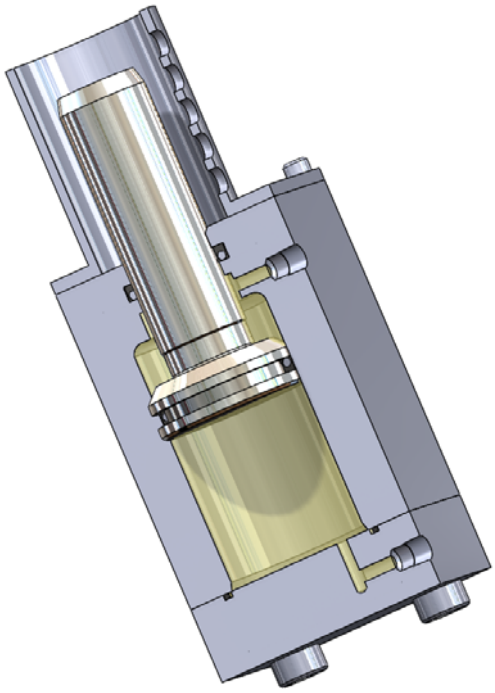
Chapter D18

Pressure staging



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1. Introduction

"Pressure staging" is the technical term for dividing fluid pressure among more than one rotary shaft seal, to handle high differential pressure. Figure 1 illustrates the basic concept. In Figure 1, the lubricant to the left of the first stage seal is at pressure P, while the lubricant on the right of the first stage seal is at P/2. In this arrangement, the first and second stage seals each retain a pressure differential equal to P/2. Any desired number of pressure stages may be used.

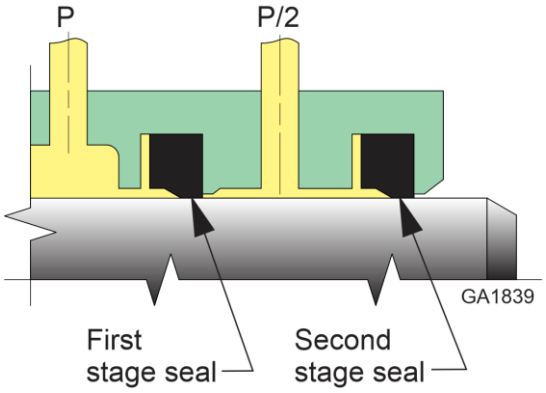

Figure 1

Pressure staging of rotary shaft seals

Pressure staging is the sharing of differential pressure across more than one rotary shaft seal. In this pressure staging example, each seal is exposed to a differential pressure equal to one half of the pressure P.

Figure 2 is a simplified schematic showing how differential area pistons can be used to produce the first and second stage lubricant pressures. Although the pistons are shown as part of a manifold assembly, the pistons could also be in individual housings. Other arrangements, such as creating back pressure with a computer controlled pinch valve, can also be used to provide the lubricant pressures. For general information on various lubricant supply systems, see Chapter D11.

The use of pressure staging with our patented laterally floating metal backup rings is shown in Figure 3. The backup rings, which are described in more detail in Chapter D17, are radially pressure balanced and axially force balanced. The radial pressure balance provides dimensional stability, and the axial force balance allows them to move laterally to follow the runout of the shaft. This combination of features allows the smallest possible extrusion gap clearance without risk of heavily loaded metal-to-metal contact, which facilitates high pressure rotary shaft seal operation.

Figure 4 schematically represents how to provide pressure staging in a side port swivel. For the highest pressures and easiest assembly, design the swivel with the floating metal backup ring arrangement shown in Figure 3.

Figure 5 illustrates the use of pressure staging with axially force balanced laterally translating seal carriers. Although laterally translating seal carriers are not as effective at minimizing extrusion gap clearance as floating metal backup rings due to radial pressure imbalance, they are more easily adapted to use with abrasive environments.

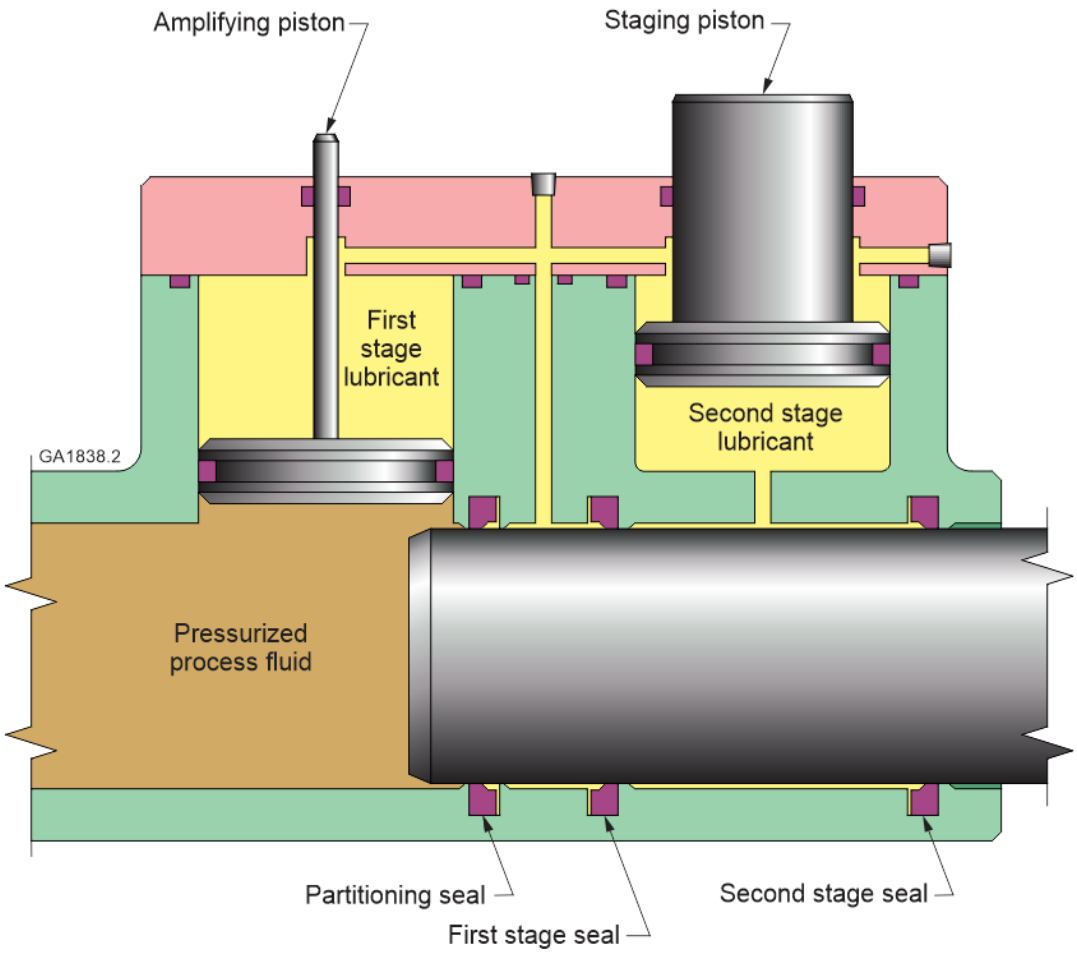

Figure 2

Schematic showing the use of pistons to produce staging pressure

In this simplified schematic, the first stage lubricant pressure is amplified above the process fluid pressure by the amplifying piston, to provide differential pressure across the partitioning seal. The staging piston reduces the second stage lubricant pressure to about one half of the first stage pressure. The first and second stage rotary shaft seals each retain a differential pressure that is about one half of the pressure of the first stage lubricant. This schematic does not show the bearings that would be required to support the rotary shaft. Ideally, the amplifying piston would be spring loaded to provide differential pressure across the partitioning seal even in the absence of process fluid pressure.

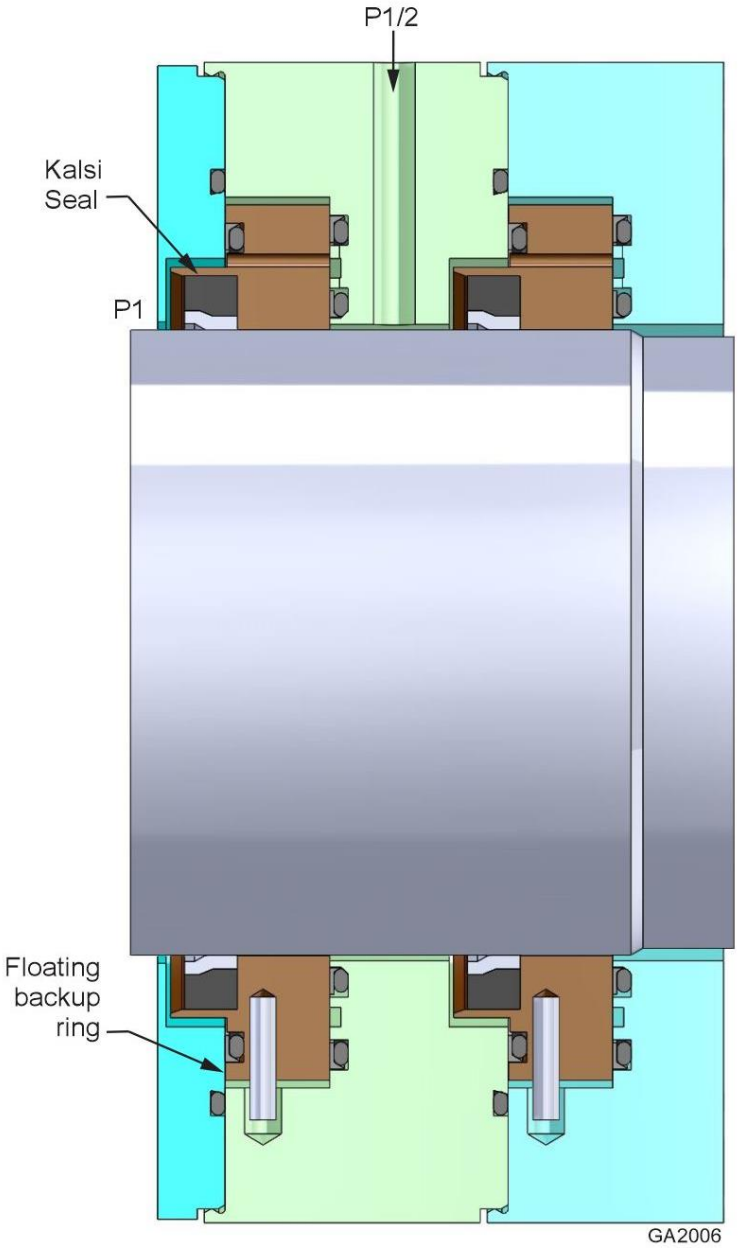

Figure 3

High pressure, staged, floating backup rings

This illustrates the use of pressure staging with our patented laterally floating backup rings (U.S. Patents 9,429,238, 9,845,879, and 10,330,203). The backup rings move laterally to follow shaft runout, which allows the smallest practicable extrusion gap clearance without risk of damaging heavily loaded metal-to-metal contact. The support housings are fastened together with a pattern of bolts that are not shown. The pressure-staged fluids can be circulated for cooling. To achieve the highest pressures and longest life, combine floating backup rings with our most capable high pressure rotary shaft seal design, the Plastic Lined Kalsi Seal™. Contact Kalsi Engineering for information about floating backup ring licensing options.

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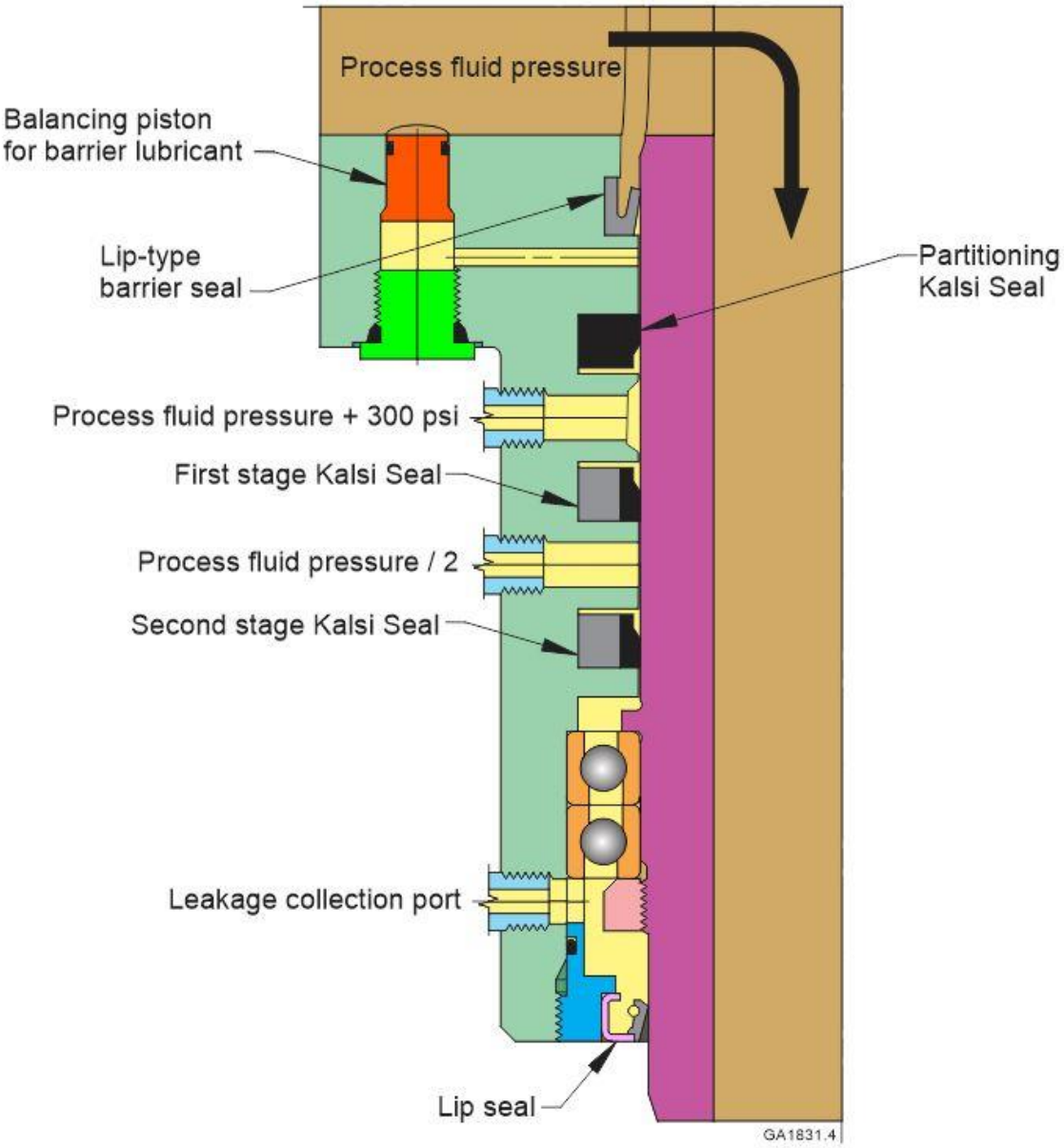

Figure 4

Pressure staging in a side port swivel (schematic)

This schematic shows the use of pressure staging in a side port swivel (only ¼ of the swivel is illustrated). In addition to pressure staging, the swivel incorporates lip-type barrier seals for added resistance to lubricant pressure lag and any chemical effects of the process fluid. The piston balances the barrier lubricant to the process fluid pressure. If the piston bottoms out in the position shown, the hydrodynamic pumping related leakage of the partitioning Kalsi Seal™ will vent past the dynamic lip of the barrier seal, lubricating the lip seal. For the easiest assembly and the most pressure capacity, incorporate our patented floating backup rings and our most capable high pressure rotary shaft seals: Plastic Lined Kalsi Seals™.

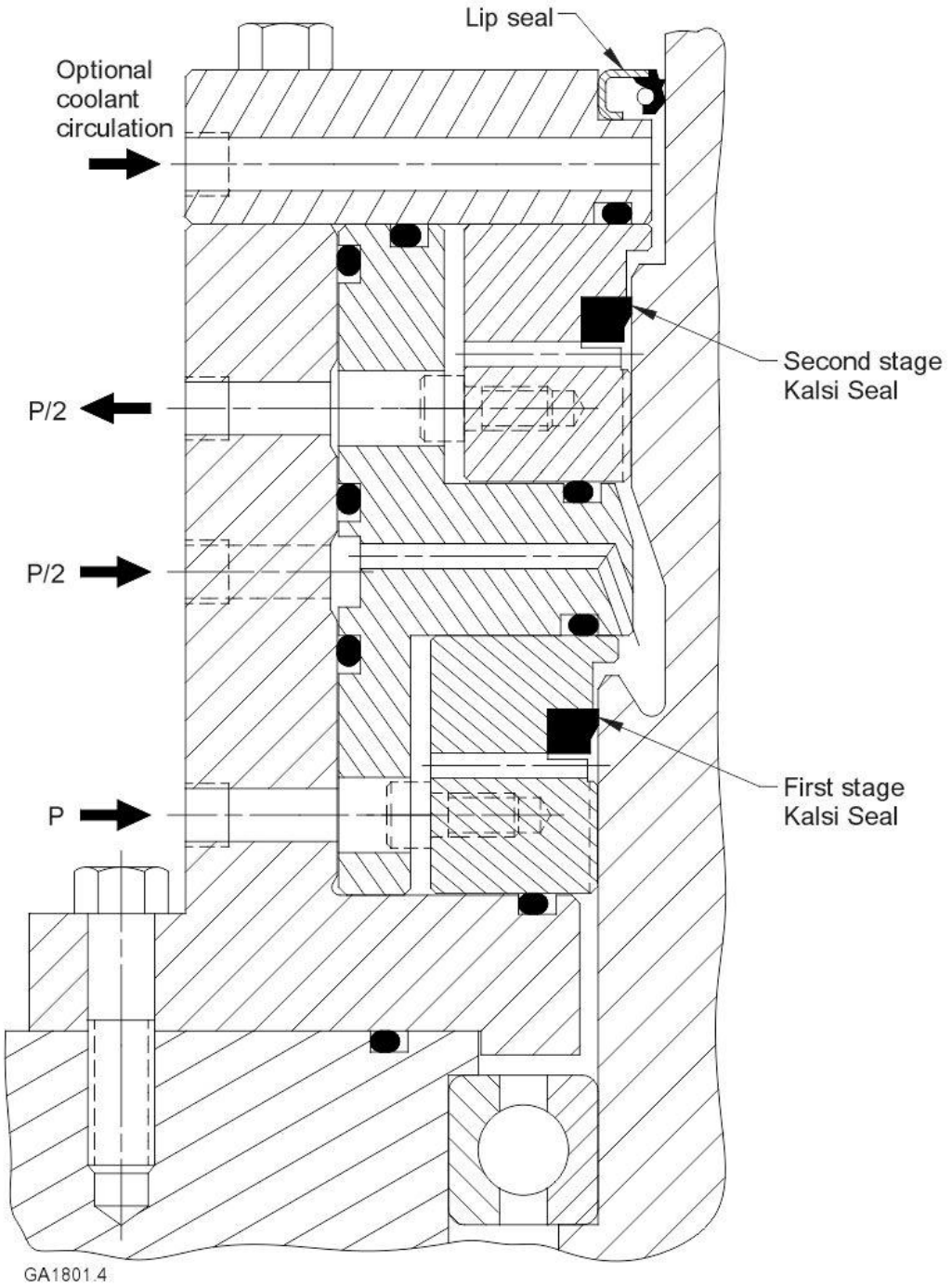

Figure 5

High pressure, staged, laterally translating seal carriers

This laterally translating seal carrier arrangement was originally developed for oilfield rotary control device (RCD) high pressure sealing, where the pressure retaining seals are exposed to abrasive drilling fluid dripping from other equipment. If desired, lubricant circulation can be employed to provide seal and bearing cooling. In this figure, the outboard lip seal is provided to accommodate circulation of a low pressure coolant. For a description of this high pressure rotary shaft seal arrangement, see expired U.S Patent 6,227,547.

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