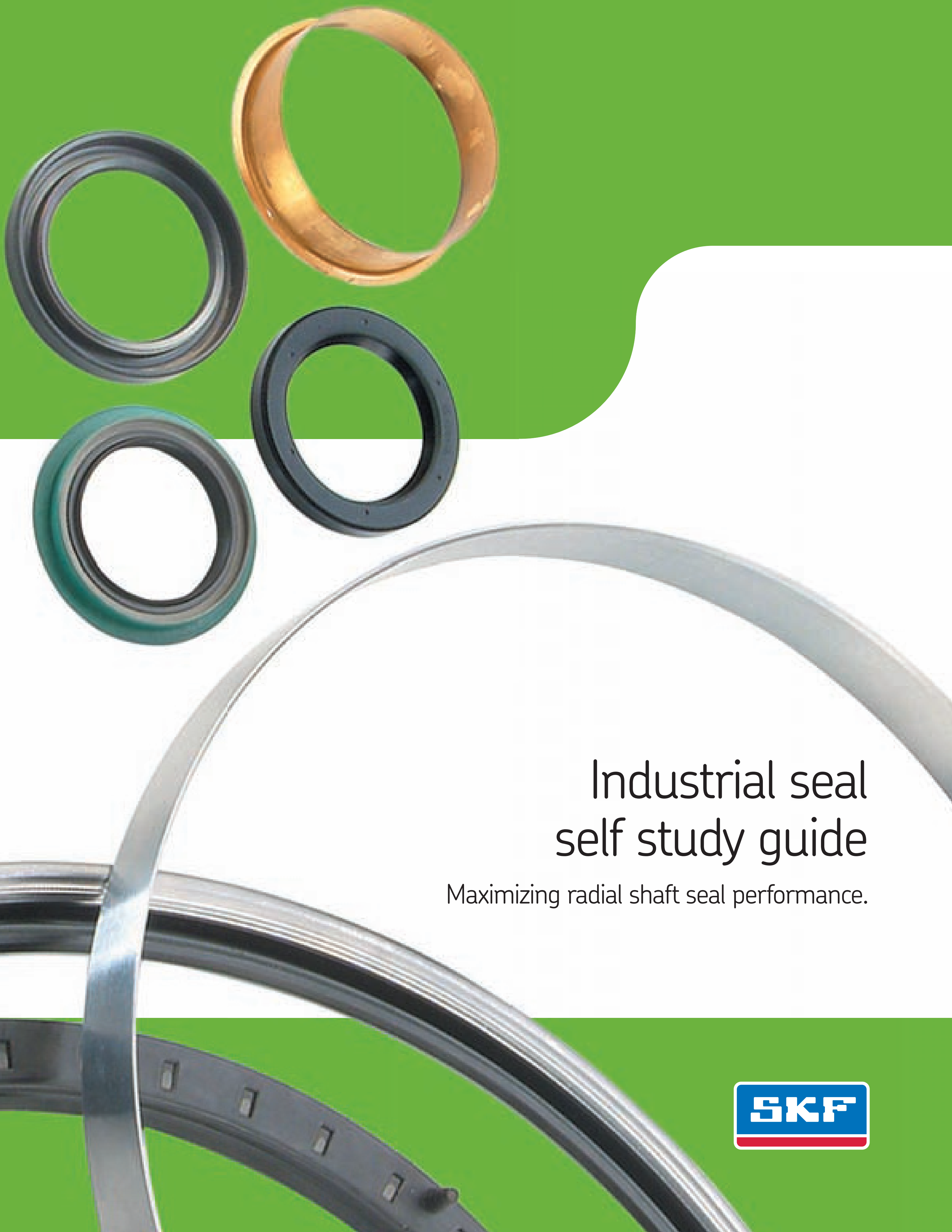


Industrial seal self study guide

Maximizing radial shaft seal performance.

SKF

TABLE OF CONTENTS

CHAPTER 1—INTRODUCTION

This book, produced for use by distributors and end-users, should prove of practical value to engineers, industrial designers, maintenance superintendents and anyone who can benefit from a thorough understanding of seals.

It will explain:

- What types of seals are available
- How to select the best seal for any given application
- How to improve performance with proper installation
- How to repair seal-worn shaft surfaces
- How to spot and correct seal problems economically

How to Use this Study Guide

This self-study guide is designed to increase performance productivity. Each chapter consists of a logical organization of material, technical diagrams and a short quiz to help you retain what you study.

Carefully read the text portion of each chapter. Make notes or underline if you wish; this can help you remember what you've read.

This material is designed for the individual's own learning pace. At the end of the program, you will have learned the same information and should retain it as well as any other "student."

The chapter quizzes are an important phase of self-study learning since they are intended to reinforce the material covered. The quiz questions are straightforward multiple choice and true–false. There are no "trick questions." Your answers can easily be checked by referring to the material presented in the chapter.

Complete each review in order before going on to the next chapter. If you are not sure of an answer to a question, check back in the chapter and review that portion again.

If you follow this procedure through all nine chapters, you should gain a thorough understanding of shaft seals.

You will be able to test your knowledge through an overall "Final Review" at the end of the book. This is a final check for the reader. A "Certificate of Merit" to those who successfully pass the final review with a minimum score of 85% will be issued. Instructions for obtaining a certificate are at the end of this book.

Brief History of the Shaft Seal

SKF Sealing Solutions invented and patented the first integrated, self-contained shaft seal in 1928 (fig. 1a). It was designed to hold grease in automobile wheel hubs and help lubricate the wheel bearing.

SKF invented the shaft seal in 1928 (fig. 1a).

In the mid 1930's, SKF pioneered the development of custom formulating, compounding and molding of elastomers (synthetic rubber) to develop higher performance materials. This led to other innovations in manufacturing processes, new sealing techniques to handle more demanding automotive and industrial applications and the compounding and molding of various elastomer seals to improve consistency and quality.

Today, SKF is the world's leading supplier of fluid sealing devices for the truck, automotive, farm equipment, aircraft, heavy machinery and machine tool industries. SKF also supplies seals for aerospace missiles, earthmoving equipment, appliances, and a wide variety of pumps, hydraulic systems, motors and sub-assemblies.

A company-wide commitment to quality earned SKF Sealing Solutions significant certifications including TS16949 in December 2002 and ISO 9001:2000 in May 1999.

SKF can supply more than 200 types of seals, over 3,000 stock sizes, and over 10,000 cataloged variations. That includes seals in both inch and metric sizes, metal and rubber O.D.'s in both bonded and assembled designs, with single or double lip elements and with or without springs or inner cases (fig. 1b).

Over 2□□ types of seals are now available from SKF (fig. 1b).

SKF sealing products fit shaft diameters from . 110″ to over 180″. They fit metric shaft diameters from 3mm to over 4572mm. All are fashioned from an ever-growing spectrum of sealing elements and materials including LongLife™ fluoroelastomer lip materials.* That, plus ongoing development of new materials and processes, will enable SKF to meet tomorrow's expectations.

*LongLife is a registered trademark of SKF

INTRODUCTION (cont.)

The Total Bearing and Seal Service Concept

When bearings fail, they can bring equipment to an unscheduled halt. Every hour of downtime due to premature bearing failure can result in costly lost production, especially in capital intensive manufacturing.

The majority of bearings outlive the machinery or equipment in which they are installed. Of the bearings that do fail, only 1/3 fail due to normal fatigue. Over half of bearing failures result from lubrication or contamination problems—both of which can be related to the sealing arrangement. Seals are vital to all bearing applications and are a critical component in an integrated systems approach to Trouble-Free Operation.

Product Quality

The SKF goal is to provide every bearing user with long, trouble-free operation. Our substantial investment in research and development has resulted in the production of bearings and seals of the highest quality.

However, quality alone cannot guarantee trouble-free operation. Other factors affect the life span of every bearing, including:

Operating Environment

Machinery must be kept in peak operating condition. The bearings should be properly aligned and protected from extreme temperatures and properly sealed from moisture and contaminants. The seals must also retain the lubricant to assure a proper oil film.

Proper Installation

Knowledge of the proper installation techniques and tools is required to ensure that the bearings and seals are not damaged.

Proper Maintenance

Following lubrication and maintenance schedules and monitoring bearing operating conditions are also important in maximizing bearing life.

Trouble-Free Operation

SKF is committed to the proper servicing and maintenance of the bearing/sealing arrangement. The Trouble-Free Operation Concept minimizes the risk of bearing downtime and ensures that your bearings achieve their full potential. A full line of products and services is available from SKF to make installation and maintenance easy to perform.

The Trouble-Free Operation Concept meets customer demands for long bearing life and cost-effective operation.

Chapter 2—Basic Seal Types

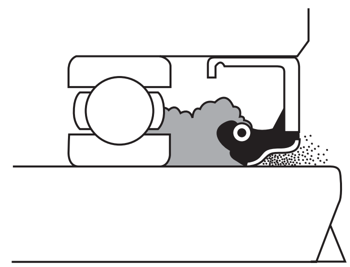
Seal Functions

Whenever a shaft rotates, it needs a bearing arrangement for smooth, effective operation. Wherever there's a bearing, you'll find a seal helping it to reach its maximum service life and reliability. In simplest terms a shaft seal is a barrier.

This barrier has four functions:

- Retain lubricants and/or liquids
- Exclude dirt/contaminants
- Separate fluids
- Confine pressure

When a seal performs these functions properly, it protects the bearing from harmful contaminants while retaining a clean lubricant supply, resulting in lengthened bearing service life and reliability. The bearings do their job better, cleanliness of production and process materials is maintained, lubricant is saved and machinery downtime is reduced. An integrated bearing/seal system approach is the best way to achieve trouble-free operation (fig. 2a).



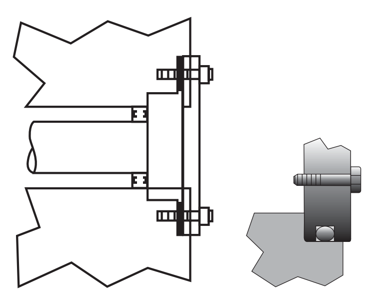
Sealing takes place as lube is retained and outside contaminants are excluded (fig. 2a).

Seals handle a broad range of media, from light oil to heavy grease to hot turbine gases. Electric motors and gear reduction units are some of the more common applications, however there are extremes requiring very special solutions.

For example, seals protect the high speed turbine pump in a rocket that accelerates from 0 to 12,000 rpm in one-fourth of a second. Other types of seals protect the drive unit in a track type earth mover, operating at only 15 to 30 rpm.

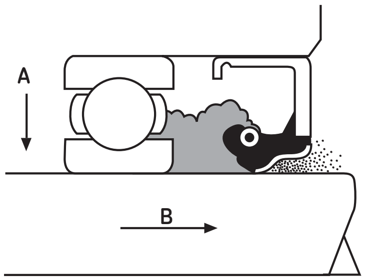
Static Seals

The function of static seals is to create barriers between relatively non-moving surfaces. Typical "static" applications of seals are valve-cover gaskets, cylinder covers, packings of many kinds, and o-rings used in stationary situations. The gasket lining a refrigerator door used to seal the inside chilled air from the outside ambient temperature is a classic static seal application. "Static" simply means that no relative motion takes place in the performance of the sealing function. The sealing devices for such applications are often tailored from o-rings. Typical sectional views of static seal applications are shown in figure 2b.



Sectional views of typical static or non-moving seal applications (fig. 2b).

BASIC SEAL TYPES (cont.)

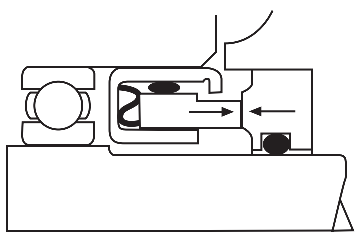


As a shaft rotates in a stationary housing, a CRW1 dynamic radial seal both retains lubricant and excludes contaminants (fig. 2c).

Dynamic “Radial” Seals

A dynamic radial seal creates a barrier or interface between surfaces in relative motion. For radial lip type seals, the interface is where the seal touches the shaft. Sealing is accomplished by two surfaces making contact radially, one usually stationary while the other rotates.

An example of a radial seal is shown in figure 2c. As the shaft rotates in a stationary housing, a CRW1 seal both retains lubricant and excludes contaminants. Typical radial seal applications include gearboxes, drives, motors, pumps and speed reducers.



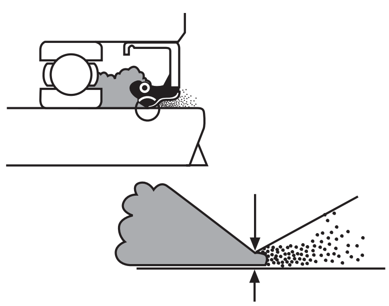
Axial mechanical seals create an interface along the shaft plane between matched components. Usually, one contact face is stationary while the other rotates with the shaft (fig. 2d).

Axial Mechanical Seals

Axial mechanical seals are face type seals which create an axial seal interface between matched, radially mounted components. In operation, one contact face is usually stationary in the housing while the other moves with the shaft. Sealing pressure is applied in the axial direction through a spring mechanism. The spring force keeps the surfaces together.

Axial mechanical seals are generally used where pressure and/or surface speeds exceed the capabilities of radial shaft seals. Typical applications are water pumps and most types of pumps used in chemical processing plants or refineries. Figure 2d is a view of such an installation.

Other types of axial seals are “non-mechanical” ones, such as V-Rings.



At the “interface” point, a thin film of lubricant separates sealing surfaces (fig. 2e).

Seal Interface

“Interface” is the point of contact between sealing surfaces (fig. 2e). But they do not really “contact” at that point, they are separated by a film of lubricant as thin as 0.00001 in.—a hundred thousandths of an inch. In metrics, that is 0.25 microns.

The lubricant film prevents rapid wear of the seal lip and/or the shaft surface. But interface tolerances must be precise to keep the lubricant from leaking. Uncontrolled conditions of run-out must be prevented. Any misalignment or eccentricity of interfacing surfaces which exceed acceptable tolerances must be corrected.

Factors Affecting Seal Selection

Every seal application has a unique set of characteristics that must be analyzed in order to specify the exact style and type of seal (fig. 2f).

Selecting the right seal depends on the basic parameters of the application, including:

- Shaft speed
- Fluid compatibility
- Primary seal function (retention or exclusion)
- Operating pressure
- Maximum temperature

How to Measure Speed

Surface speed at the point of contact between the seal and the shaft (fpm: feet per minute, or mpm: meters per minute) is generally a better indicator of seal performance than revolutions per minute (rpm).

To convert rpm to fpm, use the following formula or refer to the *SKF Handbook of Seals.*

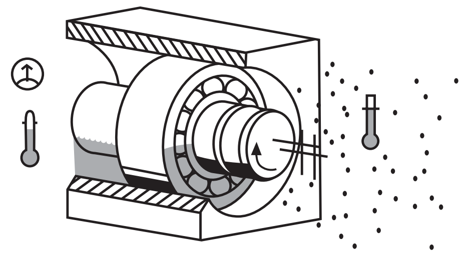
.262 x rpm x shaft diameter = fpm (feet per minute)

To convert rpm to mpm, use the following formula or refer to the *SKF Handbook of Seals.*

3.142 x .001 x rpm x shaft dia. (mm) = mpm (meters per minute)

or

3.142 x .001 x rpm x shaft dia. (mm) / 60 = ms (meters per second)



Factors such as shaft speed, operating pressure, internal and external temperature, all affect proper seal selection (fig. 2f).

Pressure

The more pressure applied to a seal, the greater the friction and heat. That means faster wear and shorter seal life. Most SKF bonded oil seals handle pressure up to 10 psi (.07 MPa), at speeds from 0 to 1000 fpm (5.08 m/s). For complete pressure ratings, consult the *SKF Handbook of Seals.*

Temperature/Fluid Compatibility

Another consideration affecting seal selection is temperature and fluid compatibility. Handbook listings are given in “continuous” ratings—the relatively constant ambient temperature next to the seal, or the temperature of the lubricant it retains.

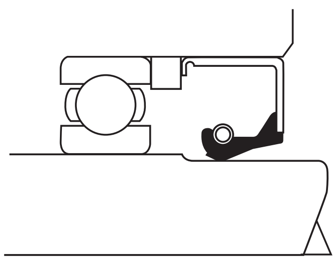
When operating conditions are under 0˚F or above 200˚F (-17 -93˚C), , the range recommended in the Handbook must be considered in selecting the type of sealing material.

BASIC SEAL TYPES (cont.)

As was earlier stated, SKF's standard nitrite compound provides good service in most sealing applications from -40˚F to 250˚F (-40˚C to 121˚C). However, silicone, polyacrylate, Longlife or PTFE may be more suitable for and should be considered for temperatures outside this range.

For more information on the temperature compatibility and abrasion resistance of various seal lip materials, turn to Chapter 4.

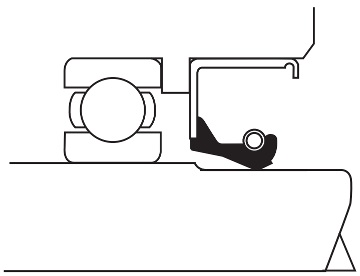
Most applications for shaft seals involve the need to retain or separate lubricants from some form of external contaminant or abrasion. But many times it must be determined which is more important, retention of lubricant or exclusion of foreign matter.



When a seal's basic function is to retain, face the seal lip toward lubricant (fig. 2g).

Retention

When the seal's basic function is to retain lubrication, pressure, or both, the lip of the seal (generally the spring side) must face toward the lubricant or the pressure being retained and generally be spring assisted (fig. 2g).

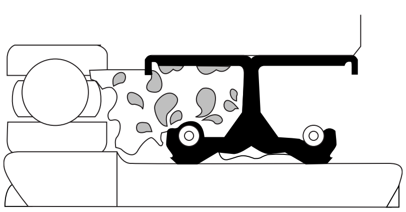


When the seal's basic function is to exclude, face the seal lip toward contaminants (fig. 2h).

Exclusion

Most bearings fail from the entrance of foreign material and from the loss or degradation of lubricant. Dirt, abrasives, water and other liquids can interfere with the film of lubricant required to support the moving parts of a bearing in a sealed system. Reliable excluders generally include V-Rings and non-spring loaded seals.

Therefore, it's vitally important for the seal to keep those materials from entering the bearing cavity. When the seal's basic function is to exclude, the lip of the seal should face toward the contaminants instead of toward the bearing (fig. 2h). However in this case, only grease lubrication should be used since oil loss could be excessive.



For retention/exclusion applications, a combination of seals in a unitized assembly can be the best solution (fig. 2i).

Retention/Exclusion

Some extreme applications require the seal to perform both the retention and exclusion functions at the same time. For example, the seal may need to confine a lubricant while excluding dust or cleaning solutions. In this case, a special type of protection is necessary either a combination of seals back-to-back or dual sealing elements within one unitized assembly (fig. 2i).

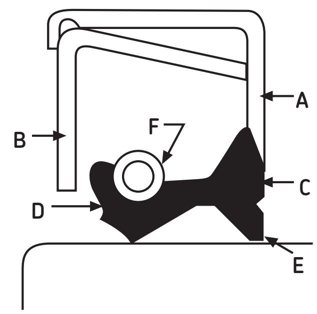
Summary

There are many factors involved in selecting seals. To avoid confusion, the *SKF Handbook of Seals* contains a “Recommended Operating Conditions” selection chart to assure a correct seal choice. All of the selection factors are grouped together along with recommendations about the type of seal to use in almost every application.

Seal Components

There are five basic seal components (fig. 2j), each performing a particular function. They include:

- Outer Shell (Case). The outer, cup-shaped, rigid structure (metal or rubber over a metal case) of the lip seal assembly. Primarily used for holding the seal in place. The lip is generally bonded to the outer shell. (A)
- Inner Shell (Case). A rigid cup-shaped component of a seal assembly, which is placed inside the outer seal case. Reinforces the outer shell. Can also function as a shield or spring retainer device. (B)
- Primary Lip (Head Section). The flexible elastomeric component of a lip seal which contacts the rotating surface. Normally points toward the most important sealing job, either retaining or excluding. (C, D)
- Secondary Lip (Auxiliary Lip). A short, non-spring loaded lip which is located at the outside seal face of a radial lip seal. Used to exclude contaminants. Used only in dual lip designs. (E)
- Garter Spring. A coiled wire spring with its ends connected. It provides a controlled radial load for the lip/shaft interface. (F)



Each of the seal’s basic components contribute to its function (fig. 2j).

CHAPTER 2 REVIEW

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself) slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1. A shaft seal is a barrier designed to retain lubricants and ________________.
   - ❑ a. confine pressure
   - ❑ b. exclude dirt
   - ❑ c. separate fluids
   - ❑ d. all of the above

1. D

2 The ________________ of a seal is a cup-shaped rigid structure that protects the head of the sealing element.
   - ❑ a. primary lip
   - ❑ b. outer shell (case)
   - ❑ c. inner shell (case)
   - ❑ d. garter spring

2. B

3. Typical radial seal applications include ________________.
   - ❑ a. gearboxes
   - ❑ b. motors
   - ❑ c. pumps
   - ❑ d. all of the above

3. D

4. Selecting the right seal depends on application parameters, including ________________.
   - ❑ a. shaft speed
   - ❑ b. fluid compatibility
   - ❑ c. operating pressure
   - ❑ d. all of the above

4. D

5. When the seal's basic function is to retain, the lip of the seal should face away from the lubricant or pressure being retained.
   ❑ True ❑ False

5. F

6. More bearings fail from the entrance of foreign material than from loss of lubricant.
   ❑ True ❑ False

6. T

7. The function of static seals is to create barriers between relatively non-moving surfaces.
❑ True ❑ False

7. T

8. Axial mechanical seals are generally used where pressure and/or surface speeds are more than radial shaft seals can handle.
❑ True ❑ False

8. T

9. Seal "interfaces" is the point of contact between sealing surfaces, but do not actually contact because they are separated by a film of lubricant.
❑ True ❑ False

9. T

10. Revolutions per minute (rpm) is generally a better indication of seal performance than feet per minute (fpm).
❑ True ❑ False

10. F

11. The more pressure you apply to a seal, the greater the frictional heat and faster the shaft wear.
❑ True ❑ False

11. T

12. Sealing lips of SKF's standard nitrile compound are correct for all applications.
❑ True ❑ False

12. F

13. Reliable exclusion seals include V-Rings and non-spring-loaded seals.
❑ True ❑ False

13. T

14. Retention/exclusion applications, sometimes require a combination of seals in one assembly.
❑ True ❑ False

14. T

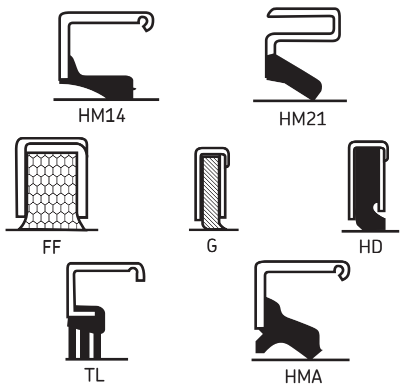
15. The sealing lip is generally bonded to the seal's inner shell.
❑ True ❑ False

15. F

CHAPTER 3—
SEAL DESIGN GROUPS

Basic Design Groups

Seals with similar functional abilities are categorized into design groups. Note that design codes are unique to each manufacturer, and the ones listed below are codes used by SKF.



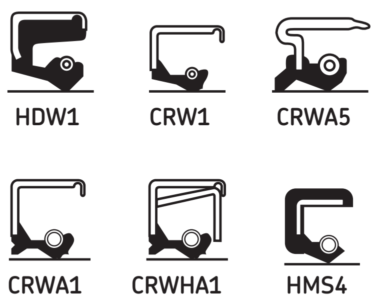
SKF's non-spring loaded designs (fig. 3a).

Non-Spring Loaded Seals

These seal designs are typically used for grease retention or dirt exclusion in slower shaft speed applications.

The seals illustrated in fig. 3a, HM14 and HM21, are SKF's standard designs. Agricultural equipment and quarry conveyor systems are typical uses. They can also be used as light-duty rod wipers. Other designs include FF, G, HD, HMA and TL. The heavy-duty TL seal is designed for severe conditions such as disc harrows. For maximum dirt exclusion, they should be installed with the lip facing outward.

Non-spring loaded seals are not intended for lube oil retention. Non-spring loaded seals, especially the HM design, are generally less expensive than spring-loaded versions, and generally cost much less than the assembled seals they replace. They also provide a good level of performance when sealing grease.



SKF's standard spring-loaded designs are typically used to retain oil and/or exclude dirt in higher shaft speed applications (fig. 3b).

Spring-Loaded Seals

These seal designs are typically used to retain oil and/or exclude dirt in higher shaft speed applications (fig. 3b). SKF's standard designs include: single lip, dual-lips, and single and double shell designs. The dual-lip design features a non-interference auxiliary lip for added exclusion protection without the heat build-up associated by traditional dual-lip designs. Typical applications include gearboxes, speed reducers, transmissions, motors and drive systems. CRW5 and CRWA5 types are designed for high pressure applications, up to 90 psi (.62 MPa). For maximum dirt exclusion, they should be installed with the lip facing outward. While this works well with grease, be aware of potentially high levels of oil leakage. The large diameter seal HDW1 type is designed for severe conditions.

Spring-loaded seals provide longer, more consistent service life in radial applications than non-spring loaded designs, and better sealability over a wide range of conditions. They also perform exceptionally well in applications where there is shaft run-out and shaft-to-bore misalignment.

Case Construction

Seal cases are constructed with either metal or rubber outer diameters. The reasons for these different constructions—their features and benefits—are as follows:

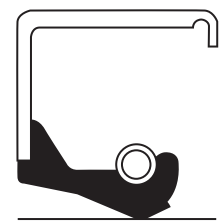
Metal O.D.

Metal O.D. seals feature a metal outer shell or case (fig. 3c). They are also available with an inner metal shell. The double metal shell provides torsional stiffness and assists in installation, especially where the assembly of the shaft is against the lip, or for "hammer" assembly of larger seals.

Dual-lip versions of metal O.D. seals are available in many selected sizes.

Applications for metal O.D. seals include engines, drive axles, transmissions, pumps, electric motors and speed reducers. Overall, the metal-clad CRW seals are recommended over the more basic HMS seals for most applications.

Metal O.D. seals perform well as economical, general-purpose designs and provide an exceptionally wide application range.



CRW1

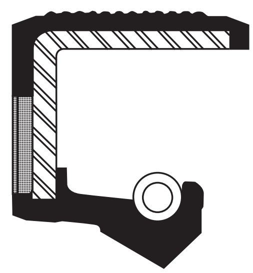
CRW1 features a metal outer shell or case (fig. 3c).

Rubber O.D.

Rubber O.D. seals feature rubber molded around a steel stamping (fig. 3d).

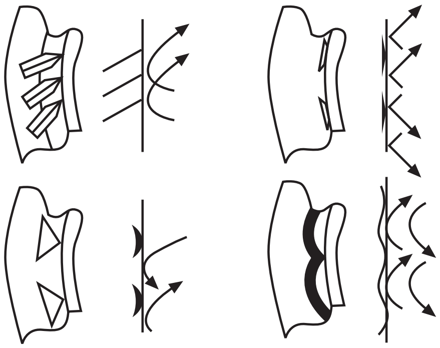
They are generally required for split housings and light alloys that are subject to thermal expansion or gaseous media.

Rubber O.D. seals can withstand reasonable abuse during installation, and can be inserted in imperfect or rough bores. Their construction provides limited additional rust resistance. Dual lip versions are available for many size combinations.



HMS5 features rubber molded around a steel stamping (fig 3d).

SEAL DESIGN GROUPS (cont.)



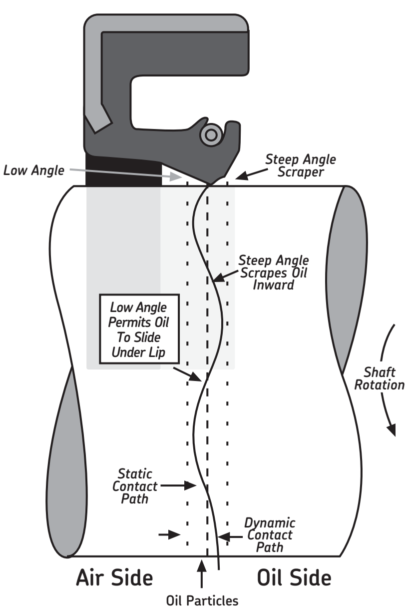
Standard hydrodynamic seal designs feature helical ribs, parabolic ribs or triangular pads (fig. 3e).

Hydrodynamic Seals

One of the most significant developments in sealing technology occurred in the 1950's with the introduction of hydrodynamic seals. Hydrodynamic seals have molded projections added to the seal lip which enables the seal to pump oil into the oil pump, improving lubricant retention.

There are a variety of molded projections used in hydrodynamic seals. Standard designs have a series of helical ribs, parabolic triangular pads molded to the lip (fig. 3e). However, these designs are not without their problems. As dirt builds up against the seal lip, the lip wears, eliminating the hydrodynamic projections. They can also become clogged with carbon or dirt. Some hydrodynamic designs are uni-directional, and can actually pump lubricant out if installed incorrectly.

SKF developed a new type of hydrodynamic seal in the early 1970's. Called "Waveseal", this design features a sealing lip molded with a sinewave pattern. This traces a wavy path over the surface of the rotating shaft.



The SKF Waveseal touches the shaft in wide 'sine' or wave pattern. Due to this unique design, contact pressure and grooving are minimized, heat generation and friction are reduced. Lubricant is pumped back to the bearing while dirt is pushed away from the lip/shaft interface (fig. 3f).

Waveseal

In technical terms, the SKF Waveseal is a smooth lip, bi-rotational hydrodynamic, molded radial lip seal. More simply, it is a shaft seal that pumps lubricant back into the sump while sealing out contaminants no matter which way the shaft is turning.

The Waveseal by SKF

- Offers longer, more dependable performance and service life than conventional trimmed lip seals and other hydrodynamic designs.
- Has almost universal applications
- Is the first standard line of shaft seals incorporating hydrodynamics

How Waveseals Work

The Waveseal by SKF makes a sweeping contact with the shaft. Its unique, specially molded lip rides the shaft forming a sinusoidal or wave pattern around the shaft surface (fig. 3f).

This unique pattern generates less heat, reduces shaft wear and provides greater lip lubrication than standard lip designs. Its pumping power is maintained at the same level throughout its service life.

Advantages

+ Traces wavy path over the surface of the shaft.

+ Generates 25-35% less heat at the contact point. This reduces early seal failure from heat checking, blistering, hardening or lubricant breakdown.

+ Generates 20% less friction torque or drag.

+ Pumps liquid back into the sump while ingesting substantially fewer contaminants.

+ Bi-rotational hydrodynamic radial lip design outlasts any other seal of its kind.

+ Performs regardless of lip wear.

Waveseal Designs

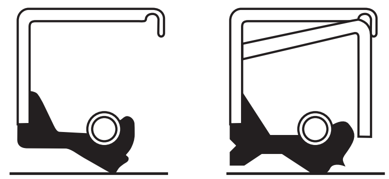
Waveseal is SKF's standard seal design, with over 3,500 part numbers to fit inch shaft diameters from 0.250" to 12.250"; metric shafts from 12mm to 280mm.

CRW1, CRWH1

Single-lip, spring-loaded Waveseals (fig. 3g). CRW1 is designed without an inner case. It is recommended for most general purpose applications engines, drive axles, transmissions, pumps, electric motors and speed reducers. CRWH1 has an inner case for greater strength and sealing lip protection. It is recommended where shaft assembly is against the lip.

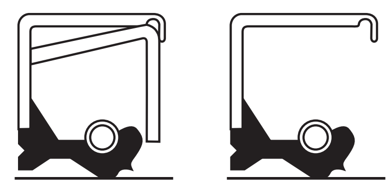
CRWA1, CRWHA1

Dual-lip, single element Waveseals feature a no-interference auxiliary lip that excludes dirt (fig. 3h). CRWA1, designed without an inner case, provides medium-duty dirt exclusion. CRWHA1, designed with an inner case, also provides medium dirt exclusion, but for heavier duty applications. (They also are used when the sealing lip requires protection during shaft assembly or operation.)



CRW1 **CRWH1**

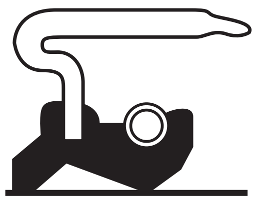
CRW1 is designed without an inner case. CRWH1 has an inner case for greater strength and sealing lip protection (fig. 3g).



CRWHA1 **CRWA1**

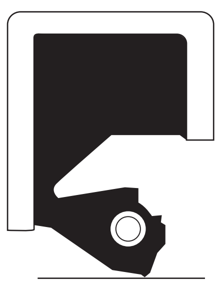
CRWHA1, with an inner case, excludes medium dirt in heavier duty applications. CRWA1 Waveseal has no inner case, provides medium-duty dirt exclusion (fig. 3h).

SEAL DESIGN GROUPS (cont.)



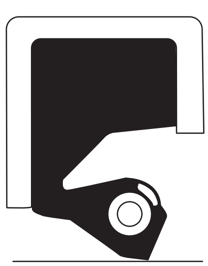
CRWA5

CRWA5, with a dual lip, is designed for applications in pressurized seal cavities (fig. 3i).



HDS1

HDS1 seal's Spring-Lock keeps the spring in position during seal handling, installation, and removal (fig. 3j).



HDS2

HDS2 has a Spring-Lock encased in a flexible Spring-Kover covering (fig. 3k).

CRWA5, CRW5

Waveseals designed without an inner case, CRWA5 has a dual lip (fig. 3i) and CRW5 has a single lip sealing element. Both are designed specifically for applications in pressurized seal cavities, up to 90 psi (.62 MPa).

Large Diameter Metal Clad Seals

Large diameter seals fit shafts 8" (203.20 mm) in diameter and larger. They come in two basic designs HDS metal clad and HS non-metal clad (all rubber) seals.

Metal Clad Seals (Type HDS)

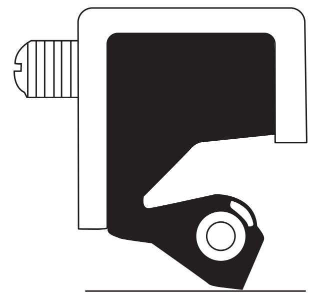
Encased in a heavy-duty steel shell, metal clad seals (type HDS) are specifically designed to withstand the conditions encountered in heavy-duty applications. These conditions range from slow speed, abrasive conditions of a scale breaker to the high-speed operation of finishing stands. They work exceptionally well in rolling mills, vertical edgers, logging operations and drag line equipment.

HDS type seals are available in three styles HDS1, HDS3 and the preferred style, HDS2. HDS1 is the basic seal design (Fig. 3j). It has a single sealing element that features Spring-Lock. The Spring-Lock 270° wrap feature keeps the spring in position during handling and seal installation as well as during seal removal. Spring-Lock is standard on all three types of metal clad seals.

HDS2 is SKF's preferred large diameter seal design. It has a single sealing element and is available with nitrile, Duralip or SKF LongLife fluoroelastomer lip material. Optional fixed width spacer lugs permit tandem seal installation, and provide a lubrication gap. HDS2 also features Spring-Lock encased with a Spring-Kover (fig. 3k). Spring-Kover is a flexible, resin covering that totally encloses the garter spring. It is used in sealing applications where dirt or other contaminants may damage the spring, or where the spring could be dislodged. The Spring-Kover protects the spring without affecting its operation.

HDS3's standard features include adjustable lugs, a Duralip sealing element for reduced wear and extended service life and a spark-free inner diameter (I.D.). Other features include Spring-Lock and Spring-Kover for maximum spring protection (fig. 3l). Spark free I.D. reduces the chance the seal shell and shaft will come into contact, due to extreme misalignment or bearing wear. Adjustable lugs allow for installing two seals in tandem.

HDS seals are available for over 4,600 inch and metric sizes, and new sizes within catalog guidelines can be created without tool changes or long lead times.



HDS3

HDS3 features a spark-free I.D. which reduces contact between the seal shell and shaft surface. (fig. 3l).

Size

Metal clad seals fit shafts 8" (203.20 mm) to 62" (1574.80 mm) in diameter.

Pressure

Pressure tolerance of 10-15 psi (.07 - .10MPa).

Speed

5,000 fpm (25.40 m/s) and greater are possible. The HDS type seal can handle these speeds in most applications.

Temperature

Handles temperatures ranging from -40˚F to 250˚F (-40˚C to 121˚C) or greater, depending on lip material.

Sealing Element Materials

Nitrile is the standard elastomer base. Duralip, Duratemp and SKF LongLife fluoroelastomer are also available.

More technical and size information on metal clad large diameter seals can be found in the *SKF Handbook of Seals.*

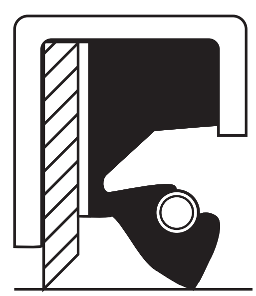
Sealing Combinations

Two metal clad seals, back-to-back or in tandem, provide extra-duty sealing, cost less and install easier than a double seal. However, in applications where the bore is not wide enough to hold two seals, two elements may be combined in one seal assembly.

Dual metal clad types are described below.

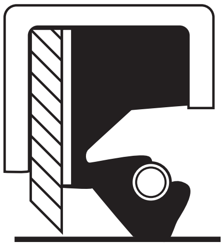
HDSA

HDSA has a single, spring-loaded sealing lip combined with a non-spring loaded auxiliary lip for maximum exclusion (fig. 3m). There are two designs available. HDSA1 has Spring-Lock; HDSA2 has Spring-Lock and Spring-Kover. In both designs, the auxiliary lip's chamfer faces the spring-loaded lip, allowing easier shaft insertion from the direction of the springloaded lip.



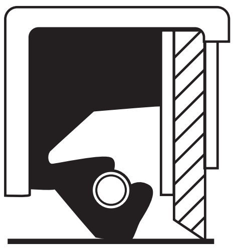
HDSA

HDSA seal is designed with or without a Spring-Kover (fig. 3m).



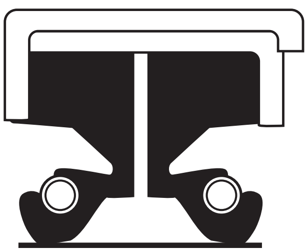
HDSB

HDSB seal has both a spring-loaded and non-spring loaded lip (fig. 3n).



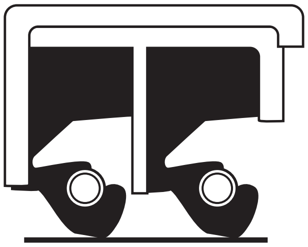
HDSC

For maximum exclusion of contaminants, HDCS seal has an auxiliary lip on the spring side of the spring-loaded lip (fig. 3o).



HDSD

For separating two fluids, HDSD has opposing sealing elements in a single shell (fig. 3p)



HDSE

Where back-up sealing action is desired, HDSE's two sealing elements serve as two seals in one (fig. 3q).

SEAL DESIGN GROUPS (cont.)

HDSB

HDSB is similar to HDSA in that it also has a non-spring loaded auxiliary lip combined with a spring-loaded lip (fig. 3n). The chamfer on the auxiliary lip of the HDSB faces away from the spring-loaded lip, permitting easier shaft insertion from the back. This eliminates the need to reverse the direction of the auxiliary lip when the shaft enters the seal. However, HDSB may be less effective in contaminant exclusion due to the direction of the auxiliary sealing element.

Two designs are available. HDSB1 and HDSB2 both have Spring-Lock, while HDSB2 also has Spring-Kover.

HDSC

HDSC (fig. 3o) is similar to HDSA, but with one exception. The auxiliary lip is placed on the spring side of the spring-loaded lip and faces the same direction, providing maximum exclusion of foreign materials. This style is recommended when excluding foreign materials is more important than retaining lubricants. When HDSC is installed, both sealing elements point toward the material being excluded. HDSC should not be used in oil lubricated systems.

HDSD

Type HDSD has two opposing sealing elements in a single shell (fig. 3p). That makes this design ideal for separating two fluids in applications where two individual seals are impractical. Both sealing lips in HDSD1 have Spring-Lock, while each sealing lip in HDSD2 has Spring-Lock and Spring-Kover. HDSD can also be used to retain and exclude.

There must be ample lubrication between the two sealing elements. Pack the cavity between the lips with grease, or optional drill lube holes from the O.D. to the I.D. for lubrication for sealing elements can be provided by SKF.

HDSE

HDSE has two sealing elements with both lips facing in the same direction (fig. 3q). This design is recommended in applications where a back-up seal is desired for retention or exclusion, but there is no room for two seals. HDSE1 features Spring-Lock on both lips, while HDSE2 features both Spring-Lock and Spring-Kover. If installed to exclude, grease lubrication should be used for the bearings.

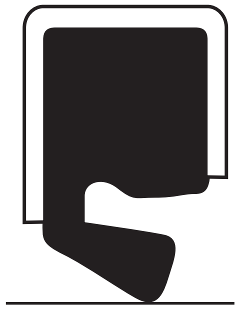
Lubricating the back-up lip is very important, since it could easily run dry. The primary lip usually stays well lubricated from the fluid being retained. SKF can provide HDSE with pre-drilled lube holes on the O.D.

EP-2000

The newest member of the HD seal family is the EP-2000 (Extra Performance construction) type HDS7; fig. 3r.

Water and solid contamination ingress is a common cause for bearing failure. SKF has developed the EP-2000 as a grease seal with enhanced exclusion capabilities.

The highly engineered EP-2000 features a computer optimized, springless lip profile designed to retain lubricants and aggressively pump contamination away from the lip. The increased ability of the EP-2000 to exclude contamination makes it an ideal equipment protector in heavily contaminated environments such as the water and scale present in rolling mill applications. With this design, the lip should always face away from the bearings.

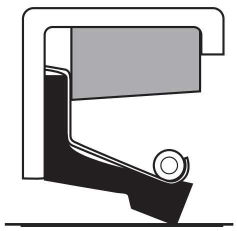


HDS7

The springless lip concept of the EP-2□□□ also reduces radial load. Radial load can be thought of as the 'squeeze' force that the seal exerts on the shaft. High radial load can lead to increased seal wear and elevated underlip temperatures decreasing seal life (fig. 3r).

HDL

The HDL seal (fig. 3s) is a premium metal clad oil seal that is especially designed to operate in severe conditions including high speeds and temperatures, high run-out, and high misalignment. The excellent high-speed performance characteristics of the HDL make it the preferred design in the severe environment encountered in the rolls of papermaking machines.



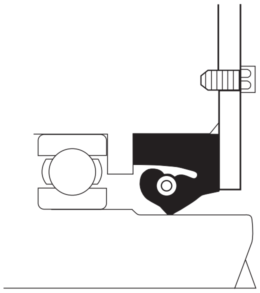
HDL

The HDL features a stainless steel garter spring that is entrapped by individual finger springs, also made of stainless steel, around the entire circumference of the seal. The spring combination allows the seal to compensate for severe conditions in order to maintain high levels of sealing performance, operational life, and equipment reliability (fig. 3s).

Non-Metal Clad Seals (Type HS)

There are two basic types of HS all-rubber seals: solid and split. All-rubber seals are popular and commonly used where space limitation and installation difficulties are major considerations. While metal-clad seals generally provide more positive lubricant retention, all-rubber seals are an excellent compromise where cost would be high to tear down and reassemble the unit for the purpose of replacing the seal. The split type offers a distinct advantage since the equipment generally doesn't need to be completely torn down to replace the seal. Split seals perform best in grease or below-centerline fluid-lubricated applications on horizontal shafts. They are generally not recommended for vertical shafts (except for HS8, covered on page 21).

SEAL DESIGN GROUPS (cont.)



All HS seals require a cover plate for proper fit (fig. 3t).

HS3

The HS3 all-rubber seal has a spring held in an open groove, permitting easy access to the garter spring (fig. 3u).

HS4

The HS4 all-rubber seal's spring is secured by a Spring-Lock (fig. 3v).

HS5

HS5 is the same as HS4, but with a Spring-Kover to provide added protection (fig. 3w).

Cover Plates

All HS type seals, split and solid, require the end-user to fabricate and use a cover plate for proper fit (fig. 3t). The cover plate provides axial compression and supplements radial press-fit to ensure a leakproof seal. Refer to Large Diameter Split Seal Installation section for details.

Solid Designs (HS3, HS4, HS5)

The differences between these three designs lie in the shape of the sealing element and the method of retaining the garter spring.

HS3

HS3 is an all-rubber seal with a single spring-loaded element (fig. 3u). The spring is held in an open groove which permits easy access to the garter spring. This design is recommended for vertical and horizontal shafts (Split version: HS9). Limited availability. All new machine designs, and field replacements, should be made with HS4 or HS5.

HS4

HS4 is an all-rubber seal with a single spring-loaded element (fig. 3v). The Spring-Lock secures the spring during installation regardless of the direction of shaft entry. It is recommended for vertical and horizontal shafts and for use with a cover plate. It is used in steel mills, work rolls and other applications requiring frequent shaft removal and installation. (Split versions: HS6).

HS5

HS5 is identical to HS4, except that it also has a Spring-Kover (fig. 3w). HS5 is recommended in applications where materials could affect the garter spring or when installation can cause the spring to pop out (Split versions: HS7 and HS8). It can be used for vertical shaft assemblies in flooded conditions.

Split Designs (HS6, HS7, HS8, HS9)

Split seals are recommended in applications where downtime is critical and shaft disconnection is impractical. The split seal design offers a distinct advantage over solid seal types. It is placed around the shaft, the spring connected and then the seal is pushed into the seal bore. A cover plate provides axial and radial compression and butts the split ends together.

Split seals perform best in grease applications or on well-lubricated horizontal applications where the oil is below the shaft centerline. Split seals generally have poor pressure sealing capability.

HS6

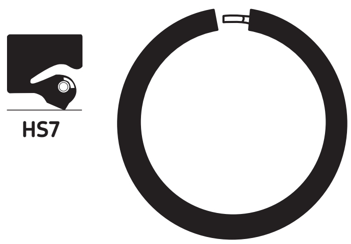
Recommended for general operating requirements, HS6 is an all-rubber split seal with a single spring-loaded element and a Spring-Lock. HS6 has a separate loose spring that can be removed easily so the ends may be connected during installation. A hook-and eye type spring connector is used with HS6 seals for shafts over 18". A threaded type spring connector is used on smaller sized seals. For proper fit, a cover plate is required.

Note: HS7 and HS8 split seals are preferred where separate seal and spring installation is unnecessary.

HS7

The most easily installed split seal design, HS7 is an all-rubber seal with a single spring-loaded element (fig. 3x). It has both Spring-Lock and Spring-Kover. A special guide wire joins the seal together, making it very easy to install (fig. 3x). After installation, the spring is reconnected by simply running the control wire into the center of the spring coil across the split (butt joint). For proper fit, a cover plate is required.

Because this sealing arrangement is not as positive as HS8 (see below), HS7 is recommended for retaining only grease lubricants on horizontal shafts at speeds under 1,500 fpm (7.62 m/s).

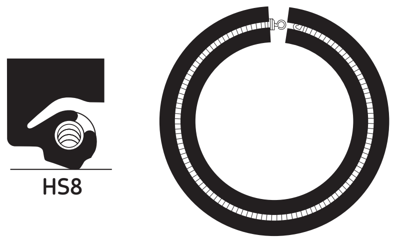


HS7 seal is all rubber with single spring protected by Spring-Lock and Spring-Kover. HS7 seal's guide wire makes installation easy (fig. 3x).

HS8

HS8 is an all-rubber seal with a single spring-loaded element (fig. 3y). It features a positive spring connection (hook-and-eye or threaded) in addition to its Spring-Lock and Spring-Kover. The spring is enclosed except for a small portion on either side of the split. Unlike other HS split seals, HS8 is recommended for vertical shafts.

Since HS8 provides the most positive seal of all split type designs, it is the preferred design in applications for the retention of light lubricants and water exclusion. It also is recommended for sealing light oils and heavy greases as well as in applications where there could be extreme misalignment or run-out. HS8 performs best on horizontal shafts, but may be used on vertical shafts that are not oil flooded at speeds up to 2,000 fpm (10.16 m/s).



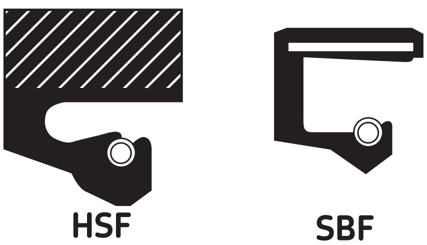
HS8 features a positively connected spring protected by a Spring-Lock and Spring-Kover. It is the most secure and versatile split seal (fig. 3y).

HS9

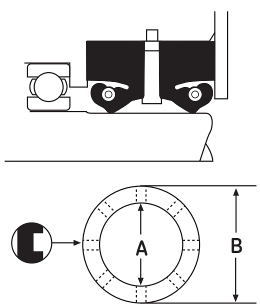
HS9 is identical to the HS3 solid seal except that it is a split design. It is recommended in applications requiring grease retention on horizontal shafts at speeds up to 1,500 fpm (7.62 m/s). HS9 can seal lighter lubricants or work at higher speeds only if misalignment or run out are not excessive. This seal has a narrow cross section and is designed for smaller shaft size, under 9" (228.6mm).

Limited availability. All new machine designs, and field replacements, should be made with HS6 or HS8.

SEAL DESIGN GROUPS (cont.)



All rubber seals do not score the bore after repeated installations and extractions. This prevents damage to the metal that can cause bypass leakage (fig. 3z).



Slotted washer installed between seals provides room for extra lubrication when needed (fig. 3aa).

SBF and HSF

The SKF family of all-rubber seals includes metal inserted (SBF) and fabric reinforced (HSF) products (fig. 3z). The fabric-reinforced series is available as solid round or with an open joint (split). When required by customers, they can be used interchangeably with all rubber HS types and are often found in imported heavy industry machinery. The inserted SBF type is an alternative to solid HS or HSF all rubber seals that eliminates the need for a cover plate. All-rubber seals do not score the bore even after repeated installations and extractions. This prevents damage to the metal that can cause bypass leakage. All rubber-seals accept rougher bore finishes, reducing machining costs. They are especially helpful for split housings. They resist corrosion and will not seize in the bore even years after assembly.

Multiple Split Seat Installation

When split seals are used in multiples, it is necessary to separate the seals and provide extra lubrication between them. For the best results, a slotted washer should be fabricated and installed between the seals (fig. 3aa). SKF does not supply slotted washers.

For best performance, multiple split seals should have staggered butt joints, for example: one joint at 10 o'clock, the other at 2 o'clock.

V-Rings

The V-Ring is an all-rubber seal that mounts directly on the shaft by hand, and is then pushed axially against a counterface, housing, bearing race or similar surface. Usually made of nitrile or flouroelastomers, other compounds may be obtained on special orders.

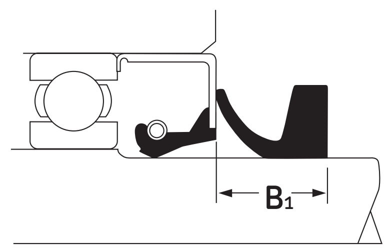
Designed with a long flexible lip, it acts like a mechanical face seal, or a flinger. The V-Ring can be used as the primary seal or as a back-up seal, to retain lubricants or exclude contaminants. The V-Ring, which has very high surface speed capabilities, can run without lubrication. Minimal friction and heat buildup results in extended seal life. V-Rings running over 1600 FPM (8.13 m/s) may require axial support and radial retention at even higher velocities.

Its design is based on three components: The body, a conical self-adjusting lip, and a hinge. The elastic body adheres to the rotating shaft while the actual sealing occurs at the point of contact between the conical lip and counterface. The counterface can be the end of a bearing, washer, suitable steel stamping or even the back of an oil seal case. The V-Ring's flexible hinge causes the sealing lip to apply very light contact pressure against the counterface. Generally, fine shaft or countersurface preparation is not necessary.

Because of its elasticity (the V-Ring stretches up to 2 1/2 times its molded diameter), the V-Ring can be easily mounted without disassembling the shaft—even over flanges, pillow blocks and other assemblies. V-Rings also may be split, rejoined by hot bonding (down to approximately 18.000"(459.20 mm shaft diameter), or cold-bonded and used for difficult installations.

V-Ring Fitted Dimension

The fitted dimension of the V-Ring is known as the B_1 dimension (fig. 3bb). This dimension changes as shaft diameters increase. It is very important when installing a V-Ring. The distance from the back or "heel" of the seal to the counterface (this is where the sealing lip contacts the surface axially) must be strictly adhered to. This dimension is listed as "seal width" in the *SKF Handbook of Seals*, V-Ring size listings section. Other key dimensions are also found in the handbook. There are no requirements for special machining, tight tolerances or stringent finishes to apply the V-Ring into an existing application. In most cases it can be retrofitted with little or no changes to the equipment.



The fitted dimension of the V-Ring is called "B1" dimension (fig. 3bb).

Applications

The V-Ring is suited for direct shaft mounting in sealing applications for:

- Conveyor rollers
- Transport equipment
- Rolling mills
- Agricultural machinery
- Paper mills
- Grinding equipment
- Appliances

Styles

V-Rings are available in five styles. Standard material is nitrile; fluoroelastomer compounds are available in many sizes and special compounds can be quoted. V-Rings for shafts 8.000" (203.20 mm) and over can be cut and rejoined by hot or cold bonding. Smaller nitrile V-Rings can be cold bonded. Note that cold bonding of LongLife materials is not possible at this time.

VR1

VR1 is the most common style V-Ring (fig. 3cc).

VR1

Ideal for conveyor rollers and appliances, VR1 is the most common style (fig. 3cc). It is available in the widest range of sizes from .110" to over 78.74" (3mm to 2000mm) nitrile and fluoroelastomer lip materials are available as standard. Other compounds can be quoted.

SEAL DESIGN GROUPS (cont.)

VR2

VR2 is the original V-ring (fig. 3dd).

VR2

This is the original V-Ring (fig. 3dd). It is designed with a wide body and tapered heel which holds the seal firmly against the shaft and acts as a deflector.

VR2 is available in sizes ranging from .177” to 8.270” (4.50mm to 210mm). It is generally used in contaminated industrial and agricultural applications.

VR3

A narrow axial cross-section makes VR3 ideal for certain applications (fig. 3ee).

VR3

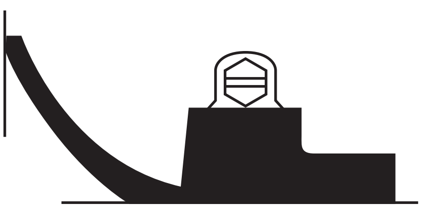
With its very narrow axial cross-section, VR3 is excellent for use in pillow blocks to supplement or replace labyrinth seals or where the fitted width (B_1) is not adequate for a style VR1 (fig. 3ee). VR3 is available with nitrite and fluoroelastomer lip materials, in sizes that fit shafts ranging from 4.13” to 79.724” (110mm to 2000mm).

VR4

VR4 is heavy-duty large diameter V-Ring (fig. 3ff).

VR4

Known as the heavy-duty large diameter V-Ring, VR4 is commonly used in rolling mills as a dirt/water excluder (fig. 3ff). Sizes range from 11.811” to over 78.740” (300mm to over 2000mm) shaft diameter. VR4 is available in nitrile and flouroelastomer.

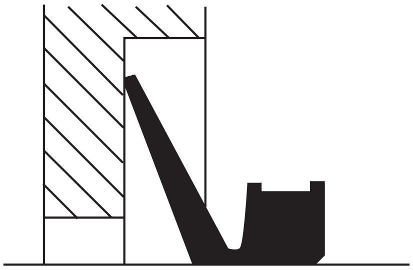


VR5

The heavy-duty, large diameter VR5 is ideal for steel mills, ball mills and papermills (fig. 3gg).

VR5

This heavy-duty, large diameter style V-Ring can be easily fitted with a standard clamping band for axial location in high-speed and large diameter applications (fig. 3gg). VR5 is ideal for steel mills, ball mills and paper mills. It is available for shaft diameters from 11.811” to over 78.740” (300mm to over 2000mm). This design can also be machined to special widths and lip heights. Available in nitrile and fluoroelastomer.



VR6

VR6 is a new heavy-duty profile similar to VR5 except it fits a more compact size (fig. 3hh).

VR6

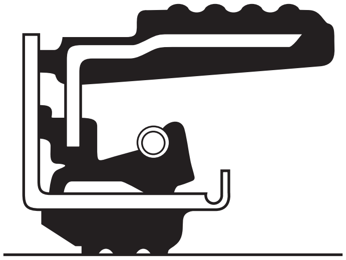
A new version, VR6, is similar except there is no “footer” extension from the housing (see fig. 3hh). It is available by special quotation. VR4 should be used for most replacement applications. VR6 is a special order profile mainly used for new machine applications and it will eventually phase in as a general catalog item.

Scotseal Oil Bath Seals

SKF Scotseal® *PlusXL*

Features

The Scotseal® *PlusXL* is a rubber unitized, one piece design. The Scotseal PlusXL consists of four sealing lips; a spring loaded primary sealing lip with patented Waveseal® design that is factory pre-lubed, a radial and axial dirt lip, plus an outer bumper lip that acts as a preliminary dirt excluder. Scotseal PlusXL requires no special installation tools and maintains a rubber-to-metal contact between the seal O.D. and the hub bore surface as well as a rubber-to-metal contact between the packing I.D. and spindle (see fig. 3ii).



Scotseal PlusXL (fig. 3ii).

3

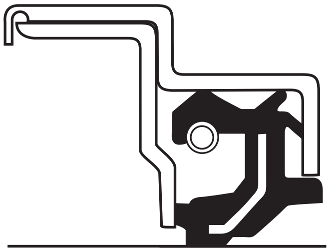
Benefits

The Scotseal® *PlusXL* design with extended life capabilities is the SKF premium performance seal, offering maximum sealing life under virtually all driving conditions. The new high-temperature, synthetic lubricant friendly material of the new Scotseal PlusXL, Hydrogenated nitrite Butadiene Rubber (HNBR), is an excellent choice for frequent braking applications. HNBR elastomeric material provides heat resistance up to 300˚F (149˚C) and broad compatibility with today's synthetic lubrication fluids. The unsurpassed exclusion properties allow the Scotseal PlusXL to perform in very harsh conditions. The new Scotseal PlusXL with the unique hand-installable design includes a fat footprint ensuring stability on the shaft. Worn hubs and spindles are not a problem for the Scotseal PlusXL.

SKF Scotseal® *Longlife*

Features

SKF Scotseal® *Longlif*e is a unitized, one piece design consisting of a sealing element (packing) that is assembled between a metal outer and inner case. The Scotseal LongLife's packing consists of four sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed, a radial and axial dirt lip, plus an outer bumper lip that acts as a preliminary dirt excluder. The Scotseal Longlife is press-fit into the hub bore using Scotseal Installation Tools. The Scotseal Longlife maintains a metal-to-metal contact between the seal O.D. and the hub bore surface as well as a metal-to-metal contact between the packing I.D. and the spindle (see fig. 3jj).

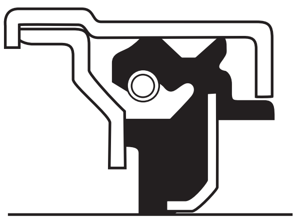


Scotseal Longlife (fig. 3jj).

Benefits

The Scotseal® *Longlif*e was built upon the success of the original Scotseal design, which gave SKF engineers a great start in their development of a new extended life seal. Computer aided design (CAD) of lip geometry and the addition of an axial dirt excluder lip was combined with a newly formulated material to produce Scotseal® Longlife–a premium performance seal with the characteristics required by many of today's demanding heavy duty environments.

SEAL DESIGN GROUPS (cont.)



Scotseal Classic (fig. 3kk).

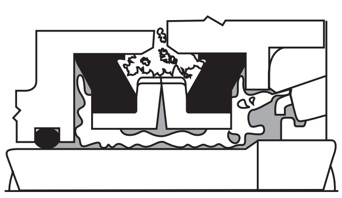
SKF Scotseal® *Classic*

Features

SKF Scotseal® *Classic* is a unitized, one piece design consisting of a sealing element (packing) that is assembled between a metal outer and inner case. The packing consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed, a dirt exclusion lip, and an outer bumper lip that acts as a preliminary dirt excluder. The seal is press-fit into the hub bore using Scotseal Installation Tools. The Scotseal Classic maintains a metal-to-metal contact between the seal O.D. and the hub bore surface as well as a metal-to-metal contact between the packing I.D. and the spindle (see fig. 3kk).

Benefits

The original Self Contained Oil Type Seal, Scotseal® Classic became the trucking industry standard—and the best value for more than 30 years. With literally trillions of road miles to its credit, Scotseal Classic has proven to be a solid choice for dependable, long lasting service. Time and time again, field studies show that when properly installed, using SKF tools and procedures, Scotseal Classic is a reliable performer for meeting the sealing requirements between brake maintenance intervals.



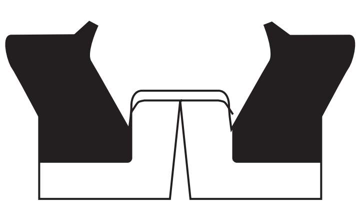
SKF's HDDF seal is designed for applications requiring both positive lubricant retention and dirt exclusion (fig. 3ll).

Heavy-Duty Mechanical Seals

SKF heavy-duty, dual face (HDDF) seals are used where positive lubrication retention and dirt exclusion are both required (fig. 3ll). Typical applications include mixers, mining equipment, grinders, rollers, off-road equipment or wherever abrasive contaminants would cause failure of a general purpose seal.

Features

SKF's heavy-duty DF seal operates on the principle that two lapped mating surfaces—a sealing ring and a mating ring—rotate against the other at right angles to the shaft. This forms an ideal, leakproof seal. Each one is composed of four components: two identical, high alloy, corrosion resistant steel sealing rings and two similar, opposed Belleville washers of compounded elastomers, one with a patented retainer lip. The seal fits easily into conventional, straight bore housings, with neither special machining or polishing of the bore required.



For protection against damage or contamination, a special retainer holds the two sealing ring faces together (fig. 3mm).

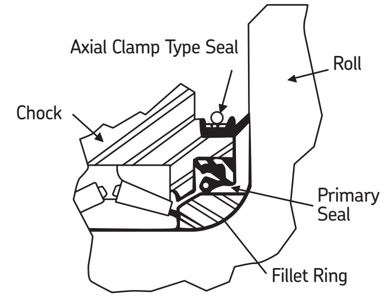
Benefits

Extensive testing under rigorous conditions proves that the heavy-duty DF seal performs dependably at least ten times longer than soft face designs, and three times longer than other metal face designs.

The one-piece heavy-duty DF seal installs simply by hand. No special tools or jigs are required. A small retaining lip on the O.D. edge of one of the washers holds and centers the entire seal in the bore while the assembler installs the companion bore or flange.

Axial Clamp Seals

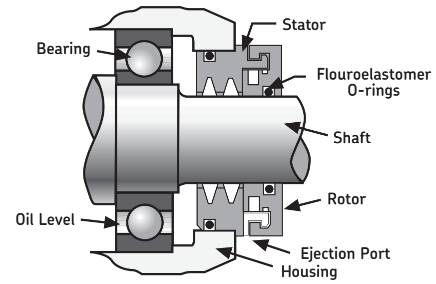
Axial clamp seals (fig. 3nn) are recommended especially for large diameter applications where additional protection from heavy amounts of contamination is required for the primary seal. Examples include steel and paper mill rolling equipment, logging operations, and rock and ore crushing applications. Clamp seals are available in 3 design variations and are intended for stationary mounting, usually on horizontal shoulders though they can also be mounted vertically. The clamp seal must be fitted against a positive stop. Assembly is usually easily done by wrapping around the shoulder diameter and tightening the stainless steel screw clamp. The seal may have no gap at the ends (butt joint) or an optional drain gap.



A stainless steel screw type clamp secures and locks the axial clamp seal in place (fig. 3nn).

Defender bearing isolator

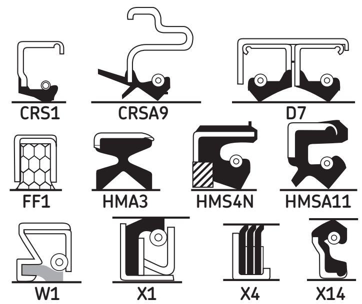
A new sealing concept known as the bearing isolator relies on very small internal clearances and dynamic non-contacting technology. SKF's Defender isolator is an assembled, two-piece labyrinth or gap seal utilizing a stator element pressed into the housing bore and a rotor fixed to the shaft. Fluid or particle contamination trying to enter the machine system is limited by the small labyrinth gap. Any that does get into the labyrinth is collected and expelled out a port at the bottom of the seal. Grease or oil lubricants can be contained so long as they do not flood the seal stator, however the Defender (fig. 3oo) itself can run dry indefinitely. Besides highly effective contaminant protection, bearing isolators offer long service life with virtually no torque drag, friction or power loss. Defender isolators are stocked for specific equipment applications or can be produced to the necessary dimensions.



Defender bearing isolators are special unitized, two piece seals that are easily installed into housing bores (fig. 3oo).

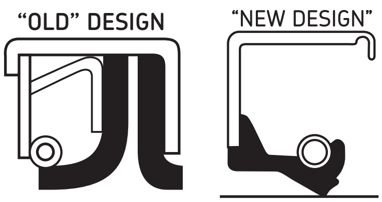
Non-Standard Seal Configurations

SKF seals include a variety of non-standard designs for specific applications. Fig. 3pp shows sectional views of their configurations. Engineered for special sealing applications by SKF, they are examples of the company's ability to respond to end-users' unique requirements. The designs shown are not all available in a complete range of sizes and/or materials. However, quantities of certain sizes/materials are inventoried. Whatever application, SKF offers consulting services to help end-users find stock or custom solutions to their shaft sealing problems.



Sectional views of SKF's non-standard seal configurations. (fig. 3pp).

SEAL DESIGN GROUPS (cont.)

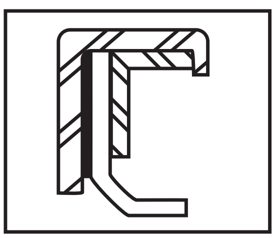


Older "clamp-type" seal (left) has been replaced by newer hydrodynamic Waveseal (right) (fig. 3qq).

Old vs. New Seal Designs

Following the "original" leather strap seals, the first engineered designs were known as "assembled" or "clamp-type" seals. They were assembled by laying two sealing elements and three metal spacer rings into an outer shell and clamping these components together. They were wide and sturdy in appearance, and tended to apply high lip pressure to the shaft, creating shaft wear. A garter spring was placed against the primary or retention element. The sealing lips were usually trimmed to size, using a knife.

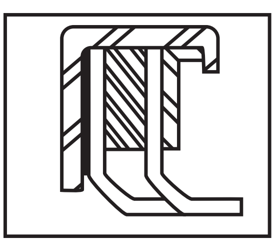
In today's designs, the sealing element is molded to size, and permanently bonded to a metal case (fig 3qq). In modern spring loaded molded seals, a garter spring is snapped into a mold-formed groove in the sealing member. Today's seals are narrower, lighter and less sturdy in appearance, but their designs give them uniform compressive sealing force. Only a thin band of lip material rubs against the shaft so they can operate at higher speeds with less friction.



General purpose design for lubricated media and moderate pressure and surface speeds (fig. 3rr).

PTFE seals

SKF PTFE seals (fig. 3rr and fig. 3ss) are assembled or machined, made-to-order radial shaft seals based on PTFE (Teflon® or polytetrafluoroethylene). This thermoplastic material has properties that exceed the capabilities of rubber compounds. PTFE seals can accept high surface speeds, pressure and dry running conditions and have high wear resistance and service life. Their temperature range is very wide and they resist attack by nearly all acids, solvents and chemical agents. They can be made for variety of inch or metric sizes from small to large diameter, often without any tooling charge. PTFE seals generally require a high quality shaft finish and hardness, and are engineered to meet specific application conditions.



Pressure design for service to 5□□ psi (35 bar). Variations for vacuum and high shaft speeds (fig. 3ss).

Chapter 3 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself) slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

3

I . Heavy-duty mechanical seals (HDDF) ________________.

- ❑ a. retain lubricants
- ❑ b. exclude contaminants
- ❑ c. can be used under severe service conditions
- ❑ d. all of the above

1. D

2. The ________________is a smooth lip, bi-rotational hydrodynamic radial lip seal that pumps lubricant back into the sump while sealing out contaminants.

- ❑ a. V-Ring
- ❑ b. metal clad seal
- ❑ c. Waveseal
- ❑ d. none of the above

2. C

3. An advantage of the Waveseal is it ________________.

- ❑ a. generates 20% less frictional torque or drag, which reduces shaft scoring
- ❑ b. pumps liquid back into the sump while drawing in less contaminants
- ❑ c. generates 25%-35% less heat at contact, which reduces early seal failure
- ❑ d. all of the above

3. D

4. HS all-rubber ________________ may be placed around the shaft, the spring connected and the assembly pushed into the seal bore.

- ❑ a. split seals
- ❑ b. solid seals
- ❑ c. both of the above
- ❑ d. neither of the above

4. A

5. When split seals are used in multiples, a________________is often used to separate the seals and provide extra lubrication between them.

- ❑ a. horizontal shaft
- ❑ b. slotted washer
- ❑ c. control wire
- ❑ d. butt joint

5. B

6. ________________ are dual face mechanical seals used where both positive lubrication and dirt exclusion are required.

- ❑ a. Waveseals
- ❑ b. V-Rings
- ❑ c. HDDF seals
- ❑ d. Retention seals

6. C

CHAPTER 3 REVIEW (cont.)

7. The V-Ring is an all-rubber seal that ________________.
   - ❑ a. mounts directly on the shaft by hand
   - ❑ b. is sealed axially against a counterface, housing bearing race or similar surface
   - ❑ c. acts like a mechanical face seal, or flinger
   - ❑ d. all of the above

7. D

8. Heavy-duty mechanical seals (HDDF) ________________.
   - ❑ a. retain lubricants
   - ❑ b. exclude contaminants
   - ❑ c. can be used under severe service conditions
   - ❑ d. all of the above

8. D

9. ________________ are recommended for large diameter applications where there is a need for two seals but room for one, as in steel and paper mills or logging operations.
   - ❑ a. Heavy-duty seals
   - ❑ b. Axial clamp seals
   - ❑ c. V-Rings
   - ❑ d. None of the above

9. B

10. HDS metal clad and HS non-metal clad (all-rubber) seals are the two basic types of large diameter seals.
    ❑ True ❑ False

10. T

11. Cover plates, required by all HS type seals, provide axial compression and supplement radial press-fit to ensure leakproof seals.
    ❑ True ❑ False

11. T

12. Pressure Waveseals (CRW5 and CRWA5) perform better than conventional lip seal designs in pressurized environments, and can be used to replace some mechanical seals.
    ❑ True ❑ False

12. T

13. Type HDSD has two opposing elements in a single shell, making it ideal for separating two fluids in applications where two seals are impractical.
    ❑ True ❑ False

13. T

14. PTFE seals can run for long periods of time without lubrication and resist attack by many acids and solvents.
    ❑ True ❑ False

14. F

15. Metal clad seals (Type HDS) are incapable of handling high speeds.
    ❑ True ❑ False

15. F

16. Two metal clad seals (Type HDS), back-to-back or in tandem, provide extra-duty sealing, cost less and install easier than a double seal.
❑ True ❑ False

16. T

17. SKF heavy-duty mechanical seals (HDDF) are not recommended when abrasives or contamination could cause premature failure of general purpose seals.
❑ True ❑ False

17. F

18. Axial clamp seats are difficult to use and require special tools for installation.
❑ True ❑ False

18. F

19. The heavy-duty DF seal has a special retainer to hold the two sealing ring faces together for protection against damage or contamination.
❑ True ❑ False

19. T

20. The V-Ring's elastic body adheres to the rotating shaft while the actual sealing occurs at the point of contact between the lip and counterface.
❑ True ❑ False

20. T

21. An axial clamp seal assembles securely and locks in place with a stainless steel screw type clamp.
❑ True ❑ False

21. T

22. The heavy-duty DF seal's seating ring and mating ring rotate against each other at right angles to the shaft to form a leakproof seal.
❑ True ❑ False

22. T

23. Scotseal oil bath seals have three seating lips: one primary lip to keep oil in, two secondary lips to keep dirt out.
❑ True ❑ False

23. T

24. Scotseal Plus oil bath seals can be installed by hand, using no more than common shop tools if any at all.
❑ True ❑ False

24. T

25. Defender bearing isolators require no lubrication but provide highly effective protection against fluid or particle contamination.
❑ True ❑ False

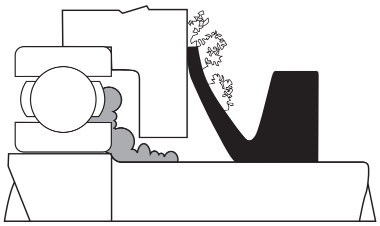
25. T

Chapter 4—
Seal Applications

Seal Selection by Application

When selecting a seal for a specific application, it is important to know what the seal is supposed to do and what operating conditions are present. Common types of applications and seal designs recommended for them are covered below.

Seals for Contaminant Exclusion



V-Ring excludes contaminants, prevents them from entering bearing cavity (fig. 4a).

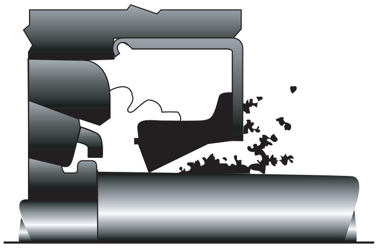
In steel mill or work roll applications, an abundance of contaminants—scale, water spray, abrasive particles—are usually present. The seal's primary function is to exclude contaminants and prevent them from entering the bearing cavity.

A back-up excluder seal, such as a V-Ring, is recommended (fig 4a). The V-Ring can function as the primary seal or, in applications where there is excessive contamination, it can provide protection for the primary sealing element, increasing its life and reliability.

The V-Ring is designed to exclude dust, mud, water and most contaminants, and can handle pressures up to 10 psi/.07 MPa (static) or 3-5 psi/.02-.03MPa (dynamic). An all-rubber design, it stretches (up to 2-1/2 times its diameter) over the shaft, easing installation.

As the seal rotates with the shaft, centrifugal force provides a "flinger" effect, keeping out dust, mud, water and most contaminants. Exclusion seals can be installed axially against any suitable counterface (bearing, other seal, pillow block, bearing assembly or other housing). They generally do not require lube for normal operating conditions.

Seals for Grease Retention



Non-spring-loaded HM seal is a cost-effective design for grease retention. Note that the lip faces the lube in this application (fig. 4b).

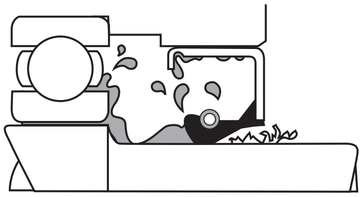
Grease lubricated applications, such as electric motors or small trailer wheels, are generally easier to seal than oil lubricated applications. When cost is also a factor, a non-spring loaded seal such as an HM design, is usually the most cost-effective design for grease retention. (fig. 4b).

The HM seal design retains grease at shaft speeds up to 2000 fpm, (10.16 m/s) and handles pressure up to 3 psi/.02 MPa. It should be installed with the lip facing the grease, except in applications where grease purge is desired. In "purge"-type applications, the lip should face away from the grease lube.

In grease retention applications where contaminants are present, a V-Ring can also be installed as a back-up excluder.

Seals for Oil Retention

Input-output shafts, gearboxes and driveshafts are oil-lubricated applications. These and other oil retention applications require spring-loaded seals, either with or without inner shells (fig. 4c). CRW and CRWA are spring-loaded Waveseals recommended for oil retention. They should be installed with the lip facing the lubricant. They are capable of handling shaft speeds up to 3600 FPM (18.29 m/s). While they are designed with nitrile, silicon or LongLife fluoroelastomer lip materials, the material selected must be compatible with the lube being used.

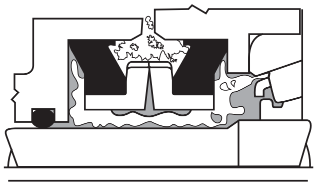


Oil retention applications require spring-loaded seals, either with or without inner shells (fig. 4c).

Seals for Exclusion/Retention

Some applications require positive oil retention and absolute dirt exclusion. The best way to solve this problem is with two seals. One faces the bearing to retain the lubricant. The other faces out to exclude contamination. A variety of combinations can be used depending on the space available and the operating conditions.

For very severe dirt, water and mud conditions, SKF has designed the HDDF series (fig. 4d). Classified as "heavy-duty mechanical" seals, their typical applications are track rollers and final drives for mining equipment, earth moving vehicles, mixer and rock crushers.



SKF's HDDF seal is designed to provide both positive oil retention and absolute dirt exclusion (fig. 4d).

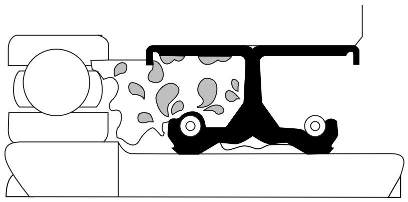
The HDDF seal has a dual face construction which retains lube while excluding water, dirt and abrasive materials. The HDDF resists abrasives that cause radial type seals to fail. Other seal recommendations include the G, HD, and HM series seals. These are for light to moderate dirt exclusion applications at slow shaft speeds.

Recommendations for severe dirt exclusion applications include the A, B, TL and XTL, which are heavy-duty designs with multiple lips.

Seals to Separate Two Liquids

Sometimes, a shaft runs through two liquids which must be kept separate. The previous seal design used in this application has two spring-loaded elements and one seal case. The D7 design has the two sealing lips point in opposite directions and both are spring-loaded. There is room between the sealing lips for a grease pack when one is needed. If necessary, holes can often be drilled from the outer to the inner diameter to align with existing lubrication grooves. Typical applications include separating different lubricants in gearboxes, transmissions and transfer cases.

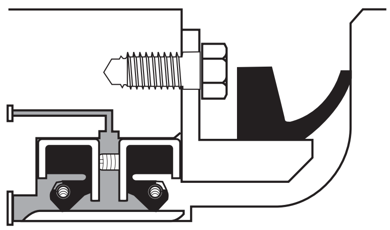
Seal Applications (cont.)



An effective solution to separating two liquids is to install two seals of same design back to back (fig. 4e).

An alternative, more effective solution is to use two seals of the same design (CRW1 or CRWH1) installed back-to-back. The sealing lips must be pointed toward the liquid which they are intended to retain. One lip should face the lube, while the other faces the fluid (fig. 4e).

To retain a fluid, a spring-loaded seal should be used. If one side will be occasionally called upon to run in a dry atmosphere, a compatible grease pack should be used in the cavity between the two seals to insure sufficient lubrication at all times.



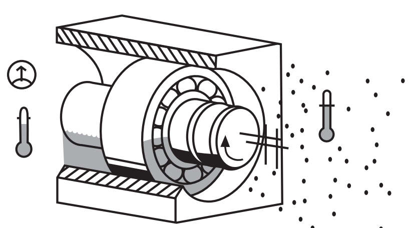
Sometimes seals are used in combination to satisfy application requirements. Here, a V-ring performs an exclusion function (fig. 4f).

Seals Used in Combination

To satisfy the needs of particularly difficult applications (such as multiple requirements in one location) or extreme operating conditions, seals can be used in combination. Such applications might be rolling mills and power take-off assemblies, where lube retention and contaminant exclusion are equally critical.

There are several combinations to choose from, depending on specific application needs. One solution would be to combine opposed CRW or HDS seals to retain lube and exclude fine contaminants. Another might be to use a V-Ring to exclude contaminants and protect radial lip seals for longer life (fig. 4f).

HDS seals used with V-Rings are usually the correct solution for applications such as roll necks in milling operations.



A variety of factors are used to determine selection of proper seal material (fig. 4g).

Factors Determining Seal Material Selection

Choosing the correct seal for an application requires satisfying a number of operating conditions (fig. 4g). Among these are the application's temperature range, lubricant compatibility, chemical compatibility, shaft speed(s), shaft surface finish, pressure (internal or external), contaminants to be excluded, housing material/condition, and abrasion.

Other factors which should be considered are run-out, shaft-to-bore misalignment, installation/handling, operating torque and, of course, cost.

Sealing Element (Lip) Materials

Seals are available with a wide variety of sealing element materials. Selection should be based on sealing application, compatibility with lubricants and fluids being retained, operation temperatures and other operating conditions.

Detailed ratings and recommendations for each material can be found in the first few pages of the *SKF Handbook of Seals*.

Synthetics

The most popular and versatile sealing element (lip) materials in use today are synthetics. These include thermoset elastometers such as nitriles (standard, carboxylated and hydrogenated), polyacrylates, silicones and fluorelastomers plus thermoplastics such as Teflon™*. Each material has its own advantages and disadvantages.

Thermoset Elastomers

Thermoset elastomers are defined as materials which are non-reversibly cross-linked through the vulcanization process. Vulcanization uses heat and catalysts to create strong molecular bonds linking polymer chains. They compose the largest group of synthetic compounds. These include nitriles, polyacrylates, silicones and LongLife elastomers (fig. 4h).

Nitrile

Nitrile is the most popular material for the majority of sealing applications today. It is a co-polymer of two basic synthetic compounds Butadiere and acrylonitrile polymers. Different properties are obtained by changing the percentage of each polymer used in the mixture (or copolymer).

Nitrile has generally replaced leather as a sealing lip material.

Operating Range

Seals with nitrile sealing lips are effective in temperatures ranging from –40°F to 250°F (-40°C to 121°C).

Advantages

+ Good oil compatibility
+ Good abrasion resistance
+ Good low temperature and swell characteristics
+ Good manufacturing qualities
+ Relatively low in cost

Disadvantages

- Not resistant to EP lubes or synthetic oils (phosphate ester, skydrol)
- Not recommended for temperatures over 250°F (121°C)
- Vulnerable to ozone, ultraviolet light conditions

Thermoset elastomers include nitriles, polyacrylates, silicones and LongLife elastomers (fig. 4h)

*Teflon is a registered trademark of E.I. DuPont.

Seal Applications (cont.)

Identification
Varies from gray-black to shiny jet black

Substitute Materials
Polyacrylate, Duralip, Duratemp or LongLife and LongLife TFE elastomers.

DURATEMP
A special nitrile compound based on hydrogenated nitrile (HNBR) Duratemp offers improved tensile strength and resistance to heat, abrasion, hardening in hot oil, ozone and weathering effects. It is mainly used in large diameter seals in heavy-duty applications; other sizes available by quotation.

Operating Range
Hydrogenated nitrile seals can be used from –40°F to 300°F (-40°C to 149°C).

Advantages
+ Tensile strength typically 50% higher than standard nitrite
+ Ozone and UV resistance considerably improved
+ Heat resistance increased 20% with less reduction in hardness and elongation, especially in hot oil with additives
+ Better abrasion resistance (equal to Duralip)

Limitations
- Decreased elasticity at cold temperatures
- Lower compression set resistance at cold temperatures (but better than Viton)
- Should not be considered a universal replacement for Viton especially considering attack by aerated lubricants and high temperature physical properties such as compression set
- In some cases, aerated oils can be a problem for HNBR

Identification
Visually the same as standard nitrile

Substitute Materials
Polyacrylate, PTFE and LongLife elastomers (depending on the operating conditions)

DURALIP

Duralip is SKF's special nitrile compound blended for extreme abrasion resistance. It is recommended where scale, sand, grit, dirt or other highly abrasive materials are present. Not usually a stocked compound, it most often is used for large diameter HDS and HS seals. It can be quoted for most CRW type seals.

Advantages

+ Extreme abrasion resistance
+ See nitrile

Disadvantages

- See nitrile

Operating Range

See nitrile

Identification

See nitrile

POLYACRYLATES

Polyacrylates are elastomers which will function at higher operating temperatures than nitriles, as well as with extreme pressure (EP) lubricants. They have limited availability from stock.

Advantages

+ Good compatibility with most oils, including EP additive
+ High resistance to oxidation and ozone
+ Tolerates higher operating temperatures than nitrile

Disadvantages

- Low compatibility with some industrial fluids
- Poor compression-set characteristics
- Should not be used with water
- Poor performance in cold conditions

Operating Range

Seals with polyacrylate lips are effective in temperatures ranging from –40°F to 300°F (-40°C to 149°C).

Identification

Generally black; slight gloss when rubbed. May have sharp odor.

Seal Applications (cont.)

Substitute Materials
Nitrile, Duratemp or LongLife and PTFE fluorocarbon lip materials.

SILICONE
Silicone's high lubricant absorbency minimizes friction and wear. It can be used in a wide range of temperatures. Silicone polymers generally are made only in bonded designs. Limited availability from stock; also available by quotation.

Advantages
+ High lubricant absorbency, minimizing friction
+ Very flexible
+ Wide temperature range

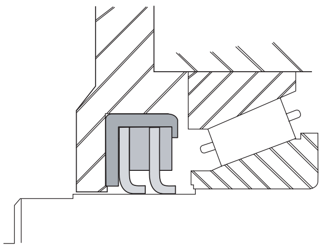
Disadvantages
- Poor compatibility with oils that have become oxidized, or with EP lube additives
- Tendency to tear and cut during installation
- Poor abrasion resistance
- Tends to wear the shaft
- Relatively high cost
- Attacked by acids, alkalai, hot water and steam

Operating Range
Silicone seals can withstand a very wide temperature range, from –100°F to 325°F (-73°C to 163°C).

Identification
Generally red or orange but sometimes gray or blue. Silicone seals feel softer and are more flexible than other materials.

Substitute Materials
Duratemp, Polyacrylate, LongLife, PTFE and fluoroelastomer lip materials. Always check the operating conditions.

SKF LongLife
SKF's LongLife fluoroelastomer is a premium synthetic lip formulation that provides extended service life under wide temperature ranges (fig. 4i). It also resists degradation caused by the newer chemically aggressive lubricants. It is compatible with an exceptionally broad range of media, including most oil additives and synthetic oils.



SKF's LongLife material extends seal service life under wide temperature ranges (fig. 4i).

Advantages

+ Extended service life.
+ Wide temperature ranges.
+ Resistance to attack by lubricants and chemicals that destroy nitriles, polyacrylates, silicones and other synthetics.
+ Compatibility with rubber solvents (benzene, toluene, carbon tetrachloride).
+ Compatible with wide range of mineral and synthetic lubricants.
+ Low swell characteristics.
+ Excellent abrasion resistance.
+ Superior heat performance and weathering.

Disadvantages

- Higher initial cost.
- Can be attacked by some special purpose lubricants, and fire-resistant fluids.
- Not recommended for applications involving low molecular weight esthers, ethers, ketones, amines and acids.
- Not the best for cold temperature applications

Operating Range

LongLife fluoroelastomers maintain thermal stability at temperatures from –40°F to over 400°F (-40°C to over 200°C).

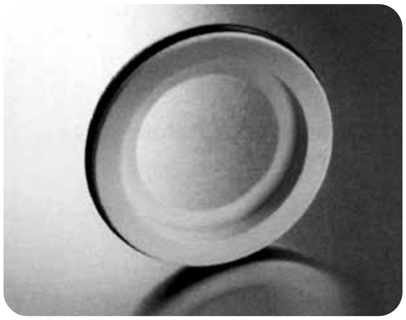
Identification

LongLife materials are brown or black.

Thermoplastics (PTFE)

PTFE (i.e. Teflon®) is the most widely used fluoropolymer thermoplastic. These materials are not cross-linked like most rubber materials. Instead they are formed by heat and pressure (sintering) into dense blocks comprised of long carbon and fluorine chains.

Teflon seals offer a wide operating temperature range, accommodate high surface speeds and provide superior dry-running characteristics (fig. 4j). They feel like plastic, having a waxy texture. These seals are usually machined or assembled designs.



Teflon seals perform well at high surface speeds (fig. 4j).

Advantages

+ Resists nearly all acids, acid-based fluids and solvents
+ Handles wide temperature range
+ Superior dry-running characteristics
+ Extreme wear resistance; longer seal life

Seal Applications (cont.)

+ Handles high surface speeds
+ Some blends are food grade compatible
+ Can accept high pressure
+ Service life capability can exceed rubber compounds

Disadvantages

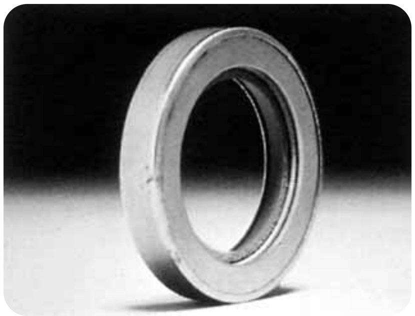
- Higher initial cost
- Normally non-stock
- Mechanical properties must be engineered in (Virgin PTFE has low mechanical strength)
- Extra care is required during assembly
- Difficult to install
- Generally requires higher shaft hardness

Operating Ranges

Thermoplastic PTFE seals handle a wide temperature range, from –400°F to 500°F (240°C to 260°C).

Identification

Red, white, gray, blue, green or brown.



Once the most popular seal material, leather is now being replaced by less expensive synthetic materials (fig. 4k).

LEATHER SEALS

Before synthetic materials were developed, leather was the sealing element commonly found in most early seals. Leather is tough, resists abrasion and works well even today in many dirt exclusion applications. However, it is expensive and can usually be replaced with another lip material (fig. 4k). SKF stocks very few leather seals.

Advantages

+ Good tensile strength and abrasion resistance
+ Performs well with minimal lubrication
+ Tends to smooth rough shaft surfaces
+ Compatible with most lubes and solvents
+ Good dry running performance
+ Good in very cold temperature operation
+ Tough

Disadvantages

- Poor compatibility with water
- Non-homogeneous matrix makes consistent high quality difficult to maintain.
- Expensive
- Vulnerable to heat above 200˚F
- Designs tend to have high torque
- Limited Availability
- Costly

Operating Range

Leather can handle temperatures ranging from –100°F to 200°F (-73°C to 93°C).

Identification

It is difficult to determine from the appearance of a used seal whether the sealing element is leather or rubber. Scratch the sealing surface. If that makes the surface much lighter (brown or beige) and fibrous, rather than black and smooth, the material is probably leather.

Substitute Lip Material

Nitrile, polyacrylate or fluoroelastomer

FELT

Felt is another non-synthetic material which has long been used as a sealing material. Made of wool and sometimes laminated with synthetic rubber washers, felt is generally limited to dirt exclusion. It can be used to retain heavy lubricants under some conditions.

Advantages

+ Excludes dust and dirt well
+ Retains grease efficiently

Disadvantages

- Cannot confine oil
- May trap metal and/or dirt particles, causing shaft wear
- Absorbs water which may cause shaft rusting
- Few stock sizes

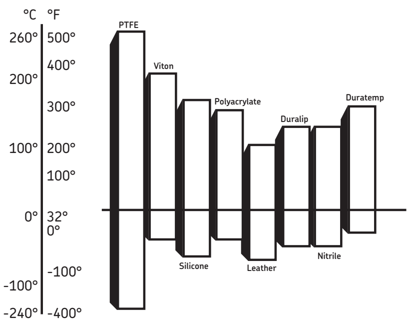
Operating Range

- Felt is used in temperatures ranging from –65°F to 200°F

Substitute Lip Materials

Nitrile, polyacrylate or fluoroelastomer

Seal Applications (cont.)



Lip materials' maximum operating temperatures fall within these ranges (fig. 4l).

Material Capabilities—Temperature Resistance

In performing their sealing function, seal lip materials work best within the following temperature ranges. (Also see fig. 4l).

	F°	C°
Polytetrafluoroethylene (PTFE)	-400° to 500°	-240° to 260°
Fluoroelastomer (LongLife)	-40° to 400°	-40° to 204°
Silicone	-100° to 325°	-73° to 163°
Polyacrylate	-40° to 300°	-40 to 149°
Duralip	-40° to 250°	-40 to 121°
Nitrile	-40° to 250°	-40 to 121°
Leather	-100° to 200°	-73° to 93°
Duratemp	-40° to 300°	-40° to 149°

Low temperatures can be as much of a problem for a seal as high temperatures. At low temperatures the sealing material gets stiff and rigid. That causes several problems. The sealing lip has trouble following the eccentricity of a shaft that's not perfectly true. That causes it to leak every time the shaft rotates "off center" and pulls away from the seal. If it gets stiff enough, the material becomes brittle and breaks up with the movement of the shaft. Another problem can appear when the lip material starts to shrink up at low temperatures.

At high temperatures, some elastomers will continue to cure again and lose their pliability. If the temperature gets high enough to burn the lip material, it often becomes hard and brittle. It can crack and break up. In such cases, it not only loses its sealing effectiveness, it can also damage the bearing and the shaft it was designed to protect.

Consequently, both upper and lower operating temperature limits should be considered when choosing a lip material. See fig. 4l for operating temperature ranges of a variety of lip materials.

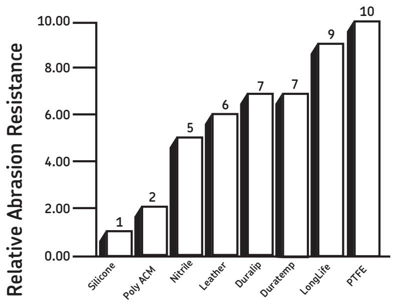
Material Capabilities—Abrasion Resistance

Usually, it's desirable for a lip material to be soft and pliable. This allows it to follow the eccentricity of a shaft and form a better seal. But in extremely dirty environments, a soft material can become a liability.

Fine dust particles and other contaminants can become imbedded in the surface of a soft lip material and turn it into an abrasive. It scores the shaft causing deep grooves which render the seal useless and the shaft in need of repair.

For example, nitrile is a compound of synthetic rubber which is formulated to optimize pliability and hardness so it covers most applications. However, other materials are available which offer better resistance to abrasive contaminants. They're harder, denser materials, and dust particles are less likely to become imbedded in them. SKF's Duralip compound was developed especially for large-diameter seals where abrasion resistance is critical. See fig. 4m for relative abrasion resistance of several lip materials.

Lip materials offering the best resistance to abrasion are PTFE and LongLife by SKF. On a scale of 1 to 10, PTFE is a "10." On the same scale and not far behind is fluoroelastomer-based LongLife with a "9." The abrasion resistance provided by both of these materials is exceptional, outperforming hydrogenated nitrile's very good "7."



On a scale of 1 to 10, abrasion-resistance capabilities of sealing lip materials are compared in the chart above (fig. 4m).

Chapter 4 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself) slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1 . Simultaneous exclusion and retention is best performed with ________________ .
- ❑ a. a combination of two seals back to back
- ❑ b. single lip design seals
- ❑ c. a combination of two seals front to back
- ❑ d. V-Ring seals

1. A

2. ________________ is the most popular material for the majority of sealing applications today.
- ❑ a. Leather
- ❑ b. Felt
- ❑ c. Nitrile
- ❑ d. Silicone

2. C

3. Polyacrylates ________________ .
- ❑ a. are compatible with high operating temperatures
- ❑ b. offer high resistance to oxidation and ozone
- ❑ c. may be used with water
- ❑ d. both a. and b.

3. D

4. Before the invention of nitriles, ________________ was the most common sealing element.
- ❑ a. rubber
- ❑ b. felt
- ❑ c. leather
- ❑ d. metal

4. C

5. Popular sealing lip synthetics in use today include ________________ .
- ❑ a. nitriles
- ❑ b. fluoroelastomers
- ❑ c. fluoropolymer (PTFE)
- ❑ d. all of the above

5. D

6. Advantages of polyacrylates include ________________ .
- ❑ a. good compatibility with most oils
- ❑ b. high resistance of oxidation and ozone
- ❑ c. better compatibility with high temperatures than nitrile
- ❑ d. all of the above

6. D

7. Advantages of silicone include ________________ .
   - ❑ a. good compatibility with oxidized oils
   - ❑ b. high lubricant absorbency
   - ❑ c. excellent abrasion resistance
   - ❑ d. low cost

7. B

8. Leather is an expensive sealing material that has a good compatibility with water.
   ❑ True ❑ False

8. F

9. V-Rings must be lubricated for all operating conditions.
   ❑ True ❑ False

9. F

10. For very severe conditions, SKF's HDDF seals resist abrasives that cause other seals to fail.
    ❑ True ❑ False

10. T

11. HDS seals used in combination with o-rings are usually the right answer for applications such as roll necks in milling operations.
    ❑ True ❑ False

11. F

12. All of the synthetic materials have the same operating characteristics.
    ❑ True ❑ False

12. F

13. Nitrile's disadvantages include poor abrasion resistance.
    ❑ True ❑ False

13. F

14. Some blends of fluoropolymer seals are food grade compatible.
    ❑ True ❑ False

14. T

15. Applications for SKF's LongLife fluoroelastomer lip materials are limited to standard lubricants
    ❑ True ❑ False

15. F

16. PTFE can often be used where temperatures and pressure would ruin rubber seals.
    ❑ True ❑ False

16.T

Chapter 5—Seal Selection

The first consideration in selecting a seal is to know:

- Is it a seal for a new application, or
- Is it a replacement seal for an existing application?

Selecting seals for new applications is covered in *Chapter 4: Seal Applications.* It would seem that selecting a seal for an existing application would be an easier chore. Even so, there are considerations such as:

- Is an exact replacement seal desired, or

- Should an alternative seal be selected which would be a "better" choice for that particular application?

How to Select a Replacement Seal

If the old seal was manufactured by SKF, you should have no trouble finding an appropriate identification number and selecting the proper replacement. SKF seals are identified by:

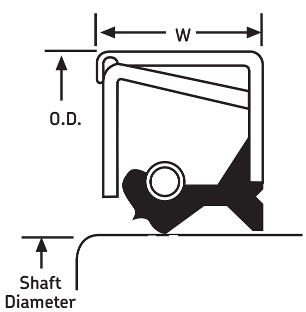
- SKF stock number
- SKF industrial part number
- SKF drawing number
- OEM part number

This number will tell you exactly which replacement seal is right for the job. If the part number on the old seal is legible, refer to the *SKF Master Interchange* for a replacement.

If you can't find an identification number, match the old seal's size with listings in the *SKF Handbook of Seals*. If there is no seal listed with the exact same width, select a narrower one.

Seal Size

Seal size (fig. 5a) is determined by:



Seal size is determined by seal bore, seal width, seal O.D. and shaft diameter (fig. 5a).

- Seal bore the diameter of the hole in the housing into which the seal is fitted.

- Seal Outer Diameter (O.D.)—the press-fit diameter. It's usually in the range .004" to .008" (.10mm to .20mm) larger than the bore for metal O.D.'s. It's usually .006" to .022" (.15mm to .55mm) for rubber O.D.'s.

- Seal Width (W)—the total width of the seal including both the inner and outer shell.

- Shaft Diameter (S.D.)—the outside diameter of the shaft at the location where the seal is mounted.

Proper Seal Measurement

Two of a seal's measurements are its outer diameter (O.D.) and its inner diameter (I.D.). To determine these, follow these procedures:

- To measure the O.D. of a seal, take three measurements equally spaced around the outside of the seal. The average of the three is the seal's O.D. (fig. 5b).
- A metal O.D. seal is generally 0.005" to 0.008" (0.13mm to 0.20mm) larger than the bore, for press fit.
- A rubber O.D. seal is generally 0.008" to 0.026" (0.203mm to 0.508mm) larger than the bore, for proper compression and interference fit.
- The inner diameter is more difficult to measure. Take about five I.D. readings, average them.
- Allow for interference, added to the lip I.D.
- When selecting seal size, use the shaft O.D. as the seal I.D. Then refer to size listings in the *SKF Handbook of Seals* for determining the correct seal part number.

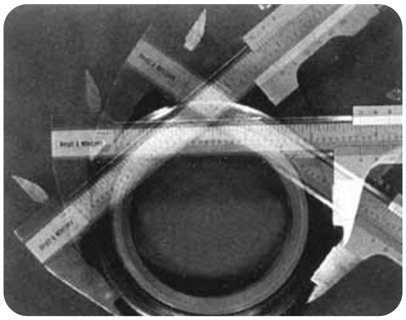
How to Substitute a New Seal for an Old Seal

When an exact replacement seal is not available, your best option is substitution of a similar material and design. Refer to the *SKF Handbook of Seals* guidelines on seal substitution. If the lip material to match the old seal cannot be found in the size listings, refer to the Recommended Operating Tables at the beginning of the Handbook.

Common lip material substitutes include:

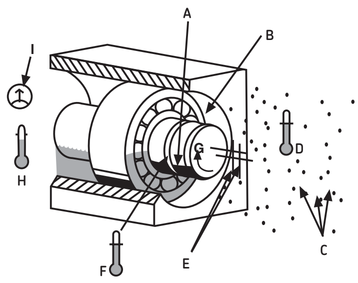
- Nitrile instead of felt
- Nitrile instead of leather
- Polyacrylate instead of nitrile
- Another nitrile instead of the original nitrile
- Fluoroelastomer instead of polyacrylate
- Fluoroelastomer instead of silicone

Note: Substitution may extend or shorten the seal life, depending on the material chosen. Lip materials are covered in Chapter 4. It is recommended that the compatibility tables shown in the *SKF Handbook of Seals* be consulted for verification of material substitution.



The average of three equally spaced measurements is the seal's O.D. (fig. 5b).

Seal Selection (cont.)



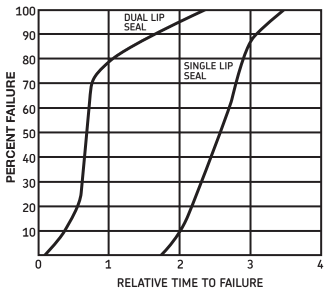
A variety of factors determine proper seal selection (fig. 5c).

Seal Selection Criteria

Factors to consider when selecting a seal for a particular application (fig. 5c) include:

- Basic seal function
- Shaft surface finish (A)
- Shaft speed and direction (G)
- Shaft and bore conditions (B)
- Shaft eccentricity (E)
- Seal material/lubricant compatibility
- Underlip temperature (F)
- Contaminants (abrasiveness) (C)
- Pressure (internal/external) (I)

In many applications, seal life can be extended simply by substituting the same size seal (O.D. and I.D.), but of slightly different design or with a different lip material. A narrower seal width can usually be used (see following "Seal Width vs. Seal Performance" section). The seal selected must be able to meet the application's requirements for operating temperature, pressure, and other factors listed above.



(fig. 5d)

Single Lip vs. Double Lip Seals Test Results

In its development of new seal designs, SKF has conducted extensive testing. One series of tests has compared single lip with double lip seals (fig. 5d). Test objectives were to determine:

- Does the double lip seal's secondary (dust) lip help or hinder the primary lip?
- How does the double lip seal's overall performance compare with that of the single lip seal?

During testing, these measurements were taken:

- Temperature vs. shaft speed.
- Dust ingestion vs. time.
- Peak performance vs. temperature rise.

Test results:

- The double lip seal failed at 270 hours.
- The single lip seal, tested under identical conditions, was still running at 1254 hours.
- The single lip seal was proven to run four times longer than the double lip seal.
- The single lip seal runs cooler.

Why Double Lip Seals Fail Faster

Lips create friction. Friction creates heat. So more lips mean more heat. Heat causes the double lip seal to become hard and brittle because the dust lip is lubricated less and can transfer its heat to the main lip.

As the brittle secondary lip wears, it allows dirt to pass and pack between the two sealing lips. This dirt builds and forces itself under the primary lip. In a short time, the dirt will mix with the lubricant which had been contained by the primary lip.

The mixture of lube and dirt becomes a lapping compound. Highly abrasive, it wears the shaft, escapes past the seal lips and enters the bearings to cause premature failure.

A Design Improvement—the Zero Interference Auxiliary Lip

SKF offers single as well as double lip designs. However, SKF has found that its Waveseal design offers the attributes of double lip capabilities with one significant difference.

The SKF Waveseal's exclusive design utilizes a secondary lip that excludes dirt without touching the shaft surface—it excludes dirt while having zero interference. The Waveseal's primary lip follows a wavy path around the shaft, dissipating the heat over a wide area. The wave lip retains and excludes at the same time, generating less friction, torque and shaft wear.

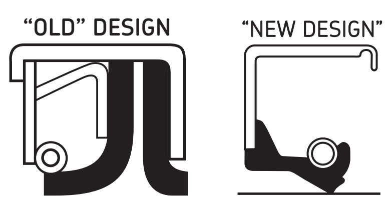
The Waveseal design is detailed in Chapter 3.

Seal Width vs. Seal Performance

Seal width is another factor to consider when selecting a replacement seal. Seal width is the measurement of the axial dimension of the seal case, not the seal lip length.

Since the width dimension doesn't take lip design into account, it does not provide a basis to explain the seal's performance characteristics. But it is important to note that, for proper seal operation, the case must provide both an effective support for the seal lip and a good surface area for proper installation. Today's "narrow" seals—their cases and their lip designs—are designed to satisfy these same requirements (fig. 5e).

Certainly, lip dimension is a key factor in how—and how well—the seal performs. This is the axial distance between the lip contact point and the base of the flex thickness (the point of deflection takes place).



Today's "narrow" provide performance effective seal lip support and surface area for proper installation (fig. 5e).

Seal Selection (cont.)

A longer lip often improves the seal's capacity to compensate for misalignments or eccentricities in the shaft surface. But lip length is not necessarily related to seal width. Often, seal widths are increased by changing the seal casing width without altering lip dimensions in any way. These variables in dimensions have allowed seal designers and manufacturers to inter-work them in producing higher performance products—including those in more compact packages.

There are special applications where seal width cannot be reduced. These often involve situations where seal widths are used as reference points for other components. There also are applications where the reduced width of a replacement seal will help extend shaft life. This is accomplished by locating the contact point of the new seal away from any damage on the shaft that may have been caused by the original wider seal.

In general, use of a narrower seal as a replacement is very proper if it is determined by a thorough examination of the application's operating conditions that all the other factors affecting the seal's performance are satisfied as well.

SKF's WasteWatcherProgram

Another benefit of using narrower seals to replace original wider ones is in inventory management. By stocking narrower seals of assorted shaft and bore sizes while consolidating widths as much as possible, inventory can be minimized while maximizing coverage.

SKF offers an inventory control system, called "WasteWatcher," in which distributors can consolidate replacement seals by I.D./O.D. sizes. The program eliminates many stocking units that differ only by their width dimensions. WasteWatcher also enables end-users to effectively substitute single lip seals for comparable double lip designs.

Within distributors' operating environments/performance requirements, it is realized that the different "kinds" of seals that are used become fewer in number over a period of time. As their sizes and application requirements become more clearly defined, stocking units can become further consolidated.

The "WasteWatcher" system is designed to streamline each end-user's inventory of replacement seals—to provide him with the seals and the quantities he should stock for his market. The benefits to him, of course, are excellent inventory cost controls and maximum efficiency in use of inventory stocking space.

Chapter 5 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself) slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1. ________________ is a premium lip material for the majority of sealing applications today.
   - ❑ a. LongLife fluoroelastomer
   - ❑ b. Fluoropolymer (PTFE seals)
   - ❑ c. both of the above
   - ❑ d. neither of the above

1. C

2. SKF seals are identified by an OEM part number or an SKF ________________ .
   - ❑ a. stock number
   - ❑ b. industrial part number
   - ❑ c. drawing number
   - ❑ d. all of the above

2. D

3. ________________ is an acceptable sealing lip material substitute for nitrile.
   - ❑ a. Leather
   - ❑ b. Felt
   - ❑ c. Another nitrile
   - ❑ d. none of the above

3. C

4. Selecting the right seal for a particular application depends on ________________ .
   - ❑ a. size and speed
   - ❑ b. pressure and temperature
   - ❑ c. fluid compatibility
   - ❑ d. all of the above

4. D

5. ________________ refers to the outside diameter of the shaft at the location where the seal is mounted.
   - ❑ a. Size bore
   - ❑ b. Seal I.D.
   - ❑ c. Seal width
   - ❑ d. Shaft diameter

5. D

6. If the same size replacement is not available, ________________ .
   - ❑ a. select a narrower seal
   - ❑ b. select a wider seal
   - ❑ c. select a different lip material
   - ❑ d. either a. or b.

6. A

Chapter 5 Review (cont.)

7. Substitute lip materials will extend a seal's life, no matter which material is chosen.
❑ True ❑ False

7. F

8. A combination seal or a double lip seal will always do a better job than a single lip design.
❑ True ❑ False

8. F

9. Seal width refers to the diameter of the hole in the housing into which the seal is fitted.
❑ True ❑ False

9. F

10. Fluoroelastomer is generally an acceptable sealing lip material substitute for silicone.
❑ True ❑ False

10. T

11. There are no acceptable sealing lip material substitutes for nitrile.
❑ True ❑ False

11. F

12. The temperature of the lubricant being retained is the only temperature reading critical to seal selection.
❑ True ❑ False

12. F

13. When an exact replacement is not available, your best option is substitution of a similar material and design.
❑ True ❑ False

13. T

14. In SKF's single lip vs. double lip test, the single lip outlasted the double lip by nearly 1000 hours.
❑ True ❑ False

14. T

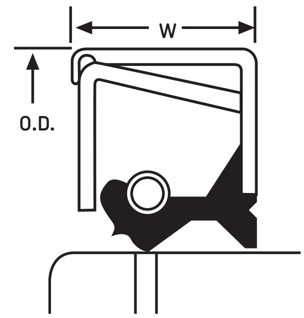
15. SKF's "WasteWatcher" seal inventory control system helps control costs of replacement seals.
❑ True ❑ False

15. T

Chapter 6—Wear Sleeves

How Shafts Wear

Seals operate with a closely controlled interference at the interface. Continuous contact between a rotating shaft and a seal produces shaft polishing friction. Under normal conditions, the friction causes a slight wear track on the shaft (fig. 6a). However, as operating conditions begin to worsen, shaft wear can accelerate. Dust, heat, dirt, shaft speed, lack of lubrication, and even a cocked seal can cause the seal lip to groove the shaft. Mechanical eccentricities can cause direct, metal-to-metal contact between the seal and shaft surface. The ultimate result is a leak.



As a seal continuously contacts a rotating shaft, it creates shaft wear (fig. 6a).

How to Identify Seal Worn Shaft Surfaces

It's not always easy to identify seal-worn shaft surfaces. The shaft may be visibly scored or grooved. You can catch your fingernail in a wear groove. A new seal that leaks soon after it's installed is another telltale sign of shaft damage.

The shaft surface can become so deeply grooved and worn that a new seal will not eliminate leaks, nor compensate for the shaft damage (fig. 6b).

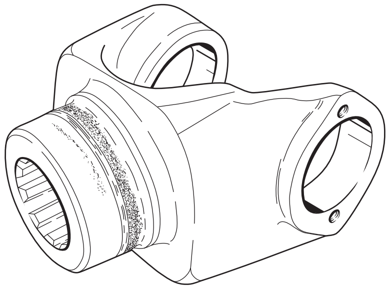
Seal replacement does not solve the problem. The new lip will ride in the rough, worn seal track and the new seal will leak and wear out quickly.

Three solutions are possible:

- Reworking or metallizing the shaft surface at a machine shop—high cost, requires hours of downtime.
- Replacing the shaft—Also expensive, with machine downtime.
- Installing a wear sleeve—Comparatively low in cost, virtually no downtime, longer life.

Wear sleeves correct shaft damage instantly with the least amount of downtime and cost. Wear sleeves require no special preparation or machining of the shaft for installation. Applied over the damaged shaft, a wear sleeve makes the shaft usable again. It eliminates shaft leaks and smooths out damaged surfaces. And often the new shaft finish created is better than the original.

SKF offers two types of wear sleeves: Speedi-Sleeves®, for nominal shafts .472" to 8.000" (12.00 to 203.20mm), and large diameter wear sleeves, for shafts 8" to 45" (203.20 to 114.300mm). Made of carbon steel and chrome-plated, the wear sleeve resists corrosion in a wide range of applications.



Shaft surface can become so deeply grooved and worn that a new seal will not eliminate leaks, nor compensate for the shaft damage (fig. 6b).

6

Wear Sleeves (cont.)

Speedi-Sleeves®

The Speedi-Sleeve is a cost-effective alternative to resizing, metallizing or replacing the severely damaged surface because it installs easily, without excessive machine downtime (fig. 6c).

Speedi-Sleeve is a highly engineered component, precision manufactured of 300 series stainless steel. Its surface is factory finished to 10-20 micro inch Ra (.25 to .50µm), with no machine lead, and requires no expensive shaft preparation or machining before installation. Once in place on the shaft, Speedi-Sleeve provides a sealing surface that is superior to most original shaft finishes and materials.

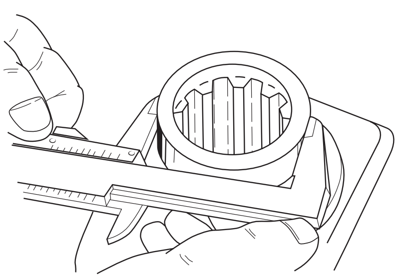
Speedi-Sleeve installs easily, without excessive machine downtime (fig. 6c).

Typically, when a wear sleeve is installed over the shaft, the new surface is thicker and requires a larger-sized seal. The wall of the Speedi-Sleeve is so thin that the original size seal can still be used. Its stainless steel construction provides a surface that can outlast the original shaft material.

Each sleeve is built with a removable flange and includes a special tool for installation. This tool is placed over the Speedi-Sleeve. Both the tool and sleeve are tapped into position on the shaft. The flange allows the sleeve to be pulled on instead of pushed on, eliminating sleeve distortion.

When the Speedi-Sleeve is in position, the tool slides off easily. The flange can be left intact, or cut and peeled off along a pre-cut line.

It takes only a few Speedi-Sleeves to meet the needs of even the biggest operators. In most cases, there is no need to stock more than one size sleeve for each seal application or location.



Averaged caliper measurements of shaft diameters at three positions will compensate for out-of-round conditions (fig. 6d).

Speedi-Sleeve Size Selection

Correct Speedi-Sleeve size selection requires that three measurements of shaft diameter be taken and averaged. Use a caliper and measure at three positions: noon and 6 o'clock, 2 and 8 o'clock, and 4 and 10 o'clock. Take these measurements at a point on the shaft ahead of the wear path. Find the average of the three readings.

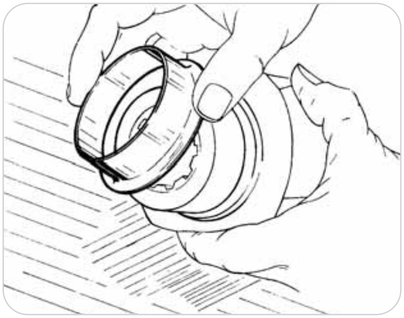
The average will compensate for out-of-round shaft conditions as well as indicate the approximate shaft diameter (fig. 6d). When that is determined, refer to the *SKF Handbook of Seals* to select the correct Speedi-Sleeve part number.

Speedi-Sleeve Installation

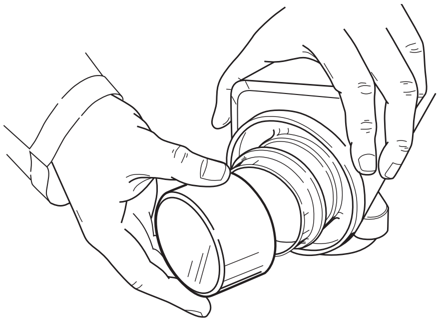
Speedi-Sleeves are available for shaft diameters ranging from .469" up to 8.005" (11.91 to 203.33mm). Each Speedi-Sleeve kit contains a disposable installation tool and every box is marked with the shaft range for proper selection.

Follow these guidelines for proper Speedi-Sleeve installation:

1. Clean the surface where the seal contacts the shaft. File down and polish any burrs, nicks or rough spots. Make sure the end is free of nicks and burrs.
2. Measure an unworn portion of the shaft where the sleeve will be positioned. Do not install Speedi-Sleeve over key-ways or splines unless their diameter is under nominal shaft size. Measure in three positions and average the reading, in case the shaft is out of round. If the average diameter is within the range for a given Speedi-Sleeve, there is sufficient press-fit built into the sleeve to keep it from sliding or spinning. No cement is necessary.
3. If the groove does not require filling, optionally a light layer of non-hardening sealant can be applied to the inner surface of the sleeve.
4. If the shaft is deeply scored, fill the groove with powdered metal epoxy type filler. Install Speedi-Sleeve before the filler hardens.
5. Speedi-Sleeves are wide enough to cover the wear pattern of both standard and wider combination seals. Where extra wide combinations are encountered, a second sleeve can be installed to butt against the first. The flange is then peeled off to provide the clearance necessary for the seal housing to slide into place. The Speedi-Sleeve installation flange can be left in place unless it could prevent oil from reaching the seal lip.
6. Determine how far back the sleeve must be positioned to cover the old seal wear tracks. Measure to the exact point, or mark directly on the shaft surface (fig. 6e).
7. The sleeve must be placed over the worn surface area, not just bottomed or left flush with the end of the shaft.



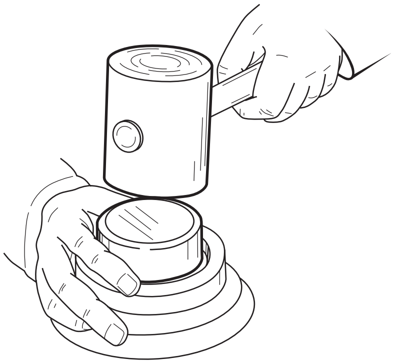
Place flanged end of Speedi-Sleeve onto shaft first. (fig. 6e).



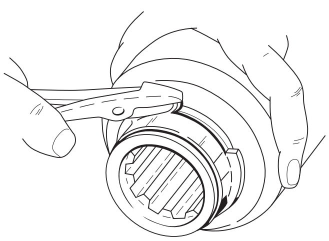
...then apply the installation tool over the sleeve and against the flange... (fig. 6f).

6

Wear Sleeves (cont.)



...then gently tap center of tool using soft-face hammer or mallet until sleeve reaches desired point on shaft (fig. 6g).



When Speedi-Sleeve is in position, flange can be removed (fig. 6h).

SKF Large diameter wear sleeve (fig. 6i).

8. Drop the Speedi-Sleeve into the end of the installation tool so only the flange end projects (fig. 6f). The flange end of the sleeve goes on the shaft first. Gently tap the center of the tool using a soft face hammer or mallet until the sleeve reaches the previously marked or pre-measured point on the shaft (fig. 6g).

9. Speedi-Sleeves may be installed to any depth required (refer to *SKF Handbook of Seals*). If the installation tool supplied with sleeve is too short, a length of pipe with a squared-off, burr-free end can be substituted if its I.D. matches the kit installation tool.

10. Inside pipe diameters should be larger than the shaft by:

Shafts less than 3" (75mm): 1/32" to 1/8" (.8mm to 3.2mm)
Shafts 3" to 6" (75-150mm): 1/32" to 3/16" (.9mm to 4.8mm)
Shafts more than 6": (150mm) 3/64" to 7/32" (1.2mm to 5.6)

The installation tool correctly places the sleeve on the shaft to the required installation depth (intermediate values can also be obtained by pressing the sleeve on more or less as required).

11. If clearance is needed, the Speedi-Sleeve flange can be removed easily with side cutters and carefully pried away from the sleeve. Bend flange back and forth until flange cracks at tear groove. The flange will peel away from sleeve surface along a precut line (fig. 6h). Be careful nothing scratches the sleeve surface.

Large Diameter Wear Sleeves

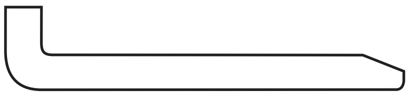
Large diameter wear sleeves correct damaged shafts from 8" to 45" (203.20 - 1143.00mm) (fig. 6i). Though they function the same as SKF Speedi-Sleeves, these sleeves are designed and built for heavy-duty, large shaft applications. Installed over a seal grooved shaft, the sleeve provides a positive sealing surface and reinforced protection. They are available with or without an installation flange. They also resist wear and corrosion, especially in contaminated environments.

SKF large diameter wear sleeves are custom-made from high quality cold-rolled steel, SAE 1005-1020. The sealing surface is machined and hard chrome-plated to provide a strong, corrosion-resistant sealing surface. The standard thickness of the sleeve is 0.094" (2.4mm). Other materials and thicknesses are available on a quote basis.

Two styles of large diameter wear sleeves are available.

Style 3

Style 3 is designed with a flange for final positioning on the shaft (fig. 6j). Actual sealing surface width is .250" (6.4mm) narrower than overall sleeve width.



LDSLV3

Style 3 features a flange for pull-on installation (fig 6j).

Style 4

Style 4 is designed without a flange (fig. 6k). It is used where space restrictions limit the width or prohibit the use of a flange.

LDSLV4

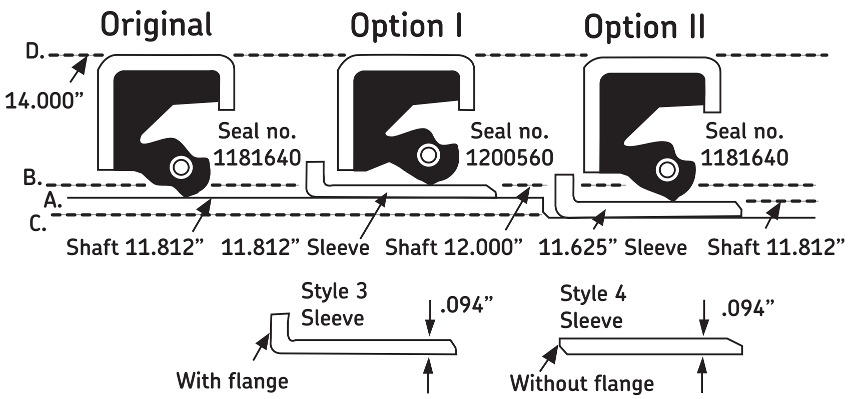
Style 4 is ideal where space prohibits use of a flange (fig. 6k).

Large Diameter Wear Sleeve Installation

Large diameter wear sleeves are designed for heated, slip-fit installation. A bearing heater (either hot air, hot oil or electric induction) is used to bring the sleeve to about 350°F (176°C). Even with heating, the sleeve may not position itself correctly and would then require pushing or pulling on the flange.

While a large diameter wear sleeve will increase shaft life and eliminate leaks, it also increases the shaft diameter. When considering seals and sleeves for a large shaft, choose one of two options:

- Machine the shaft before installing the sleeve to .188" (4.8mm) under original size. The resulting sleeve O.D. will allow use of the original size seal.
- Increase the seal size. No shaft machining is required. Use seals designed for shafts .188" (4.8mm) larger than the original.



Unlike Speedi-Sleeve, adding an LD sleeve requires either reducing the shaft diameter to compensate for the sleeve thickness or using a different seal sized for the nominal sleeve outer diameter.

Chapter 6 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself) slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1. The Speedi-Sleeve is an ultra-thin wall made of ________________ that repairs grooved shafts.
   - ❑ a. bronze
   - ❑ b. zinc
   - ❑ c. stainless steel
   - ❑ d. magnesium

1. C

2. The flange allows the Speedi-Sleeve to be ________________ eliminating sleeve distortion.
   - ❑ a. pushed on
   - ❑ b. pulled on
   - ❑ c. either of the above
   - ❑ d. none of the above

2. B

3. SKF's Large Diameter Wear Sleeves ________________ .
   - ❑ a. repair damaged shafts 8" (203mm) and larger
   - ❑ b. are built for heavy-duty applications
   - ❑ c. provide high quality sealing surfaces and improved seal performance
   - ❑ d. all of the above

3. D

4. If the shaft is deeply scored, you should fill the groove with ________________ .
   - ❑ a. powdered metal epoxy type filler
   - ❑ b. non-hardening sealant
   - ❑ c. grease
   - ❑ d. SAE 30 oil

4. A

5. A Large Diameter Wear Sleeve ________________ the diameter of the shaft.
   - ❑ a. reduces
   - ❑ b. increases
   - ❑ c. will never change
   - ❑ d. none of the above

5. B

6. When considering seals and wear sleeves for a large diameter shaft, it is possible to ________________ .
   - ❑ a. machine the shaft to a reduced diameter for use with the wear sleeve and original size seal.
   - ❑ b. apply the .094" thick (2.4mm) wear sleeve and use a larger sized seal.
   - ❑ c. both of the above
   - ❑ d. none of the above

6. C

7. When the Speedi-Sleeve is in position, the flange can be left intact, or cut and peeled along a precut line.
❑ True ❑ False

7. T

8. More than one Speedi-Sleeve size is usually required for each seal application.
❑ True ❑ False

8. F

9. While the Speedi-Sleeve repairs damaged shafts, it is inexpensive and requires little machine downtime.
❑ True ❑ False

9. T

10. Speedi-Sleeve's wall is so thin that the original size seal can still be used.
❑ True ❑ False

10. T

11. Speedi-Sleeves cannot cover the wear pattern of wider combination seals.
❑ True ❑ False

11. F

12. Large Diameter Wear Sleeves are designed for heated, slip-fit installation.
❑ True ❑ False

12. T

13. Proper Speedi-Sleeve size selection requires that seven measurements can be taken and averaged.
❑ True ❑ False

13. F

14. Speedi-Sleeve's stainless steel construction provides a surface that can outlast the original shaft material.
❑ True ❑ False

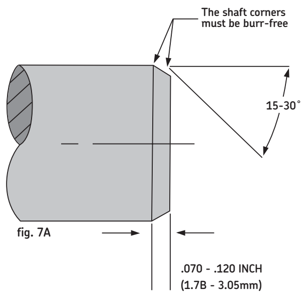
14. T

15. The most economic repair option for a worn shaft seal is to install a wear sleeve.
❑ True ❑ False

15. T

Chapter 7—Shaft and Bore Conditions

In addition to application parameters and environmental factors, shaft and bore specifications are important to proper seal selection.



Shaft surfaces must be smooth and free of nicks and rough spots

Shaft Conditions

Sealing Surface Requirements

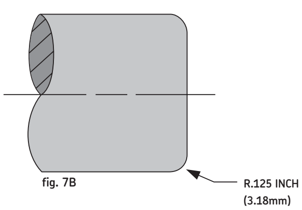
SKF produces thousands of seals in designs, sizes and lip materials to meet the most severe operating conditions.

For proper seal performance, three factors must be considered:

1. The shaft surface has no machine lead (grooves running diagonally toward or away from the sealing lip).
2. The entrance edge is chamfered or rounded.
3. The surface finish is 8-17 micro inch Ra (.20 µm to .43µm).

Shaft Requirements

A burr-free chamfer (fig. 7a) or radius (fig. 7b) is required as illustrated (c = chamfer depth).



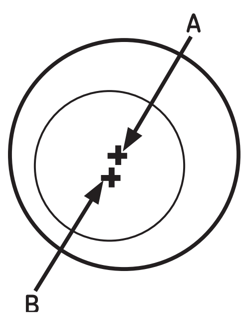
Burr-free radius alternatives can also be used (fig. 7b).

Because the seal's inside diameter is difficult to measure and varies with seal designs, the shaft diameter for which the seal was designed is used as the cataloged inside dimension.

Shaft Eccentricity

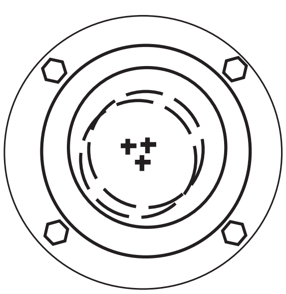
Two types of shaft eccentricity affect seal performance. They are:

- Shaft-to-bore misalignment (STBM)—The amount by which the shaft is off center, with respect to the center of the bore. This somewhat common occurrence is caused by machining and assembly inaccuracies. To measure, attach a dial indicator to the shaft (between the shaft and bore), rotate the shaft and read the indicator (fig. 7c).



A dial indicator is used to measure STBM (fig. 7c).

- Dynamic run-out (DRO)—DRO is the measure of the amount by which the shaft does not rotate around the true center. The motion away from the center may be in more than one direction. Misalignment, in-line boring tolerances, shaft bending, lack of shaft balance and other manufacturing inaccuracies are common causes. To measure, slowly rotate the shaft and calculate total movement of an indicator attached to the bore and held against the shaft's side (fig. 7d).



Dynamic run-out is also measured using a dial indicator (fig. 7d).

For specific limitations on both shaft-to-bore misalignment and dynamic run-out and the total eccentricity (combined STBM and DRO readings) indicator, refer to the *SKF Handbook of Seals*.

Shaft Speed

Maximum speeds for effective seal operation depend on shaft finish, pressure, temperature, eccentricity, lubricant or fluid being retained, seal type and other conditions. For example, shaft speeds may be increased (not to exceed manufacturer upper limit) when shaft finish is improved or eccentricity (run-out) is reduced.

The surface speed at the contact point between the seal and shaft as measured in fpm (feet per minute) or mpm (meters per minute) or fps (feet per second) or M/S (meters per second) is generally a better seal selection guide than rpm (revolutions per minute).

Shaft Tolerance

It is important to note that machinery built with inch vs. metric dimensions may use different tolerance standards. In general, the inch (RMA) system uses a 'floating' range based on the nominal shaft diameter plus or minus some value depending on the base size. With the metric (ISO) standard, the tolerances for shafts are applied as a plus zero / minus value (typically ISO h11). While the lip interference of radial lip seals is relatively less sensitive to shaft diameter variations, the best recommendation is to specify the correct size for the tolerancing system used. Refer to the *SKF Handbook of Seals* for tolerance tables and other details.

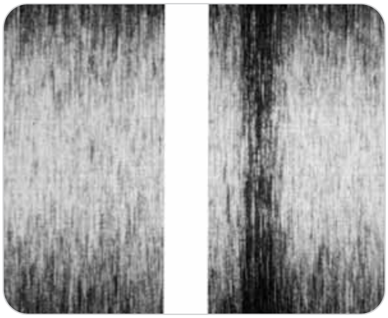
Recommended Shaft Materials

Seals perform best on medium carbon steel (SAE 1035, 1045) or stainless steel surfaces. Properly finished ceramic-coated and chrome-plated or nickel-plated surfaces are also acceptable. Brass, bronze and alloys of aluminum, zinc, magnesium or plastics are not recommended. Surface should be hardened to Rockwell C30 or higher to prevent handling damage or abrasive wear.

Recommended Shaft Finish

Shaft finish is critical to the proper functioning of a lip-type seal (fig. 7e). It is important to note that not all shaft finishes are good ones. An improper shaft sealing surface will not allow the seal to function properly. Generally, the shaft surface should be smooth enough to maintain effective contact with the seal lip. But it also must be rough enough to form lubricant holding pockets, without causing excessive seal wear.

Machine lead is always present after the shaft has been machined to size on a lathe. It is necessary to dress the shaft surface to remove the lead introduced during the machining operation.



A new shaft with the proper finish is shown on the left; normal shaft wear is shown on the right (fig. 7e).

7

Shaft and Bore Conditions (cont.)

Seal and original equipment (OE) manufacturers agree the following shaft conditions must be met:

- Shaft finish should fall between 8 and 17 micro inch Ra (.20µm to .43µm).
- Shafts should be ground with mixed number rpm ratios.
- Plunge grinding is the preferred method
- The shaft finish should be free of machine lead spiral marks that can cause lip damage and auguring out of the lubricant.
- The entrance edge should be chamfered or rounded.

**In addition to the finish roughness, parameters related to texture and other factors are important to optimum seal performance. Refer to the SKF Handbook of Seals for further information.*

To maintain a smooth sealing surface, remove any surface burrs, nicks, rough spots or grooves. Such imperfections can damage the lip seal as it slides on the shaft.

Plunge grinding is the recommended method for shaft finish (fig. 7f). (50x magnification)

Plunge Grinding

Plunge grinding is the recommended method for shaft finish. It produces short, parallel grooves or pockets which hold lubricants without letting them escape (fig. 7f). Other methods, while smooth enough, may create shaft lead or not completely remove lead patterns that may be present.

The wheel used to grind the shaft moves straight into rather than across the surface. This action eliminates any axial movement of the grinding wheel on the shaft surface and prevents spiral grooves (machine lead) that may promote seal leakage.

For plunge grinding to be effective, a cluster head dressing tool must be used. Work at a slow pace (three inches per minute), use a mixed number ratio between grinding wheel rpm and shaft rpm, and take shallow cuts (two thousandths the first pass, one thousandth the second). Run the grinding wheel until it sparks out.

Checking the Shaft for Surface Roughness

Seal manufacturers agree that the optimal shaft surface range is 8 to 17 micro inch Ra (.20µm to .43 µm), with no machine lead. A Talysurf machine can check the surface and calculate average surface roughness.

The average surface roughness appears in a digital readout. A chart provides a "picture" of the actual shaft surface. However, even if the resulting finish falls within the acceptable range, machine lead may still be present.

Testing for the Presence of Machine Lead

Testing the shaft surface for machine lead can be done simply and with a minimum of tools. The most effective method requires a 36 inch (914.4mm) length of cotton quilting thread, a one ounce weight and silicone oil.

Mount the shaft in a chuck so the shaft surface is level. Lightly coat the shaft with oil. Suspend the weight on the thread as shown here. Rotate the shaft at approximately 60 rpm. If the thread moves along the shaft, machine lead is present (fig. 7g).

Testing the shaft surface for machine lead is a simple process requiring a minimum of tools (fig. 7g).

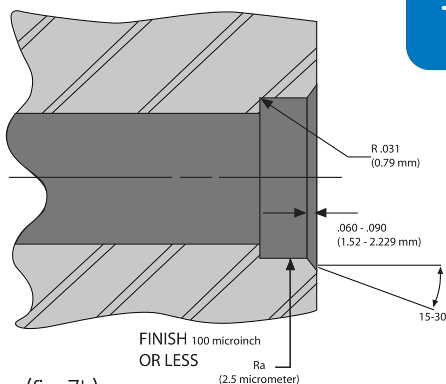
Bore Requirements

The lead corner, or entering edge, of the bore should be chamfered with a 15/30 degree angle and free of burrs. The inside corner of the bore should have a maximum radius of .031 (.79mm). This will help prevent seal damage during installation. Chamfer length should be .060" to .090" (1.50 to 2.29mm); see fig. 7h.

Bore Tolerance

Similar to shafts, the inch (RMA) system for seal bores also uses a "floating" range based on the nominal diameter plus or minus some value depending on the base size. With the metric (ISO) standard however, the tolerances for bores (typically ISO H8) are applied as a plus value/minus zero. Unlike shafts and seal lips, the bore fit for seals can be significantly affected by the tolerance applied to the hardware. For the best results, the correct bore diameter for the tolerance system used should always be observed.

Refer to the *SKF Handbook of Seals* for tolerance data and further information on housing bores.



(fig. 7h)

Bore Hardness

No specific Rockwell hardness is recommended. Bore hardness need only be high enough to maintain interference with the seal's outside diameter.

Bore Material

Ferrous and other commonly used metallic materials (like aluminum) are acceptable for the bore. Bore material must be compatible with the seal type used; if an aluminum bore is used, thermal expansion may have to be considered.

Shaft and Bore Conditions (cont.)

Bore Finish

A bore finish of approximately 100 micro inch Ra (2.54 µm) or smoother (100 to 200 micro inch Ra [2.54µm to 5.08µm] for aluminum), should be maintained to avoid leakage between the seal outer diameter and housing. An inside corner that is too rounded or a corner with too large a radius can cause the seal to distort when pressed into the bore.

SKF applies a coating of Bore-tite to the O.D. on selected metal-clad seals on production quantities at the factory. Seals without Bore-tite can be improved by applying a non-hardening, pliable sealant to the O.D. prior to installation.

Chapter 7 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself) slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1. To help ensure proper seal performance, the shaft _______________ .
   - ❑ a. entrance edge should be chamfered or rounded
   - ❑ b. surface finish should be 8-17 micro inch Ra (.20µm to .43µm)
   - ❑ c. surface should have no machine lead
   - ❑ d. all of the above

1. D

2. _______________ refers to the amount by which the shaft does not rotate around the true center.
   - ❑ a. Shaft-to-bore misalignment
   - ❑ b. Dynamic run-out
   - ❑ c. Shaft diameter
   - ❑ d. none of the above

2. B

3. The recommended method for obtaining an optimum shaft finish is _______________ .
   - ❑ a. paper polishing
   - ❑ b. roto preening
   - ❑ c. plunge grinding
   - ❑ d. diamond burnishing

3. C

4. Seals perform best on Rockwell C30 medium carbon steel (SAE 1035, 1045) or _______________ .
   - ❑ a. stainless steel
   - ❑ b. aluminum
   - ❑ c. bronze
   - ❑ d. zinc

4. A

5. To assure a smooth sealing surface, the shaft should be ground with _______________ rpm ratios.
   - ❑ a. even number (2 to 1)
   - ❑ b. odd number (3 to 1)
   - ❑ c. mixed number (3.5 to 1)
   - ❑ d. none of the above

5. C

Chapter 7 Review (cont.)

6. Spiral grooves (machine lead) may promote seal leakage.
   ❑ True ❑ False

6. T

7. Tumbled stone finishing provides a positive solution to machine lead.
   ❑ True ❑ False

7. F

8. Shaft speeds should be reduced when shaft finish or eccentricity (run-out) is reduced.
   ❑ True ❑ False

8. F

9. Revolutions per minute (rpm) is a better seal selection guide than the surface speed at the contact point between the seal and shaft (fpm: feet per minute).
   ❑ True ❑ False

9. F

10. The shaft surface should be smooth enough to prevent excessive seal wear, but "rough" enough to form lubrication holding pockets.
    ❑ True ❑ False

10. T

11. Ferrous and other commonly used metallic materials (such as aluminum) are acceptable bore materials.
    ❑ True ❑ False

11. T

12. Roto preening is recommended to dress the shaft and remove lead introduced during the machining operation.
    ❑ True ❑ False

12. F

13. Imperfections such as surface burrs, nicks or rough spots on the shaft surface can damage the lip as it slides on the shaft.
    ❑ True ❑ False

13. T

14. Bore material must be metallurgically compatible with the seal type that is used.
    ❑ True ❑ False

14. T

15. Bore-tite on a metal clad seal's O.D. efficiently fills major bore imperfections.
    ❑ True ❑ False

15. F

16. It is acceptable to use inch sized seals in metric sized equipment.
    ❑ True ❑ False

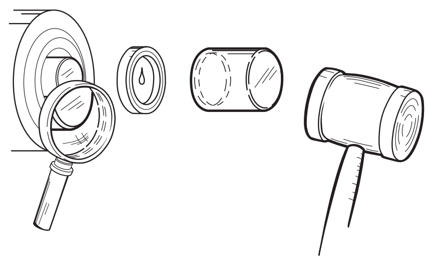
16. F

Chapter 8—Installation

The seal is ready to be installed in the bore once the shaft and bore have been checked and cleaned, and the seal has been pre-lubricated. Be sure to keep the work area and tools clean. Do not unbox the seal until immediately prior to installation. Be careful not to introduce any contaminants into the seal or bearing cavity (fig. 8a).

Inspect the Shaft and Housing

Remove any burrs or nicks which could damage the seal lip or score the O.D. Make sure that the housing and shaft have a smooth, chamfered edge.



Before installing the seal, check to see that the shaft and bore are cleaned and the seal is pre-lubricated (fig. 8a).

Pre-Lubrication

The lip of the seal must be pre-lubed with clean lubricant before the seal is installed. The seal O.D. of metal cased seals can be oiled or installed dry. However, rubber O.D. seals must always be pre-lubricated. This step is important because pre-lubrication aids mounting and provides a film on which the seal rides until there is ample lubricant in the seal cavity.

The best pre-lube to use is the lubricant being retained. This precaution can prevent any problems occurring by mixing two different lubricants together.

Choosing an improper pre-lube could damage the seal lip, causing it to shrink, swell or soften. By using the same lube as that being retained, you can eliminate the possibility of selecting a lubricant with a limit of 200°F (93°C) for an application where the temperature might run as high as 250°F or 300°F (121°C to 149°C).

Proper Installation Procedures

The first step in installation is to confirm that the seal meets the specific application requirements. Always be sure to check the dimensions, orientation of lip, helix direction, and condition of lip before pre-lubing.

To assist in mounting, always be sure to lube the O.D. of rubber covered seals. A light lube can also assist in the mounting of metal clad seals.

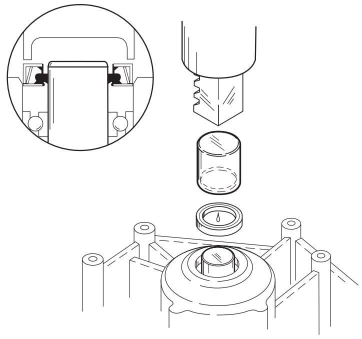
Tools

The best method for seal mounting is to use an arbor or hydraulic press that applies uniform pressure against the seal. Always use a proper size tool to apply installation force. If a press is not available or not practical, use the second best alternative—a round tool. A bearing cup is excellent. If it must follow the seal into the bore, it should be slightly smaller than the outside diameter of the seal. An O.D. .010" (.25mm) smaller than the bore is ideal.

Installation (cont.)

For best results, the center of the tool should be open so pressure is applied only at the outer edge.

The tools used to install seals can often affect seal performance. For instance, a screwdriver may easily cut the seal lip, but make the damage invisible to the eye. Even blunt-end drifts can damage the seal case or distort the seal from its proper working position.



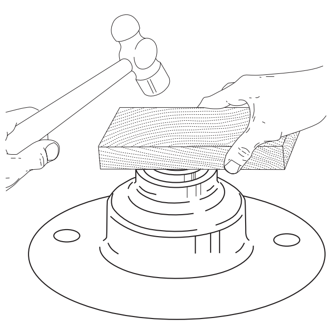
The arbor press installation method provides the uniform pressure needed to overcome seal O.D. press fit (fig. 8b).

Ideal Installation Conditions—Arbor Press

This hydraulic press method is best for providing the uniform pressure necessary to overcome seal O.D. press fit, usually 0.004 to 0.008 inches (0. 102mm to 0.203mm) larger than the bore (fig. 8b).

Before installation, pre-lube the seal. To protect the seal outer shell, apply pressure through an installation collar that contacts the seal near the O.D. and has a relieved center to avoid pressure on the I.D. of the seal face.

When installing the seal in a step bore, be careful not to squeeze or crush the seal case. When installing in a "through" bore, apply pressure through a steel plate or plug larger than bore diameter (to set the seal perpendicular to the shaft).



When using the wooden block installation method, apply force in the area over the center of the seal (fig. 8c).

Alternative Installation Method—Wooden Block Installation

Use of a wooden block as an installation tool is acceptable when the seal is to be installed flush with a housing and no arbor press is available.

Before installation, pre-lube the seal. Use the flat surface of the wood-block to press the seal in place. A steel hammer can be used to apply force to the wood block and to overcome the seal's press fit diameter.

Apply force evenly across the back of the seal. That is, avoid forcing one side of the seal first, thus cocking the seal (fig. 8c). Apply no direct force to the seal I.D.

Whatever tool is used, remember that seating force must be applied and spread out around the entire circumference of the seal. A direct blow on one side of the seal distorts the shell and can cause the lip to be pressed against the shaft. This action produces increased friction between the lip and the shaft surface.

If installation pressure is applied to the seal's inside diameter, the shell is forced upward, lifting the lip from the shaft surface. If the seal is cocked—not perpendicular to the shaft and bore—the result will be too much contact on one side, and not enough on the other.

Careless installation is one of the most common reasons for seal problems. The end-user can prevent these problems by reviewing and following the recommendations on the opposite page.

For best seal performances, use:

- Arbor or hydraulic press
- Wooden block
- Soft-faced hammer or mallet

Installation tools in order of preference:

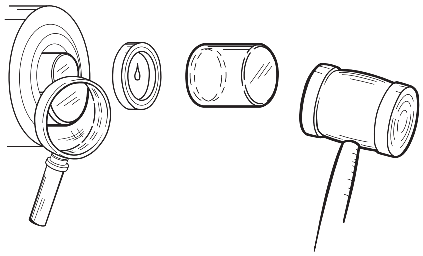
- Tools tailor-made for seal installation
- Standard driving plug
- Old bearing cup
- Wooden block

Sealing damage may result when using:

- Steel hammer
- Drift or punch
- Chisel or screwdriver
- Direct hammer blows on the face of the seal
- Starting seal into the bore at an angle (cocked)

Installation Checklist

1. Check the bore. Remove any burrs from the leading edge. Be sure there is a rounded corner or chamfer (fig. 8d).
2. Check the shaft. Remove burrs, surface nicks, grooves and spiral machine marks (machine lead).
3. Check the shaft end. Remove burrs or sharp edges. If the shaft enters the seal against the sealing lip, its end must be chamfered or a special installation tool must be used.
4. Check splines and keyways. Sharp edges should be covered with a lubricated assembly sleeve, shim stock or tape to protect the seal lip.
5. Check the dimensions. Make sure that shaft and bore diameters match those specified for the seal selected.
6. Check for part interference. Watch out for other machine parts that might rub against the seal and cause friction and damaging heat.
7. Check the seal. Damage may have occurred before installation. A sealing lip that is turned back, cut or otherwise damaged should be replaced.



Remember to check shaft and bore surfaces and pre-lube the seal before installation (fig. 8d).

Installation (cont.)

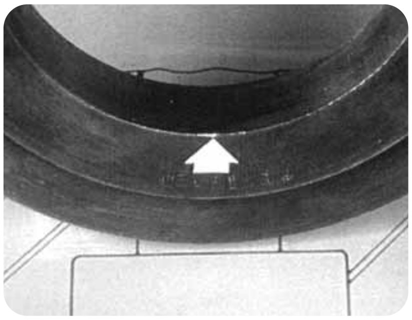
8. Check seal direction. Make sure the new seal faces in the same direction as the original one. Generally, the lip faces the lubricant or fluid being retained.
9. Use the correct installation tool. Press-fitting tools should have an outside diameter approximately .010" (.254mm) smaller than the bore size. For best results, the center of the tool should be open so that pressure is applied only at the outer edge.
10. Pre-lubricate the sealing element. Before installation, wipe the sealing element and shaft with the lubricant being retained. Rubber O.D. seals must be completely lubricated.
11. Never hammer directly on the surface of the seal. Use proper driving force such as a soft face tool, arbor press or soft workpiece (wood). To avoid cocking the seal, apply force evenly around the outer edge.
12. Position the seal properly in the housing and inspect for alignment and installation damage.

Post-Installation Tips

When painting, be sure to mask the seal. Avoid getting paint on the lip, or the shaft where the lip rides. Also, mask the vents so they will not become clogged.

If paint is to be baked or the mechanism otherwise subjected to heat, the seals should not be heated to temperatures higher than their materials can tolerate.

In cleaning or testing, do not subject seals to any fluids or pressures that could damage them. Check the Compound Selection Chart in the *SKF Handbook of Seals* when in doubt. Improper installation procedures will result in early seal failure. Three of the most common installation errors are detailed below.



A cut on the seal lip can be caused by shaft burrs (fig. 8e).

Common Installation Errors Damage from Shaft Burr

Symptoms

Shaft burr damage is evidenced when early lip leakage signals there is a cut (usually visible) in the seal lip.

Causes

This cut was probably caused by a burr on the shaft which caught and tore the seal lip. A burr on the spline or keyway of the shaft may have caught the seal lip (fig. 8e). It also could be caused by not chamfering the leading edge of the shaft or bore.

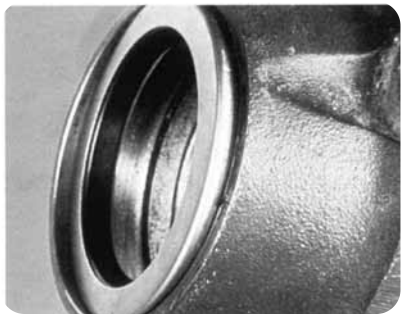
Corrective Actions
Inspect the mating surfaces of the bore and shaft. Remove any burrs and nicks from the bore and shaft. Tape the keyway or spline, then lubricate it. Chamfer the leading edges of the bore and shaft. Pre-lube the seal to ease its installation over the shaft. Use a cone or sleeve made from shim stock to slide the seal over the shaft.

Common Installation Errors—Cocked Seal

Symptoms
Markings can be tell-tale signs that the seal was cocked (tilted) during installation.

Light scratches on the front of the seal would appear when the case was first inserted. Since the seal was cocked, it takes additional force to seat the back half. This extra force causes heavier markings on the back of the seal (fig. 8f).

Other symptoms include early lip leakage, high or low wear on the lip or wide wear on the shaft.


Markings on the case or metal insert signal the seal was cocked during installation (fig. 8f).

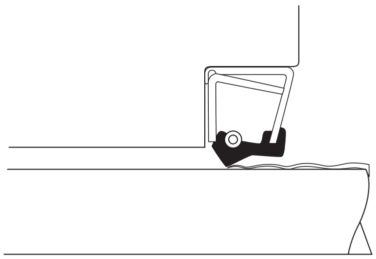
Causes
A seal can be cocked if uneven pressure was applied during installation or if the entering edge of the bore was not chamfered. Also, the housing could have been cocked during installation. This can occur during arbor press assembly if foreign material gets under the housing.

Corrective Action
If the seal is cocked, you must remove the cocked seal and put in a new one, applying uniform force to the seat during press fit installation. Be sure to use the correct tools and procedures to be sure the new seal is straight.

Common Installation Errors—Damaged Seal Case

Symptoms
Immediate lip leakage usually occurs when the case is damaged, out of round, or bent.

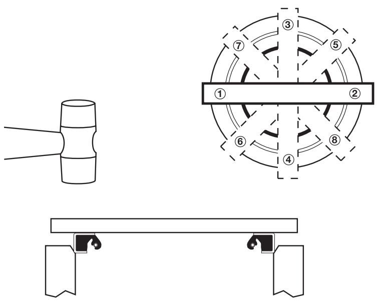
Causes
This can occur when pressure is applied incorrectly or unevenly during installation, or if improper tools that can damage the seal case are utilized. After the seal bottoms out in a step-bore, continued pressure will bend the case inward (fig. 8g).


Uneven installation pressure can damage the seal case, causing lip leakage (fig. 8g).

Installation (cont.)

Corrective Actions

Use the correct tools and procedures to apply uniform pressure to press fit the seal in the housing.



To install a large diameter seal, tap around the seal in the sequence shown above (fig. 8h).

Large Diameter Seal Installation

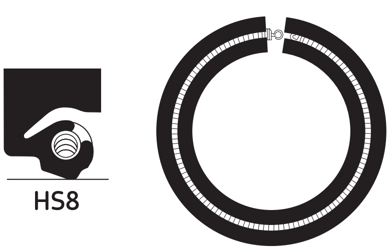
Installation of a large diameter seal follows the same procedures as those used in standard seal installation. Follow these steps:

- Check the bore, shaft, shaft ends, splines and keyways, for imperfections, dirt and anything that shouldn't be there.
- Check dimensions. Be sure the correct seal size has been selected.
- Check for parts interference. Watch out for metal-to-metal contact between the seal shell and shaft surface.
- Check the seal. Is it the right style for the application?
- Check seal direction. The seal lip should be pointed toward the lube for retention, or away from the lube for dirt exclusion.
- Pre-lube the sealing element. Always use the same lubricant as the one used in the application.
- Position the seal properly. Be sure it sits squarely in the bore.

During installation, never hammer directly on the seal. Because of their size, it is often not possible to apply uniform pressure across the seal at one time.

For flush installation:

Use a board or wooden block to progressively tap the seal into the bore. A little at a time, gradually ease the seal into the bore. Gently tap at 9 o'clock, 3 o'clock, 12 o'clock and 6 o'clock positions to avoid cocking the seal (fig. 8h).



Connect the split seal's spring after the seal is placed around the shaft (fig. 8i).

Large Diameter Split Seal Installation

A large diameter split seal is correctly installed by following these steps:

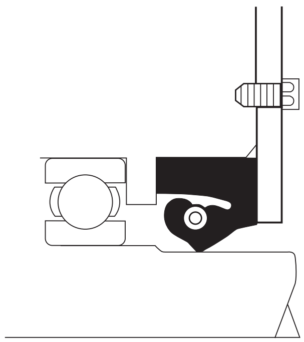
- Lightly lubricate the seal's O.D. and inner lip.
- Apply the seal around the shaft, positioning it at the desired location with the butt ends of the seal at the 12 o'clock position.
- Make the spring connection (see following section for details) (fig. 8i).
- Tap the seal in place, alternately striking lightly around its circumference.
- Install the cover plate.

Split Seal Fitting

All HS seals require a cover plate (fig. 8j). The cover plate provides the compression fit necessary to ensure a leakproof seal. It should be thick enough .250" to .500 inches (6.3mm to 12.70mm) not to bend or distort. The cover plate should also be secured by bolts or studs no more than 6" (152.40mm) apart on the bolt circle. Splitting the cover plate in two or more sections will make seal replacement easier, particularly in confined areas.

To block surges of lubricant toward the seal from the inside and to protect the seal from damage from the outside, the cover plate I.D. should be as close as practical to the shaft. Generally, 1/4" (6.3mm) over shaft size is sufficient for clearance in the presence of moderate shaft misalignment and run-out.

If supplementary sealing is required but it is impractical to machine the original housing, the seal cavity may be incorporated into a new plate which is then bolted into place.



Cover plates ensure a leakproof seal (fig. 8j.)

Procedure

- Lightly lube seal O.D. and inner lip.
- Put seal around shaft.
- Install spring into its groove if required
- Make spring connection.
- Install butt-ends first at 12 o'clock position.
- Tap into place, alternately striking around seal.
- Install cover plate.

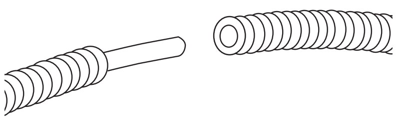
8

Installation (cont.)

Split Seal Connectors

There are three types of stainless steel spring connectors for SKF split seals:

- Control-wire
- Hook and eye
- Threaded



The control-wire connector fits into the core of the garter spring (fig. 8k).

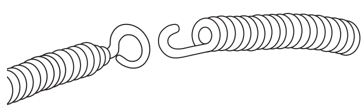
Control-Wire Connector

Making the split seal easy to install, the control-wire connector offers these features, benefits and limitations:

- The connector wire slips into the core of the garter spring for connection (fig. 8k).
- The Spring-Kover keeps the spring in place.

Of the three types of connectors, this provides the least secure spring connection. The seal ends might not join completely due to the ease of assembly feature.

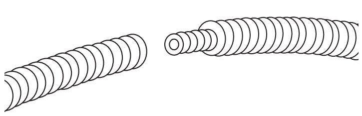
It is recommended only for horizontal shafts running at speeds below 1500 fpm (7.62 m/s), retaining grease. It is used only with SKF's HS7 seal design.



The hook and eye provides positive spring connection on seals for larger (18" diameter) shafts (fig. 8l).

Hook and Eye Connector

The hook and eye (fig. 8l) assembles easier than threaded connectors, and provides a positive spring connection. It is used only on seals for shaft diameters over 18.001 inches (457.23mm), or by special order.



Threaded connectors provide positive spring connection on seals for shaft diameters under 18" (fig, 8m).

Threaded Connectors

Most difficult to install of the three, threaded connectors (fig. 8m) provide the most positive connection of the spring. They are used on smaller seals, for shaft diameters up to 18 inches (457.22mm) or by special order.

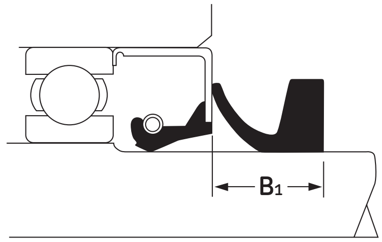
V-Ring Installation

These step-by-step procedures will assure correct SKF V-Ring installation:

- Clean the shaft and counterface. Make sure there is no grease or oil on the V-Ring's shaft seating surface.
- Apply a light coat of molycote, grease or silicone oil to the counterface or lip. This will minimize break-in wear as well as maximize the V-Ring's service life.
- Mount the V-Ring by hand. It should be stretched uniformly around the shaft (it can be stretched up to 2 1/2 times its molded diameter).
- On shaft diameters over 19.685 inches (500mm), run a blunt tool between the V-Ring and the shaft to assure uniform stretch. Make sure the V-Ring is located clear of housings or projections.

V-rings should be selected for the shaft size being used and mounted on the shaft based on the "B_1" dimension, or distance from the rear base of the ring to the surface its lip is contacting. It is called the "width of seal" in the *SKF Handbook*. Other key installation dimensions are the D2, or maximum gap between the shaft and housing and D3, the minimum radial clearance around the V-ring.

While the V-ring can stretch to fit on the shaft, sometimes it is necessary to cut the ring, fit it around the shaft and rejoin the ends. It is possible to use cold or hot bonding methods, depending on the operating conditions. SKF offers special instructions for bonding the rings based on which compound is involved.



V-Rings should be mounted to their "B_1" dimension (fig. 8n).

Chapter 8 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1. The seal is ready to be installed in the bore when _______________ .
   - ❑ a. the shaft and bore have been checked and cleaned
   - ❑ b. the seal has been pre-lubricated
   - ❑ c. both of the above
   - ❑ d. none of the above

1. C

2. For best seal performance, use a(n) _______________ or soft-face hammer for seal installation.
   - ❑ a. screwdriver
   - ❑ b. arbor press
   - ❑ c. chisel
   - ❑ d. steel hammer

2. B

3. Press-fitting tools should have an outside diameter approximately _______________ the bore size.
   - ❑ a. .010" (.254mm) smaller than
   - ❑ b. .010" (.254mm) larger than
   - ❑ c. equal to
   - ❑ d. none of the above

3. A

4. Seals which are to be flush with the outside of the housing can be pressed in with a _______________ .
   - ❑ a. drift
   - ❑ b. punch
   - ❑ c. block of wood
   - ❑ d. chisel

4. C

5. The wrong installation tool can _______________ .
   - ❑ a. cut the seal lip
   - ❑ b. damage the seal case
   - ❑ c. distort the seal
   - ❑ d. all of the above

5. D

6. A sealing lip that is cut, turned back or damaged should be _______________ .
   - ❑ a. repaired
   - ❑ b. replaced
   - ❑ c. cleaned
   - ❑ d. chamfered

6. B

7. Careless installation is a common reason for seal problems.
❑ True ❑ False

7. T

8. In wooden block installation, the sealing force of the installation tool should be applied uniformly across the seal case, not concentrated in the center.
❑ True ❑ False

8. T

9. A cocked seal is perpendicular to the shaft and bore.
❑ True ❑ False

9. F

10. Shaft and bore diameters should match those specified for the seal selected.
❑ True ❑ False

10. T

11. An arbor press does not apply uniform pressure against a seal.
❑ True ❑ False

11. F

12. A direct blow on one side of the seal distorts the shell and can cause the lip to be pressed against the shaft.
❑ True ❑ False

12. T

13. The new seal should face the opposite direction of the original one.
❑ True ❑ False

13. F

14. Using the arbor press method to set the seal perpendicular to the shaft when installing a "through" bore, apply pressure through a steel plate or plug larger than bore diameter.
❑ True ❑ False

14. T

15. The best pre-lube to use is the lubricant being retained by the seal.
❑ True ❑ False

15. T

16. V-rings can not be stretched when installing them on shafts.
❑ True ❑ False

16. F

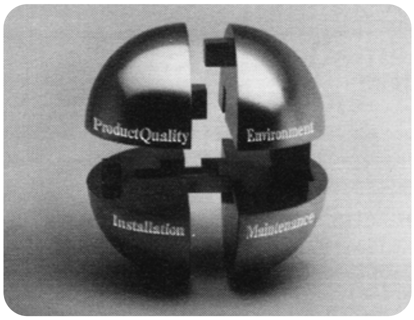
17. Control wire connections on HS7 split seals can be used for oil sealing applications
❑ True ❑ False

17. F

18. With V-rings, it doesn't matter where they are positioned on the shaft so long as the shaft diameter is correct.
❑ True ❑ False

18. F

Chapter 9—Troubleshooting



Preliminary Survey

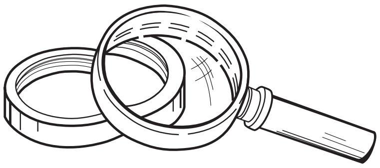
The best way to troubleshoot is to follow a sequence of steps that should lead you to the problem.

- What was the seal supposed to do? How well has it done the job in the past? If there is a history of failures, the problem may not be caused by the seal itself.
- Was it the right seal? Check the seal's part number and look up its recommended applications. If the correct seal has been installed and there is no history of repeated failures, the problem requires further investigation.
- Pinpoint the source of the leak. It may be either an I.D. leak or an O.D. leak. Also, find out when the leak first occurred and see if this relates to a change in maintenance or operating procedures.
- In the case of exceptional seal wear, what is the cause of this wear? To find out requires failure analysis.

Basic Steps in Analyzing Sealing System Failures

Follow these steps in determining why a seal has failed:

- Inspect the seal before removal to check the condition of the area, note the amount of leakage that has occurred, and determine the source of the leakage (fig. 9a).
- Wipe the area clean and inspect to determine if:
  - There are nicks on the bore chamfer,
  - The seal is cocked in the bore,
  - The seal was installed improperly,
  - There is shaft-to-bore-misalignment,
  - The seal is loose in the bore,
  - The seal case is deformed, and/or
  - There is paint on the seal.
- Rotate the shaft to determine if there is excessive end play or excessive run-out.



Inspect the seal and check for signs of failure (fig. 9a)**.**

If the leakage cannot be located, follow this procedure:

- Add ultraviolet dye to the sump or spray the area with white powder.
- Operate for 15 minutes.
- Use ultraviolet or regular light to check for leakage.
- Mark the seal location at 12 o'clock and remove it carefully. Check for nicks on the bore chamfer.

With the seal removed, check for:

- Rough bore surface.
- Shaft cleanliness (is it clean and free of carbon?)
- Coked lube on the shaft.
- Shaft damage.
- Flaws or voids in the bore.
- Shaft corrosion.
- Shaft discoloration.

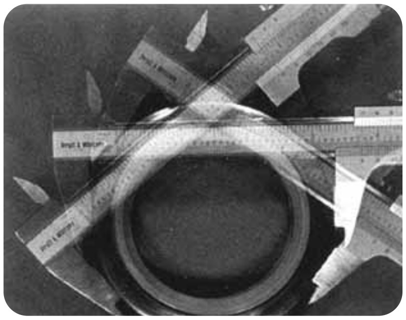
Identify the seal style and materials. Then inspect it for:

- Primary lip wear.
- Primary lip conditions.
- Seal O.D. wear/damage.
- Spring damage.

Proper Seal Measurement

Two of a seal's measurements are its outer diameter (O.D.) and its inner diameter (I.D.). To determine these, follow these procedures:

- To measure the O.D. of a seal, take three measurements equally spaced around the outside of the seal. The average of the three is the seal's O.D (fig. 9b).
- A metal O.D. seal is generally 0.005 to 0.016 inches (0. 13mm to 0.41mm) larger than the bore, for press fit.
- A rubber O.D. seal is generally 0.008 to 0.020 inches (0.20mm to 0.51mm) larger than the bore, for proper compression and interference fit.
- The inner diameter is more difficult to measure. Take about five I.D. readings, average them and add an interference figure to the lip I.D. to reach the approximate shaft I.D. (see Catalog 457010).
- Alternatively, use the shaft O.D. as the seal I.D. Then refer to size listings in the *SKF Handbook of Seals*, for determining the correct seal part number.



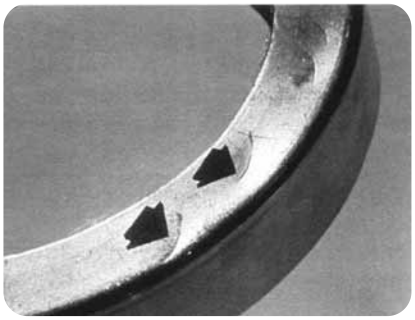
The average of three measurements around the outside of the seal is the seal O.D. (fig. 9b).

Common Sealing Problems

Common sealing problems, their causes and solutions, are detailed below.

Hammer Damage

Some obvious signs of hammer damage include visible dents on the seal back, a distorted sealing element, or a garter spring that pops out (fig. 9c).



Visible dents on the seal back are symptoms of hammer damage (fig. 9c).

Troubleshooting (cont...)

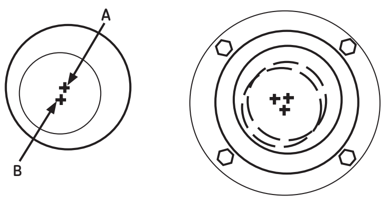
Causes

Such hammer damage can be caused by using a steel hammer on the seal housing during installation.

Corrective Actions

Never hammer directly on the seal. Seals which are to be flush with the outside of the housing should be pressed in with an installation tool larger than the seal O.D. or with a block of wood. In this case it is acceptable to use a steel hammer, a dead blow hammer or soft-faced hammer on the wooden workpiece.

When the blow is going through steel (such as a bearing ring), use a soft-faced or dead-blow hammer or mallet. This type of tool, like a block of wood, absorbs the shock wave created by the tool's impact. A hammer blow without any material to absorb the shock wave can dislodge the garter spring from its proper operating position. Once the spring is out of position, the seal will fail. It may even interfere with the action of the seal lip, or find its way into the bearing.



Shaft-to-bore misalignments (left) and dynamic run-out (right) both cause early lip leakage (fig. 9d).

Shaft-to-Bore-Misalignment Dynamic Run-Out

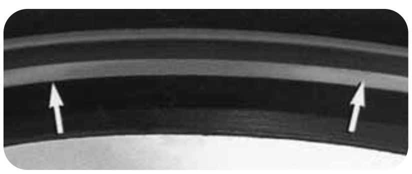
Early lip leakage, excessive (uneven) lip wear on one side of the seal, and/or excessive but consistent lip wear all around are symptoms of shaft-to-bore-misalignment or dynamic run-out.

STBM
Misaligned components in a power train create Shaft to Bore Misalignment (STBM) and leaks. The seal lip will appear worn on one side and relatively untouched on the other. Shaft alignment should always be checked before installing a new seal (fig. 9e).

Causes

Shaft-to-bore-misalignment (STBM) is a condition of excessive misalignment created by inaccurate machining, shaft bending, lack of shaft balance or worn bearings (fig. 9d and fig. 9e). Dynamic run-out (DRO) is a similar condition where the shaft does not rotate around its true center (fig. 9d and fig. 9f).

If you find a leaking seal with a wide wear band on one side, but a narrow band on the other, you can suspect high STBM (unless O.D. markings indicated the seal was cocked). The lip area with the greatest wear indicates the direction of shaft misalignment.



DRO
Dynamic Run Out (DRO) is the result of a bent, unbalanced or misaligned shaft. The sealing lip will be severely worn around the entire diameter. A dial indicator attached to the bore or housing while the shaft is rotated through 360° will reveal DRO. (fig. 9f).

Initial leakage will generally occur in the area that shows little or no seal wear. This is because of inadequate lip contact. But as the worn side is hardened from excess pressure and heat, it may crack and cause additional leakage.

Corrective Actions

Check the shaft-to-bore alignment, and adjust it. Inspect the shaft and bore before installing the replacement seal. Replace worn bearings.

Lip Wear

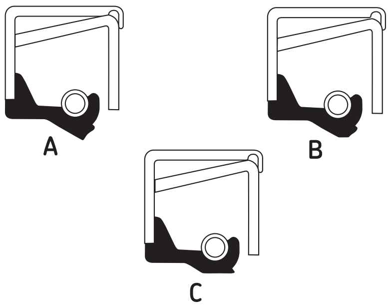
Look for clues in the sealing member of the seal. A small cut, nick or abrasives continually laying at lip/shaft interface could be the source of the leak. But if everything looks intact, it's time to look at the wear pattern of the lip (fig. 9g).

Causes

A new seal which has never been installed has a sharp edge at the contact point. Following a period of normal operation, the lip's sharp edge will be flattened some by normal wear. If the lip has been substantially worn away, the seal may not be getting enough lubrication, the shaft may be corroded, the vent in the lube system may be blocked, or the finish too rough. Extreme wear could also be caused by shaft-whip (DRO). It could also be caused by excess pressure or by misalignment (STBM).

Corrective Actions

Check the shaft-to-bore alignment. Correct the alignment. Provide proper lube for the seal if there isn't enough. Repair the shaft if the shaft is not properly finished. Use a seal designed to exclude abrasive contaminants if there is an abrasive build-up. Clean and open vents that are blocked to reduce pressure. If conditions warrant, consider using a seal designed for high pressure.



The illustration above compares the lip on a new seal (A) to one with normal wear (B) and one with excessive wear (C) (fig. 9g).

Outer Case Damage

A "curled" or rolled edge of the seal metal case indicates damage. The damaged zone may feel rough.

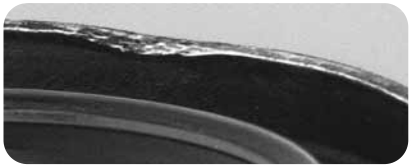
Causes

The housing bore may have a square corner or not have had a proper lead-in chamfer. Without it, the seal may bind on insertion. This can cause cocking or create a beveled or rolled end for part of its circumference. It's also possible that the bore diameter and tolerance are incorrect.

Corrective Actions

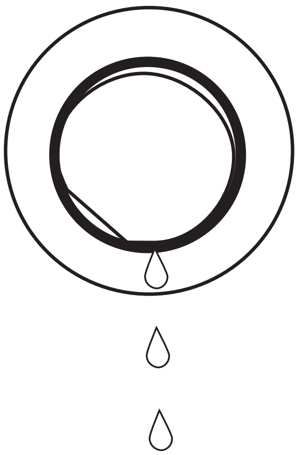
Insure that the bore does not start with a square corner. Per industry standard, it should have a 15˚-30˚ angle and the corners should be smooth and free of burrs. Confirm that the bore size is correct for the seal.

Examining the Outer Shell



No Chamfer

The beveled edge (chamfer) on the leading edge of the bore provides a ramp for starting the seal straight. Without it, it is virtually impossible to get the seal installed correctly. A 15˚-30˚ angle, clean and burr free, is recommended. (fig. 9h).



An out-of-round shaft can also cause seal leakage (fig. 9i).

Troubleshooting (cont...)

Out-of-Round Shaft

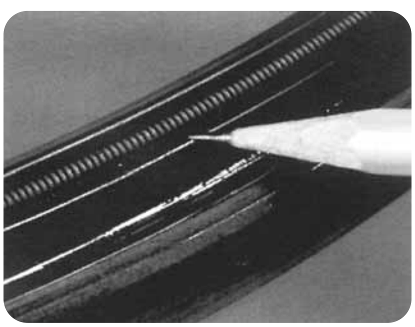
Early lip leakage is also a symptom that the shaft is out-of-round (fig. 9i). Industry specifications are listed in the 457010 *SKF Handbook of Seals.*

Causes

Inspect the shaft to see if it is out-of-round. Flat spots on the shaft can also cause early lip leakage.

Corrective Actions

Check the shaft's "roundness" by measuring with a micrometer in three equally spaced points circumferentially near the location of the seal. Tolerances should be within the allowable range for the shaft size. Be sure the shaft is carbon or stainless steel, finished 8 to 17 micro-inch Ra (0.20µm to 0.43µm), with no machine lead. One solution is to remove and resize or reshape the shaft first. Then repair the shaft with either a Speedi-Sleeve or an SKF Large Diameter Wear Sleeve.



Garter spring problems are visible and easy to spot (fig 9j).

Garter Spring Damage

Garter spring problems are easy to spot. The spring may be loose, or out of the seal. The spring may pop out and damage the mechanical components. Or, the spring may be missing (fig. 9j).

Causes

Maybe the spring was never installed in the seal. Perhaps it was dislodged from the seal prior to installation. Or maybe too much shock was transmitted to the seal during installation.

Corrective Actions

The only solution is to install a replacement seal. But first, check the spring on the new seal. It could have become dislodged during packaging or shipment. If so, install the spring into the seal. Use correct mounting tools and follow correct installation procedures. Be sure to apply press fit force uniformly.

Cut Seal Lip

Ever-so-slight seal leakage is evidence that there may be a small nick or cut in the sealing lip (fig. 9k).

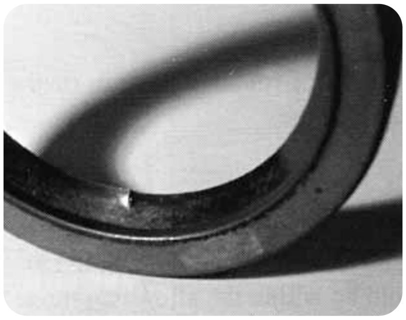
Causes

It may have been caused by a burr on the keyway, spline or shaft end.

Corrective Actions

Follow these steps to correct and prevent cuts on the seal lip:

- Use a deburring tool or emery cloth to remove any burrs. Use correct mounting tools to protect the seal lip from sharp edges. Be sure to tape the keyway or spline. Handle seals carefully. Keep seals packaged during storage or while in transit.



A nicked seal lip also causes lip leakage (fig. 9k).

Lube Breakdown

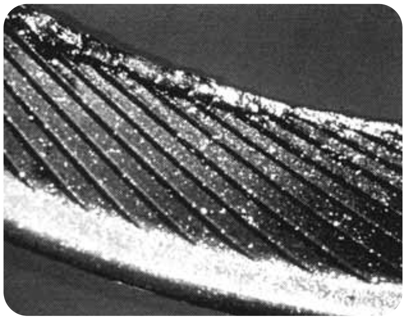
Sludge or varnish-like deposits on the seal lip and/or shaft are symptoms of lube breakdown (fig. 9l).

Causes

Sometimes heat is high enough to break down the oil, but not enough to harden the lip. In this case, sludge accumulates and is deposited on the seal lip.

Corrective Actions

Reduce operating temperature if possible, or use a seal designed for high temperatures (fluoroelastomer type). Be sure to use proper lubricant for the seal. It also helps to change the oil regularly.



Sludge deposits on the seal lip indicate lube breakdown (fig. 9l).

Heat Checking

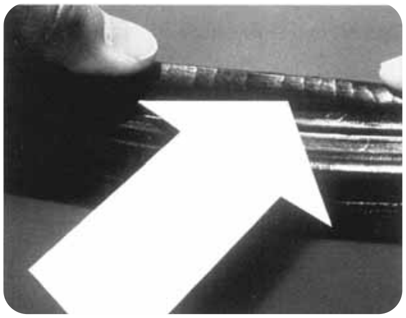
Heat checking or cracking is another common sealing problem. This may be evidenced by a hardened seal lip or fine cracks that show up in the seal lip surface (fig. 9m).

Causes

These problems with the seal may be caused by an operating temperature greater than the lip material maximum. Other reasons for heat cracking are excessive surface speeds or insufficient lubrication at the seal lip.

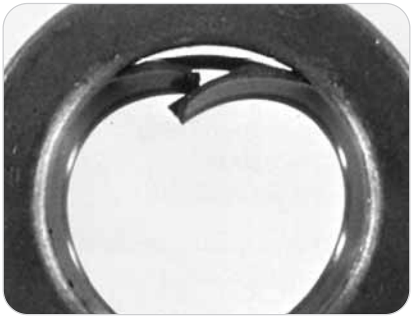
Corrective Actions

One possible solution is to reduce the temperature or select a seal material with a higher temperature range. In the other cases, change the lip material to one that is compatible with the lube or provide proper lube for the seal. For high pressure applications, be sure to use a seal designed for that purpose, such as CRWA5.



Fine cracks in the seal lip are visible signs of excess heat or pressure (fig. 9m).

Troubleshooting (cont...)



Too much pressure can rupture the seal lip (fig. 9n).

Pressure Blow-Out

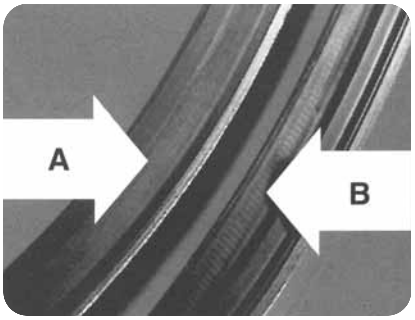
Another visible seal problem is a ruptured or inverted seal lip. Either problem results in lip leakage (fig. 9n).

Causes

Pressures exceeding seal design limitations can cause seal rupture, inverted lips and resultant lip leakage.

Corrective Actions

Check the seal cavity for excess pressure. Provide vents to reduce pressure, or use a seal designed for high pressure applications (CRWA5).



Extreme lip wear (B) is a sign of excess pressure. Note the lip with pressure (A) (fig. 9o).

Pressure Lip Wear

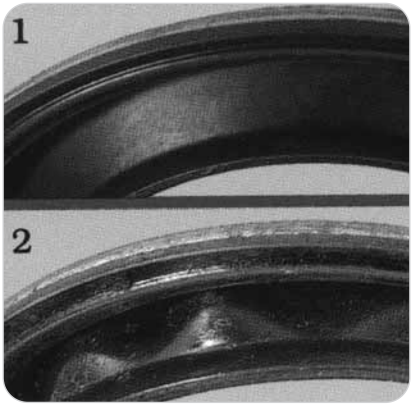
Signs of excessive pressure include extreme lip wear and lip leakage.

Causes

Excess pressure can crush the lip against the shaft. Heavy friction will eventually force the garter spring through the lip. Excess pressure can blow the lip completely off (Fig. 9o).

Corrective Actions

We recommend two ways to prevent seal failure caused by excessive pressure. First, check the air vents to be sure they are clean. If not open them to reduce pressure. Dirt or paint may block proper air flow. Second, if the system is clean, try using a medium pressure seal such as the CRW5 and CRWA5. Make sure the system operating parameters are within the seal's capability.



Chemical swelling
Incompatibility between the lip material and the operating media, including lubricants, can produce major swelling of the seal material. Above is a before (1) and after (2) example of the gross damage you may see from chemical incompatibility.(fig. 9p).

Chemical Swelling

A swollen, distorted appearance of the seal rubber element combined with a "soft" feel can indicate incompatibility between the lip compound and the media being retained or excluded.

Causes

The rubber is experiencing swell, an increase in volume resulting from the compound absorbing the attacking media. This displacement of the rubber molecular structure reduces the physical strength of the rubber leading to rapid wear and failure. In extreme cases, the rubber may dissolve completely. With some compounds, heat or other agents can also be responsible.

Corrective Actions

Consult seal catalogs and investigate to make sure that the selected seal compound is acceptable for the media and operating conditions. Sometimes a rubber type can be sensitive to a particular media but still be adequate in the expected application but in other cases it can be ruined.

Chapter 9 Review

To take this test, simply place a card or sheet of paper under the first question. After you've read it (and answered it to yourself), slide the paper down below the next question. The correct answer to the first problem will appear directly to the right of the new question. Be sure not to skip any questions.

1. Premature seal failure can be caused by ________________ .
   - ❑ a. nicks on the bore chamfer
   - ❑ b. improper seal installation
   - ❑ c. shaft-to-bore misalignment
   - ❑ d. all of the above

1. D

2. If a seal's lip shows premature wear ________________ .
   - ❑ a. the seal may not be getting enough lubrication
   - ❑ b. the shaft may be corroded
   - ❑ c. the finish is too rough
   - ❑ d. all of the above

2. D

3. A cut lip seal may have been caused by ________________ .
   - ❑ a. a damaged seal housing
   - ❑ b. shaft discoloration
   - ❑ c. coked lube on the shaft
   - ❑ d. a burr on the keyway

3. D

4. Pressures exceeding seal design limitations can cause ________________ .
   - ❑ a. seal rupture
   - ❑ b. inverted lips
   - ❑ c. lubricant leakage
   - ❑ d. all of the above

4. D

5. Heat checking or cracking is sometimes caused by lack of lubrication.
   ❑ True ❑ False

5. T

6. The only solution to garter spring damage is to install a replacement seal.
   ❑ True ❑ False

6. T

7. If high operating temperatures cannot be reduced, fluoroelastomer type seals (SKF LongLife) can be used because of their higher temperature range.
   ❑ True ❑ False

7. T

Chapter 9 Review (cont...)

8. Garter spring damage requires careful inspection, often necessitating calling in an "expert."
   ❑ True ❑ False

8. F

9. For out-of-round shaft repairs, a Speedi-Sleeve or SKF Large Diameter Wear Sleeve is often a better solution than shaft removal and reshaping.
   ❑ True ❑ False

9. F

10. When examining for STBM, the lip area with the least wear indicates the direction of shaft misalignment.
    ❑ True ❑ False

10. F

11. When using a wooden workpiece for flush installation of a seal, it is acceptable to use a steel hammer.
    ❑ True ❑ False

11. T

12. Because seal I.D. is easy to measure, only three measurements need to be taken and averaged.
    ❑ True ❑ False

12. F

13. When determining the cause of a leak, remove the seal immediately and inspect it.
    ❑ True ❑ False

13. F

14. If there is a history of seal failures for a particular installation, the problem may not be the seal's fault.
    ❑ True ❑ False

14. T

15. A hammer blow without any material to absorb the shock wave can dislodge the garter spring from its proper operating position.
    ❑ True ❑ False

15. T

16. A swollen appearance and soft feel to a seal's rubber element probably indicates chemical incompatibility with the system media.
    ❑ True ❑ False

16. T

17. There is no problem installing a seal into a bore without a lead-in chamfer.
    ❑ True ❑ False

17. F

Glossary of Seal Terms

Abrasives – Materials that cause wear, friction or irritation

All-Rubber Seals – A non-metal clad seal made of rubber commonly used where space limitation and installation difficulties are a major consideration. Two basic types of HS all-rubber seals are solid and split, both require a cover plate for proper compression and sealing.

Auxiliary Lip – See Secondary Lip

Axial Seal – Applies force along the direction of the shaft, usually between one moving and one stationary element. Examples: carbon face seal, V-Ring.

Axial Clamp Split Seal – Made of nitrile, these compact seals operate against a rotating step or roll face. Recommended for large diameter applications where there is the need for a second seal to exclude dirt.

Bearing – An anti-friction device that supports, guides, and reduces friction between fixed and moving machine parts. Rolling bearings rely on balls or roller elements riding within raceways on a thin film of lubricant. Plane or sleeve bearings use only a lubricant film.

Bi-rotational Seal – A rotary shaft seal which will seal fluid regardless of direction of shaft rotation.

Bond – The adhesion established by vulcanization between two cured elastomer surfaces, or between one cured elastomer surface and one non-elastomer surface.

Bonded Seal – Design feature of a type of radial lip seal. The heel of the sealing element is attached (bonded) to the seal case by an adhesive during the molding operation.

Bore – See Seal Bore.

Bore-tite – A sealant that fills small bore imperfections.

Bottom Out – Installation of a seal into a groove until it reaches the end of possible travel. Additional force should not be used or damage can result.

Buna-N – See nitrile.

Burr – A rough edge on metal or other material after it has been cast, cut, or drilled.

Case, Bonded – A design feature of a type of radial lip seal wherein the heel of the sealing element is attached to the seal case by an adhesive during the molding operation.

Case, Inner – A rigid, cup-shaped component of a seal assembly, which is placed inside the outer seal case.

Case, Outer – The outer thin-wall rigid structure of the lip-seal assembly which contains the inner case, the primary-seal ring, the spring parts, and the secondary seal.

Case, Seal – A rigid member to which the seal lip is attached.

Case Width – The total axial width of the seal case.

Cavity, Mold – A single unit or assembly of contoured parts in which a material, such as an elastomer, is shaped into a particular configuration.

Cavity, Seal – The annular area between a housing bore and a shaft, into which a seal is installed.

Chamfer – A surface that has a groove cut in it or the edge or corner is cut off; beveled.

Cocked – An installation in which the plane of the outside seal face is not perpendicular to the shaft axis.

Compound – A substance or material formed by the combination of two or more otherwise independent elements.

Contaminants – Foreign matter on the seal surface.

Contact Pressure – The average pressure exerted by a seal on a shaft. This pressure is computed dividing the total lip force by the total lip area. Also referred to as radial load.

Counterface – The end of a bearing, a washer, a steel stamping, or even the back of an oil seal shell.

Cover Plate – Metal plate used to compress all rubber (HS) seals in the bore and hold them securely.

Glossary of Seal Terms (cont...)

Diameter – A straight line segment passing through the center of a figure, especially of a circle or a sphere.

Diameter, Trimmed Lip – The lip diameter in the free state (no spring) developed by knife trimming the molded portion of the sealing element to form the contact line.

Diamond Burnishing – A method of shaft surface finishing in which the burnishing medium moves axially.

Double Lip – Use of two sealing elements. One is usually spring loaded, the other not. However, can also have two spring loaded lips. Can be opposed or in same direction.

Duralip - SKF's special nitrile compound for extreme abrasion resistance. Recommended where scale, sand, grit, dirt or other highly abrasive materials are present.

Duratemp – A special compound based on hydrogenated nitrile (HNBR) Duratemp offers improved tensile strength and resistance to heat, abrasion, hardening in hot oil, ozone and weathering effects.

Dynamic Run-Out (DRO) – The amount by which the shaft does not rotate around its true center.

Dynamic Seal – A seal which has rotating, oscillating, or reciprocating motion between it and its mating surface, in contrast to a stationary-type seal, such as a gasket.

DIN – "Deutcshes Institute fur Normung" German standards organization that is a member of International Standards Organization (ISO).

Eccentricity, Lip I.D. – See: variation, radial wall.

Eccentricity, Shaft – The radial distance which the geometric center of a shaft is displaced from the axis of shaft rotation.

Elastomer (Lip Material) – An elastic rubberlike substance, such as natural or synthetic rubber.

End-Play – A measure of axial movement encountered or allowed, usually in reference to the shaft on which the seal lip contacts.

EP lubes – "Extreme Pressure" lubricants which contain additives to increase the strength of the lubricant film. These additives can include sulfur, chlorine, or phosphorus compounds that can attack the sealing materials.

Exclusion – The prevention of dirt, water and contaminants from entering the bearing cavity.

Flange – A protruding rim or edge used to strengthen an object or hold it in place.

Flinger – Synonym: slinger.

Fluid Side – Side of the seal which normally faces the fluid being sealed.

Fluoroelastomer – A saturated polymer in which hydrogen atoms have been replaced with fluorine. It is characterized by excellent chemical and heat resistance.

FPM – Feet per minute; used as a measure of shaft speed instead of rpm. To convert rpm into fpm, use the formula: .262 x rpm x shaft diameter (inches) = fpm.

Garter Spring – A Helically coiled spring wire with its ends connected to form a ring. It is used for maintaining a sealing surface between the sealing element and a sealing surface.

Glass Bead Blasting – A method of shaft surface finishing in which the shaft surface dimples.

Grinding Wheel-To-Shaft-Ratio – A number ratio between grinding wheel rpm and shaft rpm. The whole number is proportionate to the number of lead grooves formed in the shaft. For example, at a 2 to 1 ratio, one groove on the grinding wheel will form two lead grooves on the shaft surface.

Groove, Spring – A depression formed in the head of the section of the seal. It is generally semicircular in form and serves to accommodate and locate the garter spring.

Hardness – The resistance to indentation. Measured by the relative resistance of the material to the indentor point of a standard diameter test instrument. The Shore A scale is commonly used for rubber materials. For steel a Rockwell Hardness Tester is used with the Rockwell or Brinnel hardness scale.

Helical – Shaped like a helix; a three-dimensional curve that lies on a cylinder or cone and cuts the elements at a constant angle; a spiral form.

Helix Seal – An elastomeric hydrodynamic lip seal having helical ribs on the outside lip surface.

Housing – A rigid structure which supports the seal assembly with respect to the shaft.

Housing Bore – A cylindrical surface which mates with the outside surface of the seal outer care (also referred to as a seal bore).

Hydraulic – Use of fluid pressure to perform work. Examples include cylinders, accumulators, motors, motor drives and pumps.

Hydraulic/Pneumatic Seals – Seals used to contain fluid or gas pressure and protect them from contamination.

Hydrodynamic Seal – A dynamic sealing device which utilizes the viscous shear and inertia forces of the fluid; imparted by a helically grooved or ribbed seal lip, to generate a pressure differential that opposed fluid flow.

Hydroseal – A sealing system having helically disposed elements formed on the shaft surface.

HDDF – SKF Heavy Duty Dual Face axial seal.

I.D. – See Seal, Inside Diameter.

Inclusion – Foreign material included in the seal material.

Interface – The region between the static and dynamic sealing surfaces in which there is contact, or which experiences the closest approach and effects the primary seal.

ISO – International Standards Organization. This is the international organization which sets standards for quality excellence in manufacturing organizations, service industries, and small companies. Sets tolerance specifications for metric systems.

Keyway – A notch cut axially into the O.D. of a shaft. Used with a key and notched component (gear, drive, etc.) to radially lock the component onto the shaft.

Large Diameter Seals – Seals that fit shaft 8” (200mm) in diameter and larger.

Lip, Dirt – See Secondary Lip.

Lip, Dust – See Secondary Lip.

Lip, Molded – A type of seal lip which requires no trimming to form the contact line.

LongLife Seal – SKF seal utilizing premium high performance fluoroelastomer materials for extended life service against high speed, heat and chemical attack.

Lubricant – Any of various materials, such as grease, or machine oil, that reduces friction when applied as a coating to remove parts; lube.

Machine Lead – Spiral grooves similar to a screw thread on a shaft surface. May be caused by improper shaft finishing. May result in early seal leakage.

Metal Clad Seals – Seals using a metal case or housing.

Metallize – Addition of new metal to fill grooves or nicks on worn shafts.

Misalignment – Physical displacement of the shaft centerline to theoretical drive center. Can be fixed (shaft to bore misalignment) or variable (dynamic run-out).

M/S – Meters per second. Calculate as (shaft diameter (mm) x RPM x .001 x 3.142) /60

Glossary of Seal Terms (cont...)

MPM – Meters per minute. Calculate as shaft diameter (mm) x RPM x .001 x 3.142

Nick – A void created in the seal material after molding.

Nitrile – A general term for the co-polymer of butadiene and acrylonitrile. ASTM class NBR.

Non-Spring loaded – Seal without a spring. Applies radial force only through elasticity of the rubber lip and interference.

Non-Synthetic – Before synthetic materials were developed, naturally occurring materials were used. Leather was the sealing element commonly found in earlier seals. Felt was also extensively used for grease and dust seals.

Oil Resistance – The measure of an elastomer's ability to withstand the deteriorating effect of lubricant on the mechanical properties.

O-Ring – A toroidal shaped seal, commonly round. Variations are square, lobed or rectangular.

Out-Of-Round, Shaft – The deviation of the shaft cross section from a true circle.

O.D. – See Seal, Outside Diameter.

Paper Polishing – Finishing the surface of a shaft with abrasive paper.

Parabolic – Like a parabola; a plane curve formed by the locus of points equidistant from a fixed line and a fixed point not on the line.

Plunge Ground – The surface texture of shaft or wear sleeve produced by presenting the grinding wheel perpendicular to the rotating shaft without axial motion.

Polyacrylate - A type of elastomer characterized by an unsaturated chain and being a copolymer of alkyl acrylate and some other monomer such as chloroethyl vinyl ether or vinyl chloroacetate. ASTM class ACM.

Press Fit – Retention force achieved by installing an element whose contact diameter is greater (or less) than its mating surface.

Primary Lip – The flexible elastomeric component of a seal lip which contacts the rotating surface, performing the main sealing function.

psi – Pounds per square inch. Measure of pressure for fluids and gases.

PTFE – Polytetrafluoroethylene. A thermoplastic polymer developed by Dupont with outstanding heat and chemical resistance.

Radial Seal – A seal which exerts radial sealing pressure in order to retain fluids and/or exclude foreign matter.

Radius – A line segment that joins the center of a circle with any point on its circumference.

Retention – To retain lubricants or pressure within the bearing cavity.

Retention Seals – These seals are often spring-loaded to retain lubricants or confine pressure in the bearing cavity.

Roller Burnishing – A method of shaft surface finishing in which the surface peaks caused by lathe cutting appear to flatten. The original lead grooves are compressed and not removed.

Roto preening – A method of shaft surface finishing in which the shaft surface dimples and kerfs at one side of the depression.

Run-In – The period of initial operation during which the seal-lip wear rate in greatest and the contact surface is developed. Synonym: bedding-in.

Run-Out – That run-out to which the seal lip is subjected due to the outside diameter of the shaft not rotating in a true circle. Usually expressed as TIR (Total Indicator Reading).

Ra – Measure of surface roughness average of all peaks and valleys from the main line within one cut-off (normally .030" or .76mm) of measurement.

RMA – Rubber Manufacturers Association. Sets inch standards.

RPM – Revolutions per minute.

Scoring – A type of wear in which the working surface of the shaft is grooved.

Scotseal – "Self Contained Oil Type." An SKF seal which integrates multiple rubber sealing elements within a housing which provides a running surface.

Seal Bore – The diameter of the hole in the housing into which the seal is fitted.

Seal, Head Section – The portion of a lip seal which is generally defined by the inside and outside lip surfaces and the spring groove.

Seal, Inside Diameter (I.D.) – The internal diameter of a lip seal assembly. Usually the inside diameter of the inner seal case.

Seal Interference – The difference between the seal lip and shaft diameters.

Seal, Outside Diameter (O.D.) – The external diameter of a lip seal assembly. Usually the outside diameter of the outer seal case.

Seal Width – The overall axial dimension of the lip seal assembly. Normally the total width measurement of the outer seal case.

Sealing Element – The normal flexible elastomeric component of a lip seal assembly which rides against the shaft.

Secondary Lip – A short, non-spring loaded lip which is located at the outside seal face of a radial lip seal. Used to exclude contaminants.

Section, Head – The portion of a lip seal which is generally defined by the inside and outside lip surfaces and the spring groove.

Shaft Diameter – The outside diameter of the shaft at the location where the seal is mounted.

Shaft Finish – The relative roughness, usually expressed in micro inches, of the outside diameter of the shaft. The smaller the number, the smoother the finish.

Shaft Hardness – Under normal conditions, the portion of the shaft contacted by the seal should be hardened to Rockwell C30 minimum. There is no conclusive evidence that hardening above this will increase the wear resistance of the shaft except under extreme abrasive conditions. Where the shaft is liable to be nicked in handling previous to assembly, it is recommended that it be hardened to Rockwell C45 minimum in order to prevent against being permanently damaged during assembly.

Shaft Seal Nomenclature – The basic seal components including: Outer Shell (Case), Inner Shell (Case), Sealing Element, Primary Lip, Secondary (Auxiliary) Lip and the Garter Spring. Each perform a particular function.

Shaft Seal – Generally considered to be a lip seal or an oil seal. A broad definition could include any sealing device mounted on a shaft or sealing shaft.

Shaft Surface Texture – A prime factor in the proper functioning of a lip seal The surface roughness should be specified as 8-17 microinch (0.20µm-0.43µm) Ra with no machine lead. The best known method to date for obtaining this roughness is plunge grinding.

Shell, Inner (Case, Inner) – A rigid, cup-shaped component of a seal assembly, which is placed inside the outer seal shell. It can function as a reinforcing member, shield, spring retainer or lip-clamping device.

Glossary of Seal Terms (cont...)

Shell, Outer (Case, Outer) – The outer, cup-shaped, rigid structure of the lip assembly. Acts as a protective cover for the head of the sealing element.

Silicone – A type of elastomer having a basic polymer of dimethyl polysilozane, with various attached vinyl or pheyl groups. (ASTM class VMQ)

Single Lip – Seal element utilizing one contact point, with or without springs.

Sinusoidal – Describing an alternative wave form centered on a fixed line.

Sirvene – SKF's tradename for synthetic rubber.

Slinger – A washer-like device used for imparting radial momentum to a liquid order too keep the latter away from the sealing interface. Often incorporated into a wear sleeve.

Small Diameter Seals – Seals that fit shafts ranging from .110" to 12.5" (2.8mm to 317.5mm) in diameter.

Solid Seals – Continuous seals without a split.

Spark Out – When the grinding wheel is allowed to run until there are no more sparks flying from the wheel.

Speedi-Sleeve – The Speedi-Sleeve is a highly engineered, precision part of the finest 300 series stainless steel. Its surface is factory finished to 10-20 micro inch Ra (.25-.50 micro meter), with no machine lead, and requires no expensive preparation or machining before installation.

Spindle – Slots of positive or negative alternating shapes used to connect two elements, one usually drives the other.

Split Seal – A seal which has its primary sealing element split, approximately parallel with the shaft axial centerline. Typically used where conventional installation methods are impractical.

Spring-Loaded – The design of most oil seals in which a spring is incorporated to provide a uniform load at the seal contact line-shaft surface junction.

Spring-Lock – A sealing lip design that extends over and surrounds most of the garter spring's diameter.

Spring-Kover – A flexible, rubber like covering that totally enclosed the garter spring.

Spring Position – The axial distance between the "seal contact line" and the centerline of the spring groove of a radial lip seal; commonly referred to as the "R" value.

Static Seal – Seal without a dynamic contact surface. Example is a refrigerator gasket.

Surface, Contact – The portion of the seal lip which circumferentially contacts the shaft to form the seal-shaft interface.

Surface Honing – A cross hatching pattern on the shaft causing a grooving which tends to act as a lead, allowing lubricant to escape under the seal lip.

Synthetics – The most popular and versatile lip sealing element in use today. These include nitriles, polyacrylates, silicones and fluoroelastomers.

Synthetic Rubber – Synthetic elastomers made by polymerization of one or more monomers.

STBM – Shaft-to-bore-misalignment. The amount by which the shaft is off center, with respect to the bore's center.

Talysurf – Device used to measure shaft surface finish.

Test, Accelerated Life – Any set of test conditions designed to reproduce in a short time the effects obtained under service conditions.

Test, Bench – A laboratory test procedure in which the functional operating conditions are approximated, but the equipment is conventional laboratory equipment and not necessarily identical with that in which the product will be used.

Test, Life – A laboratory procedure used to determine that period of operation which a component or assembly will operate until it no longer performs its intended function.

Through Bore – Bore without a diameter reduction, may have a bearing in line with a seal.

Tolerances – Bore and Seal – The bore and seal tolerances.

Torque – The tendency of a force to produce rotation about an axis.

Transverse Grinding – A shaft surface finishing method of which there are two types; either the grinding medium moves laterally while the shaft turns, or the wheel rotates in a fixed position while the shaft turns and moves laterally.

Tumbled Stone Finishing – A shaft surface finishing method in which a uniform shaft appearance is produced.

Underlip – The area under the seal lip.

Unitized Seal – A seal assembly in which all components necessary for accomplishing the sealing function are retained in a single package.

Variation, Radial Wall – The difference between the minimum and maximum radial wall dimensions when measured around 360 of the seal lip.

Vibration, Torsional – A vibration which has a circumferential or angular direction. It is often generated by a stick-slip action between mating seal surfaces.

V-Ring Seal – A versatile all-rubber seal that mounts directly on the shaft by hand and is then sealed axially against a counterface, housing bearing race or similar surface. Functions by "slinger" or deflector action.

Vulcanizing – An irreversible heat and chemical treatment process that makes rubber in a seal more elastic and durable. Used to rejoint V-rings that were split during installation.

"WasteWatcher" – An SKF program designed to consolidate seal stocking units in relation to their applications to control replacement inventory and effect cost savings for the user.

Waveseal – The SKF Waveseal is a smooth lip, bi-rotational hydrodynamic radial lip seal. A shaft seal that pumps lubricant back in the sump while sealing out contaminants – no matter which way the shaft is turning.

Wear Sleeve – A replaceable metal ring. Generally used in assemblies to eliminate expensive shaft replacement caused by grooving that may occur at the seal shaft interface.

Width – See Seal Width.

Final Exam

Congratulations. You have completed the Shaft Seals Industrial Self-Study Program. Now you are ready to test your knowledge about SKF seals, Speedi-Sleeves and Scotseals in this Final Review.

First, turn to the last page of this study guide. Remove the Final Review answer sheet by tearing it out carefully along the perforated edge.

Begin the test. Be sure to answer every question; **unanswered questions will be graded as incorrect.**

When you have finished the test, fold your answer sheet as indicated, with the return address on the outside. Staple it closed; no envelope is required. Be sure to attach the proper postage, and mail your answer sheet to SKF.

If you score 85% or more, you will receive a Certificate of Merit from SKF.
Please allow at least four weeks for grading.

If you have a seal problem that cannot be answered through this study guide, contact your SKF representative. He's backed by a full crew of technicians—product managers, engineers and service personnel—who will gladly provide the assistance you need.

When you have a question, call SKF toll-free: 1-800-882-0008.

1 . A shaft seal is a barrier designed to retain lubricants and ________________ .

❑ a. confine pressure
❑ b. exclude dirt
❑ c. separate fluids
❑ d. all of the above

2. Selecting the right seal depends on application parameters, including ________________ .

❑ a. shaft speed
❑ b. fluid compatibility
❑ c. operating pressure
❑ d. all of the above

3. When split seals are used in multiples, a ________________ is often used to separate the seals and provide extra lubrication between them.

❑ a. horizontal shaft
❑ b. slotted washer
❑ c. control wire
❑ d. butt joint

4. Premature seal failure can be caused by ________________ .

❑ a. nicks on the bore chamfer
❑ b. improper seal installation
❑ c. shaft-to-bore misalignment
❑ d. all of the above

V

5. When considering seals and wear sleeves for a large diameter shaft, it is possible to ________________ .
   - ❑ a. machine the shaft to a reduced diameter for use with the wear sleeve and original size seal.
   - ❑ b. Apply the .094" thick (2.4mm) wear sleeve and use a larger sized seal.
   - ❑ c. both of the above
   - ❑ d. none of the above

6. ________________ is the most popular material for the majority of sealing applications today.
   - ❑ a. Leather
   - ❑ b. Felt
   - ❑ c. Nitrile
   - ❑ d. Silicone

7. Waveseals ________________ .
   - ❑ a. generate less heat
   - ❑ b. reduce shaft wear
   - ❑ c. provide greater lip lubricant
   - ❑ d. all of the above

8. The seal is ready to be installed in the bore once the shaft and bore have been checked and cleaned, and the seal has been ________________ .
   - ❑ a. pre-lubricated
   - ❑ b. split
   - ❑ c. vulcanized
   - ❑ d. none of the above

9. Two metal clad seals (Type HDS), back to back or in tandem,
   - ❑ a. provide extra-duty sealing
   - ❑ b. are less expensive than a double seal
   - ❑ c. install easier than a double seal
   - ❑ d. all of the above

10. ________________ seals are the basic type large diameter seals.
    - ❑ a. HDS metal clad (all-rubber)
    - ❑ b. HS non-metal clad (all-rubber)
    - ❑ c. Both of the above
    - ❑ d. None of the above

11. Type ________________ has two opposing sealing elements in a single shell, making it ideal for separating two fluids in applications where two seals are impractical.
    - ❑ a. HDSA
    - ❑ b. HDSD
    - ❑ c. both of the above
    - ❑ d. none of the above

12. A cocked seal can cause a seal lip to ________________ .
- ❑ a. leak
- ❑ b. groove the shaft
- ❑ c. both of the above
- ❑ d. neither of the above

13. If a seal's lip shows premature wear ________________ .
- ❑ a. the seal may not be getting enough lubrication
- ❑ b. the shaft may be corroded
- ❑ c. the finish is too rough
- ❑ d. all of the above

14. The flange allows the Speedi-Sleeve to be ________________ eliminating sleeve distortion.
- ❑ a. pushed on
- ❑ b. pulled on
- ❑ c. either of the above
- ❑ d. none of the above

15. When heat is enough to break down the oil, but not enough to harden the lip, sludge accumulates and deposits on the ________________ .
- ❑ a. garter spring
- ❑ b. bore
- ❑ c. seal lip
- ❑ d. none of the above

16. Popular sealing lip synthetics in use today include ________________ .
- ❑ a. nitriles
- ❑ b. fluoroelastomers
- ❑ c. fluorocarbons
- ❑ d. all of the above

17. A cut lip seal may have been caused by ________________ .
- ❑ a. a damaged seal housing
- ❑ b. shaft discoloration
- ❑ c. a coked lube on the shaft
- ❑ d. a burr on the keyway

18. ________________, required by all HS type seals, provide axial compression and supplement radial press-fit to ensure leakproof seals.
- ❑ a. Spring-Lock
- ❑ b. Spring-Kover
- ❑ c. Cover plates
- ❑ d. all of the above

19. ________________ are dual face mechanical seals used where both positive lubrication and dirt exclusion are required.
    - ❑ a. Waveseals
    - ❑ b. V-Rings
    - ❑ c. HDDF seals
    - ❑ d. Retention seals

20. Selecting the right seal for a particular application depends on ________________ .
    - ❑ a. size and speed
    - ❑ b. pressure and temperature
    - ❑ c. fluid compatibility
    - ❑ d. all of the above

21. The V-Ring is an all-rubber seal that ________________ .
    - ❑ a. mounts directly on the shaft by hand
    - ❑ b. is sealed axially against a counterface, housing bearing race or similar surface
    - ❑ c. acts like a mechanical face seal, radial lip seal or slinger
    - ❑ d. all of the above

22. Installation of a Large Diameter Wear Sleeve without any machining ________________ the effective shaft diameter.
    - ❑ a. reduces
    - ❑ b. increases
    - ❑ c. will never change
    - ❑ d. none of the above

23. Pressures exceeding seal design limitations can cause ________________ .
    - ❑ a. seal rupture
    - ❑ b. inverted lips
    - ❑ c. lubricant leakage
    - ❑ d. all of the above

24. Heavy-duty mechanical seals (HDDF) ________________ .
    - ❑ a. retain lubricants
    - ❑ b. exclude contaminants
    - ❑ c. can be used under severe service conditions
    - ❑ d. all of the above

25. Simultaneous exclusion and retention is best performed with ________________ .
    - ❑ a. a combination of two seals back to back
    - ❑ b. single lip design seals
    - ❑ c. a combination of two seals front to back
    - ❑ d. V-Ring seals

26. In ________________ installation, the sealing force of the installation tool should be applied only in the area over the center of the seal.

- ❑ a. wooden block
- ❑ b. arbor press
- ❑ c. Speedi-Sleeve
- ❑ d. none of the above

27. Using the ________________ method to set the seal perpendicular to the shaft when installing a "through" bore, apply pressure through a steel plate or plug larger than bore diameter.

- ❑ a. wooden block
- ❑ b. arbor press
- ❑ c. Speedi-Sleeve
- ❑ d. none of the above

28. ________________ refers to the outside diameter of the shaft at the location where the seal is mounted.

- ❑ a. Size bore
- ❑ b. Seal I.D.
- ❑ c. Seal width
- ❑ d. Shaft diameter

29. SKF's Large Diameter Wear Sleeves ________________ .

- ❑ a. repair damaged shafts 8" (203mm) and larger.
- ❑ b. are built for heavy-duty applications
- ❑ c. provide positive sealing surfaces and reinforced protection
- ❑ d. all of the above

30. Advantages of polyacrylates include ________________ .

- ❑ a. good compatibility with most oils
- ❑ b. high resistance of oxidation and ozone
- ❑ c. better compatibility with higher temperatures than nitrile
- ❑ d. all of the above

31. ________________ are designed for heated, slip-fit operation.

- ❑ a. Speedi-Sleeves
- ❑ b. Large Diameter Wear Sleeves
- ❑ c. both of the above
- ❑ d. none of the above

32. Press-fitting tools should have an outside diameter approximately ________________ the bore size.

- ❑ a. .010" (.254mm) smaller than
- ❑ b. .010" (.254mm) larger than
- ❑ c. equal to
- ❑ d. none of the above

33. A hammer blow without any material to absorb the shock wave ________________ .
    - ❑ a. may interfere with the action of the seal lip
    - ❑ b. can dislodge the garter spring from its proper operating position
    - ❑ c. both of the above
    - ❑ d. none of the above

34. To assure a smooth sealing surface, the shaft should be ground with ________________ rpm ratios.
    - ❑ a. even number (2 to 1)
    - ❑ b. odd number (3 to 1)
    - ❑ c. mixed number (3.5 to 1)
    - ❑ d. none of the above

35. If the same size replacement is not available, ________________ .
    - ❑ a. select a narrower seal
    - ❑ b. select a wider seal
    - ❑ c. select a different lip material
    - ❑ d. either a. or b.

36. Before the invention of nitriles, ________________ was the most common sealing element.
    - ❑ a. rubber
    - ❑ b. felt
    - ❑ c. leather
    - ❑ d. metal

37. For best seal performance, use a(n) ________________ or soft-face hammer for seal installation.
    - ❑ a. screwdriver
    - ❑ b. arbor press
    - ❑ c. chisel
    - ❑ d. steel hammer

38. ________________ refers to the amount by which the shaft does not rotate around the true center.
    - ❑ a. Shaft-to-bore misalignment
    - ❑ b. Dynamic run-out
    - ❑ c. Shaft diameter
    - ❑ d. none of the above

39. If the shaft is deeply scored, you should fill the groove with ________________ .
    - ❑ a. powdered metal epoxy type filler
    - ❑ b. non-hardening sealant
    - ❑ c. grease
    - ❑ d. SAE 30 oil

40. A sealing lip that is cut, turned back or damaged should be ________________ .
- ❑ a. repaired
- ❑ b. replaced
- ❑ c. cleaned
- ❑ d. chamfered

41. Advantages of silicone include ________________ .
- ❑ a. good compatibility with oxidized oils
- ❑ b. high lubrication absorbency
- ❑ c. excellent abrasion resistance
- ❑ d. low cost

42. Seals perform best on Rockwell C30 medium carbon steel (SAE 1035, 1045) or ________________ .
- ❑ a. stainless steel
- ❑ b. aluminum
- ❑ c. bronze
- ❑ d. zinc

43. The seal is ready to be installed in the bore when ________________ .
- ❑ a. the shaft and bore have been checked and cleaned
- ❑ b. the seal has been pre-lubricated
- ❑ c. both of the above
- ❑ d. none of the above

44. The wrong installation tool can ________________ .
- ❑ a. cut the seal lip
- ❑ b. damage the seal case
- ❑ c. distort the seal
- ❑ d. all of the above

45. Proper Speedi-Sleeve installation requires that ________________ measurement(s) be taken.
- ❑ a. four
- ❑ b. three
- ❑ c. two
- ❑ d. one

46. The ________________ is a smooth lip, bi-rotational hydrodynamic radial lip seal that pumps lubricant back in to the sump while sealing out contaminants.
- ❑ a. V-Ring
- ❑ b. metal clad seal
- ❑ c. Waveseal
- ❑ d. none of the above

viii

47. ________________ seals have three sealing lips: one primary lip to keep oil in, two secondary lips to keep dirt out.
   - ❑ a. Scotseal oil bath
   - ❑ b. Scotseal Plus oil bath
   - ❑ c. both of the above
   - ❑ d. neither of the above

48. ________________ seals can be installed by hand, using no more than common shop tools if any at all.
   - ❑ a. Scotseal oil bath
   - ❑ b. Scotseal Plus oil bath
   - ❑ c. both of the above
   - ❑ d. neither of the above

49. If high operating temperatures cannot be reduced, ________________ type seals (LongLife) can be used because of their higher temperature range.
   - ❑ a. nitrile
   - ❑ b. large diameter
   - ❑ c. fluoroelastomer
   - ❑ d. none of the above

50. To help ensure proper seal performance, the ________________ .
   - ❑ a. entrance edge should be chamfered or rounded
   - ❑ b. surface finish should be 8-17 micro inches (.20-.43 micro meter)
   - ❑ c. shaft surface should have no machine lead
   - ❑ d. all of the above

51. ________________ is an acceptable sealing lip material substitute for nitrile.
   - ❑ a. Leather
   - ❑ b. Felt
   - ❑ c. Another nitrile
   - ❑ d. none of the above

52. On some seals, SKF applies a coating of Bore-tite to the ________________ which fills minor bore imperfections.
   - ❑ a. I.D.
   - ❑ b. O.D.
   - ❑ c. both of the above
   - ❑ d. none of the above

53. Speedi-Sleeves provide a ________________ that is superior to most original shaft material.
   - ❑ a. sealing surface
   - ❑ b. stainless steel construction
   - ❑ c. both of the above
   - ❑ d. none of the above

54. If a shaft is lightly grooved but does not require filling, _______________ before installing the Speedi-Sleeve.

- ❑ a. apply a light layer of nonhardening sealant
- ❑ b. apply a light layer of powdered metal epoxy type filler
- ❑ c. apply a light layer of cement
- ❑ d. none of the above

55. The _______________ should be smooth enough to prevent excessive seal wear, but "rough" enough to form lubricant holding pockets.

- ❑ a. inside corner of the bore
- ❑ b. bore center
- ❑ c. shaft surface
- ❑ d. both a. and b.

56. The recommended method for obtaining an optimum shaft finish is _______________ .

- ❑ a. paper polishing
- ❑ b. roto preening
- ❑ c. plunge grinding
- ❑ d. diamond burnishing

57. _______________ is a lip material for the majority of sealing applications today.

- ❑ a. LongLife fluoroelastomer
- ❑ b. Nitrile
- ❑ c. both of the above
- ❑ d. neither of the above

58. Seals which are to be flush with the outside of the housing can be pressed in with a _______________ .

- ❑ a. drift
- ❑ b. punch
- ❑ c. block of wood
- ❑ d. chisel

59. Typical radial seal applications include _______________ .

- ❑ a. gearboxes
- ❑ b. motors
- ❑ c. pumps
- ❑ d. all of the above

60. HS all-rubber _______________ may be placed around the shaft, connected and pushed into the seal bore.

- ❑ a. split seals
- ❑ b. solid seals
- ❑ c. both of the above
- ❑ d. neither of the above

61. A combination seal or a double lip seal will always do a better job than a single lip design.
❑ True ❑ False

62. Roto preening is recommended to dress the shaft and remove lead introduced during the machine operation.
❑ True ❑ False

63. The only solution to garter spring damage is to install a replacement seal.
❑ True ❑ False

64. The best prelube to use is the lubricant being retained by the seal.
❑ True ❑ False

65. When determining the cause of a leak, remove the seal immediately and inspect it.
❑ True ❑ False

66. For very severe conditions, SKF's HDDF seals resist abrasives that cause other seals to fail
❑ True ❑ False

67. When a Speedi-Sleeve is used to repair a damaged shaft, it is inexpensive and requires little machine downtime.
❑ True ❑ False

68. A cocked seal is perpendicular to the shaft and bore.
❑ True ❑ False

69. Waveseals (CRW5 and CRWA5) perform better than conventional lip seal designs in pressure applications, and can be used to replace some mechanical seals.
❑ True ❑ False

70. Substitute lip material will extend a seal's life, no matter which material is chosen.
❑ True ❑ False

71. If there is a history of seal failures for a particular installation, the problem may not be the seal's fault.
❑ True ❑ False

72. Spiral grooves (machine lead) may promote seal leakage.
❑ True ❑ False

73. More bearings fail from the entrance of foreign material than from loss of lubricant.
❑ True ❑ False

74. Bore material must be metallurgically compatible with the seal type that is used.
❑ True ❑ False

75. When examining for STBM, the lip area with the least wear indicates the direction of shaft misalignment.
❑ True ❑ False

76. Axial clamp seals are recommended for large diameter applications where there is a need for two seals but room for one, as in steel and paper mills or logging operations.
❑ True ❑ False

77. When using a wooden workpiece for flush installation of a seal, it is acceptable to use a steel hammer.
❑ True ❑ False

78. A direct blow on one side of the seal distorts the shell and can cause the lip to be pressed against the shaft.
❑ True ❑ False

79. Speedi-Sleeve's wall is so thin that the original size seal can still be used.
❑ True ❑ False

80. Revolutions per minute (rpm) is generally a better indication of seal performance than feet per minute (fpm).
❑ True ❑ False

81. Shaft and bore diameters should match those specified for the seal selected.
❑ True ❑ False

82. SKF's "WasteWatcher" seal inventory control system helps control costs of replacement seals.
❑ True ❑ False

83. The overall axial dimension of the lip seal assembly is called seal width.
❑ True ❑ False

84. Garter spring damage requires careful inspection, often necessitating calling in an "expert."
❑ True ❑ False

85. Imperfections such as surface burrs, nicks or rough spots on the shaft surface can damage the lip as it slides on the shaft.
❑ True ❑ False

86. The more pressure you apply to a seal, the greater the friction heat and faster the shaft wear.
❑ True ❑ False

87. The temperature of the lubricant being retained is the only temperature reading critical to seal selection.
❑ True ❑ False

88. Type HDSD seal has two opposing elements in a single shell, making it ideal for separating two fluids in applications where two seals are practical.
❑ True ❑ False

89. Applications for SKF's LongLife fluoroelastomers are limited to standard lubricants.
❑ True ❑ False

90. Speedi-Sleeve's stainless steel construction provides a surface that can outlast the original shaft material
❑ True ❑ False

91. In SKF's single lip vs. double lip test, the single lip outlasted the double lip by nearly 1000 hours.
❑ True ❑ False

92. The heavy-duty DF seal has a special retainer to hold the two sealing ring faces together for protection against damage or contamination.
❑ True ❑ False

93. For out-of-round shaft repairs, a Speedi-Sleeve or SKF Large Diameter Wear Sleeve is often a better solution than shaft removal and reshaping.
❑ True ❑ False

94. The V-Ring's elastic body adheres to the rotating shaft while the actual sealing occurs at the point of contact between the lip and the counterface.
❑ True ❑ False

95. More than one Speedi-Sleeve size is usually required for each seal application.
❑ True ❑ False

96. Ferrous and other commonly used metallic materials (such as aluminum) are acceptable bore materials.
❑ True ❑ False

97. The heavy-duty DF seal's sealing ring and mating ring rotate against each other at right angles to the shaft to form a leak-proof seal.
❑ True ❑ False

98. When an exact replacement is not available, your best option is substitution of a similar material and design.
❑ True ❑ False

99. V-Rings must be lubricated for all operating conditions.
❑ True ❑ False

100. The most economic repair option for a worn shaft seal is to install a wear sleeve.
❑ True ❑ False

101. A seal should be pressed into housings with a 15°-30° chamfer.
❑ True ❑ False

102. A seal can have a "swollen" appearance and still be acceptable with the system media.
❑ True ❑ False

FINAL REVIEW

Fleet Edition

Name: ______________________________ Date: ______________

(Please print)

Company: ______________________________ Daytime Phone: ( ) ______________

Street: ______________________________

(Provide complete street address, P.O. Boxes are not accepted)

City: ______________________________ State: ________ Zip: ______________

1.	❑ A ❑ B ❑ C ❑ D	35.	❑ A ❑ B ❑ C ❑ D	69.	❑ True ❑ False
2.	❑ A ❑ B ❑ C ❑ D	36.	❑ A ❑ B ❑ C ❑ D	70.	❑ True ❑ False
3.	❑ A ❑ B ❑ C ❑ D	37.	❑ A ❑ B ❑ C ❑ D	71.	❑ True ❑ False
4.	❑ A ❑ B ❑ C ❑ D	38.	❑ A ❑ B ❑ C ❑ D	72.	❑ True ❑ False
5.	❑ A ❑ B ❑ C ❑ D	39.	❑ A ❑ B ❑ C ❑ D	73.	❑ True ❑ False
6.	❑ A ❑ B ❑ C ❑ D	40.	❑ A ❑ B ❑ C ❑ D	74.	❑ True ❑ False
7.	❑ A ❑ B ❑ C ❑ D	41.	❑ A ❑ B ❑ C ❑ D	75.	❑ True ❑ False
8.	❑ A ❑ B ❑ C ❑ D	42.	❑ A ❑ B ❑ C ❑ D	76.	❑ True ❑ False
9.	❑ A ❑ B ❑ C ❑ D	43.	❑ A ❑ B ❑ C ❑ D	77.	❑ True ❑ False
10.	❑ A ❑ B ❑ C ❑ D	44.	❑ A ❑ B ❑ C ❑ D	78.	❑ True ❑ False
11.	❑ A ❑ B ❑ C ❑ D	45.	❑ A ❑ B ❑ C ❑ D	79.	❑ True ❑ False
12	❑ A ❑ B ❑ C ❑ D	46.	❑ True ❑ False	80.	❑ True ❑ False
13.	❑ A ❑ B ❑ C ❑ D	47.	❑ True ❑ False	81.	❑ True ❑ False
14.	❑ A ❑ B ❑ C ❑ D	48.	❑ True ❑ False	82.	❑ True ❑ False
15.	❑ A ❑ B ❑ C ❑ D	49.	❑ True ❑ False	83.	❑ True ❑ False
16.	❑ A ❑ B ❑ C ❑ D	50.	❑ True ❑ False	84.	❑ True ❑ False
17.	❑ A ❑ B ❑ C ❑ D	51.	❑ True ❑ False	85.	❑ True ❑ False
18.	❑ A ❑ B ❑ C ❑ D	52.	❑ True ❑ False	86.	❑ True ❑ False
19.	❑ A ❑ B ❑ C ❑ D	53.	❑ True ❑ False	87.	❑ True ❑ False
20.	❑ A ❑ B ❑ C ❑ D	54.	❑ True ❑ False	88.	❑ True ❑ False
21.	❑ A ❑ B ❑ C ❑ D	55.	❑ True ❑ False	89.	❑ True ❑ False
22.	❑ A ❑ B ❑ C ❑ D	56.	❑ True ❑ False	90.	❑ True ❑ False
23.	❑ A ❑ B ❑ C ❑ D	57.	❑ True ❑ False	91.	❑ True ❑ False
24.	❑ A ❑ B ❑ C ❑ D	58.	❑ True ❑ False	92.	❑ True ❑ False
25.	❑ A ❑ B ❑ C ❑ D	59.	❑ True ❑ False	93.	❑ True ❑ False
26.	❑ A ❑ B ❑ C ❑ D	60.	❑ True ❑ False	94.	❑ True ❑ False
27.	❑ A ❑ B ❑ C ❑ D	61.	❑ True ❑ False	95.	❑ True ❑ False
28.	❑ A ❑ B ❑ C ❑ D	62.	❑ True ❑ False	96.	❑ True ❑ False
29.	❑ A ❑ B ❑ C ❑ D	63.	❑ True ❑ False	97.	❑ True ❑ False
30.	❑ A ❑ B ❑ C ❑ D	64.	❑ True ❑ False	98.	❑ True ❑ False
31.	❑ A ❑ B ❑ C ❑ D	65.	❑ True ❑ False	99.	❑ True ❑ False
32.	❑ A ❑ B ❑ C ❑ D	66.	❑ True ❑ False	100.	❑ True ❑ False
33.	❑ A ❑ B ❑ C ❑ D	67.	❑ True ❑ False	101.	❑ True ❑ False
34.	❑ A ❑ B ❑ C ❑ D	68.	❑ True ❑ False	102.	❑ True ❑ False

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