BAL SEAL® USER'S GUIDE

Factors That Influence Bal Seal PTFE Seal Performance

Technical Report
TR-78 (Rev. E; 10-23-01)
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BAL SEAL ENGINEERING

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.
Jollemanhof 16, 5th Floor
1019 GW Amsterdam
The Netherlands
Tel +31 20 638 6523
Fax +31 20 625 6018
Email: ordersbv@balseal.nl

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Bal Seal Engineering ● Foothill Ranch, CA USA 92610-2610 ● Tel: 949 460-2100; Fax: 949 460-2300 ● Email: sales@balseal.com ● Web: www.balseal.com
Bal Seal Engineering Europe, B.V. ● Amsterdam, The Netherlands ● Tel: +31 20 638 6523, Fax: +31 20 625 6018 ● Email: info@balseal.nl ● Web: www.balseal.nl

1.0 INTRODUCTION

Bal Seal Engineering Company is committed to conducting thorough research of our products and sealing technologies which influence the performance of BAL™ Seal PTFE seals. This commitment helps us develop a diverse line of quality PTFE sealing devices that meet the high-quality criteria required by today's seal user. We believe that it is vitally important that the users of our seals have a thorough and complete understanding of the service conditions that affect BAL Seal PTFE seal performance so that you may can obtain the highest level of performance.

This report contains the abbreviated results of literally thousands of tests performed at Bal Seal Engineering on our products. Wide ranging topics which affect seal service, such as pressure, temperature, surface speed, sealed media, piston and bore materials, coatings, PV limits, surface finishes, jacket materials, and lubrication that have been tested and analyzed are discussed here. For further information about any item concerning the performance of BAL Seal PTFE seals or about general sealing technology, contact the Bal Seal Engineering technical staff. We will be happy to answer any questions or forward you one of our many technical reports dealing with specific topics of interest.

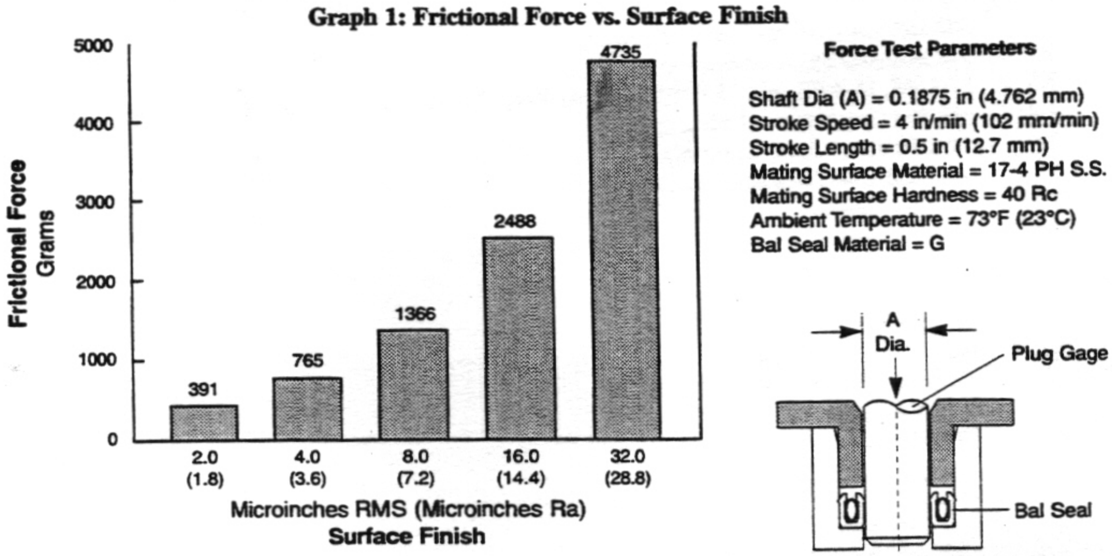
2.0 SURFACE FINISH

The performance of spring-energized BAL Seal PTFE 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.

Graph 1: Frictional Force vs. Surface Finish



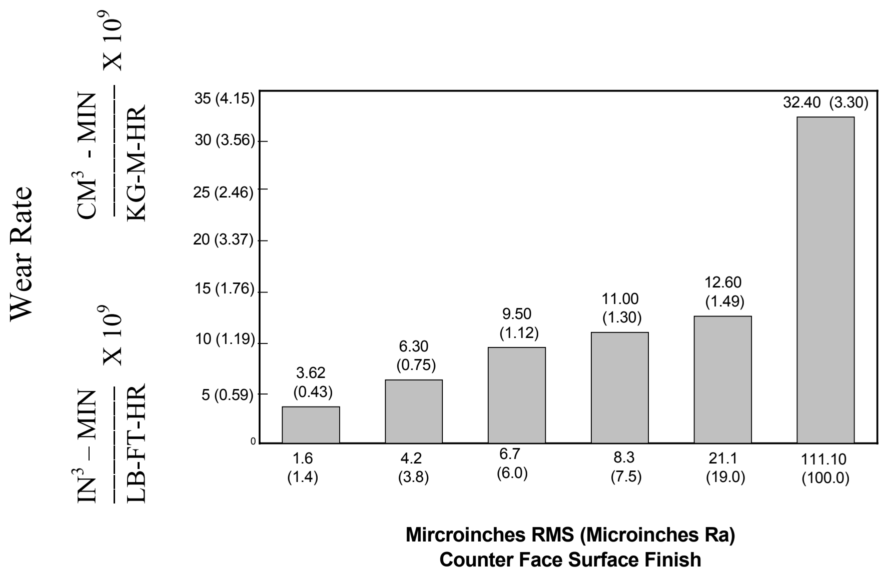
2.2 Influence of surface finish on BAL™ Seal wear

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

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
Ambient Temperature	=	microinches Ra)
Ambient Relative Humidity	=	70ºF (21ºC)
Duration	=	75% RH
BAL Seal Material	=	5 hours
		GFPA



2.3 Surface finish and sealing ability

Although many factors affect leakage, the sealing ability of a PTFE seal is generally proportional to fluid viscosity. Media with reduced viscosities (i.e. gases versus liquids) are more difficult to seal. This can be compensated for, to some extent, 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 1.

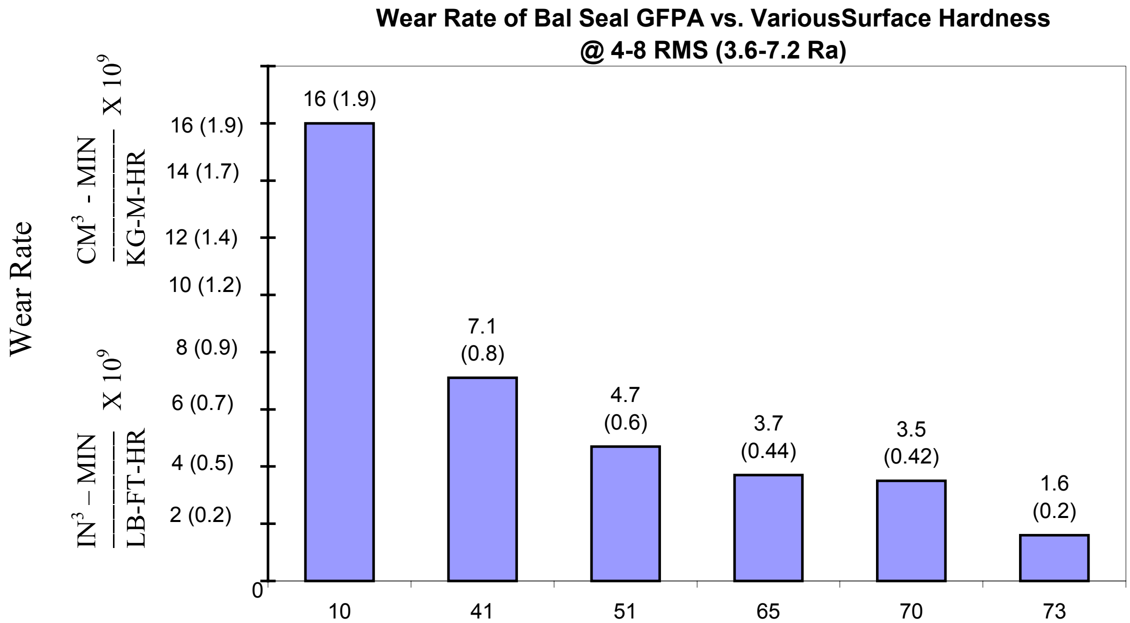
Table 1: Suggested Surface Finishes

Medium	Dynamic Surface	Static Service
Gases and Liquids At Cryogenic Temperatures	2 to 4 Microinches RMS (1.8 to 3.6 Microinches Ra)	4 to 8 Microinches RMS (3.6 to 7.2 Microinches Ra)
Gases (Air, N_2, O_2, etc.)	6 to 12 Microinches RMS (5.4 to 10.8 Microinches Ra)	12 to 32 Microinches RMS (10.8 to 28.8 Microinches Ra)
Liquids (Hydraulic Fluid, Water, etc.)	8 to 16 Microinches RMS (7.2 to 14.4 Microinches Ra)	16 to 32 Microinches RMS (14.4 to 28.8 Microinches Ra)

3.0 SURFACE HARDNESS

The hardness of the surface in contact with a BAL Seal PTFE seal has a significant effect on seal wear. Adhesion is lower between a soft PTFE seal and a hard mating surface, resulting in reduced friction. Test results indicate that harder surfaces promote less wear. See Graph 3.

Refer to TR-30, "Wear Rate of BAL Seal GFP Materials vs. Various Coatings," for complete details.



Surface Hardness (Rockwell Scale)
Graph 3

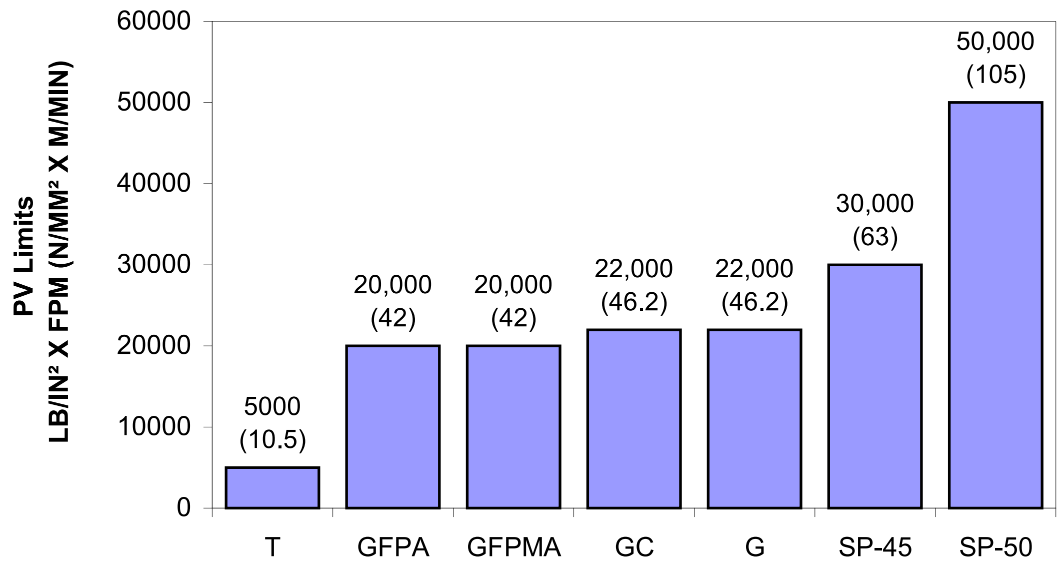
4.0 SEALING JACKET MATERIAL

The selection of the seal material should be based on a variety of considerations including the sealed media, friction requirements, pressure and velocity, wear life requirements, operating temperature, cost, lubrication, and other factors. Request report TR-8A for a complete description of the physical and mechanical properties of many BAL Seal materials.

4.1 Estimated PV limit

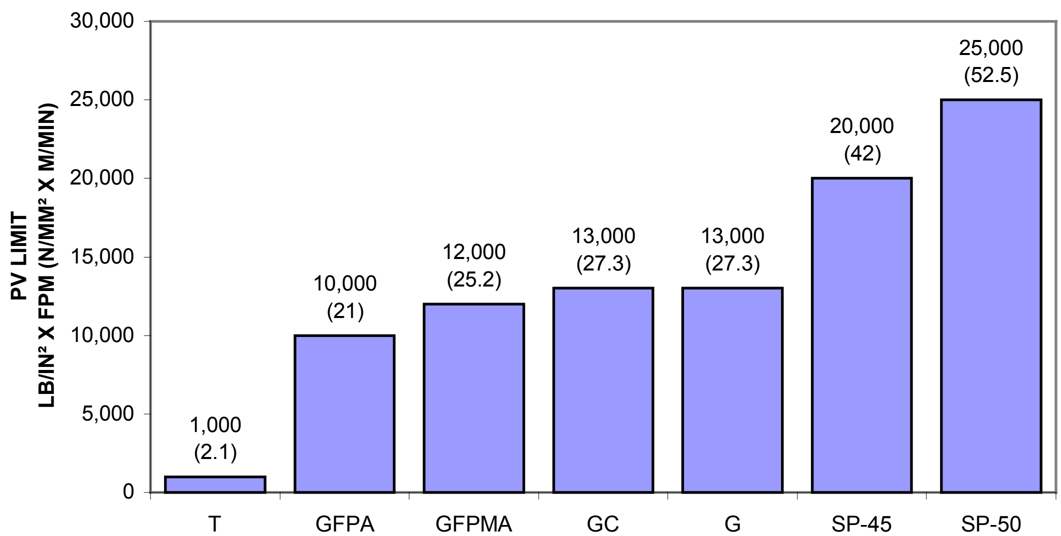
The PV limit is the medium value representing the product of pressure and velocity, lb/in^2 x fpm or N/mm^2 x m/min. The PV limit is extremely important in selecting the proper BAL Seal material to obtain maximum reliability and performance based on fluid medium. The PV limit of the seal material will be furnished with a design proposal.

PV Limits of Various Bal Seal Materials
in Air at 170 fpm (52 m/min) and 70°F (21°C)
Air at 75% relative humidity



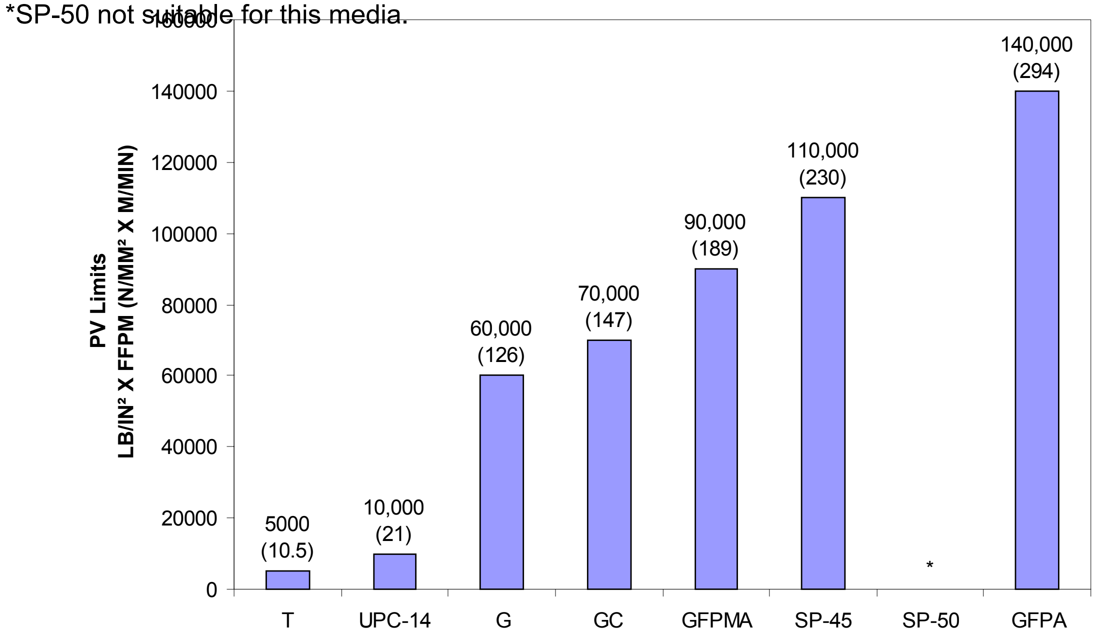
Graph 4A: Bal Seal Materials

PV Limits of Various Bal Seal Materials
In Air at 900 fpm (274 m/min) and 70°F (21°C)
Air at 75% relative humidity



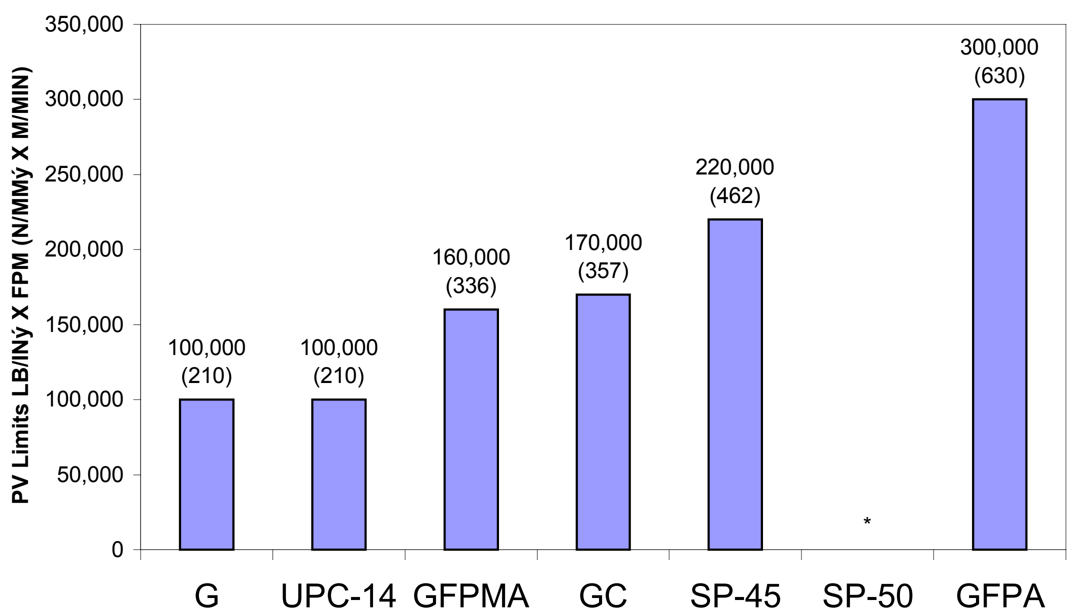
Graph 4B: Bal Seal Materials

PV Limits of Various Bal Seal Materials
In Water at 170 fpm (52 m/min) and 70°F (21°C)



Graph 4C: Bal Seal Materials

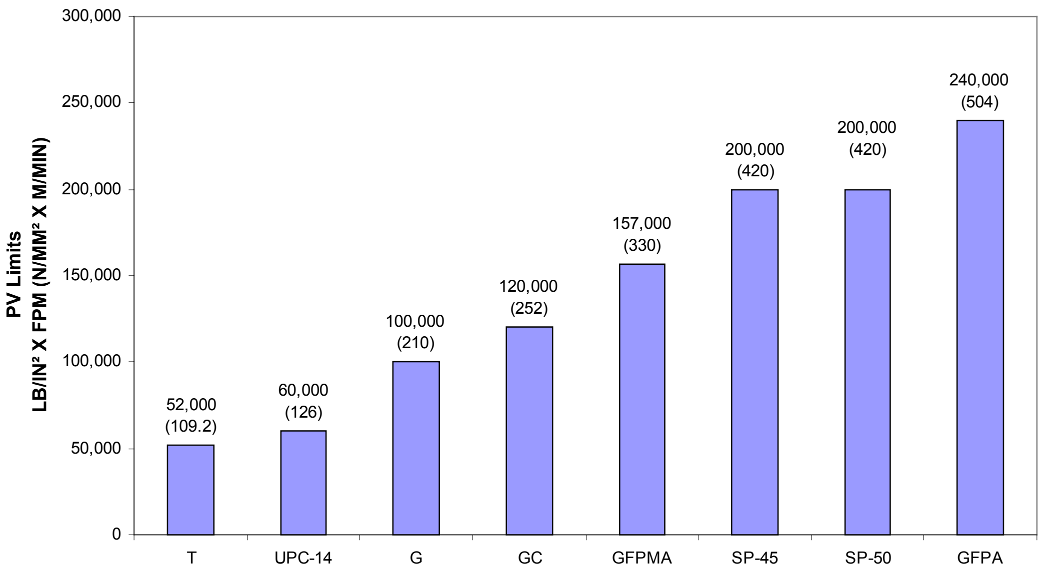
PV Limits of Various Bal Seal Materials
in Water at 900 fpm (274 m/min) and 70°F (21°C)



Graph 4D: Bal Seal Materials

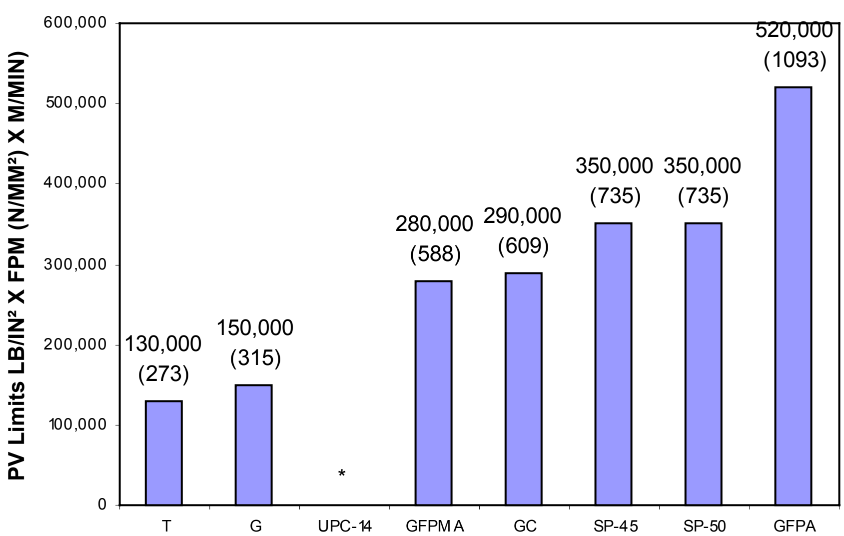
*SP-50 not suitable for this media.

PV Limits of Various Bal Seal Materials
In Oil at 170 fpm (52 m/min) and 70°F (21°C)



Graph 4E: Bal Seal Materials

PV Limit of Various Bal Seal Materials
In Oil at 900 fpm (274 min/min) and 70°F (21°C)

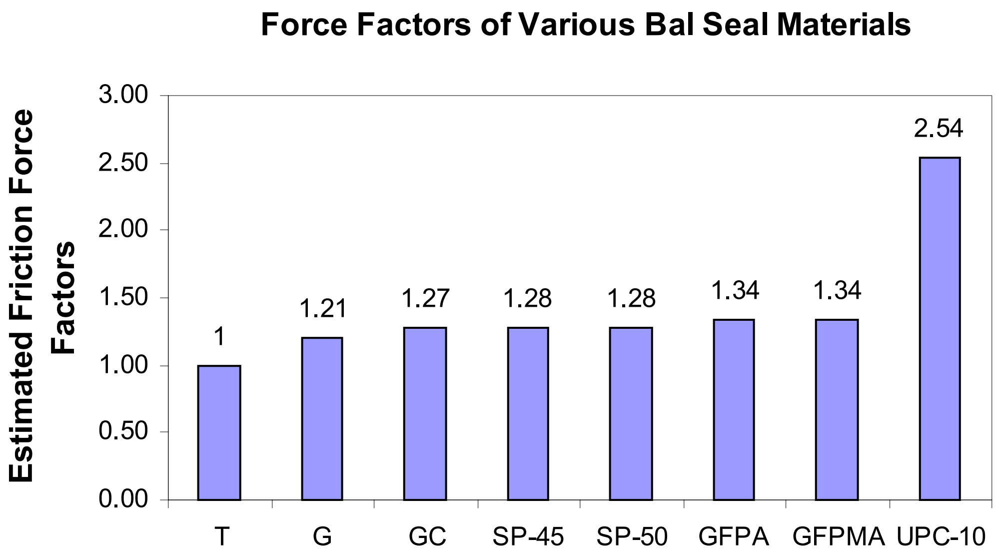


Graph 4F: Bal Seal Materials

*UPC-14 not suitable for these conditions

4.2 Influence of jacket material on friction

The friction produced by a seal sliding against a counter surface is influenced by a variety of factors, including jacket material. A relative comparison of the friction produced by various BAL Seal materials is shown in Graph 5. For example, the force produced by a seal made from UPC-10 was more than 2 ½ times greater than the force produced by a comparable BAL Seal made from virgin PTFE when tested under the same conditions.



Graph 5: Sealing Jacket Material

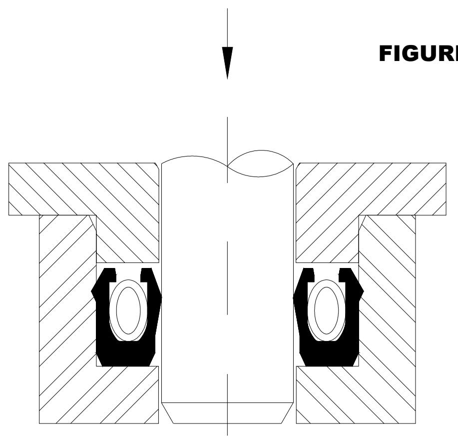
4.3 Effect of temperature on sealing jacket materials

The operating temperature of the system has a very significant effect on the physical properties of the seal material. The properties affected include extrusion resistance; wear resistance, tensile strength, elongation, and others. As the temperature in the seal area increases, the properties decline. Significant changes in material properties occur soon after the temperature rises beyond room temperature (70°F) (21°C). The increase accelerates rapidly as the temperature approaches the temperature limit of the materials (550°F for PTFE based materials). Graph 6 below shows how temperature affects the extrusion resistance of some BAL Seal materials.

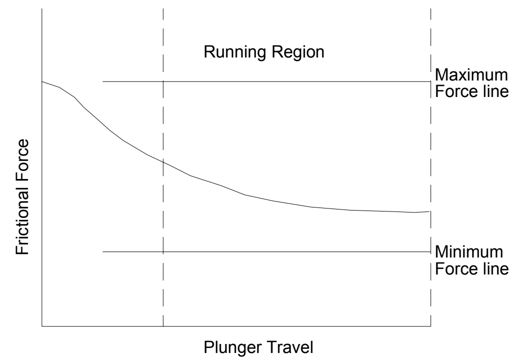
10.0 MEETING FORCE REQUIREMENTS

Superior seal performance can be obtained by taking advantage of the special quality assurance testing procedures we offer. Force testing can be implemented to maintain tighter tolerances and enhance the consistency of seal performance. The specified seal force is met by changing the loading spring. BAL Seal PTFE seals are available in various spring forces, which determine, to a great extent, the sealing ability, friction, and duration of the seal. The procedure and a typical computer printout of the frictional force of an individual seal are shown in Figure 4. Request Report TR-31 for information.

FIGURE 4: Frictional Force Testing



Method of Measuring Linear Force
View A



Force vs. Plunger Travel of Individual Seal
View B

11.0 SUMMARY

The performance of a BAL Seal PTFE seal is not dependent on just one or two operating conditions, but on a variety of factors working simultaneously. Selection of a BAL Seal PTFE seal for a particular application requires a complete understanding of these factors. At Bal Seal Engineering Company, we continuously test our materials, springs, and seals to find out how service conditions affect performance, and to discover new ways to improve seal design. We hope that by using the information contained in this report, seal users can improve the performance of their products. Please contact the Bal Seal Engineering technical staff for any additional information.