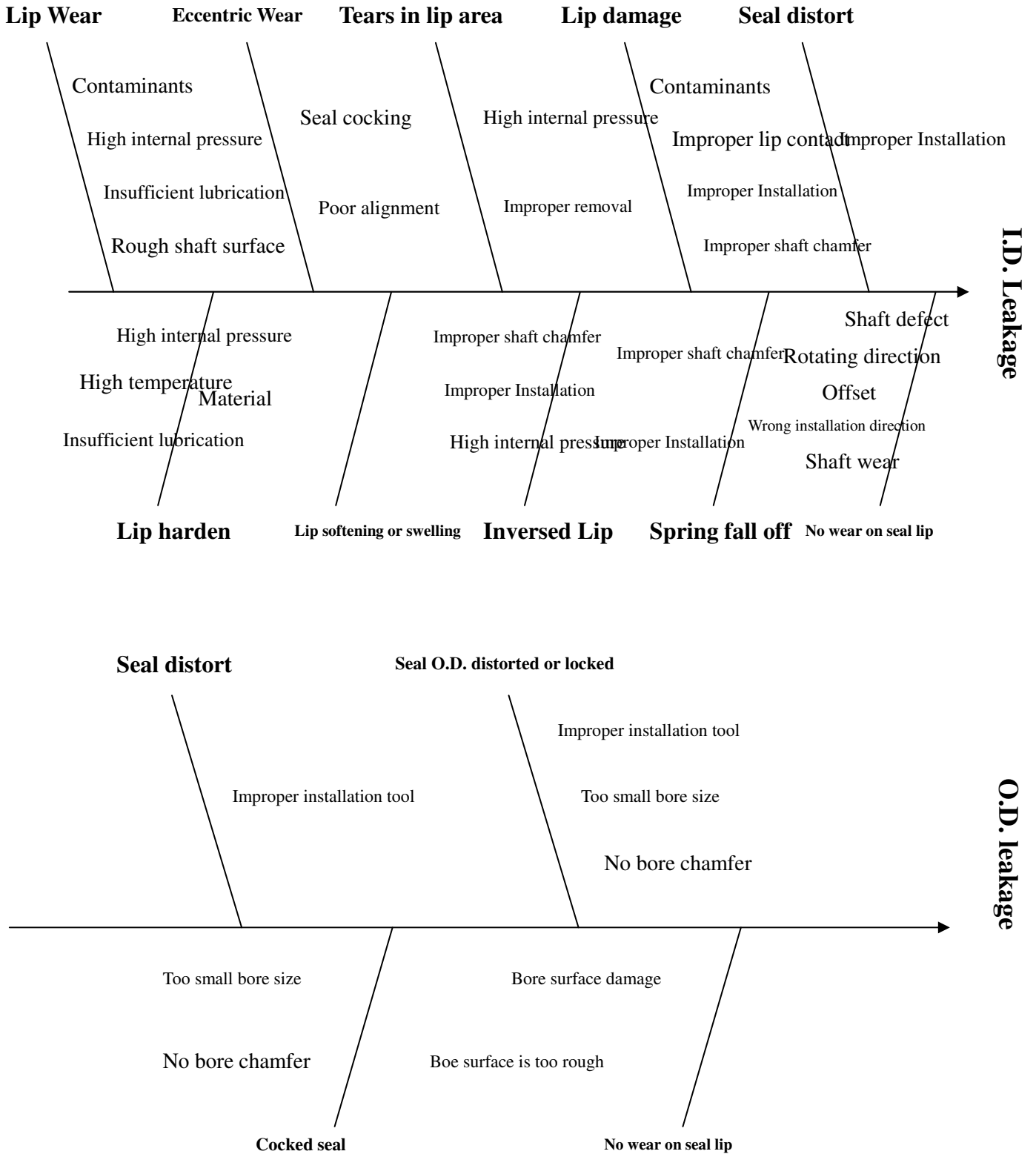


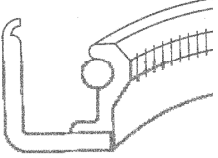
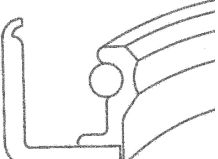
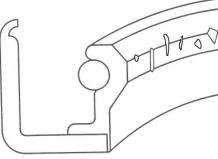
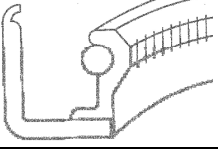
# Chapter 8 Failure Analysis

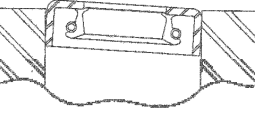
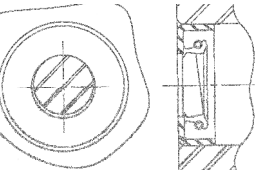
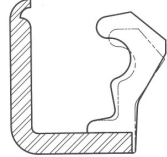
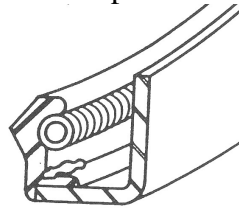

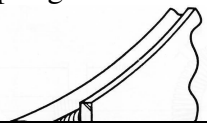



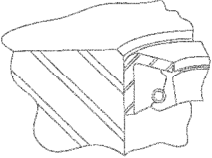
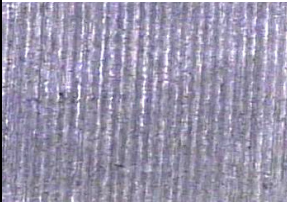
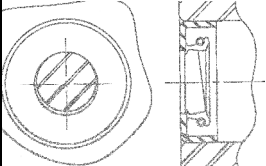
## 8.1 Sealing system leakage analysis chart

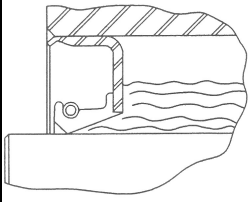


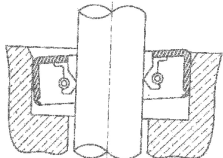
## 8.2 Failure analysis and suggestion

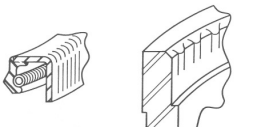
8.2.1 I.D. leakage				
Primary causes	Failure mode	Causes	Suggestion	
Lip Wear	Rough shaft surface	Excessive lip wear and traces on the lip circumferential direction. 	Shaft surface roughness exceed $Ra= 0.2-0.8\mu m$ and lead to excessive wear.	Finish the shaft to surface roughness to $Ra= 0.2-0.8 \mu m$ °  Change the shaft which the surface roughness is acceptable.
	Insufficient lubrication	Excessive lip wear	Improper lubrication can cause accelerated shaft wear	Check lubricant compatibility with lip and quantity of lubricant reaching seal.
	High internal pressure	Excessive lip wear. 	The internal pressure exceed the seal limit.	Use pressure type seal  Design a vent in the application to release the pressure.
	Contaminants	Excessive lip wear. Nicks, scratches or cuts at lip contact area. 	Dust and mud adhere between shaft and lip that causes lip wear, nicks, scratchers or cuts at lip contact area.	Shaft and seal don't contaminated by dust or mud during installation.  Add a dust lip design in the application.
Lip harden	Insufficient lubrication	Lip harden and has crack. 	Lubrication is not enough that cause dry running.	Supply lubrication oil exceeding the seal level.
	High temperature	Lip harden and has crack.	The temperature exceed the rubber heat-resistance limit.	Change the rubber to good heat-resistance material.
	High internal pressure	Contact width is large and lip is harden and have crack.	The internal pressure exceed the seal limit.	Use pressure type seal  Design a vent in the application to release the pressure.

Primary causes		Failure mode	Causes	Suggestion	
Eccentric Wear	Seal cocking	Asymmetric contact between lip and shaft.	Seal installation.	Use proper installation tool. Check installation force to insure complete installation.	
			Insufficient or improper bore chamfer.	Provide proper amount and lead in angle for chamfer	
			Excessive seal interference with rubber O.D. seal.	Check bore I.D. and seal O.D. for proper dimensions.	
	Poor alignment	Asymmetric contact between lip and shaft.	Poor initial alignment.	Review design and assembly operations and provide accurate alignment.	
			Seal manufactured with high radial wall variation.	Review production quality data and adjust process.	
Softening or swelling	Improper lip material		Volume change of material very high.	Refer to elastomer physical data and check fluid.	
			Reversion.	Check elastomer/fluid compatibility specifications.	
			Exposure to solvent used during teardown.	Review teardown procedure and elastomer compatibility specifications.	
			Operational contamination of fluid being sealed.	Check for possible exposure to unspecified media coming in contact with seal.	
Tears in lip area	Improper removal		Caused during disassembly or removal.	Review teardown and seal removal methods and check tools used.	
			High internal pressure	Circumferential tear behind lip.	Look behind lip at base for circumferential tear caused by pressure or fatigue.
Inverted Lip	Improper shaft chamfer		Whole or part of lip inverted.	Adjust the chamfer size and angle, and smear lubricant on chamfer when installation.	
	Improper installation		Lack of proper concentricity assembly.	Adjust the concentricity and smear lubricant on chamfer when installation.	
	High internal pressure		Circumferential tear behind lip.	Look behind lip at base for circumferential tear caused by pressure or fatigue.	
Spring fall off	Improper shaft chamfer		Whole or part of spring fall off.	Incorrect chamfer size and angle.	Adjust the chamfer size and angle, and smear lubricant on chamfer when installation.

	Improper installation		Lack of proper concentricity assembly.	Adjust the concentricity and smear lubricant on chamfer when intallation.
Primary causes		Failure mode	Causes	Suggestion
Lip Damage	Improper shaft chamfer	Lip damage visually.	Incorrect chamfer size and angle.	Adjust the chamfer size and angle, and smear lubricant on chamfer when intallation.
	Improper installation		The chamfer has burrs causing lip damage when installation.	Cut the burrs.
	Improper lip contact		Lip contacts sharp bodies when assembling or transporting.	Prevent contacting seal lip during assembling and transporting.
	Contaminants	Contaminants packed in seal area 	Failure of auxiliary lip	Look for cut or damaged auxiliary. Look for auxiliary lip worn excessively.
Seal distort	Improper installation 	Seal distorts that change the contact width.	The improper installation tool that cause seal distorts.	Improve the installation tool.
No wear on seal lip	Shaft defect		Shaft surface has defect visually.	Change contact position between shaft and lip.
	Rotating direction		Processed shaft in a lathe had directional when rotating the shaft. (x63) ◦ 	Use plunge grinding to change property of direction.
	Offset		Poor alignment of shaft. 	Change to the seal that can bear poor alignment. Make sure the shaft and bore is concentric.

	Wrong installation direction		Wrong installation direction. 	Turn seal oil side toward to oil.
Primary causes	Failure mode	Causes		Suggestion
No wear on seal lip	Shaft wear	Contaminants attached on the seal or shaft when assembling the seal.	Prevent mud and dust contaminate shaft and seal when assembling the seal.	
		Lubrication went bad and mixed contaminants.	Avoid overusing the lubricant.	
		Contaminants entering the lip that caused wear.	Have a dust lip design.	

8.2.2 O.D. leakage				
Primary causes	Failure mode	Causes		Suggestion
Seal distort	Seal distort	Improper installation tool causing the seal distort.	Use the proper installation tool.	
		When the seal distort on certain location.	Prevent the seal dropping or impacting.	
Cocked seal	<p>Before removing the seal, the seal seal cock can be seen by eyes.</p>  <p>After removing the seal, there is eccentric wear on the lip.</p>	Bore dimension is too small to install the seal that causes seal cock.	Use the suitable bore size.	
		No bore chamfer that causes seal damage during installing.	Chamfer the bore.	
		Use the improper installation tool.	Use the proper installation tool.	
Seal is tightly wedge	Bore damaged, seal O.D. rubber extruded or damaged.	Bore I.D. is too small to install the seal that causes seal damaged.	Use the suitable bore size.	

		No bore chamfer that causes seal damage during installing.	Chamfer the bore.
		Installation tool is not parallel with the bore that causes the seal extruded.	Require the installation tool is parallel with the bore.
Primary causes	Failure mode	Causes	Suggestion
No wear on seal lip		Contaminants attach the bore and seal O.D and damaged the bore surface during installing.	Avoid contaminant attaching on the bore and seal during installing.
		Assembly bore surface has pits or too rough.	Pay attention to surface roughness.
		Bore chamfer has burrs that cause the bore surface damaged.	Trimming the burrs of the bore chamfer.

Remark: Some materials above are adopted from RMA.