

THE INFLUENCE OF SURFACE FINISH ON BAL SEAL® SPRING-ENERGIZED SEAL PERFORMANCE

Technical Report
TR-4A (Rev. H; 10-25-01)
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19650 Pauling
Foothill Ranch, CA 92610-2610
Tel (949) 460-2100
Fax (949) 460-2300
Email: sales@balseal.com
www.balseal.com

Bal Seal Engineering Europe B.V.
VIDA Building, 1st Floor
Kabelweg 57
1014 BA Amsterdam
The Netherlands
Tel +31 20 638 6523
Fax +31 20 625 6018
Email: ordersbv@balseal.nl

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1.0 INTRODUCTION

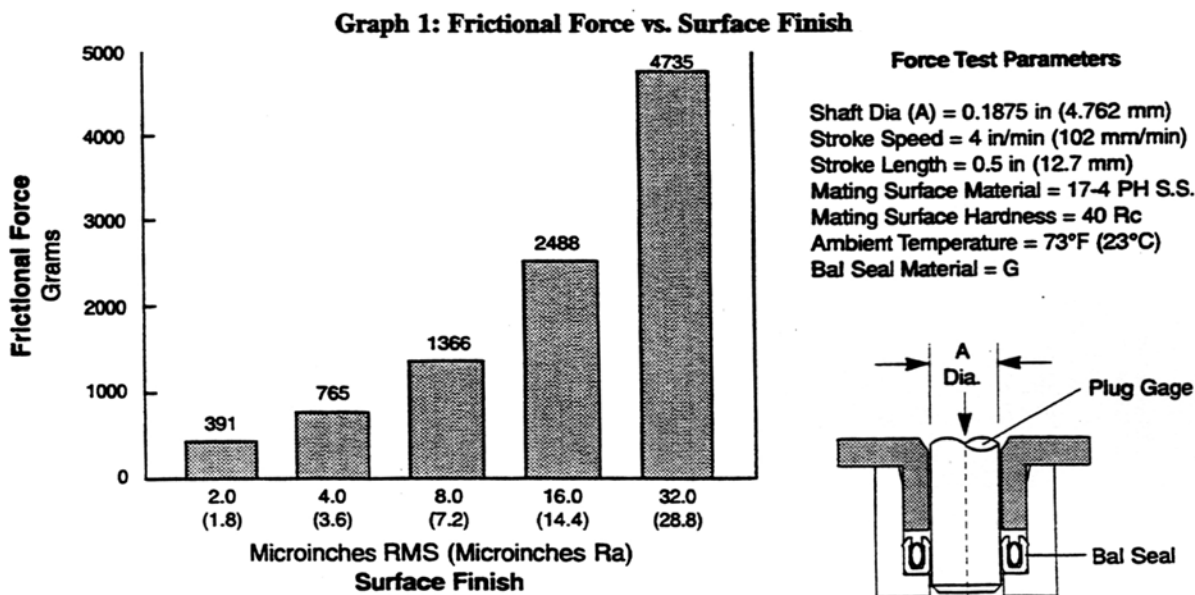
Many factors will affect the performance of a seal. Some of the more commonly discussed factors are temperature, pressure and speed. The performance of a spring-energized BAL™ Seal is also governed to a great extent by finish of the mating surface over which the seal must slide. The finish of the mating surface has a significant effect on friction, seal wear, lubrication and sealing ability.

2.0 SURFACE FINISH

The performance of spring-energized PTFE BAL™ Seals is governed to a great extent by the finish of the mating surface over which the seal slides. The surface finish has a significant effect on friction, wear and sealing ability. Detailed reports on surface finish include: TR-4, “The Influence of Surface Finish on BAL Seal Performance;” TR-29, “Methods of Obtaining Surface Finishes;” and TR-51, “Measuring Surface Finishes.”

2.1 Influence of Surface Finish on Friction

In general, PTFE seal wear is proportional to frictional force: lower friction results in reduced wear. Test results indicate that improving surface finish may reduce friction. See Graph 1.



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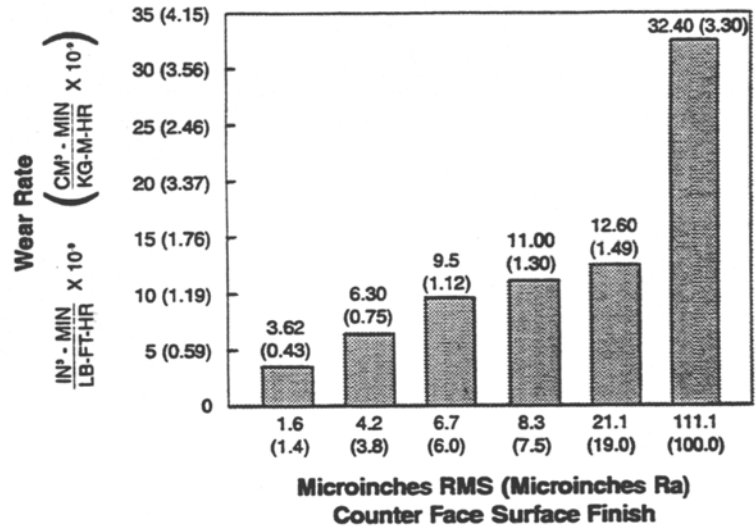
2.2 Influence of Surface Finish on Seal Wear

The finish of the mating surface influences the abrasive wear to which the seal is subjected. Abrasive wear occurs when a rough, hard surface slides over a softer surface. Wear occurs in the form of plastic chips cut from the surface of the seal. Test results indicate that smoother surfaces produce lower wear rates by reducing abrasive wear. See Graph 2.

Graph 2: Wear Rate of BAL Seal GFPA Material vs. Various Surface Finishes

Wear Test Parameters

Surface Speed	= 55 fpm (17 m/min)
Loading Stress	= 55 lb/in ² (4 Bar)
Wear Rate in Air	= @PV 3025 lb/in ² x ft/min (7.5 N/mm x m/min)
Mating Surface Hardness	= Rc 42
Mating Surface Material	= 17-4 pH Stainless Steel
Mating Surface Finish	= 1.6 to 111.1 microinches RMS (1.4 to 100 microinches Ra)
Ambient Temperature	= 70°F (21°C)
Ambient Relative Humidity	= 75% RH
Duration	= 5 hours
BAL Seal Material	= GFPA
Media	= Air



3.0 SURFACE FINISH AND SEAL WEAR

Abrasion and adhesion are the two major causes of seal wear.

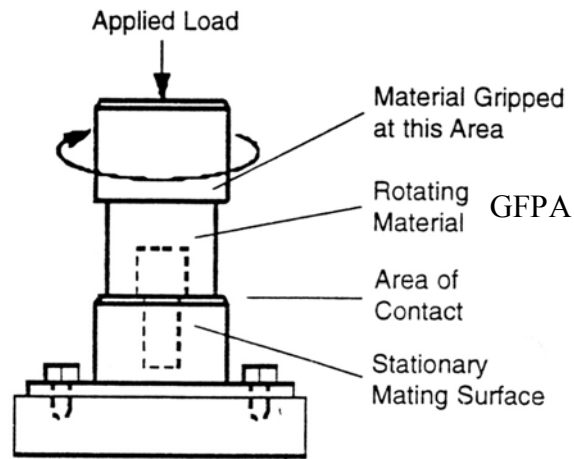
3.1 Abrasive Wear

The finish of the mating surface influences the degree of abrasive wear to which the seal is subjected. Abrasive wear occurs when a rough, hard surface slides over a softer surface and plows a series of grooves in it. Wear occurs in the form of plastic chips cut from the surface of the seal.

A series of tests have been conducted to determine how the surface finish influences the wear rate of BAL Seal GFPA material. Tests were administered using a thrust water test fixture, see Figure 1.

WEAR TEST PARAMETERS

Surface Speed = 55 ft/min (17 m/min)
 Mating Surface Hardness = Rc 43
 Mating Surface Finish = 1.4 to 100 microinches Ra
 Ambient Temperatures = 70°F (22°C)
 Loading Stress = 55 lb/in² (4 kg/cm²)
 Duration = 5 hours plus 90 minutes
 Non-Lubricated in Air



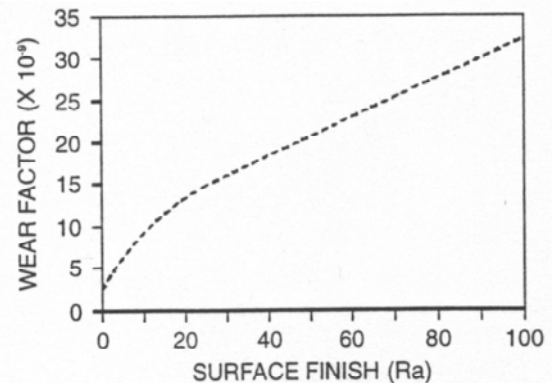
**Test Fixture
FIGURE 1**

Results are shown in Table 1 and wear rates are plotted against surface finish values in Graph 3. The results indicate that smoother surfaces produce lower wear rates by reducing abrasive seal wear.

Wear Rate of GFPA vs. Various Surface Finishes

Counterface Surface Finish (microinches Ra)	Wear Rate $\times \frac{10^{-9} \text{ in} \cdot \text{min}}{\text{lb} \cdot \text{ft} \cdot \text{hr}}$
1.4	3.62
3.8	6.30
6.0	9.50
7.5	11.00
19.0	12.60
100.0	32.40

TABLE 1



GRAPH 3

3.2 Adhesive Wear

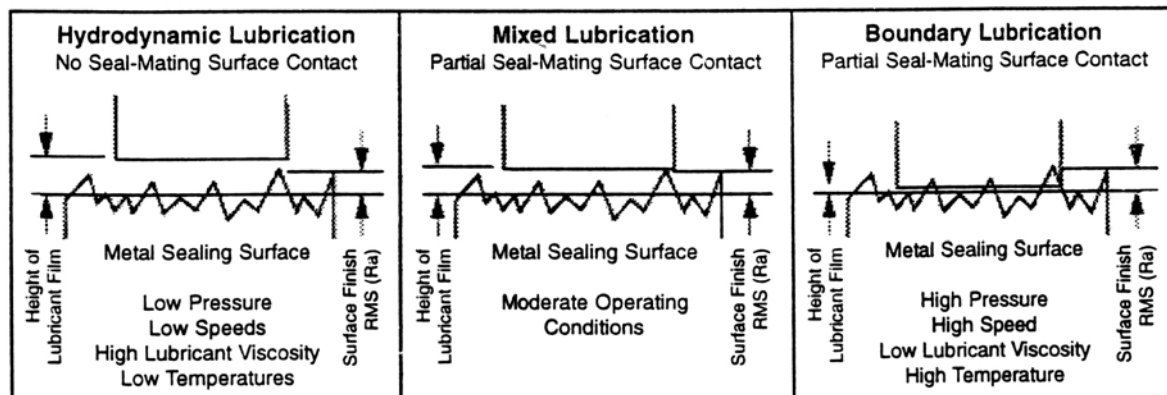
When two surfaces slide over each other, patches of one surface adhere to the other and may be removed in the form of loose wear particles. This adhesive wear occurs because of the strong bonds formed between atoms that come into intimate contact with one another.

A smooth mating surface will tend to reduce abrasive seal wear but will increase adhesive wear. This is because a smooth mating surface will increase the area of contact between the seal and sealing surface. This results in greater intimate contact between the sealing surfaces and strong adhesive bonds.

Fortunately, it is relatively simple to reduce adhesive seal wear by using a lubricant. The lubricant forms a protective layer between the sealing surfaces, which prevents the adhesive junctions from forming.

4.0 SURFACE FINISH AND LUBRICATION

The friction and wear behavior of a BAL Seal in a lubricated environment is dependent upon the extent of the lubricating film separating the seal from the sealing surface. One of three types of lubricating conditions may be present in any application. See Figure 2.



Lubricating Conditions
FIGURE 2

The surface finish should vary depending on the type of lubricating conditions present. When the lubricating film is thick, as it is during hydrodynamic lubrication, the finish of the mating surface can be rougher because the seal does not come into contact with the mating surface. When the film is thin, as it is during boundary lubrication, the finish of the mating surface should be smoother due to the greater area of contact between the seal and the mating surface.

5.0 SURFACE FINISH AND SEALING ABILITY

Although many factors affect leakage, the sealing ability of a BAL Seal is generally proportional to the viscosity of the sealed medium. Media with reduced viscosity (i.e., gases vs. liquids) are more difficult to seal. This can be compensated for to some degree by improving the finish of the mating surface. A smoother finish creates greater sealing contact between the seal and mating surface, thus improving sealing ability. See Table 2.

MEDIUM	DYNAMIC SURFACE		STATIC SURFACE
	Reciprocating	Rotary	
Cryogenics	2 to 4 RMS 1.8 to 3.6 Ra	2 to 4 RMS 1.8 to 3.6 Ra	4 to 8 RMS 3.6 to 7.2 Ra
Gases (Air, N, O, etc.)	6 to 12 RMS 5.4 to 10.8 Ra	4 to 8 RMS 3.6 to 7.2 Ra	12 to 32 RMS 10.8 to 28.8 Ra
Liquids (Hydraulic fluid, water, etc.)	8 to 16 RMS 7.2 to 14.4 Ra	8 to 12 RMS 7.2 to 10.8 Ra	16 to 32 RMS 14.4 to 28.8 Ra
Suggested Surface Finish			
TABLE 2			

6.0 SUMMARY

BAL Seal performance is influenced to a great degree by the finish of the mating surface in contact with the seal. Dynamic surfaces in contact with BAL Seals should have specified surface finishes. A specified surface finish will help to assure consistent and reliable seal performance. The surface texture standard, ANSI B46.1 – 1978 provides detailed information about the specification of surface finishes. For information about methods used to measure surface finishes, request report TR-51, “Measuring Surface Finishes.” For information on how to obtain surface finishes, request report TR-29, “Methods of Obtaining Surface Finishes.”

7.0 REFERENCES

- BAL Seal Reports 17-20; 25-30; 32-41; 100-17; 59-9; 100-54
- TR-54 Factors Which Affect Linear Force Values While Measuring the Friction of BAL Seals
- TR-20 Dry Lubricants and Their Effects on BAL Seal Performance
- TR-78 Factors Which Influence PTFE BAL Seal Performance