Sealing System Leakage

Sealing System Leakage Analysis Guide

Section 1. Introduction:

The Oil Seal Manufacturing Industry is committed to provide functional, efficient radial lip seals for all applications. If a sealing system leaks, it is most important that the manufacturer be provided with as much data about the sealing system and its environment as possible in order to provide a timely and correct solution. The mere return of a leaking seal is not sufficient information on which to base corrective action. The following is a Leakage Analysis Guide prepared by the Technical Committee of the Oil Seal Subdivision of the Rubber Manufacturers Association**.

Section 2. Sealing System:

There are four elements to any sealing system. They are:

2.1 The sealing device
2.2 The shaft or running surface
2.3 The housing bore
2.4 The medium to be sealed

It is not possible to provide an accurate analysis of a leaking sealing system without examination of all four elements.

Section 3. Purpose:

The purpose of this document is:

3.1 To provide the seal user with a systematic method of documenting all factors related to a sealing system and its immediate environment.
3.2 To provide a comprehensive list of probable causes for the factors of conditions found.
3.3 To provide possible corrective actions for conditions found. This may enable the user to solve the problem without consulting the seal manufacturer.
3.4 To provide the seal manufacturer with comprehensive documentation of a sealing system deficiency.

Section 4. Use of This Document:

This document contains a three-part checklist designed to lead an investigator through a sequential sealing system leakage analysis:

Part 1 Examination of the sealing system and immediate environment with the seal in place.
Part 2 Examination of the seal after removal
Part 3 Examination of the other three elements (i.e., housing, shaft and lubricant) of the sealing system.

Completion of this three-part checklist should provide the examiner and eventually the seal manufacturer with sufficient information to diagnose the problem. (Note: A one page Short Form of the checklist, intended for field or shop use where the more comprehensive three-part checklist may not be practical, is also included)

For each abnormal condition of the checklist, there is a reference code. Each reference code represents a page in the Causes and Countermeasures section of this guide. If a condition is checked on the list, the guide will provide a number of possible causes for that condition, as well as a number of possible countermeasures or corrective actions that could be taken by the responsible agency.

If the problem is not correctable by the user, the checklist should be forwarded, with the seal in question, to the seal manufacturer. If it is not possible to provide all of the information requested on the checklist, it would be of benefit to the seal manufacturer to have access to all elements of the sealing system so that all relevant information can be gathered.

A sealing leakage analysis chart is included to assist in the use of this document. Major reference columns are color coded between the chart and corresponding pages in this document.

**This publication has been prepared by the Technical Committee of the Oil Seal Subdivision of the Rubber Manufacturers Association. It describes methods of Sealing System Leakage Analysis.

Sealing System Leakage

Sealing System Leakage Analysis Checklist Part 1

An examination of the sealing sytem and immediate environment with the seal in place.

Seal Application: **Equipment Identification:**

Miles/Hours of Operation: **Complaint:**

Before removal, carefully inspect the seal, the shaft and the immediate area around the leakage site. Follow this checklist:

Amount of Leakage

❑ Slight ❑ Immediate area damp ❑ Heavy leakage

Source of Leakage

Check	Location	Reference Code
❑	Between shaft and seal lip	----------
❑	Between O.D. of seal and bore	B.2.5
❑	At retainer bolt holes	B.3.1
❑	At retainer gasket	B.3.2
❑	Between wear sleeve and shaft	B.3.7
❑	Through seal on assembled seal	B.3.8

Condition of Immediate Environment

❑ Seal area clean ❑ Mud or dust packed in seal area B.2.1

Wipe Immediate Area Clean and Inspect

Check	Condition	Reference Code
❑	Nicks on bore chamfer	B.1.1
❑	Seal loose in bore	B.1.2
❑	Paint spray on seal lip	B.2.2
❑	Seal cocked in bore (amount) _____	B.2.3
❑	Seal installed in wrong orientation (backwards)	B.2.4
❑	Seal case deformed	B.2.6
❑	Shaft to bore misalignment	B.3.5

Rotate Shaft if Possible Check for Radial & Axial Play

❑	Excessive shaft end play (amount) _____	B.3.3
❑	Excessive shaft runout (amount) _____	B.3.4

Note: If location of leakage cannot be confirmed at this point, either introduce ultraviolet dye into the sump or spray area with white powder, operate for 15 minutes and check for leakage with ultraviolet or regular light.

When above analysis is complete, mark the seal at the 12 o'clock position and carefully remove from the application.

❑	Oil sample obtained	B.3.6

Completed By: _____ Date:

Sealing System Leakage Analysis Checklist Part 2

Clean the removed seal in a mild solvent. Do not attempt to scrape away carbon, etc. Inspect the seal using this checklist.

Primary Lip Area

Check	Condition	Reference Code
❑	Normal wear	C.2.1.1
❑	No wear	C.2.1.1
❑	Excessive wear	C.2.1.1
❑	Eccentric wear	C.2.1.3
❑	Inverted lip due to poor installation	C.2.1.10
❑	Nicks, scratches or cuts at lip contact area	C.2.1.4
❑	Hardened or cracked rubber	C.2.1.6
❑	Coked oil on lip	C.2.1.8
❑	Softening or swelling	C.2.1.9

Seal Outside Diameter

Check	Condition	Reference Code
❑	Normal	----------
❑	Severe axial scratches	C.2.2.2
❑	Peeled rubber	C.2.2.3
❑	Hardened rubber	C.2.2.4
❑	Nonfills or cuts	C.2.2.5

Spring and Spring Groove Area

Check	Condition	Reference Code
❑	Spring normal and in place	----------
❑	Spring missing	C.2.3.1
❑	Spring corroded	C.2.3.2
❑	More than one spring	C.2.3.4
❑	Seperated spring	C.2.3.5

Make the Following Measurements

Primary lip inside diameter?	(_____)	C.2.1.7
Primary lip radial force?	(_____)	C.2.1.7
Seal outside diameter?	(_____)	C.2.2.1
Spring inside diameter?	(_____)	C.2.3.3
Spring tension?	(_____)	C.2.3.3
Primary lip wear band width?		
Min.	(_____)	
Max.	(_____)	

Comments:

Completed By: _____ Date:

Sealing System Leakage

Sealing System Leakage Analysis Checklist Part 3

An examination of the housing, shaft, and lubricant (after seal removal).

Inspect the Housing Bore Area

Check	Condition	Reference Code
❑	Measure bore diameter: (_____)	C.1.1
❑	Bore chamfer damaged	C.1.2
❑	Flaws or voids in housing	C.1.3
❑	Tool withdrawal marks in bore	C.1.4
❑	Bore surface scratched or galled	C.1.5

Inspect the Shaft in the Seal Contact Area

Check	Condition	Reference Code
❑	Measure shaft diameter: (_____)	C.3.1
❑	Shaft surface corroded	C.3.3
❑	Seal wear path in wrong location	C.3.4
❑	Scratches or nicks at lip contact area	C.3.5
❑	Measure wear path width: (_____)	C.3.7
❑	Discoloration on shaft surface	C.3.8
❑	Coked lubricant present	C.3.8
❑	Shaft chamfer damaged or missing	C.3.11
❑	Wear sleeve loose on shaft (if applicable)	C.3.13

Remove Shaft from Application for Further Inspection

Characteristic	Reference Code
Measure surface roughness: (_____Ra)	C.3.2
Measure depth of wear path: (_____)	C.3.6
Measure shaft lead: (_____Deg)	C.3.9
Measure shaft hardness: (_____Rc)	C.3.10
Check for proper shaft material	C.3.12

Inspect the Lubricant

Check		Reference Code
❑	Contaminates (particulates) in filtered lube	C.4.1

Compare Lubricant from Application with New Lubricant for Proper Type

Check	Condition	Reference Code
❑	Color different	C.4.2
❑	Viscosity different	C.4.2
❑	Odor different	C.4.2

Completed By: _____ Date:

Sealing System Leakage Analysis Checklist Short Form

Intended for field or shop work where the more comprehensive 3-part checklist may not be practical.

Seal Application: **Equipment Identification:**

Miles/Hours of Operation: **Complaint:**

Step 1: Inspect the Seal Application Before Removal

Amount of leakage	❑ Slight	❑ Seal area damp	☐ Heavy leakage
Condition of area	❑ Clean	❑ Dusty	☐ Mud packed
Leakage source	❑ Between lip and shaft	❑ Between O.D. and bore	
	❑ At retainer gasket	❑ Between elements of seal	
	❑ At retainer bolt holes	❑ Between wear sleeve and shaft	

Step 2: Wipe Area Clean and Inspect

	❑ Nicks on bore chamfer	❑ Seal loose in bore
Check	❑ Seal cocked in bore	❑ Seal case deformed
Conditions	❑ Seal installed wrong	❑ Paint spray on seal
Found	❑ Shaft to bore misalignment	❑ Other

Step 3: Rotate Shaft if Possible

Check Conditions	❑ Excessive end play	❑ Excessive runout

Step 4: If the location of the leak cannot be confirmed at this point, either introduce ultra violet dye into the sump or spray area with white powder, operate for 15 minutes and check for leakage with ultraviolet or regular light.

Step 5: Mark the Seal at the 12 O'Clock Position and Remove it Carefully

❑ Retain an oil sample

Step 6: Inspect the Application with Seal Removed

	❑ Rough bore surface	❑ Flaws or voids in bore
Check	❑ Shaft clean	❑ Shaft corroded
Conditions	❑ Coked lube on shaft	❑ Shaft discolored
Found	❑ Shaft damaged	

Step 7: Inspect the Seal

Primary	❑ Normal	❑ Excessive	❑ Eccentric
Lip Wear	❑ None		
Primary Lip	❑ Normal	❑ Damaged	❑ Hardened (stiff)
Condition	❑ Soft (flexible)		
Seal O.D.	❑ Normal	❑ Axial scratches	❑ Damaged rubber
Spring	❑ In place	❑ Missing	❑ Separated
	❑ Corroded		

Comments:

Completed By: _____ Date:

Sealing System Leakage

B.1.1 Nicks on Bore Chamfer

Probable Causes

1. Mishandling prior to seal installation (Fig. 1)
2. Insufficient material removal
3. Tool chatter on chamfer surface (Fig. 2)

Action or Countermeasures

1. Check bore/housing machining
2. Check casting dimensions for proper material allowance. Check machining locations for proper gage points
3. Review machining procedures for proper tool configuration, feed, speed and coolant.

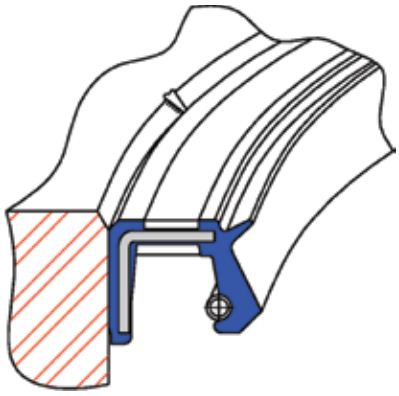


Fig 1

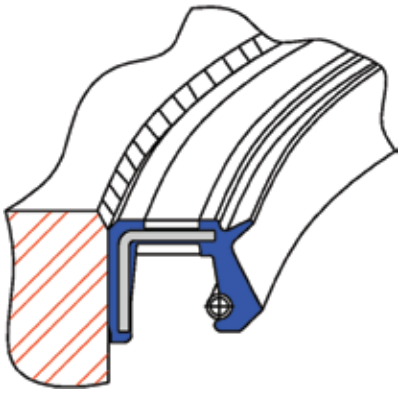


Fig. 2

B.1.2 Check for Looseness in Bore

Probable Causes

1. Oversized bore I.D.
2. Undersize seal O.D.
3. Rolling of seal into bore during installation
4. Bore sizing
5. Excessive shrinkage/hardening of rubber O.D. seal
6. Deformation of seal during installation (Fig 1)

Action or Countermeasures

1. Check bore machining dimensions for out-of-tolerance condition
2. Check seal O.D. for out-of-tolerance
3. Review installation procedure and use proper installation tools
4. Increase bore material hardness or use bore sealant
5. Review application temps, and seal material specifications
6. Review installation procedure and use of proper tool

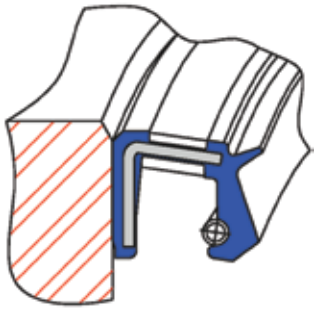


Fig. 1

B.2.1 Contaminants (Mud or Dust) Packed in Seal Area

Probable Causes
1. Failure of auxiliary lip (Fig. 1)

Action or Countermeasures
1. Look for cut or damaged auxiliary lip. Look for auxiliary lip worn excessively

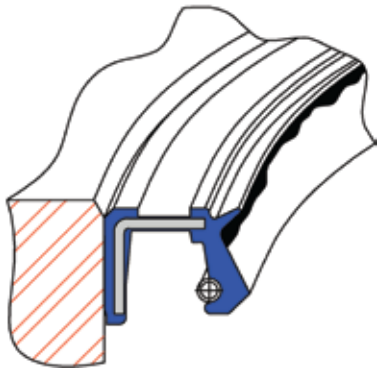
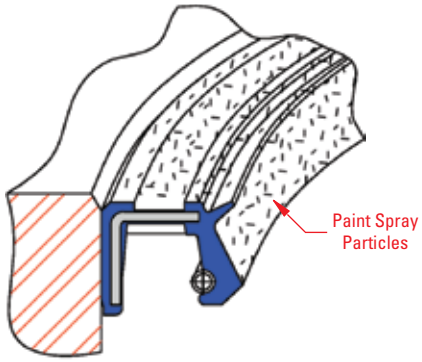


Fig. 1

B.2.2 Paint Spray on Seal Lip

Probable Causes
1. Lack of paint mask
2. Service or in-field paint procedure

Action or Countermeasures
1. Review paint procedure, recommend a mask
2. Issue a service bulletin to prevent paint overspray or specify a mask



B.2.3 Check for Seal Cocking

Probable Causes
1. Seal installation (see Fig. 1)
2. Insufficient or improper bore chamfer
3. Excessive seal interference with rubber O.D seal

Action or Countermeasures
1. Use proper installation tool. Check installation force to insure complete installation
2. Provide proper amount and lead in angle for chamfer
3. Check bore I.D. and seal O.D. for proper dimensions

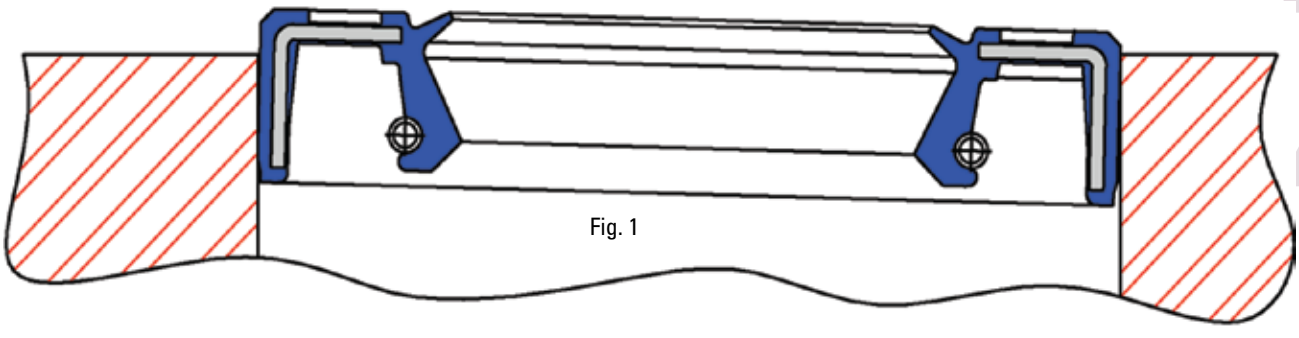


Fig. 1

Sealing System Leakage

B.2.4 Check for Proper Installation and Orientation Relative to Assembly

Probable Causes

1. Backward installation caused by lack of proper installation tool or visual aide (Fig. 1)
2. Improper axial location of seal (Fig. 2)
3. Improper axial position of shaft (Fig. 3)

Action or Countermeasures

1. Provide foolproof installation tool and/or visual aide to identify proper orientation
2. Provide proper installation tool
3. Provide proper installation tool and visual aide for proper position

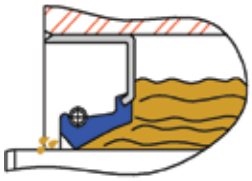


Fig. 1

Fig. 2

Fig. 3

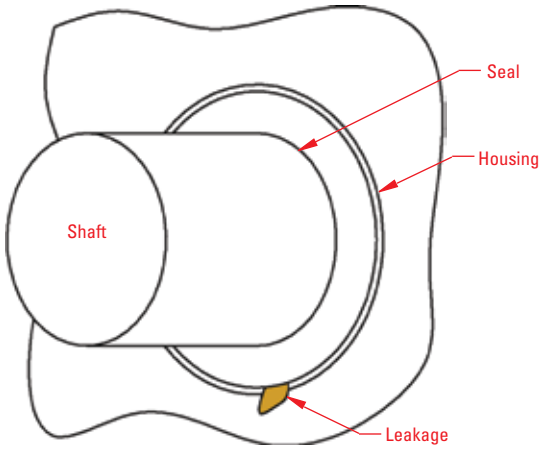
B.2.5 Check for O.D. Leakage

Probable Causes

1. Oversized bore/undersized seal
2. Damaged housing
3. Damaged seal
4. Differential thermal expansion (aluminum or magnesium housing)

Action or Countermeasures

1. Check bore and seal diameters at removal
2. Check upon removal
3. Check for O.D. damage upon removal
4. Calculate fit at maximum temperature



B.2.6 Check for Case Defomation (dishing or damage)

Probable Causes

1. Dented heel face caused by hammer installation
2. Dished heel face caused by improper tool (Fig. 2)

Action or Countermeasures

1. Provide proper installation tool
2. Provide proper installation tool

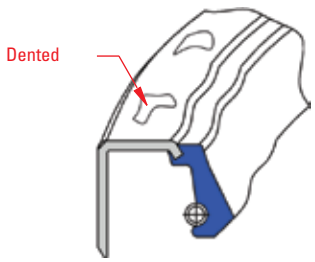


Fig. 1

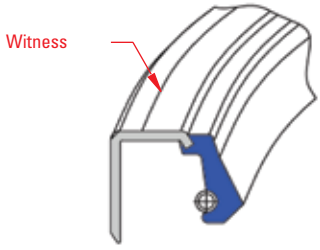


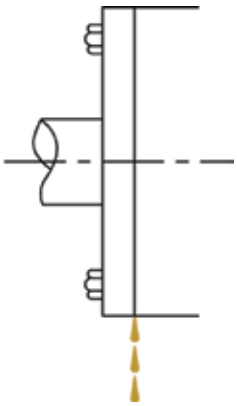
Fig. 2

B.3.1 Check Bolt Holes for Leakage

Probable Causes	Action or Countermeasures
1. Threads in housing tapped into fluid reservoir	1. Review product machining specifications
2. Insufficient bolt tightening	2. Provide proper installation tool
3. Undersize bolt diameter or oversize thread tap	3. Measure bolt and bolt hole for fit
4. Material thermal expansion incompatability	4. Insure the bolt, housing material have similar thermal characteristics for temperature extremes
5. Vibration	5. Use locking method so bolt won't work loose
6. Bolt fracture	6. Check bolt loading specs and operating parameters
7. Contamination	7. Insure bolt hole is free of particles or corrosive fluids prior to bolt installation
8. Corrosion	8. Insure bolt housing and material are compatible with application environment
9. Bolt missing	9. Install specified bolt
10. Cross threading	10. Retap and use correct bolt
11. Improper bolt	11. Change to correct bolt size
12. Improper head type	12. Change to correct bolt

B.3.2 Check Gaskets for Leakage

Probable Causes	Action or Countermeasures
1. Heat aging causes stress or cracking	1. Use high temperature gasket material compression set
2. Improper machining of mating surfaces	2. Review machining procedure for proper machining techniques
3. Casting porosity or other hardware surface	3. Inspect hardware surface for visual defects prior to gasket installation
4. Excess gasket preload resulting in compression	4. Review bolt torque requirementsset
5. Gasket swell, soft, hard from chemical attack	5. Check fluid compatibility of gasket material
6. Torn gasket	6. Use proper installation procedures and tools
7. Crimped or folded gasket	7. Use proper installation procedures and tools
8. Gasket blown out	8. Review system pressure specs, field application conditions,check gasket hardness
9. Dry gasket	9. Replace gasket
10. Wrong size	10. Use correct gasket
11. No sealant on gasket	11. Apply sealant
12. No gasket	12. Install gasket



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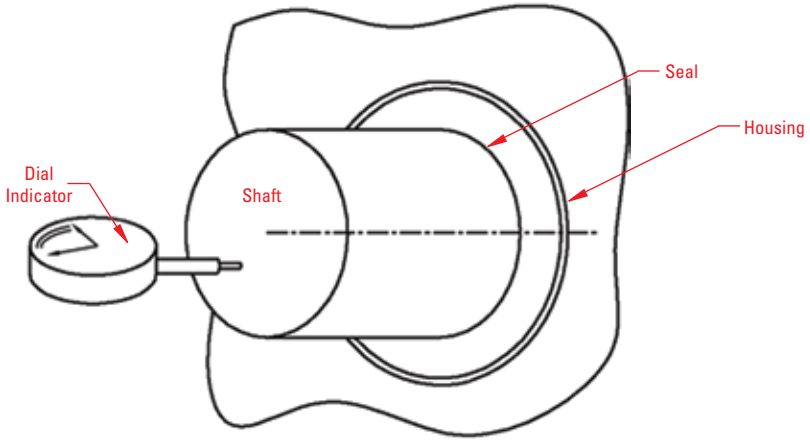
B.3.3 Check for Axial Shaft End Play

Probable Causes
1. Worn thrust bearing
2. Shearing of lock ring or locking key
3. Wear sleeve on shaft is loose
4. Negative stack-up in hardware tolerances

Action or Countermeasures
1. Replace bearing
2. Check hardness of lock device and dynamic
3. Check press or bond fit for sleeve
4. Review product prints

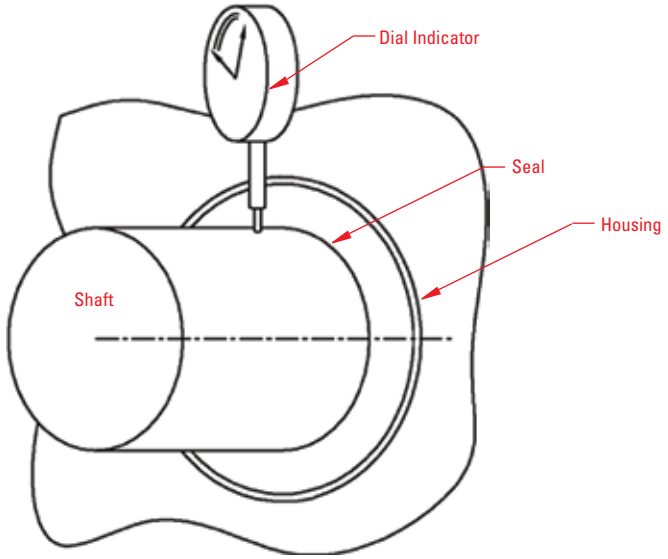


B.3.4 Check for Excessive Shaft Runout

Probable Causes
1. Failed bearing

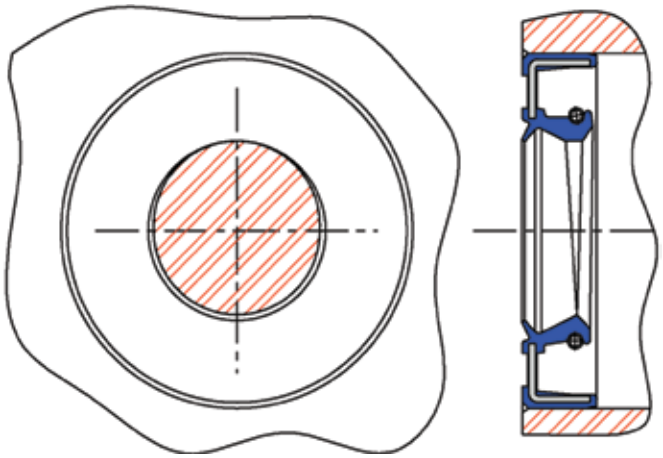
2. Excessive shaft defleciton
3. Shaft machined out of tolerance

Action or Countermeasures
1. Exceeded bearing load capacity. Excessive wear or contamination-replace bearing
2. Balance shaft and/or support shaft better
3. Review shaft print specs and production limits and tolerances, and adjust process



B.3.5 Check for Shaft to Bore Misalignment

Probable Causes	Action or Countermeasures
1. Poor initial alignment (Fig. 1a & b)	1. Review design and assembly operations and provide accurate alignment
2. Seal manufactured with high radial wall variation	2. Review production quality data, adjust process



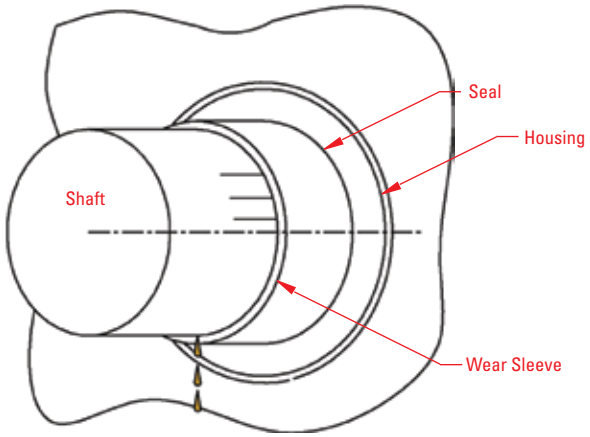
a Fig. 1 b

B.3.6 Obtain Oil or Sealed Lubricant Sample

Probable Causes	Action or Countermeasures
1. Wrong fluid	1. Correct procedure for initial fill
2. Degraded fluid	2. Review fluid specification verses sump temperature and change the fluid requirement or sump temperatures
3. Degraded pre-lube	3. Specify pre-lube with temperature capabilities equal or better than fluid sealed
4. Contaminated fluid	4. Locate source of contamination and remove

B.3.7 If a Wear Sleeve is Used, Check for Leakage Between Shaft and Sleeve

Probable Causes	Action or Countermeasures
1. Improper sleeve press fit	1. Inspect at removal
2. Damaged shaft	2. Inspect at removal
3. Improperly finished shaft (chatter)	3. Inspect at removal



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B.3.8 If Assembled Seal, Check for Leakage Between Clamped Elements

Probable Causes

1. Improper seal manufacturing (insufficient clamping force) (Fig. 1)
2. Severe dish or bulge of seal assembly at time of installation (fig. 2)

Action or Countermeasures

1. Consult seal manufacturer

2. Excessive interference between seal O.D. and bore

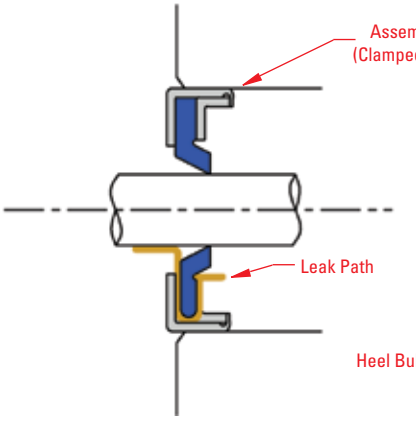


Fig. 1

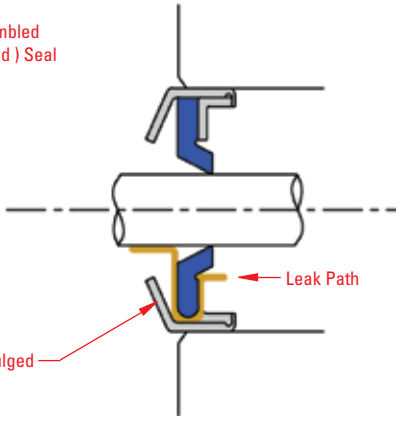


Fig. 2

C.1.1 Measure Bore Diameter

Probable Causes

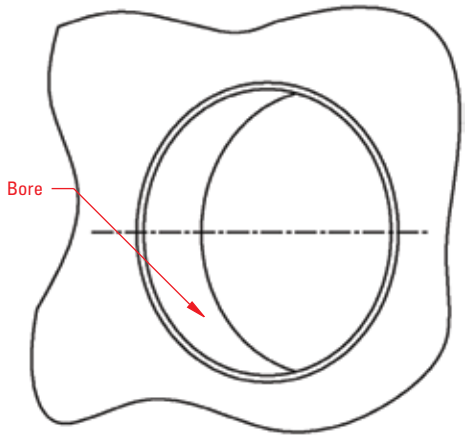
1. Seal loose

2. Oversize bore diameter resulting from seal press fit deformation
3. Tapered bore diameter resulting from improper machining techniques
4. Undersize or oversize bore due to design error
5. Oversize bore not in dimensional agreement with OEM specification
6. Seal collapsed

Action or Countermeasures

1. Use correct O.D. seal - machine bore to correct size
2. Check seal for proper O.D. size. Increase housing radial wall in area of seal gland
3. Specify maximum axial diameter taper

4. Contact OEM for corrective action
5. Unit may be a rebuild. Check seal O.D. diameter and order proper replacement part
6. Replace damaged seal with correct size



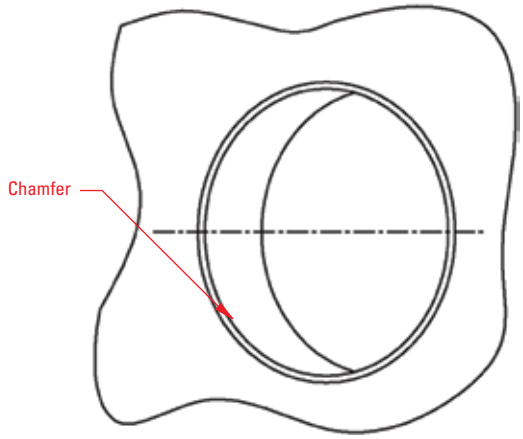
C.1.2 Check Bore Chamfer

Probable Causes

1. Chamfer lead-in not adequate to install seal due to improper chamfer angle
2. Deformation of lead-in chamfer edge due to chamfer diameter less than maximum O.D. of seal
3. Chamfer not present due to machining or product drawing error
4. Chamfer deformed due to seal installation
5. Chamfer too long causing insufficient flat area for seal retention

Action or Countermeasures

1. Review machining practices and product drawing
2. Check O.D. of seal to insure not oversize, check I.D. of chamfer to insure it meets specs
3. Review product drawing and make the appropriate changes
4. Increase bore hardness, use rubber O.D. seal
5. Check drawing and chamfer angle. Measure seal width to insure proper part and fit



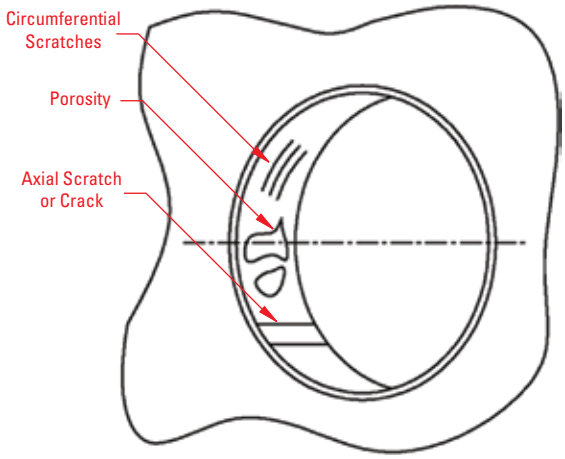
C.1.3 Inspect for Flaws or Voids in Housing

Probable Causes

1. Porosity in housing resulting from casting defect
2. Circumferential scratches, burrs, and gouges due to machining
3. Cracks in housing due to heat treating or mishandling
4. Grinding media embedment producing rough surface

Action or Countermeasures

1. Review foundry practices
2. Review machining techniques and specification
3. Review material heat treating specification and handling practices
4. Review machining practices



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C.1.4 Check for Tool Withdrawal Marks on Bore

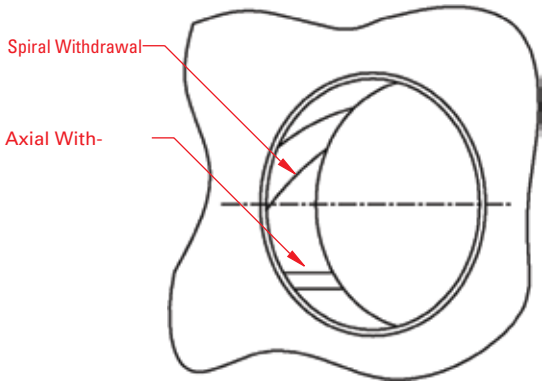
Probable Causes

1. Poor machining practices. Tool in contact with surface during removal
2. Leakage thru machine marks

Action or Countermeasures

1. Review machining techniques

2. Apply O.D. sealant to seal and/or bore. Machine to larger O.D. and use larger seal. Machine bore and install sleeve



C.1.5 Check for Severe Scratches or Galling Marks on Bore

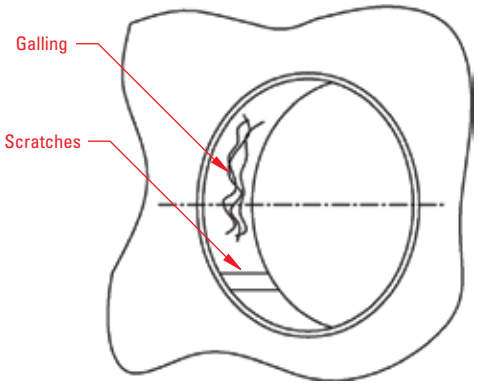
Probable Causes

1. Scratches and galling due to poor handling techinques
2. Scratches and galling due to machining operations
3. Scratches and galling due to part assembly; i.e. shaft, seal and bearings
4. Leakage through imperfections

Action or Countermeasures

1. Review handling and shipping practices
2. Review machining practices
3. Review assembly practices

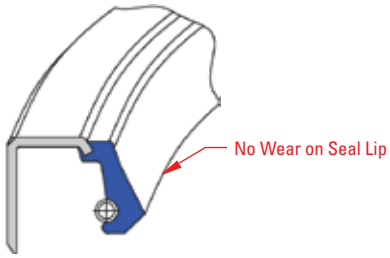
4. Machine and use larger O.D. seal. Machine and install sleeve



C.2.1.1 Lack of Wear

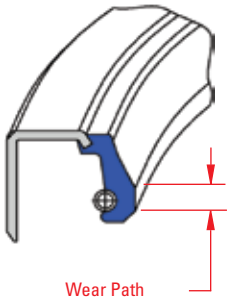
Usually associated with insufficient radial force or over-abundance of lubrication

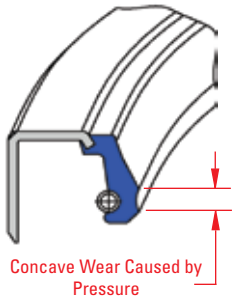
Probable Causes	Action or Countermeasures
1. No interference with shaft	1. Check seal I.D. for garter spring. Check shaft dia. Observe shaft for evidence of contact. Look for concave distortion on outside face of seal
2. Very light interference with shaft	2. Check seal I.D. for low radial load. Look for concave distortion on seal outside face
3. Seal installed backwards	3. Check installation method and teardown report
4. Heavy continuous leakage from startup, possibly from another source	4. Check fluid consumption reports - look for excessive media outside seal area. Check shaft size and seal interference. Leakage may be occurring through a defect; check seal I.D. and shaft for defects
5. Dynamic lift-off from centrifugal force, flutter or stick-slip action	5. Check for low radial load and spring presence. Check lip opening pressure on shaft size mandrel
6. Reverse hydrodynamic pumping direction	6. Check shaft rotation direction with helix. Check for spiral lead or axial scratches on shaft



C.2.1.2 Excessive Wear

Probable Causes	Action or Countermeasures
1. Excessive interference	1. Check seal I.D. and shaft size (interference)
2. Excessive radial force	2. Check for high radial load. Look for small I.D. garter spring
3. Excessive pressure on lip	3. Check system pressure at operating conditions
4. Rough shaft finish	4. Inspect shaft for defects, measure surface finish
5. Insufficient lubrication at seal lip	5. Provide lube on seal airside or between lips





Sealing System Leakage

C.2.1.3 Eccentric Wear

Probable Causes

1. Seal cocked in assembly (Fig. 1)
2. Excessive radial wall variation of lip
3. Excessive shaft to bore misalignment
4. Angled or cocked shaft (Fig. 3)
5. Side load applied to shaft

Action or Countermeasures

1. Check shaft for wide wear path. Check installation procedure and equipment
2. Measure seal radial wall variation and relate to wear pattern
3. Check shaft to bore offset (Fig. 2)
4. Check shaft alignment, excessive runout or bent shaft
5. Check possible side deflection or loose bearings

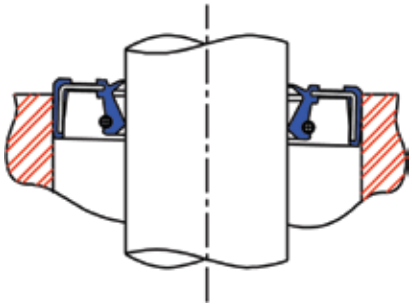


Fig. 1
Cocked Seal

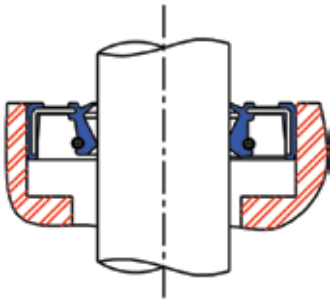


Fig. 2
Excessive STBM

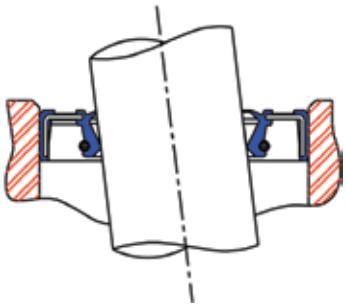


Fig. 3
Cocked Shaft

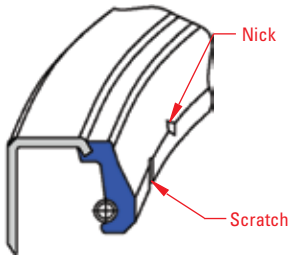
C.2.1.4 Nicks, Scratches or Cuts at Lip Contact Area

Probable Causes

1. Sharp edge or burrs on end of shaft
2. Sharp edge or burrs on installation tool
3. Seal installed over keyway or splines
4. Trimming knife cuts (Fig 1)
5. Nibbled appearance at sealing edge
6. Cuts from packaging method

Action or Countermeasures

1. Inspect shaft for burrs or sharpness
2. Inspect installation tool for burrs, sharp edge
3. Use installation sleeve for splines, keyways
4. Check supplier's knife trimming methods
5. Defects may be caused by bulk finishing or handling by supplier
6. Check supplier's packaging and shipping methods



C.2.1.5 Tears or Separations in Lip Area

Probable Causes

1. Stress fatique in flex section (Fig. 1)
2. Bond separation at I.D. of metal case (Fig. 2)
3. Migration of low temperature crack
4. Circumferential tear behind lip (Fig. 3) possibly from another source
5. Caused during disassembly or removal

Action or Countermeasures

1. Check system pressure. Seal may be deformed in I.D. flex section
2. Check seal for bond, burrs, and blisters
3. Check lip contact area for minor cold cracks. Suspect severe side load at low temperature
4. Look behind lip at base for circumferential tear caused by pressure or fatigue
5. Review teardown and seal removal methods and check tools used

Fig. 1

Fig. 2

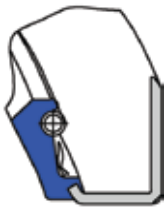


Fig. 3

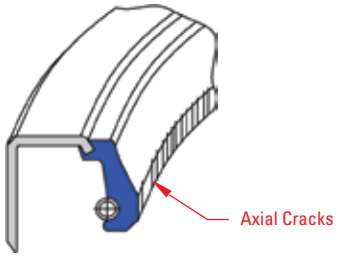
C.2.1.6 Hardening or Cracking of Rubber

Probable Causes

1. Prolonged or excessive high temp exposure
2. Flexing of lip at temps below rubber capability
3. Extended dry running causing localized high temperature under lip
4. Cracking from disassembly or observation techniques
5. Ozone exposure

Action or Countermeasures

1. Check rubber spec. vs. system temp profile
2. Check rubber spec. vs. system temp profile. Check offset, runout and sideplay
3. Check fluid level, check that shaft isn't too smooth
4. Review procedures and look for other damages
5. Check other dry areas of rubber, consider excessive solar or electrical exposure



Sealing System Leakage

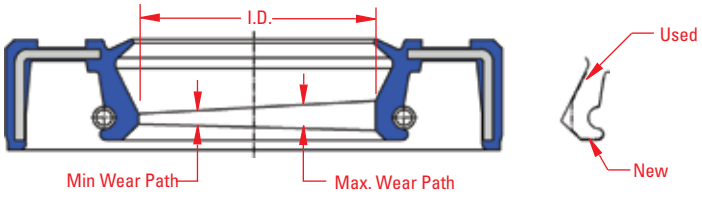
C.2.1.7 Measure I.D. and Radial Load

Probable Causes

1. Measure I.D. using non-contact device
2. Measure wear pattern width and variation
3. Compare profile with profile of new seal
4. Measure radial I.D. force

Action or Countermeasures

1. Use optical comparator or linear scope. Record min/max readings and relate to leak
2. Use optical means, photographic, or cross sections in comparator
3. Section seal and mount on glass slide for magnified comparator viewing
4. Use electronic split mandrel type radial load device (ref: RMA doc. OS-6)



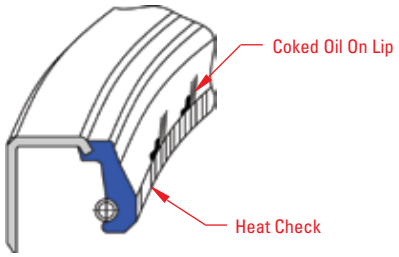
C.2.1.8 Coked Oil on Lip

Probable Causes

1. Hard and glazed deposit on I.D. (Fig. 1)
2. Insufficient hydrodynamic pumping action
3. Excessive under-lip temperature

Action or Countermeasures

1. Possibly decomposed fluid. Scrape and analyze
2. Helices ineffective
3. Check fluid specs. vs. operating parameters



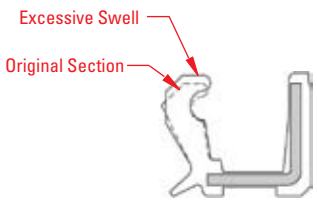
C.2.1.9 Softening or Swelling

Probable Causes

1. Volume change of material very high
2. Reversion
3. Exposure to solvent used during teardown
4. Operational contamination of fluid being sealed

Action or Countermeasures

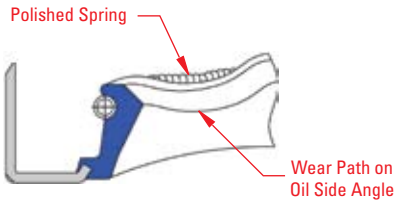
1. Refer to elastomer physical data, check fluid
2. Check elastomer/fluid compatibility specs
3. Review teardown procedure and elastomer compatibility with solvents
4. Check for possible exposure to unspecified media coming in contact with seal



C.2.1.10 Inverted Lip Due to Poor Installation

Probable Causes
1. Oil to air side assembly
2. Lack of proper concentricity assembly

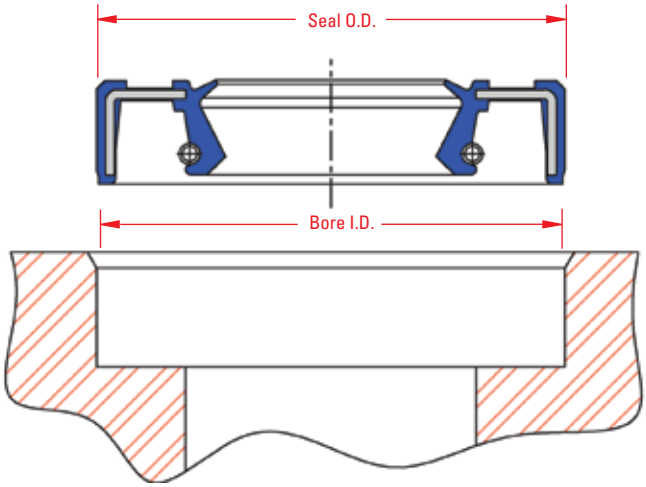
Action or Countermeasures
1. Provide installation aide such as bullet nose for shaft
2. Provide centering aide for assembly such as locating pins



C.2.2.1 Measure Seal Outer Diameter

Probable Causes
1. Wrong seal for application
2. Bore or housing reworked

Action or Countermeasures
1. Check for proper seal identification
2. Check housing print. Also check for evidence of rework such as chuck marks



C.2.2.2 Check for Severe Scratches on O.D.

Probable Causes
1. Damaged bore or bore chamfer (Fig. 2)
2. Die scratches from case operation

Action or Countermeasures
1. Check bore and chamfer condition
2. Check for O.D. coating or sealant in scratch

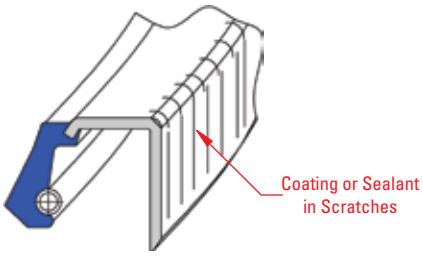


Fig. 1

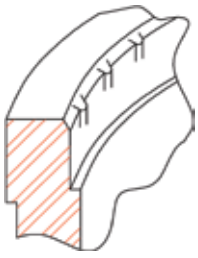


Fig. 2

Sealing System Leakage

C.2.2.3 Check for Peeled Rubber on O.D.

Probable Causes
1. Poor rubber bond to case (Fig. 1)
2. Lack of lubrication of O.D. at assembly
3. Lack of proper lead-in chamfer (Fig. 2)

Action or Countermeasures
1. Case O.D. clean at rubber interface
2. Case O.D. has rubber adhering to it
3. Check bore chamfer condition

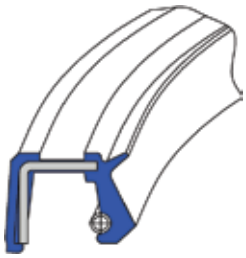


Fig. 1

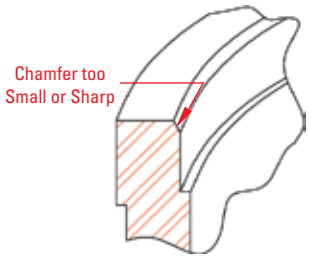
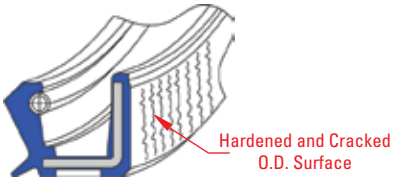


Fig. 2

C.2.2.4 Check for Hardened Rubber on O.D. (Rubber O.D. Design)

Probable Causes
1. Excessive heat in application
2. Improper seal material selection

Action or Countermeasures
1. Check for other evidence of overheating
2. Check material vs. operating temperature or lube compatibility



C.2.2.5 Rubber O.D. Nonfills/Cuts

Probable Causes
1. Improper seal manufacture. Prep weight or shape out of spec (Fig. 1)
2. Bore chamfer sharp or damaged (Fig. 2)

Action or Countermeasures
1. Consult seal manufacturer

2. Inspect bore chamfer

Fig. 1

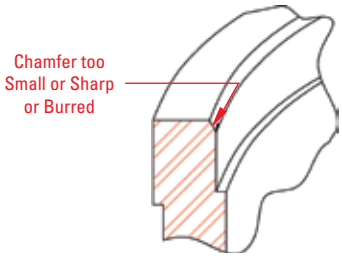
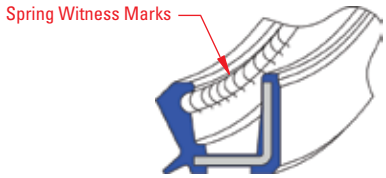


Fig. 2

C.2.3.1 Missing Spring

Probable Causes	Action or Countermeasures
1. Seal may never have had a spring	1. Check for spring witness marks in spring groove. Also light wear on primary lip
2. Spring may have become dislodged during seal or shaft installation	2. Check installation procedures
3. Spring joint may have seperated	3. Check installation procedures. Check garter spring joint quality (RMA OS-5)

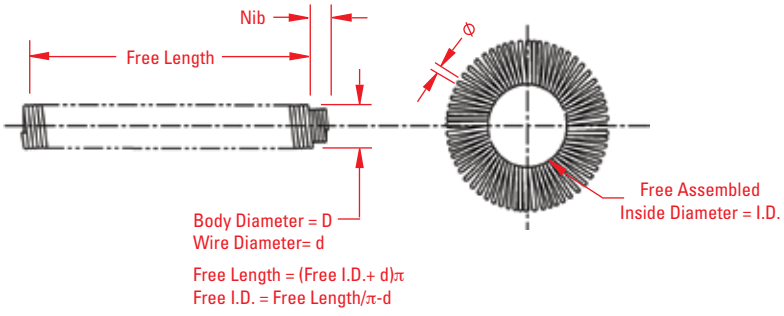


C.2.3.2 Corroded Spring

Probable Causes	Action or Countermeasures
1. Spring may not have had proper rust	1. Check new seals from same supplier
2. Application may be exposed to excessive moisture	2. Check for moisture in lube or corroded components
3. Application may contain a corrosive fluid	3. Specify stainless steel spring
4. Seal may have been improperly packaged and/or stored prior to installation	4. Check service stock
5. Wrong spring material	5. Consult supplier

C.2.3.3 Check for Correct Dimensions and Spring Load

Probable Causes	Action or Countermeasures
1. Wrong spring on seal (excessive or no wear on primary lip) groove	1. Check seal drawing for spring dimensions. Also light wear on primary lip
2. Spring not properly normalized	2. Check seal drawing. Check for proper heat treatment (RMA OS-5)
3. Improperly manufactured spring	3. Check seal drawing for spring dimensions



Sealing System Leakage

C.2.3.4 Multiple Springs

Probable Causes

1. Malfunctioning spring installation equipment at seal manufacturing location
2. Loose springs at seal installation station. Extra spring installed by assembler

Action or Countermeasures

1. System audit at supplier
2. Review installation station. Remove any loose springs. Review seal design and packaging

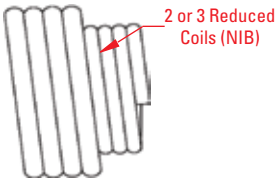
C.2.3.5 Seperated Spring

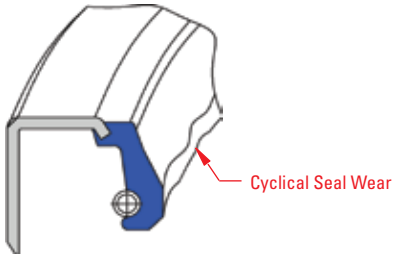
Probable Causes

1. Improper spring nib configuration
2. Excessive vibration or stick-slip of seal
3. Improper seal installation procedures

Action or Countermeasures

1. Inspect spring per RMA OS-5 (Fig. 1)
2. Inspect primary lip for excessive, cyclical seal wear (Fig. 2)
3. Review installation





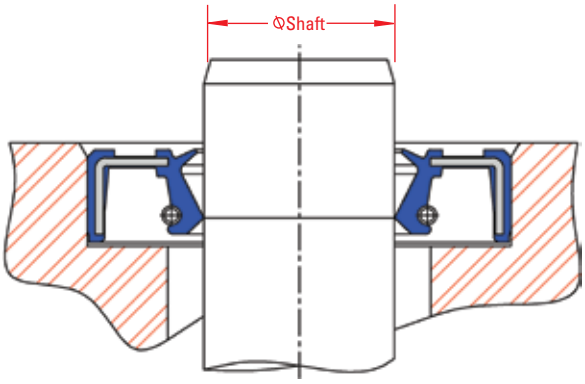
C.3.1 Shaft Diameter

Probable Causes

1. Oversize shaft may accelerate lip wear, increase heat generation, shaft wear and may cause lip to invert during installation
2. Undersize shaft may result in insufficient lipinterference to seal properly, resulting in premature leakage

Action or Countermeasures

1. Replace shaft, or, if oversize, machine to proper diameter



C.3.2 Shaft Surface Roughness (Primary Sealing Surface)

Probable Causes

1. Excessively rough shaft may accelerate lip wear and if too rough, leak upon initial startup
2. Undersize shaft may result in insufficient lip interference to seal properly, resulting in early leakage

Action or Countermeasures

1. Replace shaft or, if oversize, machine to proper diameter

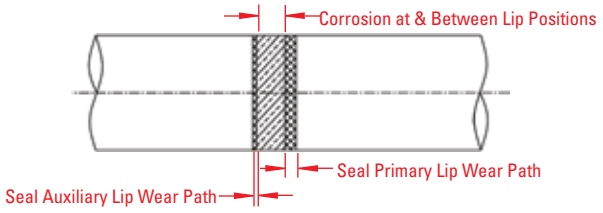
C.3.3 Shaft Corrosion

Probable Causes

1. Corrosion on the shaft in the area of the lip contact will interfere with lip's ability to seal against the shaft surface properly. The increased surface roughness may provide leakage paths and lip wear may increase from higher roughness

Action or Countermeasures

1. Apply corrosion-resistant shaft material
2. Use replaceable corrosion-resistant shaft sleeve
3. Change assembly design to limit access of corrosive contaminates
4. Change to seal design that will protect shaft from corrosion so lip can function normally
5. If corrosion from inventory storage before assembly - change inventory system



C.3.4 Lip Wear Band in Wrong Location on Shaft

Probable Causes

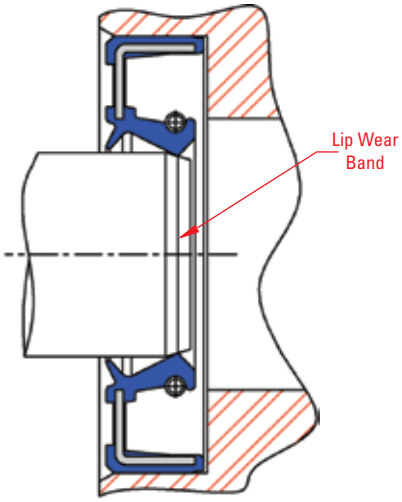
1. Insufficient/excessive lip interference may occur affecting lip's ability to seal
2. Improper seal of seal lip may contact shaft resulting in high temperature or leakage due to improper lip orientation

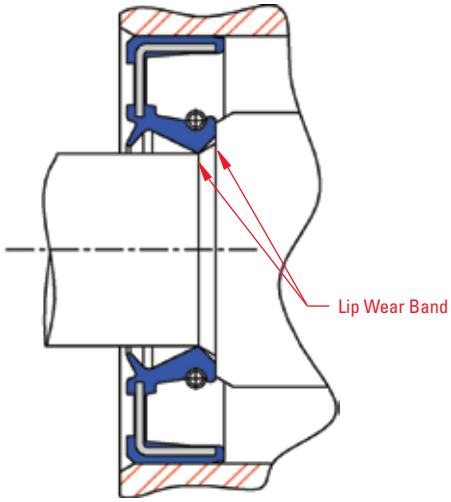
4. Seal moving after installation
5. Metal case of seal deformed during installation

Action or Countermeasures

1. Make sure proper seal is used (width to specs?)

2. Make sure seal installed to proper depth (not too deep / shallow) installation tool/procedure may be revised to ensure proper depth
3. Check shaft or assembly per specs
4. Check install method, seal and bore diameter
5. May orientate lip improperly





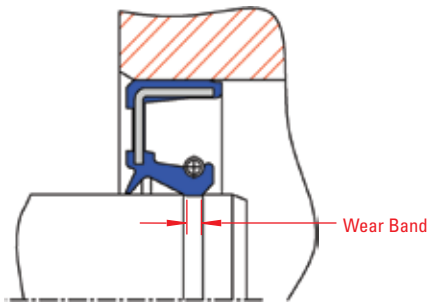
Sealing System Leakage

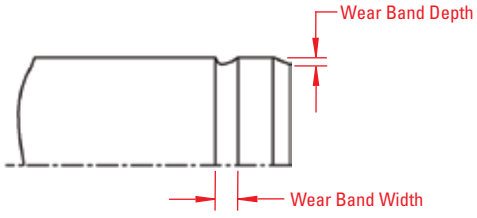
C.3.5 Scratches or Nicks at Lip Contact Area on Shaft

Probable Causes	Action or Countermeasures
1. Scratches or nicks (if large enough) across the seal contact area of shaft act as leakage paths	1. Check handling procedures of shaft from time shaft is machined until it reaches assembly area special carrying trays that protect shafts from hitting each other are suggested. Special cardboard or nylon mesh sleeves are commonly used
2. Shaft damaged during actual assembly	2. May require assembly method or jig change
3. Worker mishandling causing damage	3. Improve handling method
	4. It may be possible to rework shaft to remove defect but shaft roughness or diameter should not be altered outside of design spec
	5. Harden shaft to minimum RC 45 to improve resistance to scratching or nicking

C.3.6 Excessive Shaft Wear

Probable Causes	Action or Countermeasures
1. Seal lip will have difficulty sealing against the shaft wear band if depth is too large or width is too wide	1. Check shaft hardness, may get harder shaft
	2. Outside contaminant ingestion may cause problem. Use contaminant-resistant design
	3. Improper lubrication can cause acceleerated shaft wear. Check lube compatibility with lip and quantity of lubricant reaching seal
4. Contaminant present in fluid to be sealed	4. Check compatibility and change fluid more frequently or filter more effectively
	5. Proper lip interference. Check shaft diameter and seal to make sure to specs
6. Excessive eccentricity can cause unusual wear	6. Check for excessive runout or shaft to bore misalignment





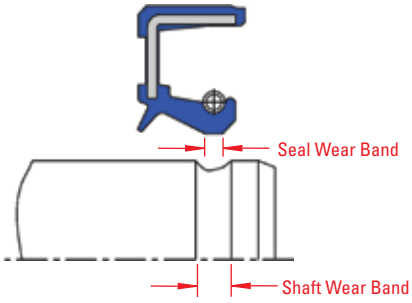
C.3.7 Wide Shaft Wear Band Relative to Seal Wear Band

Probable Causes

1. Leakage may result prematurely as lip cannot maintain proper orientation against the shaft
2. Leakage may occur as wide shaft wear band may act as leakage path

Action or Countermeasures

1. Check for seal cocking and correct installation procedure if found
2. Excessive axial motion can cause this type of wear. Check assembly and replace bearings if defective or worn



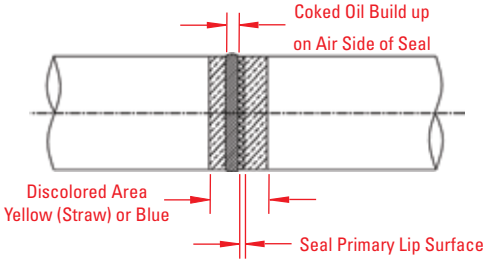
C.3.8 Shaft Discoloration or Coked Oil on Shaft

Probable Causes

1. Discoloration may indicate excessively high temperatures. The high temperatures may affect other characteristics of seal (lip hardness) resulting in premature failure
2. Coked oil buildup will interfere with the seal lip's ability to contact shaft which will result in failure
3. Bearing preload too high causing temperatures in seal area to be very high
4. Shaft too smooth causing seal to run hot
5. Excessive pressures in seal cavity can load seal lip excessively against shaft causing high temperatures

Action or Countermeasures

1. Check quantity of lubricant reaching seal and increase if necessary
2. Was shaft diameter or lip I.D. causing too much interference? Change to reduce interference
3. Set bearings to proper preload
4. Check shaft roughness
5. Reduce pressure or use pressure-resistant seal design
6. Change oil to high temperature resistant fluid
7. Reduce operating temperature of final assembly to range compatible with lube and seal material



Sealing System Leakage

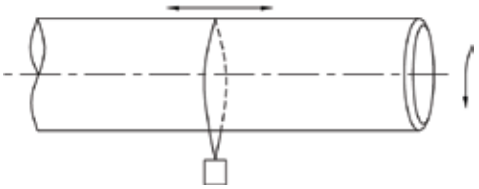
C.3.9 Machine Lead

Probable Causes

1. Machine lead may hydrodynamically pump medium to be sealed out, depending on shaft rotation direction

Action or Countermeasures

1. Finish shaft as recommended in RMA document OS-1 to eliminate machine lead



Shaft being checked for lead per procedure in OS-1

C.3.10 Shaft Hardness

Probable Causes

1. Shaft with hardness less than Rc 30 may experience accelerated wear, especially if sealing in a highly abrasive environment
2. Rc 45 is the preferred hardness if handling defects (scratches or nicks) are likely

Action or Countermeasures

1. Harden shaft or use harder shaft material proper diameter
2. Use wear sleeve
3. Reduce amount of contaminants reaching seal by changing to contaminant-resistant seal design or changing assembly design to limit outside contaminants. Change fluid more frequently if inside contaminants. Using better wear resistant bearing, gear, or other metal components inside assembly will help reduce contaminants in lubricant

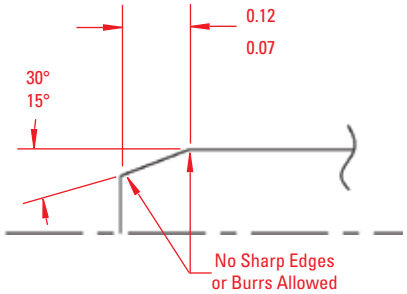
C.3.11 Shaft Chamfer Condition

Probable Causes

1. Insufficient chamfer may cause seal lip to invert, cause garter spring to pop off or make installation very difficult
2. Sharp edges or burrs may cut seal lip or cause lip to invert

Action or Countermeasures

1. Apply proper shaft chamfer as recommended in RMA document OS-4
2. Use a shaft sleeve, mandrel, or bullet to protect seal lip during installation



C.3.12 Proper Shaft Material

Probable Causes

1. Primary concern is achieving recommended shaft hardness and/or resistance to corrosion if in a highly corrosive environment

Action or Countermeasures

1. Change shaft material to compatible material for application
2. Shaft wear sleeve may be applied

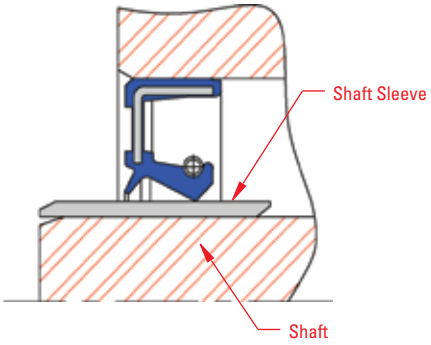
C.3.13 Wear Sleeve Fit

Probable Causes

1. Improper fit of the sleeve may result in a deformed sleeve
2. Leakage may occur between sleeve I.D. and shaft diameter
3. If sleeve is loose, it may rotate separate from shaft resulting in excessive heat generation

Action or Countermeasures

1. Follow proper installation methods to insure sleeve is not damaged during installation
2. Check shaft chamber for burrs or nicks or improper angle/depth and correct
3. Use additional sealant to prevent sleeve I.D./shaft interface leakage
4. Check shaft diameter O.D./sleeve I.D. to see if correct-replace if necessary. Also, sealant such as loctite or permatex may prevent sleeve from spinning



C.4.1 Contaminants in Oil

Probable Causes

1. Inadequate cleaning of unit prior to assembly
2. Ingestion of contaminates past seal
3. Wear debris: e.g. bearing, shaft, and other dynamic contact parts
4. Oil contamination during storage
5. Oil contamination by vendor
6. Break-down of hydraulic hosing and similar system components due to material deterioration
7. Sobotage
8. Worn seal
9. Sintered (powdered metal) components

Action or Countermeasures

1. Review procedure to insure removal of machining debris prior to part assembly
2. Inspect seal for presence of exclusion lip. For spring load seal, check for spring
3. Inspect dynamic components for excessive wear
4. Check storage procedures for bulk oil supply
5. Check in-house and incoming oil containers for contaminates
6. Check material fluid compatability
7. Install tamper-proof fill cap
8. Replace oil, filter oil, and clean housing

C.4.2 Composition of Lubricant Compared to New

Probable Causes

1. Changes in fluid lubricity, viscosity
2. Apparent color differences
3. Noticeable odor difference
4. Noncompatible “substitute” fluid
5. Contaminates in fluid

Action or Countermeasures

1. Send oil sample to vendor for anaylsis
2. Send oil sample to vendor for analysis
3. Send oil sample to vendor for anaylsis
4. Use fluid specified by OEM
5. Replace fluid; filter fluid

Projects

Contact: _____ Date: _____

Company: _____ Phone: _____

Email: _____ Fax: _____

Notes: _____