

# **SAPPHIRE VS. CHROME-PLATED STAINLESS STEEL PISTONS: A COMPARISON OF WEAR ON BAL SEAL® SPRING-ENERGIZED SEALS**

Technical Report  
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(54-12)



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## TABLE OF CONTENTS

- 1.0 Summary
- 2.0 Materials, apparatus and procedures
  - 2.1 Materials
  - 2.2 Apparatus
  - 2.3 Procedures
- 3.0 Results
  - 3.1 Piston surface finish
  - 3.2 Piston surface structure
  - 3.3 Piston hardness
- 4.0 Conclusions
- 5.0 References

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## 1.0 SUMMARY

This report contains the results of a series of tests performed by Bal Seal Engineering Company to determine the effect of two types of pistons used in a plunger pump. The tests compare the wear of BAL™ Seals made from GPFA and UP-40 polyethylene. A series of tests were run comparing the effects of sapphire and chrome-plated stainless steel pistons. The results indicate that the use of sapphire pistons results in substantially greater BAL Seal life.

## 2.0 MATERIALS, APPARATUS AND PROCEDURES

### 2.1 Materials

The testing involved BAL Seal UR134-106-MB made from GPFA and UP-40. The seals were run in a typical plunger pump against sapphire and chrome-plated stainless steel pistons.

#### 2.1.1 GPFA

GPFA is a BAL Seal graphite fiber-filled PTFE compound that provides excellent service under high pressure, high speed, or elevated temperatures.

#### 2.1.1 UP-40

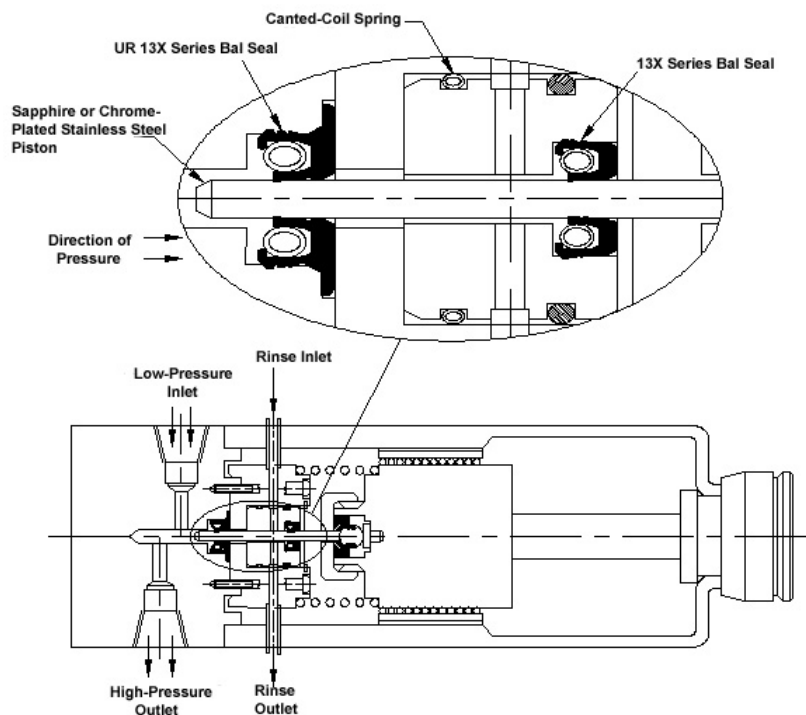
UP-40 is a BAL Seal polyethylene type material. It provides excellent service in water or water-based fluids due to its ability to transfer a lubricating film to a counter surface in aqueous media.

#### 2.1.2 Pistons

The seals were run in contact with 0.1875 inch (4.76 mm) diameter sapphire and chrome-plated stainless steel pistons. The sapphire piston had a surface finish of 1.0 microinch Ra (1.1 microinches Rq); the chrome-plated stainless steel piston, plated per specification QQC-320B Class 2E, had a surface finish of 2.5 microinches Ra (2.8 microinches Rq).

## 2.2 Apparatus

A sketch of a typical plunger pump is shown in Figure 1.



**FIGURE 1: TYPICAL PLUNGER PUMP WITH UR-13X SERIES BAL™ SEALS**

## 2.3 Procedures

Each seal material was run in contact with the sapphire piston and the chrome-plated stainless steel piston per the operating parameters indicated below. Failure occurred when visible leakage was present.

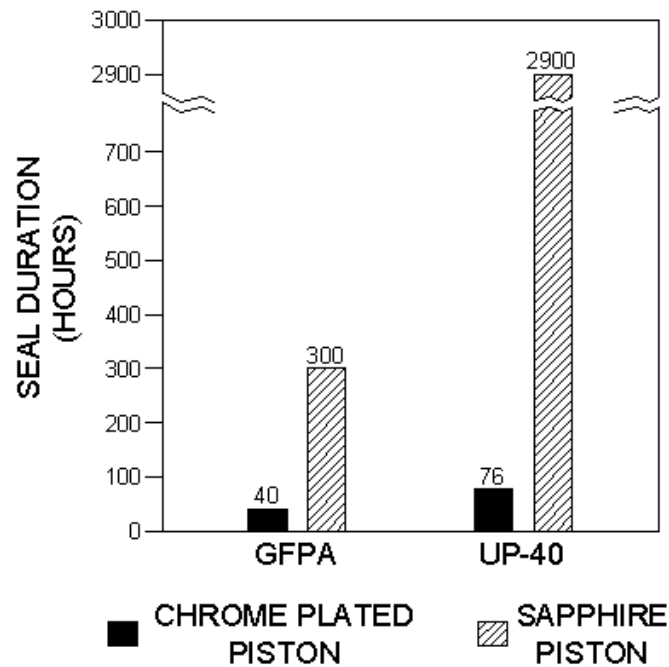
### OPERATING PARAMETERS:

Pressure:	6,000 psi (422 kg/cm <sup>2</sup> )	
Stroke Length:	0.200 inches (5.08 mm)	
Speed:	4 feet per minute (0.02 m/s)	
Medium:	Distilled water	
Flow Rate:	9.99 ml/min	
BAL Seals:	UR-134-106-MB seals made from GFPA and UP-40	
Pistons:	Sapphire Chrome-plated stainless steel	
Base Material:	Aluminum Oxide 316 SS	
Surface Finish:	1.0 μin Ra (1.1 μin Rq) 2.5 μin Ra (2.8 μin Rq)	
Diameter:	0.1875 inches (4.76 mm)	0.1875 inches (4.76 mm)

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### 3.0 RESULTS

Chart 1 shows that the type of piston used in a plunger pump has a significant effect on the BAL Seal life.



**CHART 1: SEAL LIFE COMPARISON BETWEEN A CHROME-PLATED STAINLESS STEEL PISTON AND A SAPPHIRE PISTON USING BAL SEAL GFPA AND UP-40 SEALS. (213-5-1)**

Seal life with a sapphire piston is approximately ten times greater than that of a chrome-plated stainless steel piston. The following parameters affect seal life.

#### 3.1 Piston surface finish

In general, smoother piston surfaces result in lower BAL Seal wear rates.

#### 3.2 Piston surface structure

The sapphire piston surface structure is nodular, while the hard chrome-plated piston surface structure is jagged. A nodular structure reduces abrasion of the BAL Seal and results in substantially less wear.

### **3.3 Piston hardness**

A sapphire piston has an approximate Rc 78 hardness while a hard chrome-plated 316 stainless steel piston has an approximate Rc 65 hardness. In general, there is less adhesion between a hard piston and a BAL Seal than between a soft piston and a BAL Seal. Reduced adhesion produces lower friction, which results in lower seal wear rates.

### **4.0 CONCLUSIONS**

Results indicate that seal life is longer with a sapphire piston than with a hard chrome-plated stainless steel piston because of better surface finish, nodular surface structure and greater hardness of the sapphire pistons.

### **5.0 REFERENCES:**

Bal Seal Engineering Reports (100-32); (54-12); and (213-5-1).