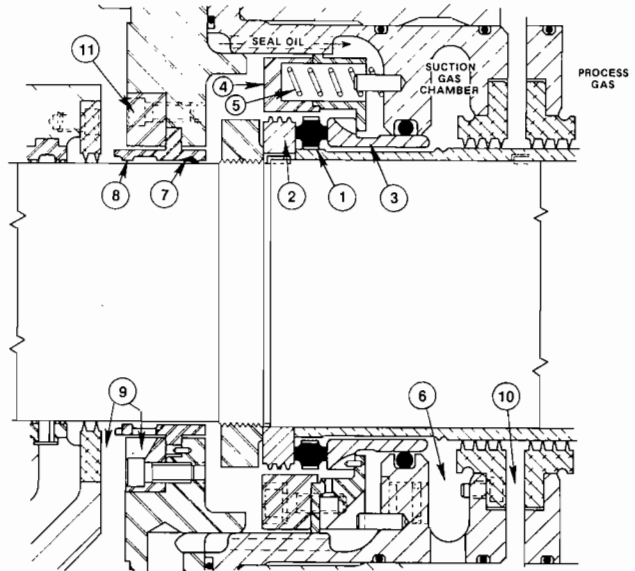
THEORY OF OPERATION

The mechanical contact shaft seal has two major elements, as seen in Figure 1. These are the oil to process gas seal or carbon ring ①, and the oil to uncontaminated seal oil drain seal or breakdown bushing ⑦. In operation, seal oil pressure is held at a differential of 35 to 50 PSID over the process gas pressure which the seal is sealing against. This high pressure oil can be seen entering in the top of the figure and completely fills the seal cavity. Some of the oil (a relatively small percentage ranging from 2-8 GPD/seal depending on machine size) is forced across the carbon ring seal faces which are sandwiched between the rotating seal ring ② which is rotating at shaft velocity, and the stationary sleeve ③ which is non-rotating and forced against the carbon ring by a series of peripheral springs. The actual rotative speed of the carbon ring can, therefore, be anywhere between zero RPM and full rotational speed. Oil crossing these seal faces contacts the process gas (or buffer gas if it is used) and is thus "contaminated oil." This oil flows out the contaminated drain ⑥ where it is trapped in a drainer.

The majority of the oil flows out the uncontaminated seal oil drain ⑨ after taking a pressure drop from design seal oil pressure to atmospheric pressure across the breakdown bushing ⑦. An orifice ⑪ is placed in parallel with the breakdown bushing to meter the proper amount of oil flow for cooling.

FEATURES

This type of seal will normally be found to have provision for buffering via a single ported labyrinth located inboard of the seal ⑩ and a positive shutdown device which will attempt to maintain gas pressure in the casing when the compressor is at rest and seal oil is not being supplied. Because of the many ways this shutdown device is applied by different manufactur-



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|-----------------------------------|--------------------------------------|
| 1. ROTATING CARBON RING | 7. FLOATING BABBITT-FACED STEEL RING |
| 2. ROTATING SEAL RING | 8. SEAL WIPER RING |
| 3. STATIONARY SLEEVE | 9. SEAL OIL DRAIN LINE |
| 4. SPRING RETAINER | 10. BUFFER GAS INJECTION PORT |
| 5. SPRING | 11. BYPASS ORIFICE |
| 6. GAS AND CONTAMINATED OIL DRAIN | |

Figure 1. Mechanical Contact Shaft Seal.

ers, the method may vary but the net result is to tightly sandwich the carbon ring ① between the rotating seal ring ② and stationary sleeve ③ with gas pressure to prevent gas from leaking out when no oil pressure is available. A user option to have the bearing oil drain either combined with the seal oil uncontaminated drain or separate is also normally available; however, the separate arrangement will increase bearing span and lower critical speeds.

Typical parameters are:

Oil to gas ΔP range	35-50	PSID	(2.4-3.4 BAR)
Maximum sealing gas pressure	600-800	PSIG	(41-55 BAR)
Maximum oil inlet temperature	120-140	°F	(49-60°C)
Normal discharge temperature	140-170	°F	(60-77°C)
Maximum discharge temperature	240	°F	(115°C)

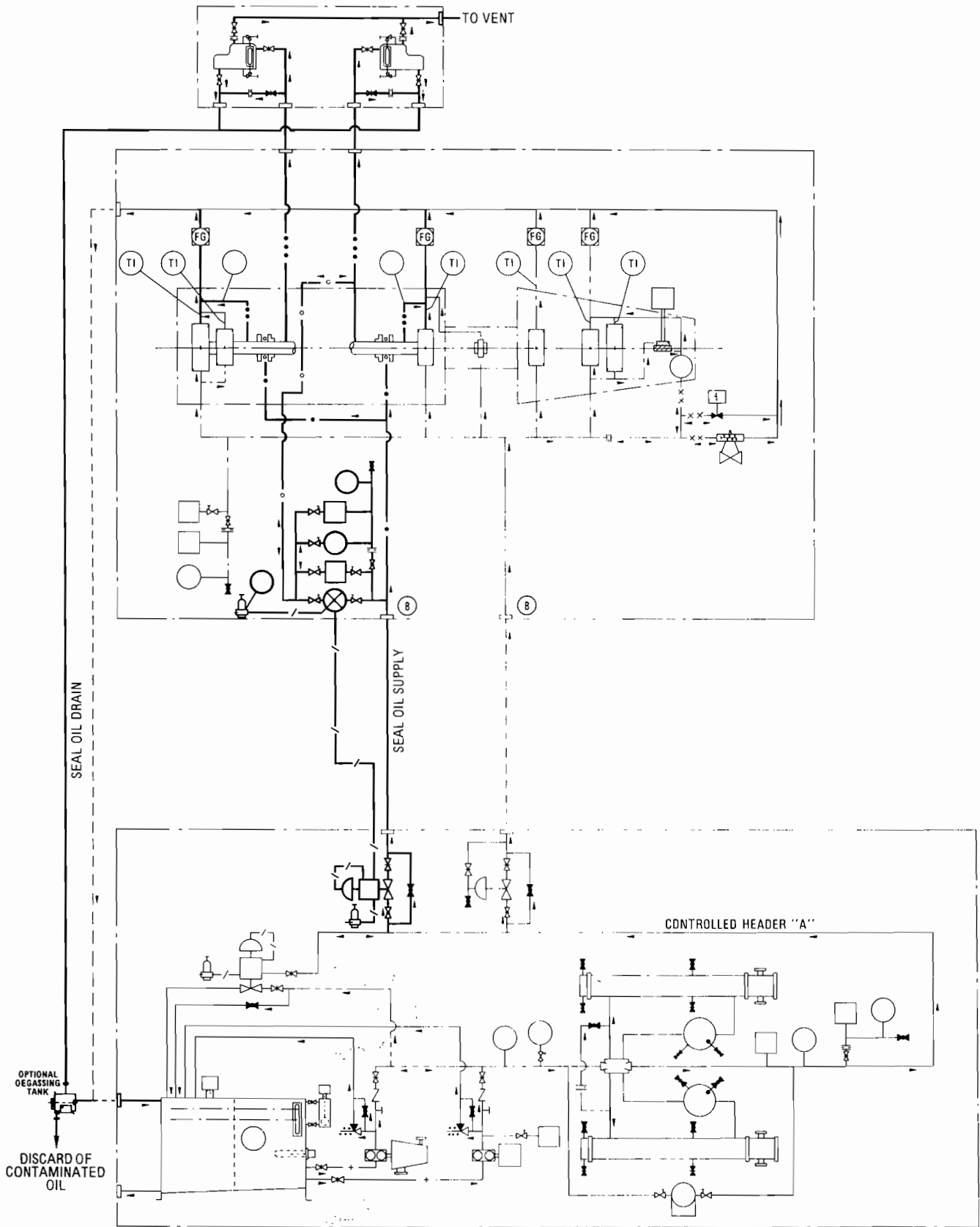


Figure 2. Mechanical Contact Seal Lube Oil System.

ASSOCIATED OIL SYSTEM

One of the advantages for the mechanical contact seal is that the associated seal oil supply system may be relatively simple as opposed to other types of seals, as seen in Figure 2. The relatively high oil to gas differential and wide allowable range allows simple differential regulators to be used to control the oil supply system, rather than a complex overhead tank arrangement. The dark lines in Figure 2 represent the seal oil system used for this type of seal. Seal oil is taken from a controlled header "A" and dropped to the required ΔP via a relatively inexpensive regulator control. The sensing point for this ΔP control is off the contaminated drain cavity (Ⓒ in Figure 1) on the high pressure end of the compressor. By sensing off the high pressure end, a minimum ΔP of oil to gas is always held on both ends of the compressor. (The high pressure end may be at a slightly higher pressure than the inlet end due to any pressure drop through the equalizing line.) Also, note that any pressurizing of the contaminated drain cavity due to buffer gas being used is also automatically followed by using a sensing point located in the contaminated drain oil cavity.

In the system shown in Figure 2, the "uncontaminated oil" drained through Ⓓ in Figure 1 combines immediately with lube oil and returns to the reservoir whereas the "contaminated oil" drained through Ⓒ in Figure 1 is trapped by a drainer and automatically drained to be optionally discarded or returned to the reservoir via a degassing tank.

APPLICATIONS

The relative complexity of the mechanical contact seal over the alternate high pressure seal, the bushing seal, is at first misleading because the mechanical contact seal lends itself to a more simple associated seal oil system, with a higher differential better able to follow system upsets. This has led this seal to be preferred by many up to about a 600 PSIG pressure level. Other advantages include a "built-in" grounding brush across the "microscopic" clearances of the carbon ring, and an apparent resistance to back-diffusion of H₂S; again most probably due to the "microscopic" dimensions of the oil film on the carbon ring seal face. Many users have been able to specify a combined lube and seal oil system even in sour gas service and gain some appreciable critical speed margin because of it. On the negative side, the seal itself, as mentioned before, is more complex than other seal types, and has an upper operating pressure limit which restricts its use on very high pressure applications. We presently know of few seals of this type running above 800 PSIG, although short term runs to 1100 PSIG have been established.

Compressors using this type of seal have included hydrocarbon mixes (both sweet and sour), all refrigerant gases, oxygen (using water as the lubricant), and hydrogen mixes. In short, most all chemical/refinery applications where pressure levels allow may use this type of seal.