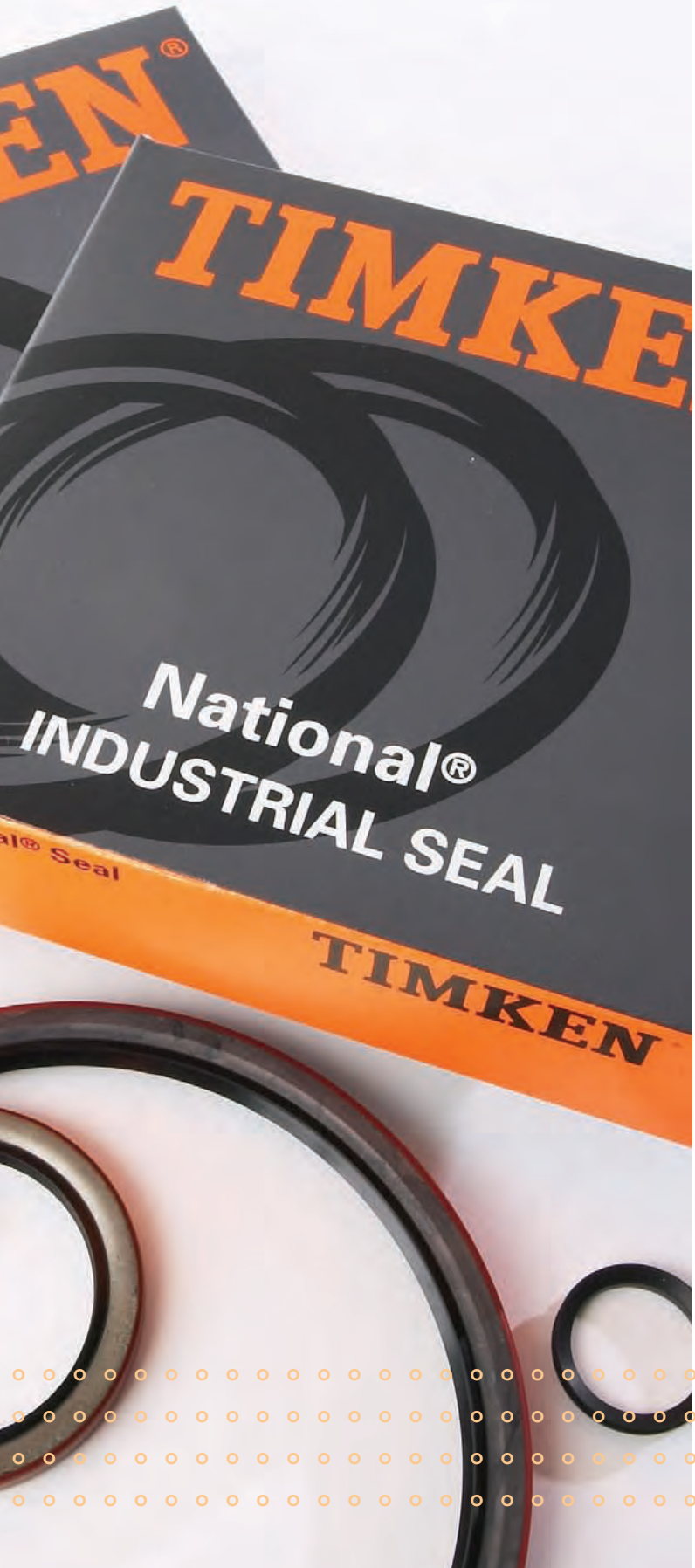
TIMKEN

National®
Industrial Seals



Timken

offers an extensive line of sealing solutions for original equipment manufacturers and the aftermarket. Our line of National® industrial seals is made from ***innovative*** *materials and process solutions that* ***enhance*** *life and performance in many industrial applications. This line of industrial seals adds value to the company's portfolio of friction management solutions. The seals are backed by the company's experienced technical support and distribution networks, giving* ***distributors*** *a single source for a wide range of bearings and* ***value-added extras*** *to help keep equipment running optimally.*

TIMKEN

National®
Industrial Seals

Redi-Seals®

Sealing Solutions Custom Made Overnight

Timken offers cost-effective and quick sealing solutions that help reduce downtime and help keep equipment running smoothly. Redi-Seals® help minimize downtime since they are available within 24 hours and in the right quantities – even a single seal.

Through an innovative manufacturing process, Redi-Seals are produced without long lead times, which offers distributors a more flexible and efficient way of doing business. Timken offers 11 types of Redi-Seals, custom made to fit your design, size, application, material and other specifications.

Redi-Seals are unique, high-quality sealing devices that require specific information before manufacturing. When ordering, you will need to specify the following information:

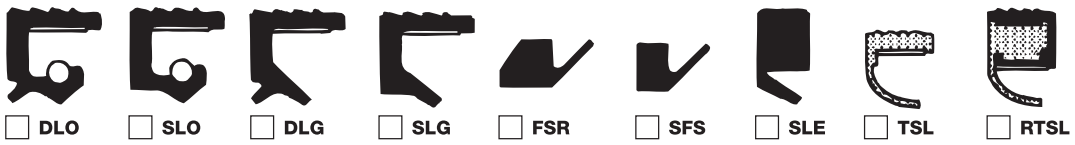
- Seal design or type
- Size: ranging from 0.827" (21mm) shaft to 13" (330mm) housing bore
- Inch or metric size
- Seal applications: industrial, agricultural or vehicular
- Seal material: Nitrile or Viton®
- Special features, including split seals

CUSTOM SEALS IN 24 HOURS

Redi-Seal Specification Checklist

Although Redi-Seals are manufactured to the same exacting standards and specifications as the stock product lines, exact dimensions are required before a seal can be made.

Please review the specifications manual before contacting Timken. A Zero Duplication™ seal may already meet your sealing requirements.



☐ DLO ☐ SLO ☐ DLG ☐ SLG ☐ FSR ☐ SFS ☐ SLE ☐ TSL ☐ RTSL

1. Choose a style. *NOTE: SLO and DLO also are available in split designs.*

2. Measure the required dimensions to the nearest 0.001" or 0.05mm.

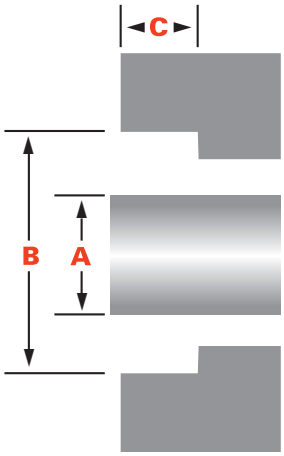
- ❑ Shaft Diameter _____
- ❑ Bore Diameter _____
- ❑ Width _____

3. Select the appropriate seal material

- ❑ Nitrile: -50° F to +250° F (-45° C to +121° C)
- ❑ Fluoroelastomer: -40° F to +400° F (-40° C to +205° C)
- ❑ PTFE: -650° F to +4500° F (-55° C to +232° C)
- ❑ R.O.D. PTFE (Type RTSL): -65° F to +300° F (-55° C to +150° C)

4. Note any important application details:

- ❑ Shaft Speed _____ RPM
- ❑ Temp Range _____
- ❑ Lubricant _____
- ❑ Comments _____



A) Shaft Diameter
B) Bore Diameter
C) Width

To order National industrial seals, contact your Timken sales representative or call 1.877.4.TIMKEN in the U.S. In Canada, call 1.800.565.4927 for English or 1.800.565.0438 for French-Canadian. Visit us on the Web at www.timken.com/industrialseals.

CAUTION: Redi-Seals are not recommended for the following applications:

- **Rear-wheel bearing seals on rear-wheel drive vehicles**
- **Stub-shaft seals on front-wheel-drive vehicles**
- **Automatic transmission front pump seals**
- **Power steering pump seals**
- **Any nuclear applications**
- **Any aircraft/aviation/aerospace applications**

Redi-Sleeves®

REPAIR DAMAGED SHAFTS ... OR PROTECT NEW ONES

Redi-Sleeves® offered by Timken are precision stainless steel wear sleeves, designed to be pressed onto a shaft to provide an enhanced sealing surface. Redi-Sleeves are fast, inexpensive repair options for grooved or worn shafts.

Redi-Sleeves are pressed onto a shaft where indications of seal wear, such as tracks or grooves, have developed. Using a Redi-Sleeve gives the shaft a smooth, ideal sealing surface.

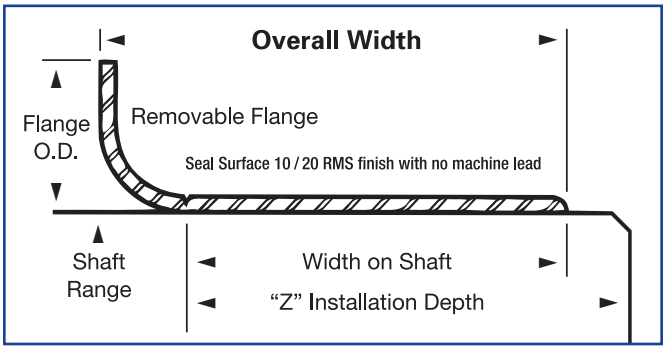
Fast, Inexpensive Shaft Repairs

Timken's line of Redi-Sleeves are easy to install and feature a removable flange and an installation tool. When using Redi-Sleeves, you receive:

- Strong, durable stainless steel construction that provides a corrosion-free sealing surface
- Ultra-thin construction that allows original seal size to be used with minimal additional lip loading
- Redi-Sleeve sealing surfaces that are ground to a 10-20 microinch Ra (0.25-0.50 Micrometer Ra) finish without lead
- Options for shafts from 0.5" (12.7mm) to 8" (203mm) diameters

Redi-Sleeve Size Selection

Selecting the proper size Redi-Sleeve is key to making sure equipment is up and running faster. To select the correct size, measure the shaft diameter where the sleeve will be positioned – ahead of the wear path. Do not measure the track worn by the old seal. The shaft needs to be measured in three positions: 12 o'clock to 6 o'clock, 2 o'clock to 8 o'clock and 4 o'clock to 10 o'clock. Average the three readings together to compensate for possible shaft out of round or error in measurement. Use the averaged measurement to select a part number from the size chart provided.



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Shaft Repair Kits

Shaft Repair Kits provided by Timken save time and costly shaft replacements. These kits include the industry-tested, technician-approved seal in addition to a Redi-Sleeve.

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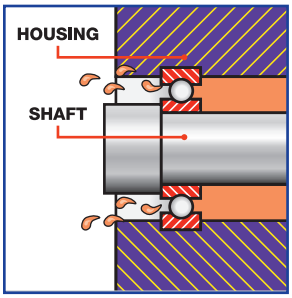
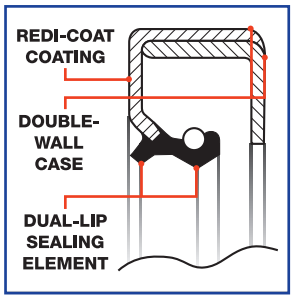
KIT INFORMATION			INCH				METRIC			
Kit Number	Seal	Redi-Sleeve	Shaft Size	Housing Bore	Outside Diameter	Width	Shaft Size	Housing Bore	Outside Diameter	Width
412920K	412920	99225	2.250	3.371	3.376	0.375	57,15	85,62	85,75	9,53
470380K	470380	99149	1.500	2.375	2.378	0.312	38,10	60,33	60,40	7,92
470625K	470625	99150	1.500	2.250	2.254	0.312	38,10	57,15	57,25	7,92
470712K	470712	99112	1.125	1.874	1.878	0.250	28,58	47,60	47,70	6,35
471255K	471255	99062	0.625	1.375	1.379	0.250	15,88	34,93	35,03	6,35
471271K	471271	99248	2.500	3.251	3.256	0.375	63,50	82,58	82,70	9,53
471272K	471272	99225	2.250	3.000	3.005	0.375	57,15	76,20	76,33	9,53
471413K	471413	99125	1.250	1.752	1.756	0.250	31,75	44,50	44,60	6,35
471652K	471652	99112	1.125	1.624	1.628	0.250	28,58	41,25	41,35	6,35
471750K	471750	99125	1.250	1.983	1.987	0.250	31,75	50,37	50,47	6,35
471766K	471766	99125	1.250	2.000	2.004	0.250	31,75	50,80	50,90	6,35
472258K	472258	99133	1.375	2.000	2.004	0.312	34,93	50,80	50,90	7,92

Zero Duplication™ Program

Keep lubricants and other critical fluids in, water and other contaminants out.



A seal keeps contaminants out and lubricants in to protect and extend bearing life.



Typical Zero Duplication seal design.

By consolidating your inventory into one systematic collection of premium-quality seals, the Zero Duplication program offered by Timken provides comprehensive coverage while minimizing the number of replacement seals you carry in inventory.

Zero Duplication is an effective way to do more with less. This program features a special selection of oil seals that are designed to meet the requirements of applications with shaft diameters up to 12" or 300mm – with zero duplication of comparable seals.

Improve Coverage and Reduce Inventory

Each Zero Duplication seal offered by Timken effectively replaces several similar seals, providing comprehensive application coverage with less inventory. This line of seals incorporates the most effective performance features in a range of common sizes.

Design Features*

Spring-loaded, dual-lip sealing element. Uses two sealing lips, one spring-loaded tightly against the shaft to retain lubricants, the other functioning as a contaminant excluder.

Double-wall case. Reduces deformation to the case during installation and forms a secure, stable base for optimum sealing element performance.

Exclusive Redi-Coat® coating. Seals minor bore defects to help ensure a tight, leak-proof seal.

Optional fluoroelastomer sealing element (available in selected part numbers in addition to standard Nitrile seals). Provides excellent high-temperature capabilities, good compatibility with a wide range of fluids and long life.

*Seal designs may vary. Not all features are used in all Zero Duplication seals.

MORE EFFICIENT, MORE PROFITABLE SEAL INVENTORY MANAGEMENT

Trust Zero Duplication Seals for Optimal Performance

Typically, a seal is replaced by an identical seal. Zero Duplication seals, however, offer performance equal and often superior to original seals. Even if the width, case design or sealing elements differ, Zero Duplication seals can provide optimal performance.

The Zero Duplication program offers tangible advantages for your customers:

- Faster, more responsive customer service
- Optimal seals for a wide range of applications
- The right seals in stock

Three Zero Duplication stocking plans have been developed to maximize coverage:

- **Gold** (up to 6"/160mm shaft sizes) – seals used in heavy industry (pulp and paper mills, ore processing, mining operations)
- **Silver** (up to 4"/100mm shaft sizes) – seals used in general industry (including heavy-duty, high-horsepower motors)
- **Bronze** (up to 2.5"/60mm shaft sizes) – seals used in light-duty service (including motion-control equipment, conveying operations)

We can also develop a customized Zero Duplication assortment based on an analysis of your present inventory.

Determining Zero Duplication Coverage

Zero Duplication seals are available to fit shafts from 0.250" to 12" in diameter and bore sizes from 0.499" to 14". Metric Zero Duplication seals are available to fit shafts from 7mm to 300mm in diameter and bore sizes from 16mm to 340mm.

Any part number listed in the Industrial Seals catalog that is in bold-face type is a Zero Duplication seal.

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Advantages of the Zero Duplication program:

- Faster, more responsive service
- Simple, easy replacement seal selection
- Simplified ordering process
- Reduced acquisition costs
- Reduced storage costs and requirements
- Elimination of obsolete seals

27576 - 29840

Competitor Number	National Size & Type	Zero Duplication or Recommended Industrial
29292	416654	**416654**
29292	475012	**416654**
29300	416654	**416654**
29305	47665N	**416654**
29310	416654	**416654**
29316	416654	**416654**
29317	416654	**416654**
29317	475012	**416654**
29322	475012	**416654**
29360	475012	**416654**
29370	416654	**416654**
29371	416654	**416654**
29375	416654	**416654**

Zero Duplication part numbers are listed in bold-faced type.

Using This Catalog

COMPLETE PRODUCT SELECTION DATA

Product Specification Section

The Specification section contains complete product data for Timken's line of National industrial seals. Size Listings for each style and type of seal or sleeve, as well as Material and compound selection guide, Compound compatibility chart, Recommended operation conditions chart, Installation instructions and Troubleshooting guidelines, also are included.

The Specification section contains an introduction, technical sections, complete size listings, numerical index, metric listing and seal/component design illustrations. All numbers are listed by size sequence and by the part number sequence.

Example:

PART NUMBER: If a part number is known and dimensional data is required, consult the **NUMERICAL LISTING**

DIMENSIONS: If the dimensions of a seal are known and a part number is required, consult the **SIZE LISTING** for specific information

Interchange Guide

The Interchange guide will assist in converting a competitor's part number to a corresponding seal. Begin by finding the identical first character of the product number (whether a letter or a numeral). Part numbers beginning with a letter will be listed in alphabetic, then numeric order.

All part numbers comprising numerals only will be listed in strict numeric order. For instances in which a letter appears in the middle of a part number (for example, 7A2125), the part number with the letter will be listed before any part numbers with a numeral in the same sequential position.

Example: **7A2125**
71250
Part number 7A2125 will be listed before part number 71250

TABLE OF CONTENTS

SECTION 1-A TECHNICAL

OIL SEAL DESIGN AND SELECTION

OIL SEAL NOMENCLATURE AND COMPONENTS

While industry has generally preferred the double lip or single lip, spring loaded seals, a wide variety of types and styles are produced to satisfy various application requirements.

To simplify the identification process of the oil seals a Type/Illustration column has been included in the Size, Numerical and Metric Listings of this catalog. The Type/Illustration number refers to the Oil Seal Illustration Chart. Just find the number on the illustration chart and the configuration of the component can be identified.

The National® Oil Seal Design Description is provided to illustrate seal types and to provide operating data and limitations for typical applications. Factors relative to oil seal design and selection are also reviewed. After size, application and seal requirements are determined, the proper seal can be located in the Size Section. Likewise, when the National part number is known, the size and type can be easily located in the Numerical Section.

NATIONAL SEAL PART NUMBERING SYSTEM

The National Oil Seal Engineering Department assigns the part numbers for all general purpose and special purpose seals. Each type and size combination manufactured is identified by an individual part number.

Three numbering systems are generally used to identify National Oil Seals:

1. General Purpose Seals—Five or six digit numbers. The first one or two digits usually signify seal type or construction. The last four digits refer to a specific assigned shaft and bore size combination but do not indicate seal size.They are assigned in consecutive order as a new shaft/bore combination is established. It may be possible to interchange seals for which the first one or two digits are different but for which the following digits are the same. Such an interchange determination should be based on whether alternative seal designs would meet the requirements of the specific application. Letter suffixes to part numbers within this manual usually refer to the sealing lip compound used.
2. A four digit number system is used for some seals and general purpose seal kits with primarily automotive applications. The numbers have been assigned consecutively and do not relate to seal size.
3. Preassigned blocks of numbers are used to identify certain groups of miscellaneous and special purpose seals:

370000A — Wheel End Seals
380000A — PTFE Wheel End Seals
39000 to 39999 — PTFE Seals
410000 to 499999 — Plain Round
710000 to 799999 — Misc. Round Application
99000 — Redi Sleeves

200000 to 200500 — Triple Lip Designs
200600 to 200899 — Triple Lip Designs External
200900 to 200999 — Dual-Lip Design
201000 to 205999 — Wheel Seals
220000 to 230000 — Automotive Metric
800000 — V-Seals
J, JV, JX etc. — Wear Sleeves

If an oil seal has a prefix and/or suffix that is not included within this manual, contact your regional Timken Representative for more specific information.

SECTION 1-A TECHNICAL

OIL SEAL DESIGN AND SELECTION

THE SEAL AND ITS FUNCTION

Oil Seal Definition

As products, oil seals may be simply described as devices that close or *seal* the spaces between stationary and moving components in mechanical equipment . . .*they prevent lubricant from escaping*.

Oil seals often called grease, fluid or dirt seals are the vital components of practically every type of machine and vehicle in operation. These seals fulfill an exacting function . . . they protect all types of precision constructed, close fitting ball, sleeve and roller bearings.

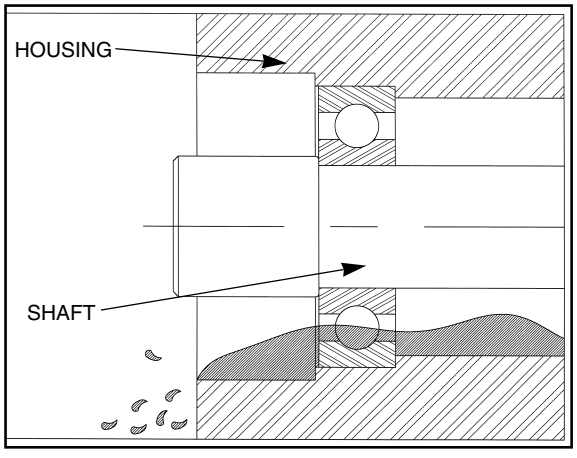
Oil Seal Function

Oil seals are used wherever shafts rotate and bearings require lubrication. In short, a seal is a barrier with three basic functions: 1) Retaining lubricants and liquids 2) Excluding contaminants 3) Seal or separate dissimilar fluids or gases.

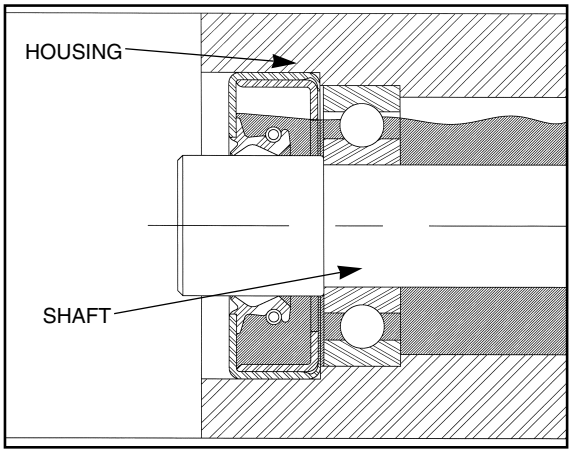
- Precision bearings rely on the oil seal to prevent lubricants from escaping the bearings or a specific area.
- Components of machines rely on the oil seal to prevent abrasives, corrosive moisture and other harmful contaminants from entering the mechanics of the machine.
- Separation of fluids and gases may completely rely on the seal to prevent intermixture of two different mediums such as lubricating oil and water.

Oil Seal In Use

In a typical application, the oil seal is installed adjacent to a bearing, sealing in or sealing out, as necessary, the various liquids, gases or solids encountered by the particular mechanism.



Without an oil seal . . . essential lubricant can escape through the bearing and . . . harmful dirt and foreign matter can enter.



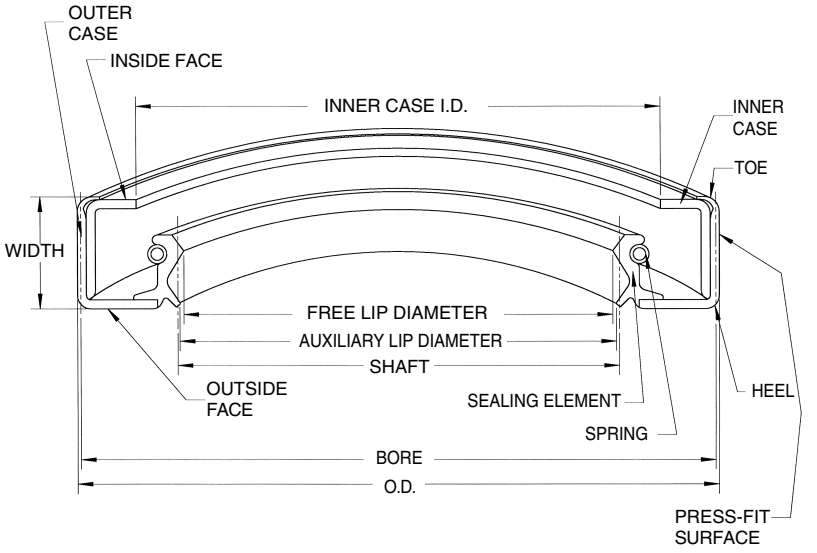
With a properly designed and fitted oil seal . . . the space between the housing and shaft is securely closed or sealed. Lubricant cannot escape . . . harmful dirt and foreign matter cannot enter.

SECTION 1-A TECHNICAL

OIL SEAL DESIGN AND SELECTION

OIL SEAL NOMENCLATURE AND COMPONENTS

The Society of Automotive Engineers (SAE) and the American Society of Testing Materials (ASTM) have developed and adapted a standard to identify component parts that make up an oil seal, as well as terminology and basic lip seal designs.



CONVERSION CHART - RPM TO FPM

Shaft Diameter is in inches

SHAFT DIAMETER

SHAFT SPEED

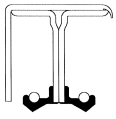
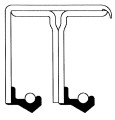
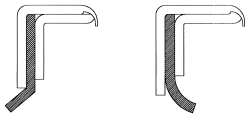
SPEED RANGE	RPM	1/2"	3/4"	1"	1-1/4"	1-1/2"	1-3/4"	2"	2-1/2"	3"	3-1/2"	4"	5"	6"	7"	8"	9"	10"
	100	13	20	26	33	39	46	52	65	79	92	105	131	157	183	209	236	262
	300	39	59	79	98	118	137	157	196	236	275	314	393	471	550	628	707	785
	500	65	98	131	164	196	229	262	327	393	458	524	654	785	916	1047	1178	1309
	1000	131	196	262	327	393	458	524	654	785	916	1047	1309	1571	1833	2094	2356	2618
	1500	196	295	393	491	589	687	785	982	1178	1374	1571	1963	2356	2749			
	2000	262	393	524	654	785	916	1047	1309	1571	1833	2094	2618					
SLOW	2500	327	491	654	818	982	1145	1309	1636	1963	2291	2618						
	3000	393	589	785	982	1178	1374	1571	1963	2356	2749							
	3500	458	687	916	1145	1374	1604	1833	2291	2749								
	4000	524	785	1047	1309	1571	1833	2094	2618									
	4500	589	884	1178	1473	1767	2062	2356	2945									
	5000	654	982	1309	1636	1963	2291	2618										
	6000	785	1178	1571	1963	2356	2749											
	7000	916	1374	1833	2291	2749												
	8000	1047	1571	2094	2618													
	9000	1178	1767	2356	2945													
MODERATE	10000	1309	1963	2618														
	12000	1571	2356															
	14000	1833	2749															
	16000	2094																
HIGH	18000	2356																
	20000	2618																

This table is carried out to the limits of the recommended speeds expressed in FPM (feet-per-minute) for seals of standard construction. Sizes and speeds beyond this table require special analysis of all conditions related to the application. For intermediate shaft sizes of RPM, the standard procedure of interpolation will apply.

SECTION 1-A TECHNICAL

OIL SEAL DESIGN AND SELECTION

NATIONAL OIL SEAL DESIGN DESCRIPTION

Type Description	Representative Cross-Sections of Sealing Elements	Type Numbers	Shaft Speeds Feet Per Minute
Spring Loaded Design Single Lip		5L, 5S, 33, 35, 45, 48, 51, 54, 62, 75, 83, 91, 100	3000
Spring Loaded Design Multi-Lip		1L, 1S, 2L, 2S, 3L, 21, 25, 30, 32, 40, 41, 43, 47, 52, 56, 57, 59, 61, 66, 68, 69, 70, 71, 72, 74, 76, 78, 79, 86, 87, 88, 90, 92, 93, 94, 96, 99	3000
Spring Loaded "Convolute" Design		64, 65	3000
Springless Designs Single-Lip For Grease Retention And Slow Speed Applications		4L, 4S, 24, 29, 31, 34, 44, 201, 203, 204, 205, 230, 271, 272, 273, 277, 278, 279, 283, 290	2000 Type 4L 1000
Springless Designs Multi-Lip For Grease Retention And Slow Speed Applications		49, 97, 98, 274, 276, 280, 281, 282, 284, 285, 286, 287	2000
External Lip To Seal At Bore Slow Speed Applications		8L, 8S, 26, 36, 46, 200, 200E	750
Spring Loaded Dual Opposing Lips Separates 2 Fluids		7L, 7S	3000
Dual Spring Loaded Same Direction Inner Lip Stems Lube Surges		9L, 9S	3000
Utilized Oil Bath Seal Design H.D. Truck & Trailer Hubs		37-1,2,3,4,5,6,7,8,9,10,11,12	3000
General Purpose PTFE Design		D, F, P, W	6500

VAMAC® THE REGISTERED TRADEMARK OF E I DUPONT
AFLAS® IS A REGISTERED TRADEMARK OF 3M COMPANY

SECTION 1-A TECHNICAL

OIL SEAL DESIGN AND SELECTION

NATIONAL OIL SEAL DESIGN TYPE DESCRIPTION

Maximum Pressure PSI @ FPM	Shaft Finish (Micro Inch) μ	Shaft Hardness	STBM Maximum (Shaft to Bore Misalignment @ RPM	Maximum Shaft Dynamic Runout (DRO)
7 @ 1000 FPM 5 @ 2000 FPM 3 @ 3000 FPM	10-20	Above Rockwell C-45	.015" ECC @ 800 RPM .010" ECC @ 4200 RPM	.025" TIR @ 800 RPM .020" TIR @ 2200 RPM .015" TIR @ 4200 RPM
7 @ 1000 FPM 5 @ 2000 FPM 3 @ 3000 FPM	10-20	Above Rockwell C-45	.020" ECC @ 4200 RPM	.060" TIR @ 4200 RPM
Atmospheric	10-25	Above Rockwell C-45	.005" ECC	.005" TIR
Atmospheric	10-25	Above Rockwell C-45	.010" ECC	.010" TIR
7 @ 1000 FPM 5 @ 2000 FPM 3 @ 3000 FPM	10-20	Above Rockwell C-45	.015" ECC @ 800 RPM .010" ECC @ 4200 RPM	.025" TIR @ 800 RPM .020" TIR @ 2200 RPM .015" TIR @ 4200 RPM
2 @ 2000 FPM	100 Max.	Above Rockwell C-45	.010" ECC Max.	.015" TIR

SECTION 1-B TECHNICAL

Sealing Element Compounds

MATERIALS AND COMPOUNDS AVAILABLE FOR SEALING ELEMENTS

The environments in which a seal will operate should be determined before selecting the sealing element or lip material. Two of the most important factors in material selection are Lubricant Temperature and Type.

National Oil Seals offer a variety of sealing lip materials and compounds. The temperature limitations and fluid/lubricant compatibility for most compounds are shown within the Compound Selection Chart on the following pages.

National Seals are used in a wide range of applications. The seal is part of a system and is dependent on proper shaft and bore operation to function correctly.

Runout, lubrication, shaft-to-bore misalignment, shaft speed, temperature, and other factors vary greatly from one application to another and each may affect the seal's life. In a perfect system, these factors would be nominalized to achieve maximum life for all components. To assist our customers in getting maximum performance from their sealing system, we have provided recommendations below.

Operating a seal at one extreme condition will have a small effect on seal life. However, when a seal is operating at multiple extremes in the system, it will have a much greater impact on performance. Therefore, we ask you to use the following recommendations as a guide to achieving the maximum performance from your seal. Each material or compound has been assigned a specific letter code and is referenced in various tables and listings throughout this manual.

Compound	Code	Advantages	Disadvantages/Limitations	Range	Substitute	Code
Felt	F	Adequate seal for heavy lubricants. Primarily a wiper seal.	Poor performance at low shaft speeds. Inadequate when excessive moisture is present.	-65°F to 200°F -48°C to 93°C	Nitrile Polyacrylic Vamac® Flouroelastomer Aflas® PTFE	S N E V A T
Leather	L	Good dry running capabilities.	Poor heat resistance. More expensive than Nitrile.	-50°F to 200°F -46°C to 93°C	Nitrile Polyacrylic Vamac® Flouroelastomer Aflas® PTFE	S N E V A T
Urethane	U	Good lubricant and ozone resistance. Good abrasion resistance. Durable, less susceptible to damage during installation than Silicone	Undergoes substantial softening above 250°F Poor resistance to hot water or steam.	Dependent upon exact compound and usage.	None	
Nitrile	S	Low cost. Good low temp. capability. Low swell in hydrocarbon fluids.	Does not have excellent heat resistance. Poor resistance to lubricants containing sulphur or EP additives, hydrocarbons/ oxygenate blends (gasoline/methanol). Poor ozone resistance.	-40°F to 225°F -40°C to 107°C	Polyacrylic Vamac® Fluoroelastomer Aflas® PTFE	N E V A T
Polyacrylate	N	Resistance to EP lubricants. Higher heat capabilities than Nitrile. Low swell in hydrocarbon fluids.	Limited low temperature capability. Poor dry running capability. Subject to attack in aqueous media. Higher cost than Nitrile	-20°F to 300°F -29°C to `49°C	Vamac® Fluoroelastomer Aflas® PTFE	E V A T
Ethylene-Acrylic (Vamac®)	E	Higher heat capabilities than Nitrile or Polyacrylic. Better low temp. performance than Polyacrylic. Good abrasion and dry running capability. Intermediate cost.	High swell in hydrocarbon fluids. Limited capabilities to follow eccentric shafts or perform in high frequency applications.	-30°F to 325°F -34°C to 163°C	Fluoroelastomer Aflas® PTFE	V A T
Silicone	H	Good dry heat resistance. Excellent low temperature capability.	Easily damaged during installation. Poor chemical resistance to certain EP additives and oxidized oil. High swell, poor dry running performance Higher cost than Nitrile.	-80°F to 350°F -62°C to 176°C	Fluoroelastomer Aflas® PTFE	V A T
Fluoro-Elastomer	V	Excellent high temperature capabilities. Compatible with wide range of fluids. Very long life.	Poor resistance to basic (high ph>7) fluids. Attack by high performance gear lubes. Expensive relative to other materials.	-40°F to 400°F -40°C to 204°C	Aflas® PTFE	A T
Tetrafluoro-Ethylene Propylene (Aflas®)	A	Better chemical resistance to all hydrocarbon fluids, acids, bases and oxidizing agents than Fluoroelastomers. Capable of performing in the complete range of hydraulic fluids. Continuous heat resistance over 400°F. Fair dry abrasion and radiation resistance.	Poor chemicl resistance to hydrocarbon/oxygenate blends (gasoline/methanol). Poor low temperature capabilities. More expensive than Fluoroelastomers.	-30°F to 400°F -34°C to 204°C	PTFE	T
PTFE	T	Excellent dry running capabilities. Low coefficient of friction. Excellent chemical resistance. Resistant to hydrocarbon/oxygenate blends.	Poor abrasion resistance to dirty environments. High thermal expansion. Susceptible to damage during iinstallation.	-100°F to 450°F -73°C to 232°C	None	

VAMAC® THE REGISTERED TRADEMARK OF E I DUPONT

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SECTION 1-B TECHNICAL

SEALING ELEMENT COMPOUNDS
Compound Selection Chart

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®
Durometer	60-80	70-75	70-90	80-90	75-85	75-95
Oil Resistance	Very Good	Fair	Good	Fair	Excellent	Excellent
Abrasion Resistance	Excellent	Fair	Good	Poor	Good	Good
Max. Service Temp.	225°F	300°F	325°F	350°F	400°F	400°F
Min. Service Temp.	-40°F	-20°F	-30°F	-80°F	-40°F	-30°F

Ratings: 1 = Minor effect 2 = Moderate effect 3 = Static only 4 = Not Recommended — = insufficient data

Elastomer	S	N	E	H	V	A
Acetaldehyde	4	4	3	2	4	4
Acetamide	1	4	1	2	2	1
Acetic Acid, Glacial	3	4	4	2	3	4
Acetic Acid, 30%	2	4	3	1	2	4
Acetic Anhydried	3	4	3	3	4	4
Acetone	4	4	4	3	4	4
Acetophenone	4	4	4	4	4	4
Acetyl Chloride	4	4	4	3	1	1
Acetylene	1	4	4	2	1	1
Acrylonitrile	4	4	4	4	3	2
Adipic Acid	1	—	2	2	—	1
Aero Shell 17 Grease	1	—	2	4	1	1
Aero Shell 750	2	—	2	4	1	1
Aero Shell 7 A Grease	1	—	2	2	1	1
Aero Shell IAC	1	—	—	—	1	1
Alkazene (Dibromoethylbenzene)	4	4	4	4	2	2
Alum-NH_3-Cr-K(aq)	1	4	4	1	4	2
Aluminum Acetate (aq)	2	4	4	4	4	3
Aluminum Chloride (aq)	1	1	1	2	1	1
Aluminum Floride (aq)	1	—	—	2	1	1
Aluminum Nitrate (aq)	1	—	—	2	1	1
Aluminum Phosphate (aq)	1	—	—	1	1	1
Aluminum Sulfate (aq)	1	4	1	1	1	1
Ammonia Anhydrous	2	4	4	3	4	1
Ammonia Gas (Cold)	1	4	4	1	4	1
Ammonia Gas (Hot)	4	4	4	1	4	1
Ammonium Carbonate (aq)	4	4	4	—	—	1
Ammonium Chloride (aq)	1	—	1	—	1	1
Ammonium Hydroxide (conc)	4	4	4	1	2	1
Ammonium Nitrate (aq)	1	2	2	—	—	1
Ammonium Nitrite (aq)	1	—	—	2	—	1
Ammonium Persulfate (aq)	4	4	—	—	—	1
Ammonium Phosphate (aq)	1	—	—	1	—	1
Ammonium Sulfate (aq)	1	4	1	—	4	1
Amyl Acetate (Banana Oil)	4	4	4	4	4	4
Amyl Alcohol	2	4	4	4	2	3
Amyl Borate	1	—	—	—	1	1
Amyl Chloronapthalene	4	4	4	4	1	2
Amyl Naphthalene	4	2	3	4	1	1
Aniline	4	4	4	4	3	1
Aniline Dyes	4	—	4	4	4	1
Aniline Hydrochloride	4	4	4	3	2	2
ANILINE OILS	2	4	2	4	2	1
Animal Fats	2	1	4	2	1	1
Ansul Ether (Anesthetics)	1	4	1	4	4	4
API GL-5	3	1	4	4	1	1
Aqua Regina	4	4	4	4	2	2
Aroclor, 1248	3	4	4	2	1	1
Aroclor, 1254	4	4	4	3	1	1
Aroclor, 1260	1	4	4	2	1	1
Arsenic Acid	1	3	4	1	1	1
Arsenic Trichloride (aq)	1	—	—	—	—	—
Askarel	2	4	4	4	1	1
Asphalt	2	2	—	4	1	1
ASTM Method D-471						
1	1	1	1	3	1	1
2	1	1	2	3	1	1
3	1	1	3	3	1	2
ASTM #4 Method D-471	2	—	—	4	1	—
ASTM Ref Fuel A (MIL-2-3136B (Type 1)	1	2	2	4	1	2
ASTM Ref Fuel B (MIL-S-3136B (Type 3)	1	—	2	4	1	2
ASTM Reference Fuel C	2	4	3	4	1	2
ATF Type (Mercon)	1	1	2	2	1	1
ATF Type A	1	1	2	2	1	1
ATF Type F	1	1	2	2	1	1
ATF Type I	1	1	2	2	1	1
ATF Type II	1	1	2	2	1	1
Automotive Brake Fluid	4	—	4	4	4	4
Banana Oil (Amyl Acetate)	4	4	4	4	4	4
Barium Chloride (aq)	1	1	2	1	1	1
Barium Hydroxide (aq)	1	4	2	1	1	1
Barium Sulfate (aq)	1	4	2	1	1	1
Barium Sulfide (aq)	1	4	2	1	1	1
Beer	1	4	1	1	1	1
Beet Sugar Liquors	1	4	2	1	1	1
Benzaldehyde	4	4	4	2	4	4
Benzene	4	4	4	4	1	2
Benzene Sulfonic Acid	4	4	4	4	1	1
Benzine (Ligroin) (Nirtobenzine) (Pet Ether)	1	1	—	4	1	1
Benzoic Acic	3	3	2	3	1	1
Benzoyl Chloride	4	4	4	—	1	1
Benzyl Alcohol	4	4	4	2	1	2
Benzyl Benzoate	4	4	4	—	1	1
Benzyl Chloride	4	4	4	4	1	1
Biphenyl (Diphenyl) (Phenylbenzene)	4	4	4	4	1	1
Blast Furnace Gas	4	4	4	1	1	1
Bleach Solutions	4	4	4	2	1	1
Borax	2	2	1	2	1	1
Bordeaux Mixture	2	4	4	2	1	1
Boric Acid	1	4	1	1	1	1
Brake Fluid (Non-Petroleum)	4	—	4	4	4	4
Brake Fluid (Wagner 21B)	3	—	4	3	4	3
Brine	1	4	3	1	1	1
Bromine-Anhydrous	4	4	4	4	1	1
Bromine Triflouride	4	4	4	4	4	2
Bromine Water	4	4	4	4	1	1
Bromobenzene	4	4	4	4	1	1
Bunker Oil	1	1	2	2	1	1

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®

Ratings: 1 = Minor effect 2 = Moderate effect 3 = Static only 4 = Not Recommended — = insufficient data

Elastomer	S	N	E	H	V	A
Butadiene	4	4	4	4	1	1
Butane	1	1	2	4	1	1
Butter (Animal Fat)	1	1	1	2	1	1
Butyl Acetate	4	4	4	4	4	4
Butyl Acetyl Ricinoleate	3	—	—	—	1	—
Butyl Acrylate	4	4	4	—	4	4
Butyl Alcohol	1	4	1	2	1	1
Butyl Amine	3	4	4	4	4	2
Butyl Benzoate	4	4	4	—	1	1
Butyl Carbitol	4	4	4	4	1	4
Butyl Cellosolve	3	4	4	—	4	4
Butyl Oleate	4	—	2	—	1	1
Butyl Stearate	2	—	1	—	1	1
Butylene	2	4	1	4	1	1
Butyraldehyde	4	4	4	4	4	2
Calcium Acetate(aq)	2	4	4	4	4	3
Calcium Bisulfite (aq)	4	4	2	1	1	1
Calcium Carbonate	1	—	1	1	1	1
Calcium Chloride (aq)	1	1	1	1	1	1
Calcium Hydroxide (aq)	1	4	2	1	1	1
Calcium Hypochlorite (aq)	2	4	2	2	1	1
Calcium Nitrate (aq)	1	1	1	2	1	1
Calcium Phosphate	1	—	1	1	1	1
Calcium Salts	1	—	1	—	—	1
Calcium Sulfide (aq)	1	4	4	2	1	1
Cane Sugar Liquors	1	4	1	1	1	1
Carbamate	3	4	4	—	1	1
Carbitol	2	4	3	2	2	4
Carbolic Acid (Phenol)	4	4	4	4	1	1
Carbon Bisulfide	3	3	4	4	1	1
Carbon Dioxide	1	—	1	2	1	1
Carbonic Acid	2	1	1	1	1	1
Carbon Monoxide	1	—	1	1	1	1
Carbon Tetrachloride	3	4	4	4	1	4
Castor Oil	1	1	2	1	1	1
Cellosolve	4	4	4	4	3	4
Cellosolve Acetate	4	4	4	4	4	4
Cellulube (Fryquel)	4	4	4	1	1	1
China Wood Oil (Tung Oil)	1	—	2	4	1	1
Chlorine (Dry)	4	4	4	4	1	1
Chlorine (Wet)	4	4	4	4	1	1
Chlorine Dioxide	4	4	4	—	1	1
Chlorine Trifluoride	4	4	4	4	4	4
Chloroacetic Acid	4	4	4	—	4	4
Chloroacetone	4	4	4	4	4	4
Chlorobenzene	4	4	4	4	1	1
Chlorobromomethane	4	4	4	4	1	1
Chlorobutadiene	4	4	4	4	1	1
Chlorododecane	4	4	4	4	1	1
Chloroform	4	4	4	4	1	4
O-Chloronaphthalene	4	4	4	4	1	1
1-Chloro-1-Nitro Ethane	4	4	4	4	4	2
Chlorosulfonic Acid	4	4	4	4	4	2
Chlorotoluene	4	4	4	4	1	2
Chlorox (Sodium Hypochlorite NaOC1)	2	4	4	2	1	1
Chrome Plating Solutions	4	4	4	2	1	1
Chromic Acid	4	4	4	3	1	1
Citric Acid	1	—	1	1	1	1
Coal Tar (Creosote)	1	1	4	1	1	
Cobalt Chloride (aq)	1	4	4	2	1	1

Elastomer	S	N	E	H	V	A
Cocoanut Oil	1	1	1	1	1	1
Cod Liver Oil	1	1	2	2	1	1
Coke Oven Gas	4	4	3	2	1	1
Copper Acetate (aq)	2	4	4	4	4	4
Copper Chloride (aq)	1	1	1	1	1	1
Copper Cyanide (aq)	1	1	2	1	1	1
Copper Sulfate (aq)	1	4	1	1	1	1
Corn Oil	1	1	1	1	1	1
Cottonseed Oil	1	1	1	1	1	1
Creosote (Coal Tar)	1	1	4	4	1	1
Cresol	4	4	4	4	1	1
Cresylic Acid	4	4	4	4	1	1
Crude Oil	2	—	2	4	1	1
Cumene	4	4	4	4	1	1
Cutting Oil	1	—	2	4	1	1
Cyclohexane	1	1	3	4	1	2
Cyclohexanol	3	—	1	4	1	2
Cyclohexanone	4	4	4	4	4	2
P-Cymene	4	4	4	4	1	1
DC44M Hi Temp Silicone Grease	3	3	3	3	1	1
Decaline	4	—	—	4	1	1
Decane	1	1	2	2	1	2
Delco Brake Fluid	4	—	4	4	4	4
Denatured Alcohol	1	4	3	1	1	1
Detergent Solutions	1	4	1	1	1	1
Developing Fluids	1	—	2	1	1	1
Dextron	1	—	2	4	1	1
Diacetone	4	4	4	4	4	4
Diacetone Alcohol	4	4	4	2	4	4
Dibenzyl Ether	4	—	4	—	4	4
Dibenzyl Sebecate	4	4	4	3	2	2
Dibromoethylbenzene (Alkazene)	4	4	4	4	2	2
Dibutyl Amine	4	4	4	3	4	1
Dibutyl Ether	4	3	4	4	3	2
Dibutyl Phthalate	4	4	4	2	3	1
Dibutyl Sebecate	4	4	4	2	2	1
O-Dichlorobenzene	4	4	4	4	1	1
Dichloro-Isopropyl Ether	4	3	4	4	3	4
Dicyclohexylamine	3	4	—	—	4	1
Diesel Oil	1	1	1	4	1	2
Di-Ester Lubricant (MIL-L-7808)	2	—	4	4	1	2 or 3
Di-Ester Synthetic Lubricant	2	—	4	4	1	2 or 3
Diethylamine	2	4	4	2	4	1
Diethyl Benzene	4	—	—	4	1	1
Diethyl Ether	4	3	4	4	4	4
Diethylene Glycol	1	2	1	2	1	1
Diethyl Sebecate	2	4	4	2	2	1
Diisobutylene	2	4	4	4	1	1
Diisopropyl Benzene	4	—	—	—	1	1
Diisopropyl Ketone	4	4	4	4	4	4
Diisopropylidene Acetone (Phorone)	4	4	4	4	4	4
Dimethyl Aniline (Xylidine)	3	4	4	4	4	2
Diethyl Ether (Methyl Ether) (Monomethyl Ether)	1	4	4	1	1	3
Dimethyl Formamide	2	4	3	2	4	4
Dimethyl Phthalate	4	4	4	—	2	1
Dinitrotoluene	4	4	4	4	4	4
Dioctyl Phthalate	3	4	4	3	2	1

SECTION 1-B TECHNICAL

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®

Ratings: 1 = Minor effect 2 = Moderate effect 3 = Static only 4 = Not Recommended — = insufficient data

Elastomer	S	N	E	H	V	A
Dioctyl Sebecate	4	4	4	3	2	1
Dioxane	4	4	4	4	4	4
Dioxalane	4	4	4	4	4	4
Dipentene	2	4	4	4	1	1
Diphenyl (Biphenyl) (Phenylbenzene)	4	4	4	4	1	1
Diphenyl Oxides	4	4	4	3	1	1
Dowtherm Oil	4	4	2	3	1	1
Drink Water (See Note Re. Water)	1	—	1	1	1	1
Dry Cleaning Fluids	3	4	3	4	1	2
Elco 28-EP Lubricant	1	—	1	4	1	1
Engine Oil (Diester Motor Oil)	2	1	2	1	1	1
Engine Oil (Hydrocarbon Motor Oil)	1	1	1	1	1	1
Epichlorohydrin	4	4	4	4	4	4
EP Lubes	2	1	2	4	1	1
ESSO GX 80W90 (GL-5)	2	1	2	4	1	1
ESSO Motor Oil	1	—	1	4	1	1
ESSO Transmission Fluid (TYPE A)	1	—	2	4	1	1
ESSO XP90 EP Lubricant	1	—	2	4	1	1
Ethane	1	1	2	4	1	1
Ethanol (Ethyl Alcohol)	1	4	3	1	3	2
Ethanolamine	2	4	4	2	4	1
Ethyl Acetate	4	4	4	2	4	4
Ethyl Acetoacetate	4	4	4	2	4	4
Ethyl Acrylate	4	4	4	2	4	2
Ethyl Alcohol	1	4	3	1	3	1
Ethyl Benzene	4	4	4	4	1	2
Ethyl Benzoate	4	4	3	4	1	2
Ethyl Cellosolve	4	4	4	4	4	4
Ethyl Cellulose	2	4	3	3	4	1
Ethyl Chloride	1	4	4	4	1	1
Ethyl Chlorocarbonate	4	4	4	4	1	1
Ethyl Chloroformate	4	4	4	4	4	4
Ethyl Ether	3	4	4	4	4	4
Ethyl Formate	4	—	4	—	1	4
Ethyl Mercapton	4	—	4	3	2	1
Ethyl Oxalate	4	4	4	4	1	1
Ethyl Pentachlorobenzene	4	4	4	4	1	1
Ethyl Silicate	1	—	—	—	1	1
Ethylene	1	—	4	—	1	1
Ethylene Chloride	4	4	4	4	2	1
Ethylene Chlorohydrin	4	4	4	2	1	2
Ethylene Diamine	1	4	4	1	4	1
Ethylene Dichloride	4	4	4	4	1	1
Ethylene Glycol	1	3	1	1	1	1
Ethylene Oxide	4	4	4	4	4	4
Ethylene Trichloride	4	4	4	4	1	1
Fatty Acids	2	—	1	3	1	1
Ferric Chloride (aq)	1	1	2	2	1	1
Ferric Nitrate (aq)	1	1	2	3	1	1
Ferric Sulfate (aq)	1	1	2	2	1	1
Fish Oil	1	—	—	1	1	1
Fluorinated Cyclic Ethers	—	—	4	—	—	4
Fluorine (Liquid)	4	4		4	2	2
Fluorobenzene	4	4	4	4	1	1
Fluoroboric Acid	1	—	—	—	—	1
Fluorocarbon Oils	—	—	4	—	—	3
Fluorolube	1	—	4	1	2	2
Fluorosilicic Acid (Hydrofluosilicic Acid)	1	—	2	4	1	1
Formaldehyde (RT)	3	4	4	2	4	3
Formic Acid	2	—	2	2	3	2
Freon 11	2	—	3	4	1	4
Freon 12	1	1	3	4	2	4
Freon 13	1	—	3	4	1	4
Freon 21	4	—	3	4	4	4
Freon 22	4	2	4	4	4	4
Freon 31	4	—	3	—	4	4
Freon 32	1	—	3	—	4	4
Freon 112	3	—	3	4	1	4
Freon 113	1	—	3	4	2	4
Freon 114	1	—	3	4	2	4
Freon 115	1	—	3	—	1	4
Freon 134A	4	4	2	4	4	4
Freon 142b	1	—	3	—	4	4
Freon 152a	1	—	3	—	4	4
Freon 218	1	—	3	—	1	4
Freon C316	1	—	3	—	—	4
Freon C318	1	—	3	—	2	4
Freon 1381	1	—	3	4	1	4
Freon 114B2	2	—	3	4	2	4
Freon 502	2	—	3	—	2	4
Freon TF	1	—	3	4	2	4
Freon T-WD602	2	—	3	4	1	4
Freon TMC	2	—	3	3	1	4
Freon T-P35	1	—	3	1	1	4
Freon TA	1	—	3	3	3	4
Freon TC	1	—	3	4	1	4
Freon MF	1	—	3	4	2	4
Freon BF	2	—	3	4	1	4
Fuel Oil	1	1	1	4	1	1
Fumaric Acid	1	4	—	2	1	1
Furan, Furfuran	4	4	4	—	—	4
Furfural	4	4	4	4	4	4
Fyrquel (Cellulube)	4	4	—	1	1	1
Gallic Acid	2	4	4	—	1	1
Gasohol (10% Ethanol Ormethanol)	2	4	4	4	1	2
Gasoline (Lead And No-lead)	2	4	3	4	3	2
Gasoline	2	4	2	4	1	1
Gelatin	1	4	1	1	1	1
Glauber's Salt (aq)	4	4	1	—	1	1
Glucose	1	—	1	1	1	1
Glue	1	—	1	1	1	1
Glycerine	1	3	1	1	1	1
Glycols	1	4	1	1	1	1
Grease	1	2	2	1	1	1
Green Sulfate Liquor	2	2	1	1	1	1
Gulf High Temperature Grease	1	—	1	4	1	1
Halowax Oil	4	—	—	4	1	1
N-Hexaldehyde	4	—	2	2	4	3
Hexane	1	1	1	4	1	2
N-Hexene-1	2	1	1	4	1	1
Hexyl Alcohol	1	4	1	2	1	1
High Viscosity Lubricant, H2	1	—	1	1	1	1
High Viscosity Lubricant, U4	1	—	1	1	1	1
Hydrazine	2	—	—	3	4	3
Hydraulic Oil (Petroleum)	1	1	1	3	1	1
Hydrobromic Acid	4	4	2	4	1	1

SECTION 1-B TECHNICAL

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®

Ratings: 1 = Minor effect 2 = Moderate effect 3 = Static only 4 = Not Recommended — = insufficient data

Elastomer	S	N	E	H	V	A
Hydrobromic Acid 40%	4	4	4	4	1	1
Hydrochloric Acid (Cold) 37%	3	4	4	3	1	1
Hydrochloric Acid (Hot) 37%	4	4	4	4	2	1
Hydrocyanic Acid	2	4	—	3	1	1
Hydrofluoric Acid (Con.) Cold	4	4	4	4	1	1
Hydrofluoric Acid (Conc.) Hot	4	4	4	4	3	1
Hydrofluoric Acid — Anhydrous	4	4	4	4	4	1
Hydrofluosilicic Acid (Fluosilicic Acid)	1	—	—	4	1	1
Hydrogen Gas	1	2	1	3	1	1
Hydrogren Peroxide (90%)	4	4	4	2	2	1
Hydrogen Sulfide (Wet) Cold	4	4	4	3	4	1
Hydrogen Sulfide (Wet) Hot	4	4	4	3	4	1
Hydroquinone	3	4	—	—	2	2
Hyjet	4	—	4	—	4	3
Hyjet III	4	—	4	—	4	3
Hyjet S	4	—	4	—	4	3
Hyjet W	4	—	4	—	4	3
Hypochlorous Acid	4	4	4	—	1	1
Iodine Pentafluoride	4	4	4	4	4	—
Iodoform	—	—	—	—	—	—
Isobutyl Alcohol	2	4	1	1	1	1
Isooctane	1	1	1	4	1	2
Isophorone	4	4	4	4	4	4
Isopropyl Acetate	4	4	4	4	4	4
Isopropyl Alcohol	2	4	1	1	1	1
Isopropyl Chloride	4	4	4	4	1	1
Isopropyl Ether	2	3	4	4	4	4
Kerosene	1	1	3	4	1	1
Lacquers	4	4	4	4	4	3
Lacquer Solvents	4	4	4	4	4	4
Lactic Acid (Cold)	1	4	3	1	1	1
Lactic Acid (Hot)	4	4	3	2	1	1
Lard	1	1	1	2	1	1
Lavender Oil	2	2	2	4	1	1
Lead Acetate (aq)	2	4	4	4	4	4
Lead Nitrate (aq)	1	—	4	2	—	1
Lead Sulfamate (aq)	2	4	4	2	1	1
Legroin (Benzine) (Nitrobenzine) (Pet Ether)	1	1	4	4	1	2
Lime Bleach	1	4	4	2	1	1
Lime Sulfur	4	4	4	1	1	1
Lindol (Hydraulic Fluid)	4	4	4	3	2	1
Linoleic Acid	2	—	3	2	2	1
Linseed Oil	1	1	1	1	1	1
Liquified Petroleum Gas	1	3	1	3	1	1
Lubricating Oils (Petroleum)	1	1	1	4	1	1
Lye	2	4	4	2	2	1
Magnesium Chloride (aq)	1	—	1	1	1	1
Magnesium Hydroxide (aq)	2	4	1	—	1	1
Magnesium Sulfate (aq)	1	4	1	1	1	1
Maleic Acid	4	4	1	—	1	1
Maleic Anhydride	4	4	—	—	4	1
Malic Acid	1	4	3	2	1	1
Mek ((MMehtyl Ethyl Ketone)	4	4	4	4	4	4
Mercury Chloride (aq)	1	—	—	—	1	1
Mercury	1	—	1	—	1	1
Mesityl Oxide	4	4	—	4	4	—

Elastomer	S	N	E	H	V	A
Methane	1	1	1	4	2	1
Methanol (Methyl Alcohol)	1	4	1	1	4	2
Methyl Acetate	4	4	4	4	4	4
Methyl Acrylate	4	4	4	4	4	4
Methylacrylic Acid	4	4	4	4	4	1
Methyl Alcohol	1	2	1	1	4	1
Methyl Bromide	2	3	—	—	1	1
Methyl Butyl Ketone (Propyl Acetone)	4	4	4	3	4	4
Methyl Cellosolve	3	4	4	4	4	1
Methyl Chloride	4	4	4	4	2	1
Methyl Cyclopentane	4	4	4	4	2	1
Methylene Chloride	4	4	4	4	2	2
Methyl Ether (Dimethyl Ether) (Monomethyl Ether)	4	4	4	4	2	2
Methyl Ethyl Ketone	4	4	4	4	4	4
Methyl Formate	4	—	4	—	—	—
Methyl Isobutyl Ketone	4	4	4	4	4	4
Methyl Methacrylate	4	4	4	4	4	3
Methyl Oleate	4	—	—	—	2	1
Methyl Salicylate	4	—	—	—	—	1
Milk	1	4	1	1	1	1
Mineral Oil	1	1	1	2	1	1
Monochlorobenzene	4	4	4	4	1	2
Monomethyl Aniline	4	4	4	—	2	1
Monoethanol Amine	4	4	4	2	4	4
Monomethyl Ether (Methyl Ether) (Dimethyl Ether)	1	4	1	1	1	3
Monovinyl Acetylene	1	—	—	2	1	1
Mustard Gas	—	—	—	1	—	1
MIL-L-644 B	1	2	2	3	—	—
MIL-L-2104 B	1	1	1	3	1	1
MIL-L-2105 B	1	1	1	3	1	1
MIL-G-2108	1	1	1	3	1	1
MIL-S-3136 B Type 1	1	2	2	4	1	2
MIL-S-3136 B Type II	1	—	—	4	1	2
MIL-S-3136 B Type III	1	—	4	4	1	2
MIL-S-3136 B Type IV	1	1	1	3	1	2
MIL-S-3136 B Type V	1	1	1	3	1	2
MIL-S-3136 B Type VI	1	1	1	3	1	2
MIL-S-3136 B Type VII	1	—	—	4	1	2
MIL-L-3150 A	1	1	1	3	1	2
MIL-L-3503	1	1	1	3	1	2
MIL-L-3545 B	2	2	2	4	1	2
MIL-C-4339 C	1	1	1	3	1	2
MIL-G-4343 B	2	1	—	4	1	1
MIL-L-5020 A	1	2	2	4	1	2
MIL-J-5161 F	1	—	2	4	1	2
MIL-C-5545 A	2	2	—	4	1	2
MIL-H-5559 A	1	3	2	2	2	1
MIL-F-5566	1	—	2	1	1	1
MIL-F-5602	1	1	3	3	1	2
MIL-H-5606 B (Red Oil)	1	1	2	4	1	—
MIL-J-5624 G JP-3, JP-4, JP-5	1	2	3	4	1	2
MIL-O-6081 C	1	1	2	3	1	2
MIL-L-6082 C	1	1	2	3	1	2
MIL-H-6083 C	1	1	2	3	1	2
MIL-L-6085 A	1	3	4	3	1	2
MIL-L-6086 B	1	1	2	3	1	2
MIL-L-6387 A	1	—	—	3	1	2
MIL-C-6529 C	2	2	3	4	1	2
MIL-F-7024 A	1	2	3	4	1	2
MIL-H-7083 A	1	3	2	2	2	1

SECTION 1-B TECHNICAL

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®

Ratings: 1 = Minor effect 2 = Moderate effect 3 = Static only 4 = Not Recommended — = insufficient data

Elastomer	S	N	E	H	V	A
MIL-G-7118 A	1	3	4	3	1	2
MIL-G-7187	1	1	2	3	1	2
MIL-G-7421 A	1	—	—	3	1	2
MIL-H-7644	2	2	3	4	1	1
MIL-L-7645	2	2	3	4	1	2
MIL-G-7711 A	1	1	2	3	1	2
MIL-L-7808 F	1	3	4	3	1	2
MIL-L-7870 A	1	1	2	3	1	3
MIL-C-8188 C	1	3	3	3	1	3
MIL-A-8243 B	1	3	2	2	2	1
MIL-L-8383 B	1	1	2	3	1	2
MIL-H-8446 B (MLO-8515)	2	3	4	4	1	2
MIL-1-8660 B	1	—	—	4	1	1
MIL-L-9000 F	1	2	3	4	1	2
MIL-T-9188 B	4	4	4	4	4	2
MIL-L-9236 B	1	3	3	4	1	3
MIL-L-10295 A	1	1	2	3	1	2
MIL-L-10324 A	1	1	2	3	1	2
MIL-G-10924 B	1	1	1	3	1	2
MIL-L-11734 B	1	3	2	3	1	2
MIL-O-11773	1	3	3	3	1	2
MIL-P-12098	2	2	2	4	1	1
MIL-H-13862	1	1	1	3	1	2
MIL-H-13866 A	1	1	1	3	1	2
MIL-H-13910 B	2	2	2	4	1	1
MIL-H-13919 A	1	1	1	3	1	2
MIL-L-14107 B	3	—	1	4	1	2
MIL-L-15017	1	1	1	3	1	2
MIL-L-15018 B	1	1	1	3	1	2
MIL-L-15019 C	1	1	1	3	1	2
MIL-L-15719 A	2	2	2	4	1	1
MIL-G-15793	1	3	3	3	1	2
MIL-F-16929 A	1	3	4	3	1	2
MIL-L-16958 A	1	1	1	3	1	2
MIL-F-17111	1	1	1	3	1	2
MIL-L-17331 D	1	1	1	3	1	2
MIL-L-17353 A	1	—	—	3	1	2
MIL-L-17672 B	1	1	1	3	1	2
MIL-L-18486 A	1	1	1	3	1	2
MIL-G-18709A	1	1	1	3	1	2
MIL-H-19457 B	4	4	4	4	4	3
MIL-F-19605	1	—	—	4	1	2
MIL-L-19701	1	3	3	3	1	2
MIL-L-21260	1	1	1	3	1	2
MIL-S-21568 A	1	1	1	4	1	1
MIL-H-22072	1	3	2	2	2	2
MIL-L-22396	1	1	1	3	1	2
MIL-L-23699 A	1	3	2	3	1	2
MIL-G-23827 A	1	3	2	3	1	2
MIL-G-25013	1	2	2	4	1	2
MIL-F-25172	1	—	—	4	1	2
MIL-L-25336 B	1	3	3	3	1	2
MIL-F-25524 A	1	—	1	4	1	2
MIL-G-25537 A	1	1	1	3	1	2
MIL-F-25558 B (RJ-1)	1	1	1	3	1	1
MIL-F-25576 C(RP-1)	1	1	1	4	1	1
MIL-H-25598	1	1	1	3	1	2
MIL-F-25656 B	1	—	—	4	1	1
MIL-L-25681 C	1	2	2	4	1	1
MIL-G-25760 A	1	3	3	4	1	2
MIL-G-25968	1	3	3	3	1	2
MIL-L-26087 A	1	1	2	3	1	2
MIL-G-27343	1	—	—	4	1	1
MIL-H-27601 A	2	2	2	4	1	2
MIL-G-27617	4	—	—	4	1	1

Elastomer	S	N	E	H	V	A
MIL-I-27686 D	1	3	2	2	2	2
MIL-L-27694 A	1	—	—	4	1	1
MIL-L-46000 A	1	3	3	3	1	2
MIL-H-46001 A	1	1	1	3	1	2
MIL-L-46002	1	—	—	3	1	2
MIL-H-46004	1	1	1	3	1	2
MIL-P-46046 A	2	2	2	4	1	1
MIL-H-81019 B	1	1	1	3	1	2
MIL-S-81087	1	—	—	4	1	1
Naphtha	2	2	4	4	1	1
Naphthalene	4	—	4	4	1	1
Naphthalenic Acid	2	—	—	4	1	1
Natural Gas	1	2	4	1	1	1
Neats Foot Oil	1	1	4	2	1	1
Neville Acid	4	4	4	4	1	1
Nickel Acetate (aq)	2	4	4	4	4	4
Nickel Chloride (aq)	1	3	4	1	1	1
Nickel Sulfate (aq)	1	4	4	1	1	1
Niter Cake	1	4	4	1	1	1
Nitric Acid (Con.)	4	4	4	4	3	2
Nitric Acid (Dilute)	4	4	4	2	1	2
Nitric Acid — Red Fuming	4	4	4	4	4	2
Nitrobenzene	4	4	4	4	2	1
Nitrobenzene (Petroleum Ether)	1	1	4	4	1	1
Nitroethane	4	4	4	4	4	1
Nitrogen	1	1	1	1	1	1
Nitrogen Tetroxide	4	4	4	4	4	1
Nitromethane	4	4	4	4	4	1
O-A-548 a	1	3	2	2	2	—
O-T-634 b	3	4	4	4	1	—
Octachlorotoluene	4	4	4	4	1	2
Octadecane	1	2	2	4	1	1
N-octane	2	4	1	4	1	1
Octyl Alcohol	2	4	1	2	1	1
Oleic Acid	3	4	3	4	2	1
Oleum Spirits	2	—	4	4	1	2
Olive Oil	1	1	1	3	1	1
O-Dichlorobenzene	4	4	2	4	1	1
Oxalic Acid	2	—	1	2	1	1
Oxygen — Cold	2	2	4	1	1	1
Oxygen — (200-400°F)	4	4	4	2	2	1
Ozone	4	2	1	1	1	1
Paint Thinner, Duco	4	4	4	4	2	2
Palmitic Acid	1	2	—	4	1	1
Peanut Oil	1	1	1	1	1	1
Perchloric Acid	4	4	4	4	1	1
Perchloroethylene	2	4	4	4	1	1
Petroleum — Below 250°F	1	2	2	2	1	1
Petroleum — Above 250°F	4	4	2	4	2	1
Phenol (Carbolic Acid)	4	4	4	4	1	1
Phenylbenzene (Diphenyl) (Diphenyl)	4	4	4	4	1	1
Phenyl Ethyl Ether	4	4	4	4	4	3
Phenyl Hydrazine	4	4	4	—	1	1
Phorone (Diisopropylidene Acetone)	4	4	4	4	4	4
Phosphoric Acid — 20%	2	—	2	2	1	1
Phosphoric Acid — 45%	4	—	2	3	1	1
Phosphorus Trichloride	4	—	—	—	1	1

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®

Ratings: 1 = Minor effect 2 = Moderate effect 3 = Static only 4 = Not Recommended — = insufficient data

Elastomer	S	N	E	H	V	A
Pickling Solution	4	4	4	4	2	1
Picric Acid	2	—	4	4	1	1
Pinene	2	4	4	4	1	1
Pine Oil	4	—	2	3	1	1
Piperidine	4	4	4	4	4	—
Plating Solution — Chrome	—	—	—	4	1	1
Plating Solution — Others	1	—	—	4	1	1
Polyvinyl Acetate Emulsion	—	—	1	—	—	—
Potassium Acetate (aq)	2	4	4	4	4	4
Potassium Chloride (aq)	1	1	1	1	1	1
Potassium Cupro Cyanide (aq)	1	1	1	1	1	1
Potassium Cyanide (aq)	1	1	1	1	1	1
Potassium Dichromate (aq)	1	1	2	1	1	1
Potassium Hydroxide (aq)	2	4	4	3	4	1
Potassium Nitrate (aq)	1	1	1	1	1	1
Potassium Sulfate (aq)	1	4	—	1	1	1
Producer Gas	1	2	1	2	1	1
Propane	1	1	1	4	1	1
i-Propyl Acetate	4	4	4	4	4	4
n-Propyl Acetate	4	4	4	4	4	4
Propyl Acetone (Methyl Butyl Ketone)	4	4	4	3	4	4
Propyl Alcohol	1	4	1	1	1	1
Propyl Nitrate	4	4	4	4	4	1
Propylene	4	4	4	4	1	1
Propylene Oxide	4	4	4	4	4	4
Pydraul, 10E, 29 ELT	4	4	4	4	1	1
Pydraul, 30E, 50E, 65E, 90E	4	4	4	1	1	1
Pydraul, 115E	4	4	4	4	1	1
Pydraul, 230E, 312C, 540C	4	4	4	4	1	1
Pyranolo, Transformer Oil	1	1	4	4	1	1
Pyridine	4	4	4	4	4	1
Pyroligneous Acid	4	4	4	—	4	—
Pyrrole	4	4	4	2	4	3
P-S-661 b	1	—	—	4	1	—
P-D-680	1	—	—	4	1	—
Radiation	3	3	1	3	4	1
Rapeseed Oil	2	2	2	4	1	1
Red Oil (MIL-H-5606)	1	1	2	4	1	1
RJ-1 (MIL-F-25558 B)	1	1	2	4	1	1
RP-1 (MIL-F-25576 C)	1	1	2	4	1	1
SAE 30	1	1	1	1	1	1
SEA 90	1	1	1	4	1	1
SAE 90 EP(GL-5)	2	1	2	4	1	1
Sal Ammoniac	1	1	1	2	1	1
Salicylic Acid	2	—	1	—	1	1
Salt Water	1	4	1	1	1	1
Sewage	1	4	1	1	1	1
Shell Alvania Grease #2	1	—	1	2	1	1
Silicate Esters	2	—	4	4	1	1
Silicone Greases	1	1	1	3	1	1
Silicone Oils	1	1	1	3	1	1
Silver Nitrate	2	1	1	1	1	1
Skydrol 500	4	4	4	3	4	2
Skydrol 7000	4	4	4	3	2	2
Soap Solutions	1	4	1	1	1	1
Soda As	1	—	1	1	1	1
Sodium Acetate (aq)	2	4	4	4	4	4
Sodium Bicarbonate (aq) (Baking Soda)	1	—	1	1	1	1
Sodium Bisulfite (aq)	1	4	1	1	1	1
Sodium Borate (aq)	1	—	1	1	1	1
Sodium Chloride (aq)	1	—	1	1	1	1
Sodium Cyanide (aq)	1	—	1	1	1	1
Sodium Hydroxide (aq)	2	3	1	2	2	1
Sodium Hypochlorite (aq (Chlorox)	2	4	2	2	1	1
Sodium Metaphosphate (aq)	1	—	—	—	1	1
Sodium Nitrate (aq)	1	—	—	4	—	1
Sodium Perborate (aq)	2	—	2	2	1	1
Sodium Peroxide (aq)	2	4	3	4	1	1
Sodium Phosphate (aq)	1	1	2	4	1	1
Sodium Silicate (aq)	1	—	1	—	1	1
Sodium Sulfate (aq)	1	4	2	1	1	1
Sodium Thiosulfate (aq)	2	4	2	1	1	1
Soybean Oil	1	1	2	1	1	1
Stannic Chloride (aq)	1	—	2	2	1	1
Stannous Chloride (aq)	1	—	2	2	1	1
Steam Under 300°F	4	4	1	3	4	1
Steam Over 300°F	4	4	1	4	4	1
Stearic Acid	2	—	4	2	—	1
Stoddard Solvent	1	1	3	4	1	1
Styrene	4	4	4	4	2	2
Sucrose Solution	1	4	1	1	1	1
Sulfite Liquors	2	4	4	4	1	1
Sulfur	4	4	2	3	1	1
Sulfur Chloride (aq)	3	4	2	3	1	1
Sulfur Dioxide (Dry)	4	4	2	2	1	1
Sulfur Dioxide (Wet)	4	4	2	2	1	1
Sulfur Dioxide (Liquified) Under Pressure)	4	4	2	2	1	1
Sulfur Hexafluoride	2	4	4	2	1	1
Sulfur Trioxide	4	4	4	2	1	1
Sulfuric Acid (Dilute)	3	2	4	4	1	1
Sulfuric Acid (Conc.)	4	4	4	4	1	1
Sulfuric Acid (20% Oleum)	4	4	4	4	1	1
Sulfurous Acid	2	4	4	4	1	1
Sunoco All Purpose Grease	1	—	1	4	1	1
Sunoco SAE 10	1	—	2	4	1	1
Tannic Acid	1	4	2	2	1	1
Tar, Bituminous	2	4	4	2	1	1
Tartaric Acid	1	—	2	1	1	1
Terpineol	2	—	—	—	1	1
Tertiary Butyl Alcohol	2	4	3	2	1	1
Tertiary Butyl Catechol	4	4	4	—	1	—
Tertiary Butyl Mercaptan	4	4	4	4	1	1
Tetrabromoethane	4	4	4	4	1	1
Tetrabromomethane	4	—	4	4	1	1
Tetrabutyl Titanate	2	—	—	—	1	1
Tetrochloroethylene	4	4	4	4	1	1
Tetraethyl Lead	2	—	3	—	1	1
Tetrahydrofuran	4	4	4	4	4	4
Tetralin	4	—	—	4	1	1
Thionyl Chloride	4	4	4	—	2	1
Titanium Tetrachloride	2	4	4	4	1	1
Toluene	4	4	4	4	1	4
Toluene Diiscocyanate	4	4	4	4	4	4
Transformer Oil	1	2	1	2	1	1
Transmission Fluid Type A	1	1	1	2	1	1
Triacetin	2	4	4	—	4	2
Triaryl Phosphate	4	4	4	3	1	1
Tributoxy Ethyl Phosphate	4	4	4	—	1	1
Tributyl Mercaptan	4	4	4	4	1	1
Tributyl Phosphate	4	4	4	4	4	1

Properties	S Nitrile	N Acrylates	E Vamac®	H Silicone	V Fluoroelastomers	A Aflas®

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Elastomer	S	N	E	H	V	A
Trichloroacetic Acid	2	4	4	—	3	2
Trichloroethane	4	4	4	4	1	1
Trichloroethylene	4	4	4	4	1	4
Tricresyl Phosphate	4	4	2	3	1	1
Triethonol Amine	2	4	1	—	4	1
Triethyl Aluminum	4	4	4	—	2	1
Triethyl Borane	4	4	4	—	1	1
Trinitrotoluene	4	4	4	—	2	2
Trioctyl Phosphate	4	4	2	3	2	1
Tung Oil (China Wood Oil)	1	—	2	4	1	1
Turbine Oil	2	1	2	4	1	1
Turbo Oil #35	1	—	2	4	1	1
Turpentine	1	2	4	4	1	1
Type I Fuel (MIL-S-3136)	1	—	1	4	1	1
Type II Fuel (MIL-L-3136)	2	—	2	4	1	1
Type III Fuel (MIL-L-3136)	2	—	4	4	1	1
TT-N 95 a	1	—	—	4	1	2
TT-N-97 B	1	3	3	4	1	2
TT-I-735 b	1	—	—	1	1	1
TT-S-735 Type I	1	2	2	4	1	2
TT-S-735 Type II	1	—	—	4	1	2
TT-S-735 Type III	1	—	—	4	1	2
TT-S-735 Type IV	1	1	2	3	1	2
TT-S-735 Type V	1	1	1	3	1	2
TT-S-735 Type VI	1	1	1	3	1	2
TT-S-735 Type VII	1	—	—	4	1	2
TT-T656b	4	4	4	4	4	3
Unsymmetrical Dimethyl Hydrazine (UDMH)	2	—	—	4	4	—

Elastomer	S	N	E	H	V	A
Varnish	2	4	1	4	1	1
Vegetable Oils	1	1	1	2	1	1
Versilube F-50	1	1	2	3	1	1
Vinegar	2	4	2	1	1	2
Vinyl Chloride	4	4	4	—	1	1
VV-B-680	2	2	2	4	1	1
VV-G-632	1	1	2	3	1	2
VV-G-671c	1	1	2	3	1	2
VV-H-910	2	2	2	4	1	1
VV-I-530a	1	1	2	3	1	2
VV-K-211d	1	—	—	4	1	2
VV-K-220a	1	2	2	4	1	2
VV-L-751b	2	2	2	4	1	2
VV-L-800	1	1	1	3	1	2
VV-L-820b	1	1	1	3	1	2
VV-L-825a Type I	1	1	1	3	1	2
VV-L-825a Type II	1	1	1	3	1	2
VV-L-825a Type III	2	2	3	4	1	2
VV-O-526	1	1	2	3	1	2
VV-P-216a	1	1	2	3	1	2
VV-P-236	2	2	3	4	1	2
Wagner 21 Brake Fluid	3	—	4	3	4	1
Water	1	4	1	1	1	1
Whiskey, Wines	1	4	1	1	1	1
White Pine Oil	2	—	—	4	1	1
White Oil	1	1	1	4	1	1
Wood Oil	1	1	1	4	1	1
Xylene	4	4	4	4	1	3
Xylidine (Di-methyl Aniline)	3	4	4	4	4	2
51-F-23	1	1	1	3	1	1

SECTION 1-C TECHNICAL

Sealing System Preparation And Seal Installation

STORAGE AND HANDLING OF OIL SEALS

Introduction

Careful storage and handling of radial lip type seals is necessary to avoid hazards prior to installation which would adversely affect service life.

General Storage

Radial lip type seals are very robust long lived components. However, as with any precision components they should be stored with care as the service life of bearings and/or other costly machined parts may depend upon how well the seal performs. Hazards which may be encountered include: temperature, ozone, humidity, radioactive materials, fumes, dust, grit and mechanical damage.

The storage area should be cool (60° to 90°F) and with average (40 to 70%) humidity. Seals should be stored on a first in - first out basis, since even under ideal conditions, an unusually long shelf life may cause deterioration of element materials. Excessive heat and/or exposure to ozone can cause premature aging of some types of sealing elements thus reducing service life. Avoid storage near sources of heat. To prevent ozone aging, keep away from direct or reflected sunlight and electrical equipment that may generate ozone. Excessive humidity will deteriorate some seal element materials as well as cause corrosive damage to metal cases and springs.

Oil seals should be stored in a place other than a work area to avoid possible mechanical damage by equipment or falling objects. A closed container will provide protection from mechanical damage, as well as dust, grit and other contaminants.

Mechanical Damage

Many oil seal failures can be traced to improper handling or storage of the seal. To avoid damage:

- Keep in the box in which they were originally packed. Never store seals unprotected in open bins.
- Never hang seals on a hook.
- Never tag seals.
- Keep seals clean.
- Avoid dropping seals. This may dislodge the spring, distort or contaminate the seal.
- Never use old or damaged seals.

Lip Compound Age Resistance (Shelf Life)

Resistance to deterioration in storage varies between elastomers. Proper storage under conditions which minimize aging effect is extremely important. The chart below presumes proper storage conditions and reflects general usage applications.

Type of Lip Material	Shelf Life
Urethane	3 to 5 years
Nitrile	5 to 10 years
AFLAS®, Fluoroelastomer, Silicone,	Up to 20 years
Polyacrylate, VAMAC®	Up to 20 years
Felt, Leather, PTFE	Indefinite

SECTION 1-C TECHNICAL

Sealing System Preparation And Seal Installation

SHAFT REQUIREMENTS

Proper engineering of the components of the assembly is necessary for seal reliability. Shaft requirements have been determined by the Rubber Manufacturer's Association, through thousands of hours of testing. The following items should be considered at the original equipment design stage or whenever anexisting application is to be upgraded.

Shaft Finish — Shaft finish, a prime factor in proper functioning of a lip seal, should be specified as 10-25 microinches Ra (0.20-0.60 micrometers Ra) with no machine lead.

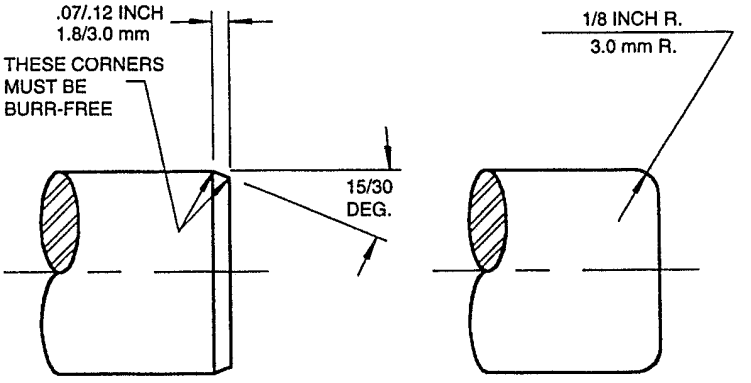
Shaft Lead — Maximum permissible lead angle is 0 ± 0.05°. The most acceptable method for obtaining this surface characteristic is plunge grinding.

Shaft Diameter — Shaft diameter tolerances are shown below. Tolerances greater than those shown should be used only if agreed upon between user and supplier.

Shaft Diameter (inches)	Tolerances	Shaft Diameter (mm)	Tolerances
To and including 4.000	± .003	To and including 100	± 0.08
4.001 through 6.000	± .004	100.01 through 150	±0.10
6.001 through 10.000	± .005	150.01 through 250	± 0.13
10.001 and larger	± .006	250.01 and larger	± 0.15

Shaft Hardness — Radial lip type seals will function satisfactorily on mild steel, cast iron or malleable iron shafts. Under normal conditions, however, the section of the shaft contacted by the sealing lip should be hardened to Rockwell C30 minimum. If, however, the shaft may be nicked or damaged during handling or assembly, a Rockwell C45 minimum is recommended.

Shaft Chamfer — To aid installation and help prevent damage to the seal lip, the leading edge of the shaft should have a chamfer or radius which must be smooth and free of nicks or rough spots.



Shaft-to-Bore Misalignment (STBM) — The distance the center of rotation is displaced from the center of the bore. It usually exists to some degree due to normal machining and assembly tolerances. Misalignment results in uneven wear and, if excessive, will shorten seal life. To measure, attach a dial indicator to the shaft and indicate off the seal bore while rotating the shaft. For specific limitations see the National Oil Seal Design Type and Description charts on page 6 & 7.

Dynamic Runout — Twice the distance the center of the shaft is displaced from the center of rotation. It can result from a bent shaft, lack of shaft balance or other manufacturing variables. To measure, find the total movement of an indicator held against the seal area of the slowly rotating shaft. For specific limitations see the National Oil Seal Design Type and Description charts on page 6 & 7.

Shaft Material — Steel, stainless steel and certain cast irons all provide good sealing surfaces if finished properly. Brass or bronze shafts are not recommended nor are alloys of aluminum, zinc, magnesium and other similar elements. If plating is considered, it should be hard nonporous chrome plate. Flaking or plating exposes razor edges which may cut the seal lip.

SECTION 1-C TECHNICAL

Sealing System Preparation And Seal Installation

BORE REQUIREMENTS

Maintaining proper bore characteristics is important if the integrity of the sealing system is to remain intact. To provide proper fit of National Oil Seals, the dimensions relative to Bore Tolerance and seal Press Fit should be followed.

Bore Tolerances and Seal Press Fit

The Table below indicates recommended Bore Tolerances and seal Press Fit for both Metal and Rubber O.D. seals.

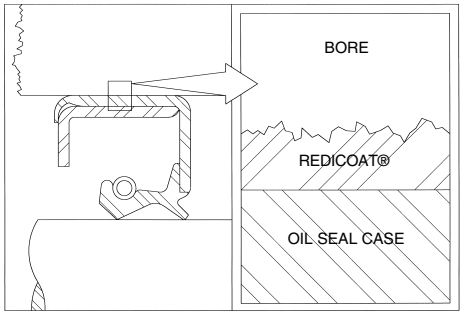
Bore Diameter	Bore Tolerance	Nominal Press Fit Metal O.D.	Metal O.D. Tolerance	Nominal Press Fit Rubber O.D.	Rubber O.D. Tolerance
Up to 2.000	± 0.001	0.005	± 0.002	0.008	± 0.003
2.000 to 3.000	± 0.001	0.005	+0.003 / -0.002	0.010	± 0.003
3.001 to 4.000	± 0.0015	0.006	± 0.003	0.011	± 0.003
4.001 to 5.000	± 0.0015	0.006	± 0.003	0.011	± 0.003
5.001 to 7.000	± 0.0015	0.007	± 0.003	0.012	± 0.004
7.001 to 12.000	± 0.002	0.008	+0.004 / -0.003	0.013	± 0.004
12.001 to 20.000	± 0.003	0.012	± 0.005	0.015	± 0.005
20.001 to 40.000	± 0.004	0.013	± 0.005	0.018	± 0.006
40.001 to 60.000	± 0.006	0.016	± 0.006	0.020	± 0.007

Bore Material

Ferrous materials are commonly used for bore housings. The table above applies to these types of materials. However, if other materials are used (i.e., aluminum or composites) higher rates of thermal expansion are usually involved and should be considered.

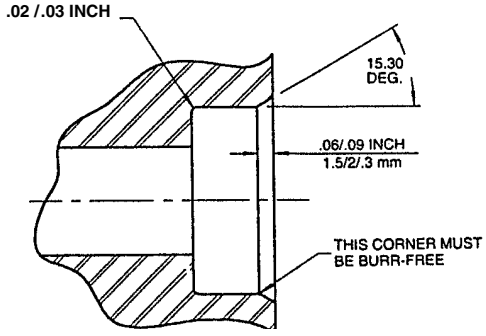
Bore Finish

A finish of 125 microinches Ra (3.2 micrometers Ra) or smoother should be maintained to assure a leak free emvironment. If the bore is rougher than 125 microinches Ra (3.2 micrometers Ra) National Oil Seal offers an environmentally friendly waterbase resinous coating on all of the O.D.'s of the metal cases. This coating process or material is termed Redicoat .



Bore Configuration

The lead corner of the seal bore should be chamfered for ease of seal installation. Rough corners or burrs can scratch the seals outside diameter and cause potential leak paths.



REDICOAT IS A REGISTERED TRADEMARK OF FEDERAL-MOGUL CORP.

Sealing System Preparation And Seal Installation

INSTALLATION OF SEALS, PROCEDURES, GUIDELINES AND TOOLS

Oil Seal Installation Procedure

1) Inspect the bore. Insure that it is clean and free of burrs that might distort the seal or cut the O.D., that may cause leakage. Check for roundness and make sure the leading edge is either rounded or chamfered.

2) Inspect the shaft. Look for machining lead, burrs, dirt and paint that might damage the seal or provide a leak path. If the old seal has worn a groove into the shaft, it needs to be repaired. In many cases, National Redi-Sleeves will enable you to quickly and inexpensively repair this condition. For more information, regarding National Redi-Sleeves see page 23 & 24.

3) Inspect the Shaft End. Remove all burrs and sharp edges. The shaft should be chamfered or radiused to assure the seal is not damaged during installation. If this is not possible, then an installation sleeve should be used.

4) Inspect Splines and Keyways. If the shaft has splines or keyways, cover with a sleeve, shim stock or tape to protect the seal lip.

5) Inspect the Seal. Check the seal for any damage (nicks, cuts, scratches or distortion of the sealing lip) that may have been caused during shipping. A damaged seal should be replaced.

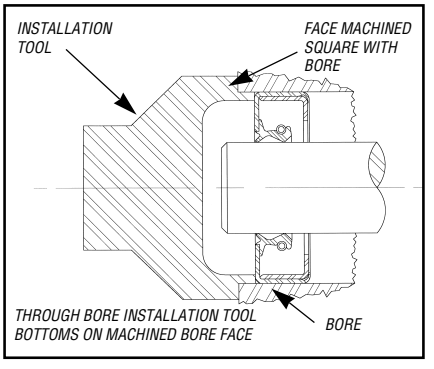
6) Assure Proper Seal Direction. The sealing lip usually faces toward the medium to be sealed.

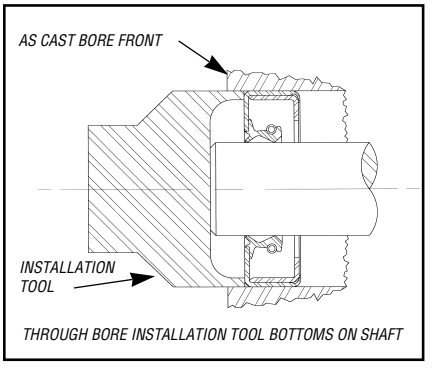
7) Prelube the Seal. Prior to installation, the sealing lip should be prelubed with the lubricant to be sealed. It is not necessary for the O.D. of metal parts to be lubed, however, a light film of oil should be applied to the O.D. of rubber coated seals to aid in the installation process and reduce sheer stress during installation. This prelube should reduce or eliminate the possibility of a rubber O.D. seal from backing out of the bore immediately after installation.

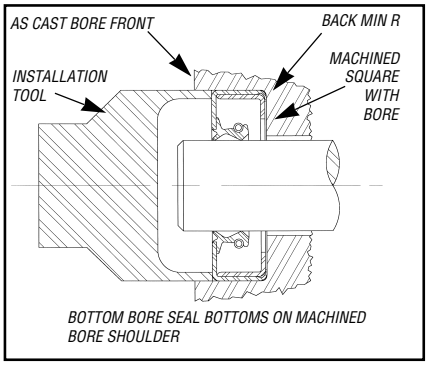
8) Installation Tools. Select an installation tool (see Fig below). For easy, accurate installation of National's popular standard style oil and grease seals use the RD-2000 which can easily install seals up to 3.375" (85.7 mm) O.D. The best tool will have a diameter slightly smaller than that of the housing bore and will apply force only on the seal case. Bearing races may be used as an installation tool adapter when "approved tools are not available.

9) Never Hammer Directly On the Seal. Screwdrivers, drift pins or punches should not be used as installation tools. Steel hammers are not recommended for use with approved installation tools; the shock of steel on steel can dislodge the garter spring. After the seal has engaged the bore, the seal should be driven in evenly with only enough force to seat it in the bore.

Recommended Installation Tools







SECTION 1-D TECHNICAL

GENERAL INFORMATION

OIL SEAL DISTRESS ANALYSIS, TROUBLE SHOOTING CHECKLIST

The following chart is intended to assist in the evaluation of oil seal distress. It is not intended to be complete and should not be interpreted as inclusive of all distress causes. Questions or requests for additional information relative to oil seal distress should be directed to your Timken Representative.

Symptom	Probable Cause of Leak
Sealing Lip Surface Hardened	Can be caused by excessive operating temperatures, by inadequate lubrication or by incompatibility with sealed fluid.
Sealing Lip Brittle or Cracked	Operating temperatures of lubricant may exceed recommended limits for the type of sealing member material. Make sure seal is proper size. Too tight a fit on shaft will cause overheating. Check adequacy of lubricant for the type seal used.
Sealing Lip Shows Excessive Wear (around entire circumference)	Shaft finish may be too rough at point of lip contact. Seal not properly prelubricated before installation. Check adequacy of lubrication for the type seal used. Make sure seal is proper size. Too tight a fit on the shaft can cause overheating and rapid wear. Shaft run-out or shaft whip may exceed recommended limits. See that the seal seats close to the bearing and check for excessive looseness in bearing or splines.
Sealing Lip Worn On One Side	Usually due to misalignment of shaft to bore. This causes rapid wear at one point on the sealing lip.
Sealing Lip Contact On Shaft Too Light	Make sure seal is proper size. Check shaft for excessive wear at point of contact. Shaft may be too soft . . . check minimum hardness specifications for the existing operating conditions. Check the installation tools used. Mounting cones and sleeves must not have O.D. of more than 1/32" greater than the shaft . . . or the sealing lip may be overstretched.
Sealing Lip Nicked or Scratched	Careless storage, handling or use of improper assembly tools. Failure to clean and prepare shaft. Failure to protect sealing member when installing over splines, keyways, etc.
Sealing Lip "Blown-Out" (direction of lip contact reversed)	Look for excessive pressure build-up or plugged-up vents. Vents should be masked during painting to prevent clogging. Make sure the lubricant level is correct. Heating of the lubricant causes expansion and the pressure can blow out the seal.
Sealing Lip Surface Softened	Spongy lip is result of incompatibility between fluid and sealing element.
Seal Case Distorted	O.D. of seal may be too large for housing bore. Bore diameter should not vary from that recommended for the size of the seal. Housing bore may be excessively out-of-round. If bore diameter and out-of-round limits are correct . . . look for evidence of careless handling or use of improper installation tools.

Symptom	Probable Cause of Leak
Seal Garter Spring Damaged	May be caused by careless handling or use of improper installation tools or methods. Excessive spreading of the sealing lip during installation can damage the spring.
Inner Parts of Seal Assembly Loose	Improper installation tools used. Check out-of-round limits of housing bore and make sure seal O.D. is not too large for bore. Either condition can cause seal distortion which, although not readily apparent, may be enough to loosen the inner parts of the seal and cause leakage.
Seal Cocked In Housing	Usually due to improper tools or installation methods. Make sure seal O.D. is not too large for bore. Check bore for burrs, scale or chips that prevent the seal from properly seating.
Excessive Shaft Wear	Check for presence of abrasive dirt and grit. Shaft may not have been properly cleaned before installation or exterior dirt and dust conditions may be too severe for the type of seal used. Shaft may be too soft. Shaft hardness limits are dictated by the severity of exterior dirt conditions, the amount of lubrication and surface speeds. Make sure seal is proper size. Too tight a fit on the shaft will cause excessive wear on both lip and shaft. Check for insufficient lubrication at the seal.
Shaft Scratched or Gouged	Proper installation procedure call for careful inspection and preparation of the shaft prior to installation of the seal. Shaft must be thoroughly cleaned before installing the seal. Paint, shellac or cement on the surface where the lip contacts the shaft prevents proper sealing.
Spiral Machine Grooves on Shaft	Shafts should be polished at point of sealing lip contact or reground so spiral marks direct the fluid inward rather than outward under the sealing lip.
Leakage Around the O.D. of the Seal	Check housing bore for out of-roundness. If eccentricity is only slight (.001"), the use of special cement on the O.D. surface of seal may offset the condition. Check O.D. surface of seal for evidence of damage due to careless handling or improper installation. Seal may be cocked in housing. Check interior of bore for excessive roughness, dirt, scratches or burrs.
Excessive Prelubrication	This is not actually leakage, although it may look like it. When too much prelubricant is used, the excess melts and runs out. Check this possibility before removing a seal that has the appearance of leaking.

GENERAL INFORMATION

REDI-SLEEVES INSTALLATION AND REMOVAL

Redi-Sleeves Installation

Each Redi-Sleeve comes with its own installation tool and removable installation flange. The installation tool reduces the possibility of sleeve distortion and provides for sleeve installation without removal of the shaft from the serviced equipment.

1) Minimum shaft surface preparation is required. Clean the old seal surface thoroughly and file down burrs and rough areas.

2) Determine sleeve position necessary to cover the seal wear tracks. Measure to a convenient point or mark directly on the shaft.

3) Redi-Sleeves may be installed to any depth. The column labelled “Installation Depth” in the *Redi-Sleeve Size Listing* indicates the maximum distance from the end of the shaft the sleeve can be installed using the supplied installation tool. Check whether the supplied tool will reach this position. If not, a tool can be fabricated using tubing or pipe to make deeper installations. If this is required, make sure the ends are cut square and are deburred.

4) Fill any deep scores or gouges on the shaft with a thread repair compound. Make sure to install the sleeve prior to the filler hardening.

5) Drop the Redi-Sleeve into the installation tool so that only the flange projects. Note that the flanged end of the sleeve goes on the shaft first.

6) Gently pound the center of the installation tool with a wood block or large soft face mallet until the sleeve reaches the previously measured point on the shaft. The wood block or large soft face mallet reduces the possibility of distorting the installation tool.

7) If clearance is required after installation, the Redi-Sleeve flange can be removed. Prior to installation, use side-cutters to cut through the flange to the pre-cut line. After the sleeve is installed, pry flange away from the seal surface. The flange will peel away along the pre-cut line.

Redi-Sleeve Removal

Suggested methods of sleeve removal:

1) Application of heat will cause the sleeve to expand and permit removal.

2) Wire cutters may be used to “tear” the sleeve from the shaft using a twisting motion.

3) With the flange removed, tapping the sleeve with a hammer may cause stretching on the sleeve and allow for removal.

GENERAL INFORMATION

NATIONAL WEAR SLEEVES DESCRIPTION, INSTALLATION & REMOVAL

National Wear Sleeves

National wear sleeves are precision components that press fit onto a shaft, actually becoming part of the shaft. The outside diameter is ground to provide a surface finish of 10-25 microinches Ra (.25-.64 Micrometers Ra). A radius of the I.D. of the sleeve facilitates installation on to the shaft. National wear sleeves are designed to be installed at ambient temperatures, heating of the wear sleeve is not required for proper installation. The opposite end of the wear sleeve is also radiused on the O.D. to minimize the potential for damaging the seal during assembly.

Wear sleeves offer cost reduction opportunities to original equipment manufacturers who must now machine large or complex shafts or spindles to tight dimensional and finish tolerances in order to provide an adequate running surface for the seals. While transporting or moving the shaft from place to place, extreme care must be taken to prevent damage to a finished shaft. When wear sleeves are used, scratching or scoring of the shaft is eliminated since the seal will run on the precision-finished sleeve, installed when the seal and/or hub is installed.

Installation

1) Remove all dirt and oil from the sealing surface.
2) Coat shaft surface with a liquid sealant or gasket cement.
3) Press wear sleeve into position with an installation tool or use a flat plate against the sleeve. Do not hammer on the thin edge of the sleeve or the wear sleeve may become warped or out of round.
4) Remove excess sealant from the wear sleeve edges. No sealant should be left on the finished sleeve surface or seal leakage may result.

Removal

Suggested methods of wear sleeve removal:

1) Application of heat will cause the sleeve to expand and permit removal.
2) Tapping the sleeve with a hammer may cause stretching of the sleeve and allow for removal.
3) Careful use of a rounded, blunt chisel may remove the sleeve.
   Caution. It is not nesessary to cut the sleeve completely prior to removal.

Shaft Tolerances For National Wear Sleeves

Up to 3.000" ± .001"
3.001" to 6.000" ± .0015"

Shaft Finish

Prime shaft finishes of 125 RMS or better may require very little cement under the sleeve. With shaft finishes of over 125 RMS, complete inside penetration of the cement is recommended.

Prefix Explanation

J = Ground 10-25 RMS
JV = Unground phosphate coated

GENERAL INFORMATION

V-SEALS DESCRIPTION, MATERIAL, STYLES & DIMENSIONAL REFERENCE

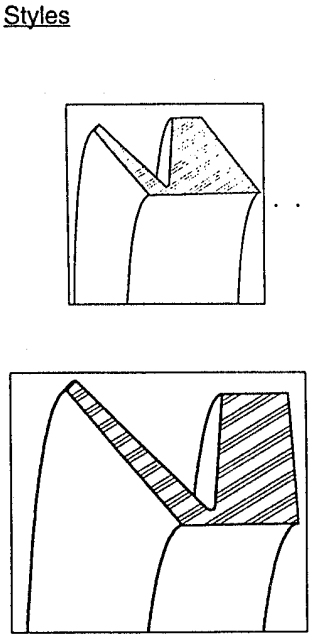
Description

The V-Seal is a simple and versatile elastomeric "face" type seal produced in Nitrile or Viton. It can be the primary sealing element in an application or it can be a contaminant excluder or back-up seal. The seal mounts on, and typically rotates with the shaft while the lip lightly contacts the counterface. The elasticity of the V-Seal design eases installation, permits a broader range of shaft sizes and allows use on eccentric and misaligned shafts.

Material Data

	Nitrile	Fluoroelastomer
Temp. Range:	-40° to 225°F	-30° to 325°F
Max. Shaft Speed (FPM):	2,400	1,300
Color:	Black	Brown

Styles



VRS1 The standard design of the industry covers a shaft range of 0.11" to 79.53" (3 mm to 2000 mm).

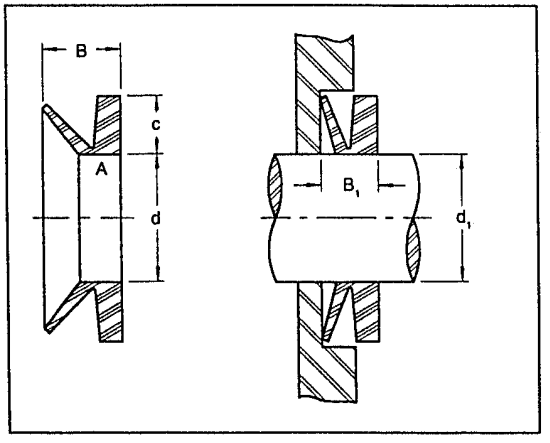
VRS2 The original style V-Seal offers a slightly more robust body when needed. Shaft coverage is from 0.18" to 8.27" (5 mm to 199 mm).

VRS 3 With its narrow body style, this V-Seal works on shafts from 5.32" to 18.70" (140 mm to 450 mm).

VRS4 This heavy-duty V-Seal with its special design covers a shaft range of 17.72" to 79.12" (450 mm to 2000 mm).

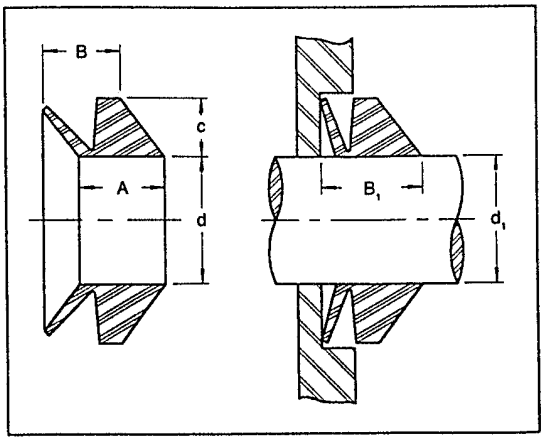
Dimensional Reference

VRS1, VRS3, and VRS4



Profile dimensions Assembly dimensions

VRS2



Profile dimensions Assembly dimensions

Other Quality Industrial Products

V-Seals™

A simple, versatile elastomeric "face-type" seal produced in Nitrile or Viton, Timken's line of V-Seals™ function as an additional sealing element. V-Seals are recommended for extreme, high-contaminant environments.

The V-Seal typically mounts on and rotates with the shaft while the lip lightly contracts the counterface. The elastic design eases installation, within a broad range of applications.

Wear Sleeves

As precision components that press-fit onto a shaft, Timken's line of Wear Sleeves may deter damage to shafts and spindles, both in use and during transport.

Designed for ambient-temperature assembly and available in various sizes and finishes, Wear Sleeves provide protective seal running surfaces and reduce the need for complex and expensive shaft machining, repair or replacement.

O-Ring Seal Kits

Available in inch and metric sizes, Timken's line of O-Ring Seal Kits have the coverage you need for the most popular applications. O-Ring Seals are made of a high-quality Nitrile rubber or a high-temperature fluoroelastomer.

Timken can provide you with three assortments: OK-311, OK-312 and OK-411. The MD-999 O-Ring identification gauge, designed to measure and identify O-Ring sizes.

Installation Tools

The RD-2000 and RD-2001 tools help to properly install seals and prevent unnecessary downtime.

Timken's RD-2000 Seal Driver puts seals in place quickly, easily and without damage, allowing smooth equipment operation without premature seal leakage.

The RD-2001 Bearing Race and Seal Driver easily installs bearings and seals without damaging the bearing race or housing.

Less Friction. More Solutions

Timken also offers the time-saving RD-2004 O-Ring Installation and Removal Tool, as well as the durable and precise MD-2000 Metal Caliper.

To order National industrial seals, contact your Timken sales representative or call 1.877.4.TIMKEN in the U.S. In Canada, call 1.800.565.4927 for English or 1.800.565.0438 for French-Canadian. Visit us on the Web at www.timken.com/industrialseals.

Timken is your resource for quick, cost-effective sealing solutions. To learn more about how Timken can enhance your line of seals, call Timken in the U.S. at 1.877.4.TIMKEN and in Canada at 1.800.565.4927 for English and 1.800.565.0438 for French-Canadian. Visit us on the Web at www.timken.com/industrialseals

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