Chapter D21

Sticky drawer effect

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1. Introduction

Most people are familiar with the "sticky drawer effect", where a cocked, partially open wooden bureau drawer will not close, no matter how much closing force is applied. In fact, the more one pushes, the tighter the drawer is stuck. The same effect can occur in many types of equipment,[1] including the piston type lubricant reservoirs used with Kalsi-brand rotary seals. This chapter explains how to avoid the "sticky drawer effect".

2. Avoiding the sticky drawer effect in lubricator pistons

In piston type lubricant reservoirs, the piston can cock due to factors such as an eccentric spring load, and unevenly distributed seal friction. For this reason, the length of the piston should be sized to prevent binding caused by the "sticky drawer effect".

Figure 1 is a schematic representing three different types of lubricant reservoir pistons. The figure illustrates the engagement length and width that govern piston sticking. The threshold binding coefficient of friction can be determined by dividing the engagement length by the engagement diameter. For example, if the engagement length is 0.8" and the engagement diameter is 4.0", the threshold binding coefficient of friction would be 0.8"/4.0" = 0.2. If such a piston becomes cocked due to an offset load or unevenly distributed sliding friction, the piston will bind if the coefficient of friction between the components is greater than or equal to 0.2.

Design the engagement length so that the threshold binding coefficient of friction is higher than your estimate of what the actual coefficient of friction[2] will be, considering the mating materials that establish the engagement diameter and engagement length, and considering the lubricant that is being used.

Figure 2 is a patent application drawing that illustrates a piece of equipment that failed in service due to "sticky drawer effect". The engagement length of the annular lubricator pistons (330, 332) was too short, relative to engagement length, resulting in stuck pistons.

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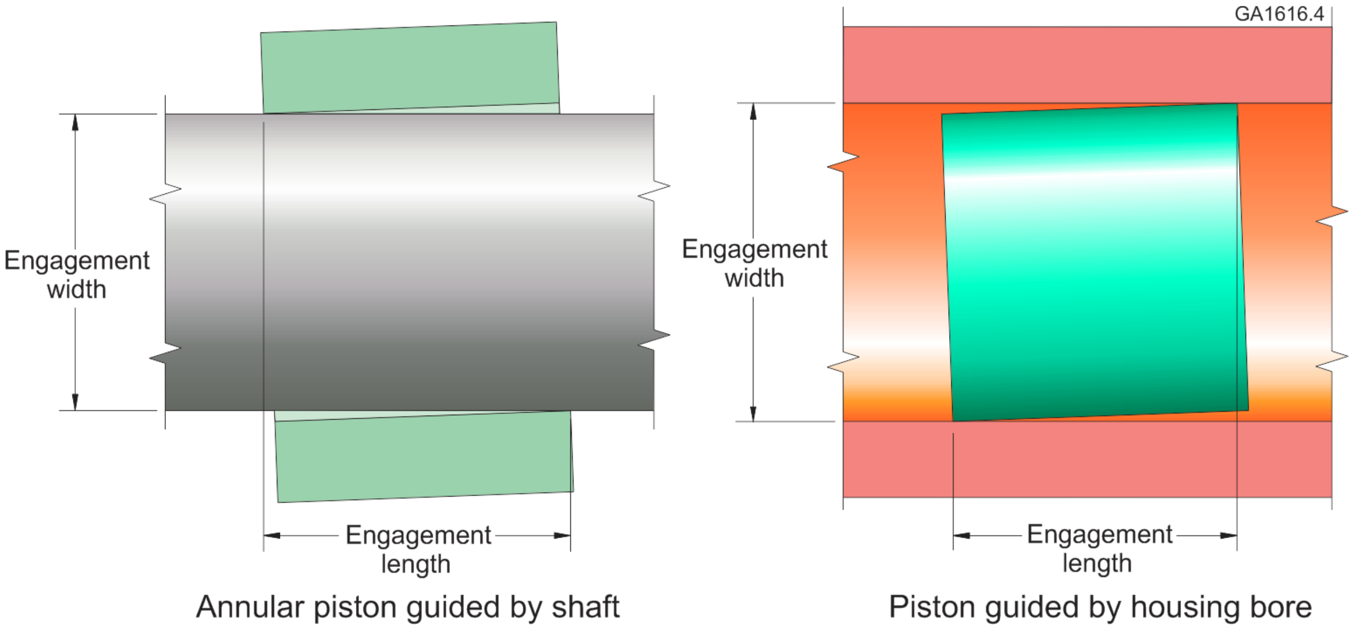
1 Some types of devices, such as a hunter's climbing tree stand, exploit the "sticky drawer effect" to produce an intentional locking action. For an example of such a device, see U. S. Patent application 20050145436.

2 One source of information on coefficient of friction is **Mark's Standard Handbook for Mechanical Engineers** (McGraw-Hill Book Company).



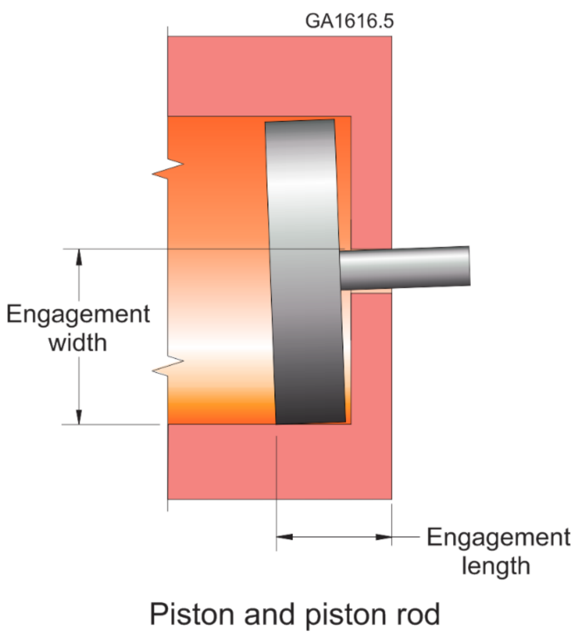


Figure 1

Calculating the threshold binding coefficient of friction

An offset axial load, or unevenly distributed friction, can cause pistons to cock relative to mating guide surfaces. If ratio of the engagement length to the engagement width is too small, the pistons may bind when tilted. The threshold binding coefficient of friction can be determined by dividing the engagement length by the engagement diameter. If the actual coefficient of friction is equal to or greater than the threshold binding coefficient of friction, the piston may stick if sufficiently tilted while axial force is being applied to the piston.

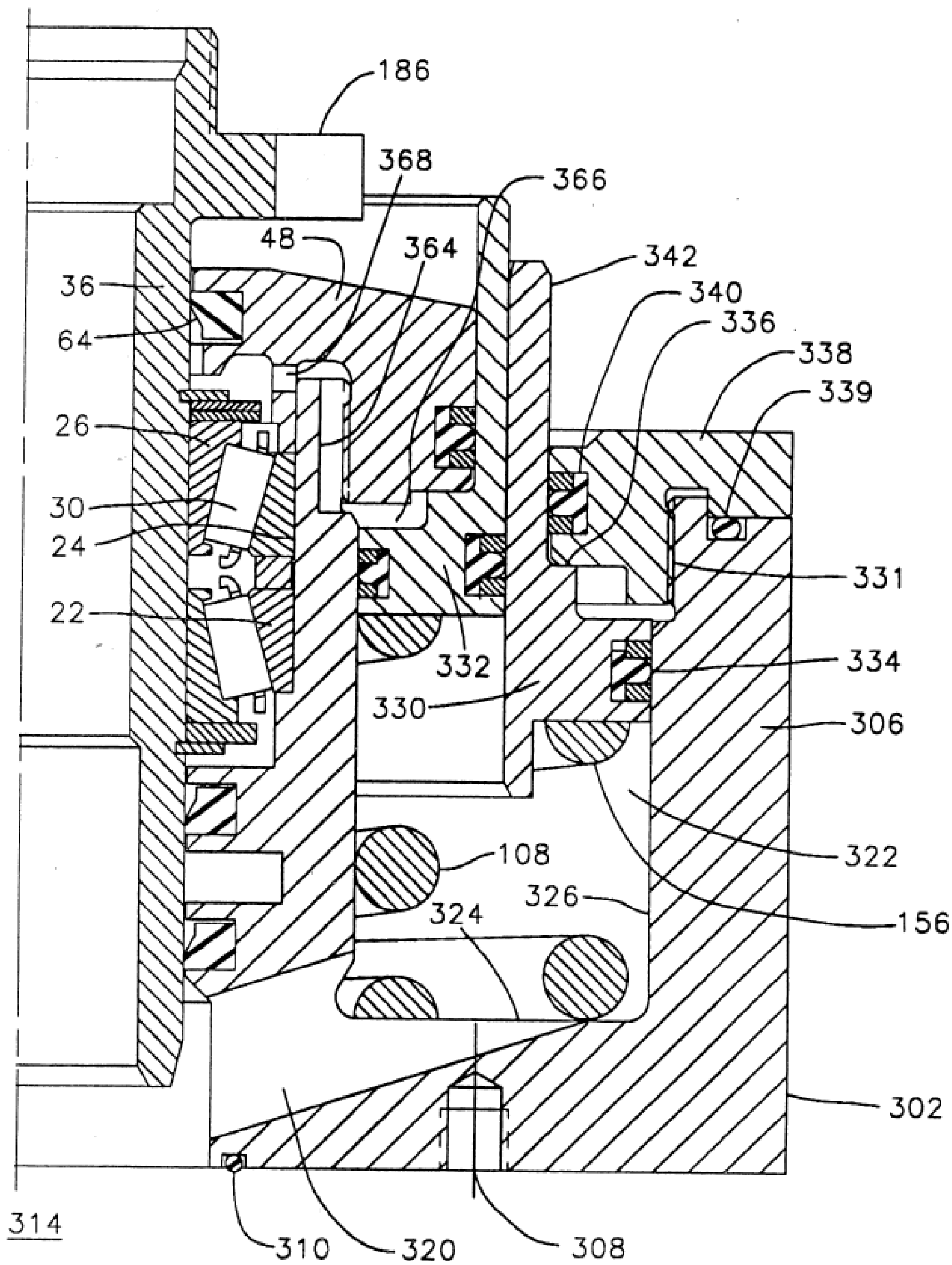


Figure 2

Example of pistons that failed due to "sticky drawer effect"

This image, which is from a patent application, illustrates a pair of pressure amplifying lubricator pistons (330, 332) that were designed to supply lubricant to Kalsi-brand rotary shaft seals. These pistons failed in service due to "sticky drawer effect" because the engagement length was too short, relative to diameter.

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3. Minimizing sticking when using precision fitted surfaces

Many young engineers are unpleasantly surprised the first time they try to assemble equipment they have designed using an RC 2 sliding fit or an RC 3 precision running fit. If the two parts become slightly misaligned during assembly, they can become stuck tightly together.

Figure 3 is a schematic that exaggerates the angular misalignment, to illustrate the root cause of the sticking problem. Because of the tight fit between the components, a slight amount of angular misalignment causes corner contact on opposite sides of the assembly. The engagement length is very small, compared to the engagement width, and therefore the threshold binding coefficient is very low.

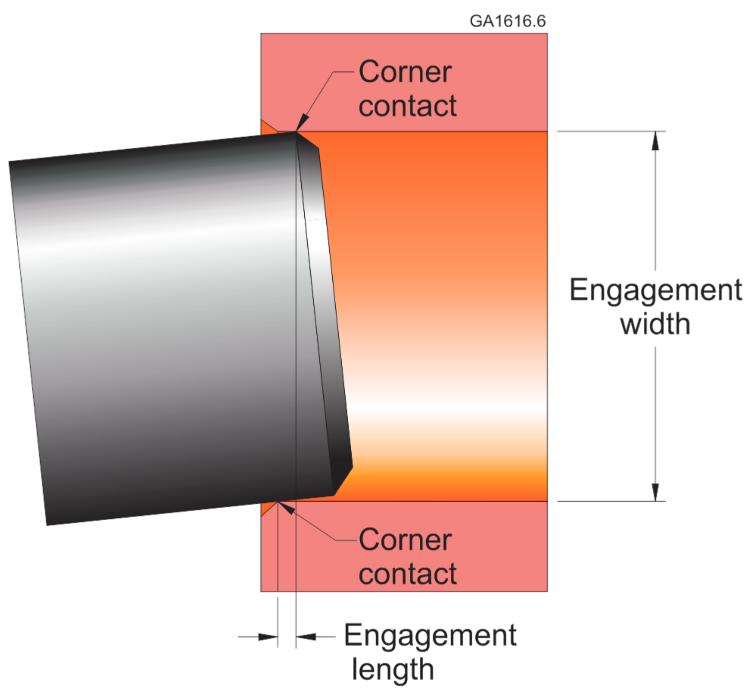

Figure 3

Precision fits are prone to "sticky drawer effect" during assembly

This schematic, which exaggerates angular misalignment, shows the corner contact that causes "sticky drawer effect" during the assembly of precision fits. The threshold binding coefficient of friction is equal to the engagement length divided by the engagement width. With a precision fit, any slight misalignment leads to corner contact as the parts are assembled. If the apparent coefficient of friction between the parts is greater than the engagement length divided by the engagement width, the parts will become stuck together during assembly.

There are several ways to minimize sticking issues when assembling precision fits:

- Provide one of the parts with a lead-in diameter that provides more clearance than the precision-fitted surfaces. Provide the lead-in diameter with sufficient length to minimize angular misalignment during assembly, before the precision diameters begin to engage.
- Provide fixturing that prevents angular misalignment during assembly.
- Prior to assembly, heat the outer part and cool the inner part, to increase clearance at the time of the assembly.

4. A short pilot length prevents the "sticky drawer effect"

One typical use of precision fits is to minimize eccentricity between mating components. This objective can be achieved by restricting the precision fit to a relatively short piloting region, rather than applying the precision fit over the length of the components.

Figure 4 shows the use of a short, precision fitted piloting region, with a pilot length P_L. If the pilot length P_L kept to a minimum, the "sticky drawer effect" can be completely avoided, because corner contact cannot occur on opposite sides of the parts, regardless of the degree of angular misalignment.

Binding due to the "sticky drawer effect" cannot occur if:

$$[P_{Dmax}\hat{}2 + P_{Lmax}\hat{}2]\hat{}.5 < P_{Bmin}.$$

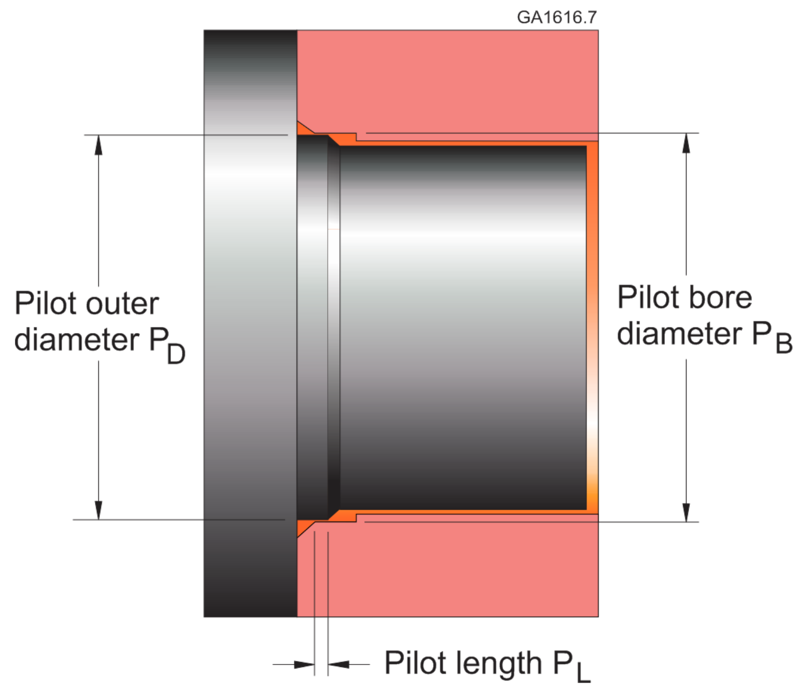

Figure 4

A short pilot length prevents "sticky drawer effect" during assembly

Because the pilot length is short, the corner contact that causes the "sticky drawer effect" cannot occur, regardless of the degree of angular misalignment between the components.