



AEROSPACE INFORMATION REPORT	AIR1707™	REV. C
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	Superseding AIR1707B	
Patterns of O-Ring Failures		

RATIONALE

This standard has been revised to remove a misplaced Figure 19 and to renumber the remaining figures.

1. SCOPE

The information presented herein describes the commonly observed patterns of O-ring failure by means of both text and illustration. Possible causes and corrective actions are indicated for alleviating the problem.

1.1 Purpose

This document is intended to provide a guide for analyzing O-rings which have failed in order to correct the circumstances which have caused the failure. A great deal can be learned toward solving a sealing problem involving O-rings by close observation of the failed O-ring.

2. REFERENCES

There are no referenced publications specified herein.

3. FAILURE PATTERNS

3.1 General

Failures are usually due to a combination of causes. The patterns of O-ring failure described herein, then, represent the modes most often encountered. Subtle variations will occur, but the major cause generally predominates.

- 3.1.1 Note that this document does not advise on rubber compound selections or design details, although some general guidance comments are made. Consult an applications engineer for material selection, design details, and the proper use of antiextrusion devices. Also, consider the substitution of other sealing types for the O-ring.

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3.1.2 The failures discussed herein have been classified under the following headings:

Extrusion and Nibbling	3.2
Spiral Failure	3.3
Abrasion	3.4
Compression Set	3.5
Weather and Ozone Cracking	3.6
Heat Aging and Oxidation	3.7
Plasticizer Extraction	3.8
Installation Damage	3.9
Gas Expansion Rupture	3.10
Failure Due to Backup Ring	3.11

3.2 Extrusion and Nibbling

3.2.1 Occurrence

Usually associated with dynamic rod or piston seals but can occur in a static seal with pressure pulsations, especially where it opens and closes the clearance.

3.2.2 Appearance

Exhibits many small nibbles removed from the O-ring adjacent to the downstream clearance area, or a small section of the O-ring may be extruded. Typical of high pressure systems, this process sometimes erodes half of the O-ring cross-section before major leakage occurs.

3.2.3 Cause

Clearance is too large, pressure is too high, O-ring is too soft, O-ring is softened and swelled by fluid, clearance increases under pressure, eccentricity causes irregular gap, and corners of O-ring gland are too sharp.

3.2.4 Corrective Action

Closer metal fits (reduce diametral clearance or reduce plate gap,) use of backup rings or other antiextrusion devices such as cap strips, harder O-ring material, use of O-ring more compatible with system fluid, more rigid or concentric metal components, and break edges of gland to a radius of about 0.001 to 0.002 inch (0.025 to 0.050 mm). T-seals that fit into the same gland may also be substituted.

3.2.5 Examples



Figure 1 - Extrusion and nibbling

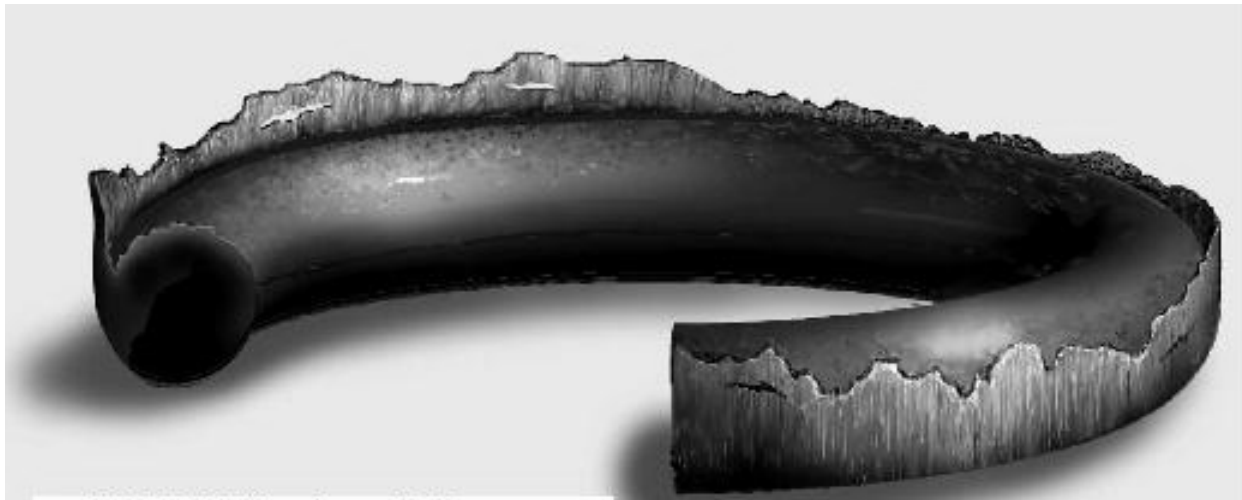


Figure 2 - Extrusion and nibbling (used with permission from R. L. Hudson)



Figure 3 - Nibbling and skiving



Figure 4 - Nibbling and abrading



Figure 5 - Nibbling and extrusion

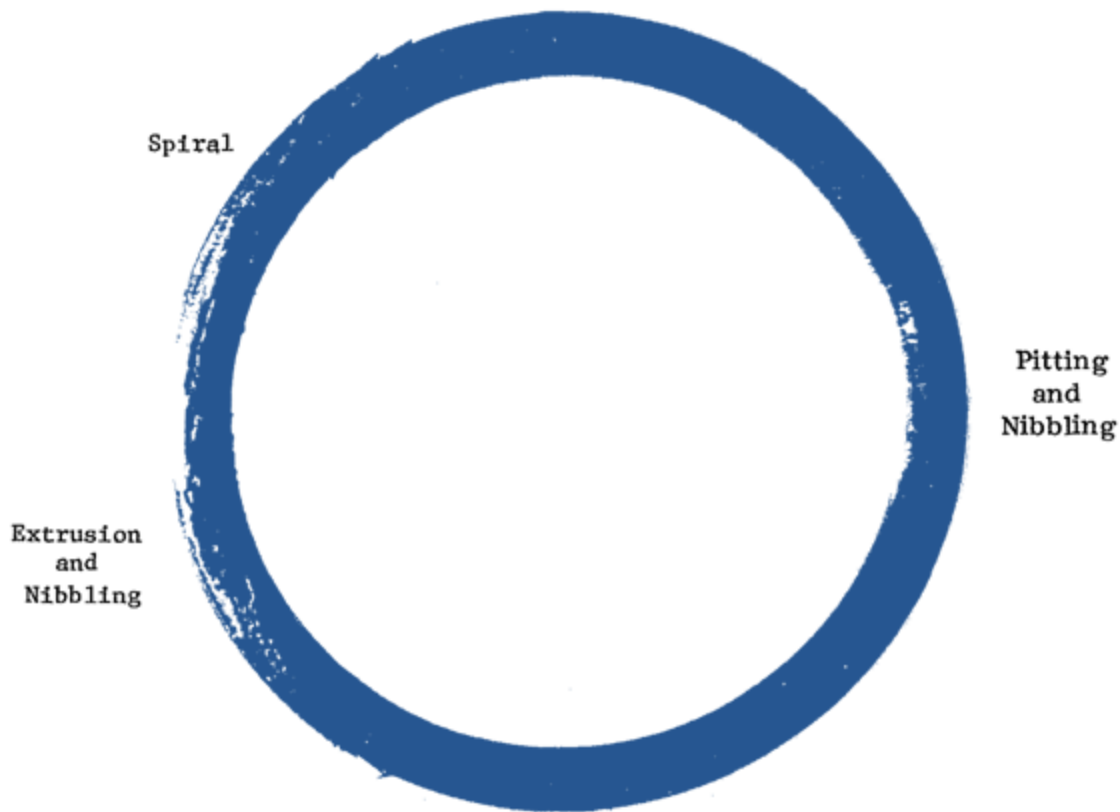


Figure 6 - Nibbling, extrusion, pitting, and spiral failure

3.3 Spiral Failure

3.3.1 Occurrence

Usually associated with long stroke piston seals but can occur with dynamic rod seals. Has been observed even on short stroke pneumatic piston seals.

3.3.2 Appearance

Exhibits a deep spiral cut (usually at about 45 degrees) into the O-ring cross-section.

3.3.3 Cause

Conditions which cause segments of the O-ring to slide and others to roll, simultaneously. The O-ring generally gets pinched or "hung up" at one point of its periphery. Side loads causing the O-ring to get caught in an eccentric component, uneven surface finishes, poor or uneven dispersion of lubricant, and stroke speeds contribute.

3.3.4 Corrective Action

Improve metal surface finish to the 10 to 20 μin (0.25 to 0.50 μm) range, improve lubrication, use backups or other antiextrusion devices if possible, reduce gap, and consider seals other than O-rings such as T-seals.

3.3.5 Examples

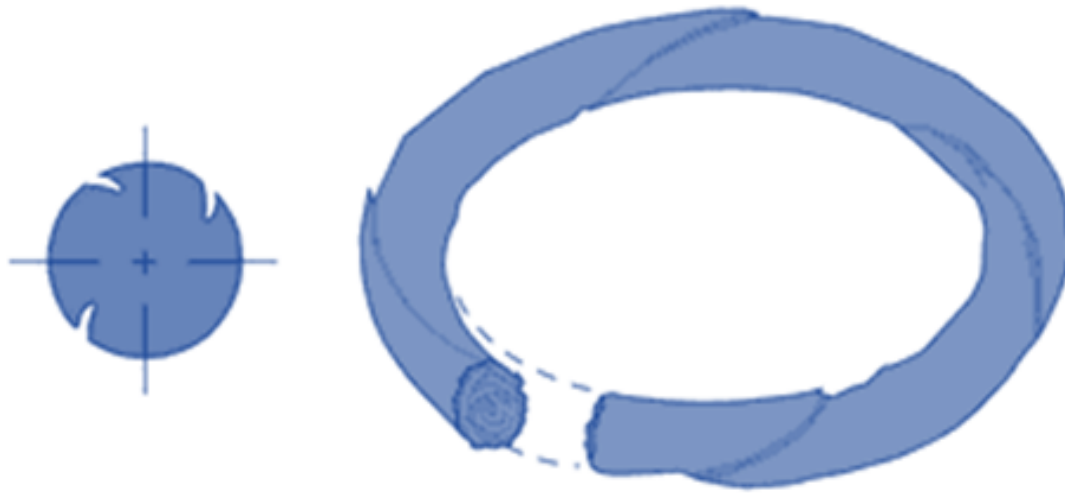


Figure 7 - Spiral failure

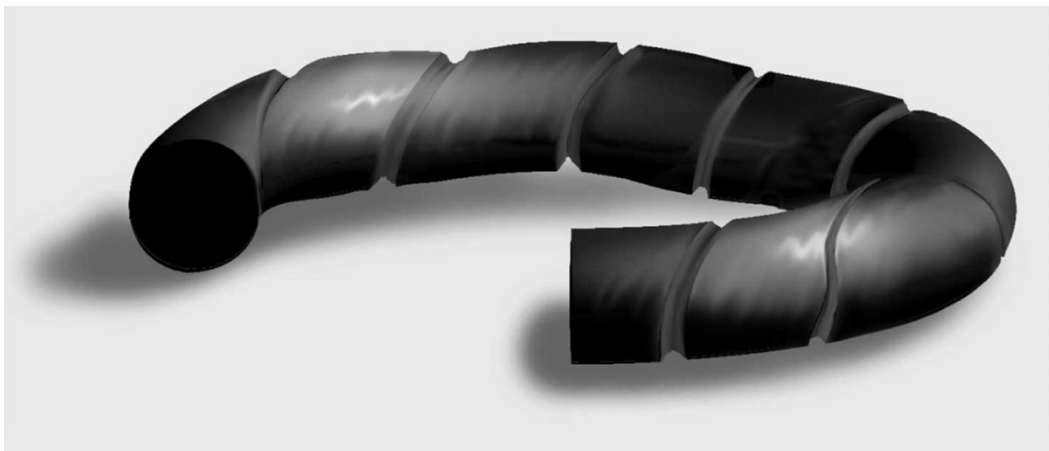


Figure 8 - Spiral failure (used with permission from R. L. Hudson)