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Bearing Failure Analysis With A Focus on Lubrication

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- **Bearing Basics**
- **Common Bearing Failures**

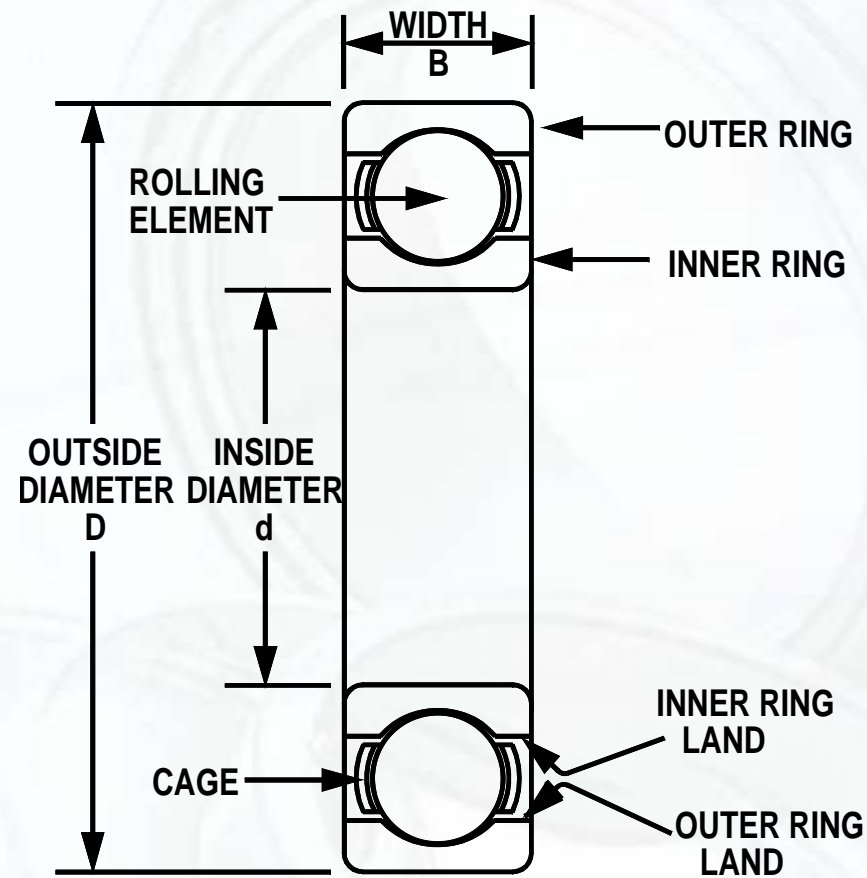
- **Two main types of bearings**
 - Friction bearings
 - Anti-friction bearings

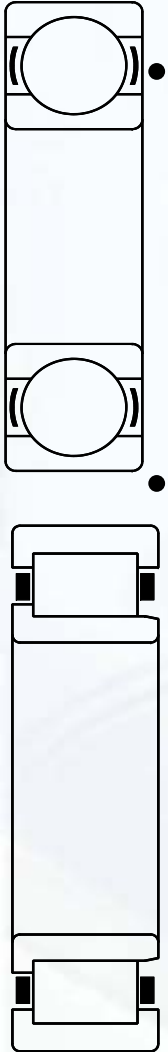


The Basics

- Definition of Anti-Friction Bearing

*An **anti-friction** bearing takes advantage of the rolling action of balls or rollers in allowing the rotation of one moving machine component relative to another.*





• Ball Bearings

- Radial Ball Bearings
 - Deep groove ball, angular contact ball, self-aligning units
- Axial Ball Bearings
 - Single direction thrust ball, double direction angular contact thrust ball



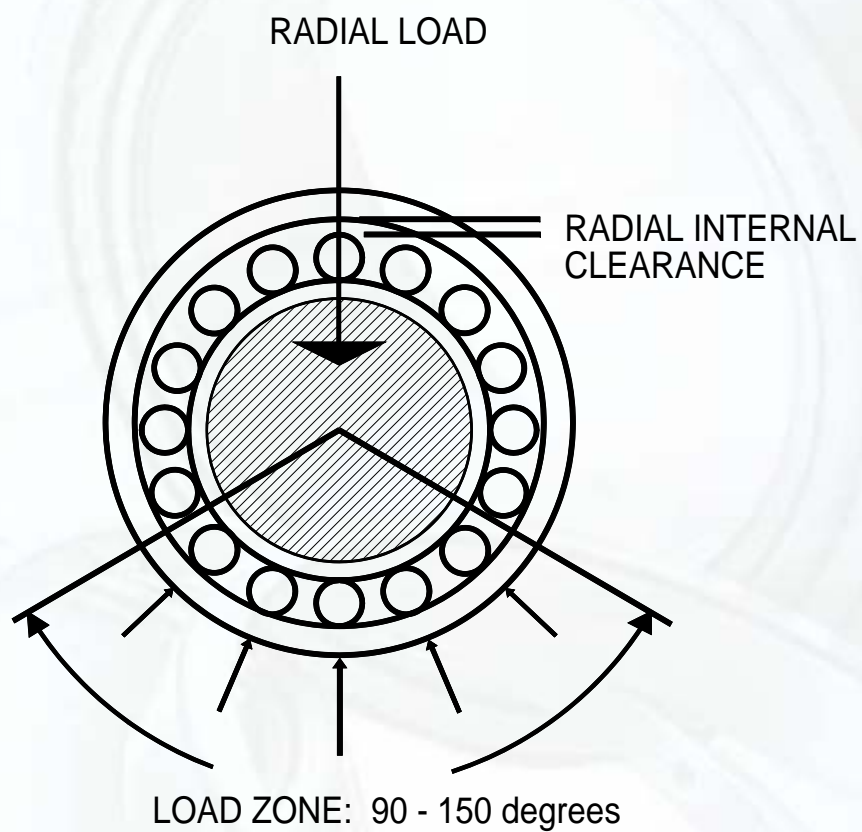
• Roller Bearings

- Radial roller bearings
 - Cylindrical roller, needle roller, tapered roller, spherical roller
- Axial roller bearings
 - Cylindrical roller thrust, needle roller thrust, tapered roller thrust, spherical roller thrust



- **Made to International Standards**
 - ISO 15, ISO 335, and ISO 104 for envelope dimensions and nomenclature
 - ISO 492, ISO 199, ISO 578, and ISO 1224 for tolerances
 - ISO 281/I 1977 and ISO 76 1987 for load ratings.

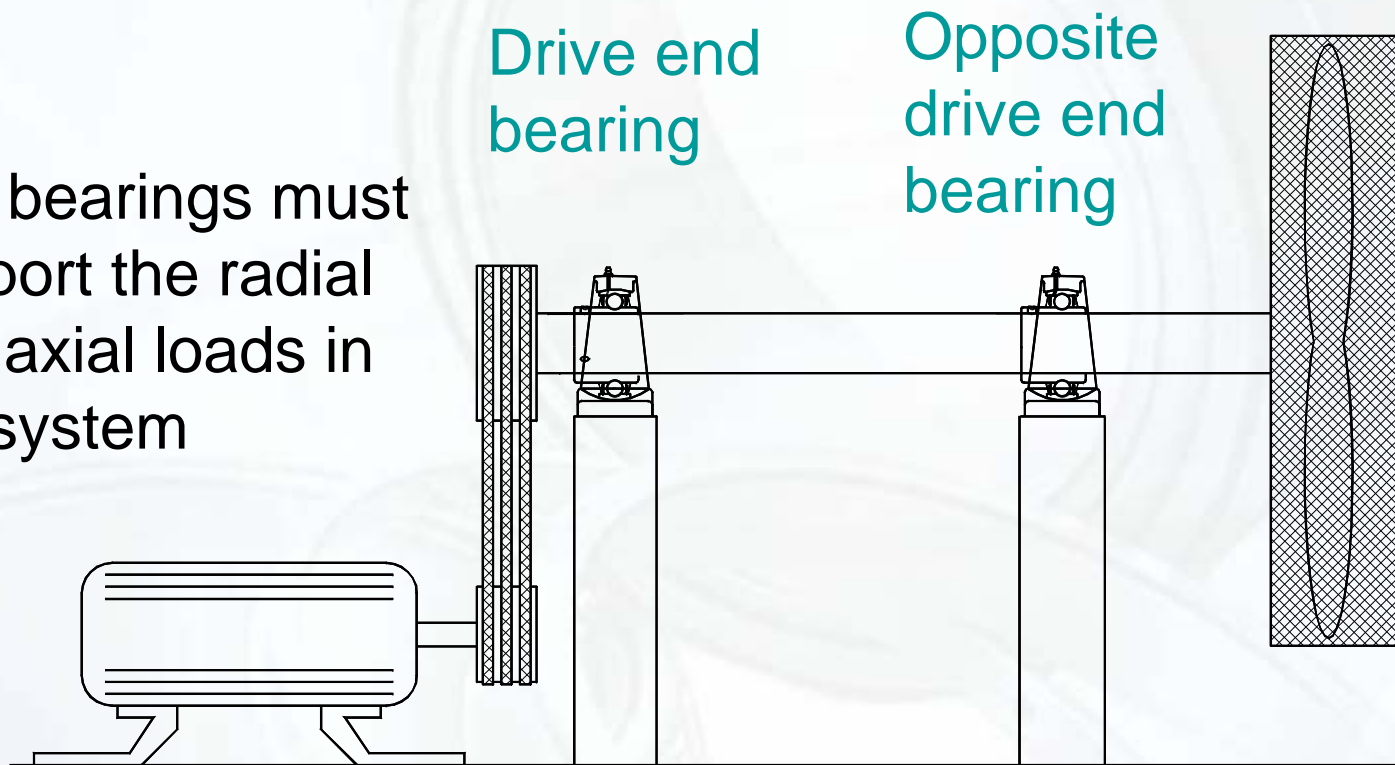
The Load Zone



	BALL BEARINGS	ROLLER BEARINGS
SPEED	High	Low to moderate
LOAD	Light to moderate	High

A Typical Fan Application

The bearings must support the radial and axial loads in the system



- **Importance**
 - billions of bearings in operation
 - typically constitute less than 10% of the value of capital equipment
 - when they fail prematurely, the cost of lost production is immense

- **TTC Rocket**
 - \$710M cost for 240 cars
 - \$0.760M for journal bearings



- The monitoring of the millions of NTN-SNR bearings sold has allowed us to establish very precise statistics on the origin of faults. This collection of data highlights one essential fact: it is rare that the bearing itself is the cause of premature failure.
- In 90% of cases, the cause can be found in external components which can be classified into 4 categories:

- **Inadequate lubrication: 55%**
- **Contamination: 18%**
- **Incorrect mounting: 17%**
- **Fatigue: 10%**

- Adequate lubrication
 - Ball bearings, cylindrical roller bearings and needle roller bearings: 13 mm²/s
 - Spherical roller bearings, tapered roller bearings, needle roller thrust bearings: 20 mm²/s
 - Self-aligning roller thrust bearing: 30 mm²/s

Table 11.8 Required lubricating oil viscosity for bearings

Bearing type	Kinematic viscosity mm ² /s
Ball bearings, Cylindrical roller bearings, Needle roller bearings	13
Spherical roller bearings, Tapered roller bearings, Needle roller thrust bearings	20
Self-aligning roller thrust bearings	30

Table 11.8 Selection standards for lubricating oils (Reference)

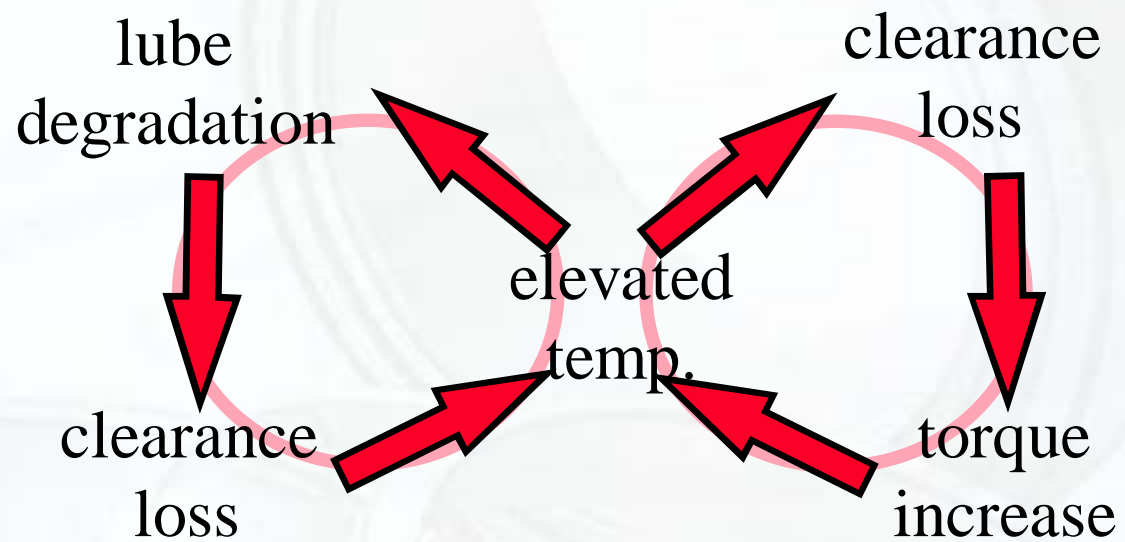
Bearing operating temperature °C	d_m -value	Lubricating oil ISO viscosity grade (VG)		Suitable bearing
		Normal load	Heavy load or shock load	
-30 ~ 0	Up to allowable rotational speed	22, 32	46	All types
0 ~ 60	Up to 15,000	46, 68	100	All types
	15,000 ~ 80,000	32, 46	68	All types
	80,000 ~ 150,000	22, 32	32	All types but thrust ball bearings
	150,000 ~ 500,000	10	22, 32	Single row radial ball bearings, cylindrical roller bearings
60 ~ 100	Up to 15,000	150	220	All types
	15,000 ~ 80,000	100	150	All types
	80,000 ~ 150,000	68	100, 150	All types but thrust ball bearings
	150,000 ~ 500,000	32	68	Single row radial ball bearings, cylindrical roller bearings
100 ~ 150	Up to allowable rotational speed	320		All types
0 ~ 60	Up to allowable rotational speed	46, 68		Self-aligning roller bearings
60 ~ 100	Up to allowable rotational speed	150		

Note 1: Applied when lubrication method is either oil bath or circulating lubrication.

Note 2: Please consult NTN Engineering in cases where operating conditions fall outside the range covered by this table.

- **Inadequate lubrication**
 - Improper lubrication
 - Not enough
 - Too much
 - Improperly applied
 - Contaminated lubricant

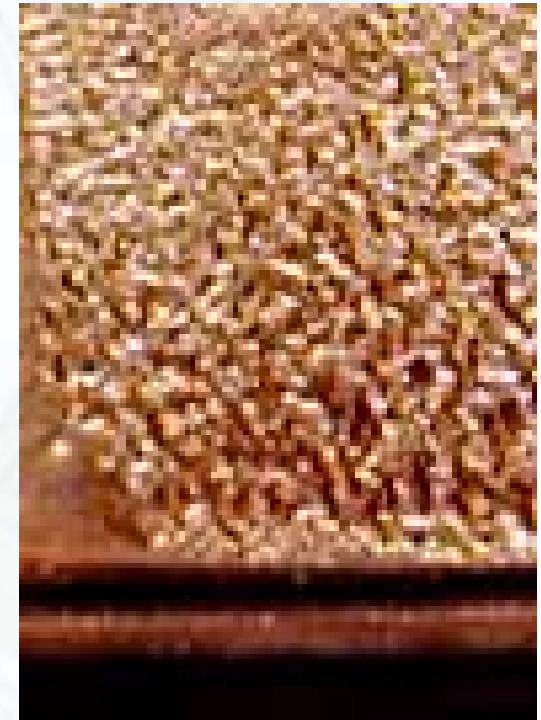
- Vicious cycle or vicious bicycle



- Spalling or Flaking



- Spalling



- Symptom: Spalling or flaking
- Cause: One or all of the above (mixing incompatible greases)
- Secondary symptoms: Heat generation; clearance loss; contamination; fragment indentation
- Other causes for Spalling: Age; overloading; improper handling; poor shaft or housing fits; installation error; contamination; ...

- Cage (retainer) failure







- Symptom: Cage failure
- Cause: Lubrication problem, any or all of above
- Secondary symptoms: Heavy wear; fragment indentation; spalling; cage material plating; heat discolouration
- Other causes for cage failure: Vibration; moment loading

- Water etching





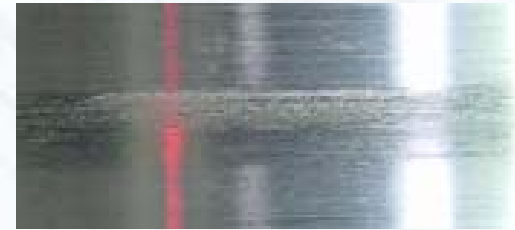
- Symptom: Water etching
- Cause: Water or moisture, snow, ice
- Secondary symptoms: Heavy wear; heat generation; spalling; seal disfigured
- Other causes for water etching: More water

- Rust / corrosion



- Symptom: Rust / corrosion
- Cause: Water or moisture, snow, ice
- Secondary symptoms: Lubrication washout; water etching; spalling; fragment indentation
- Other causes for rust: Caustic liquids (acids or bases); cleaners; etc.

- Contamination





Failure Analysis



- Symptom: Contamination
- Cause: Improper storage of lubricant; not wiping grease fitting before relubrication; mixing incompatible lubricants
- Secondary symptoms: Water etching; spalling; fragment indentation; galling; heat discolouration
- Other causes for contamination: Name something; environment during the installation of bearing; seal failure; improper cleaning of machined parts

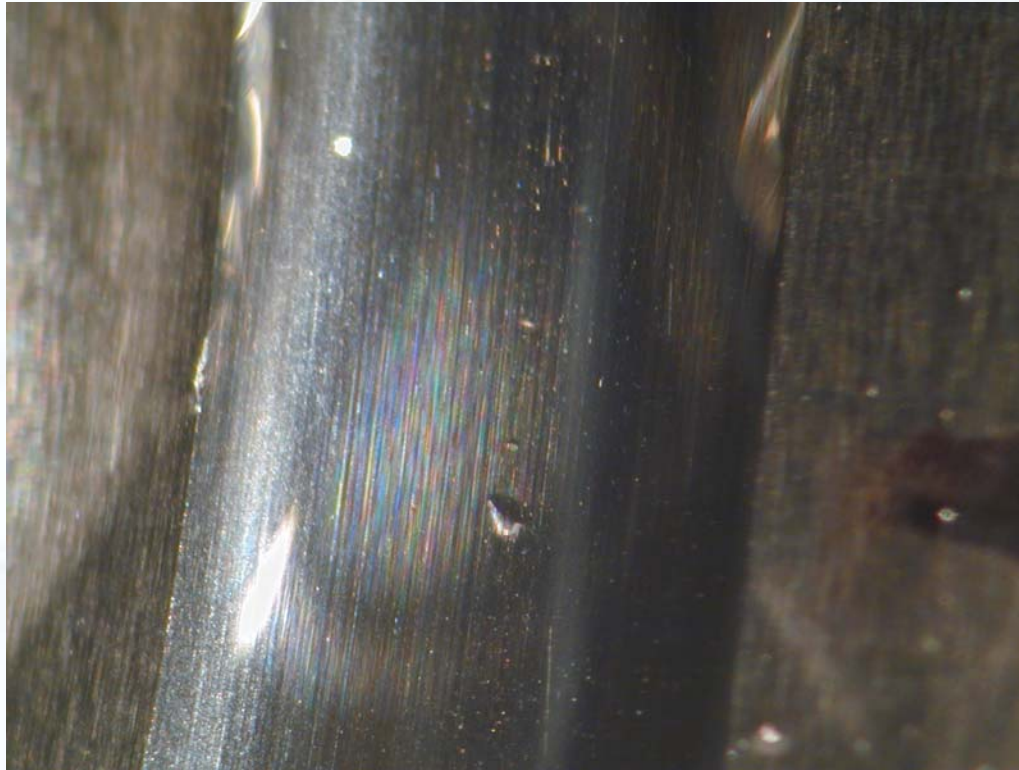




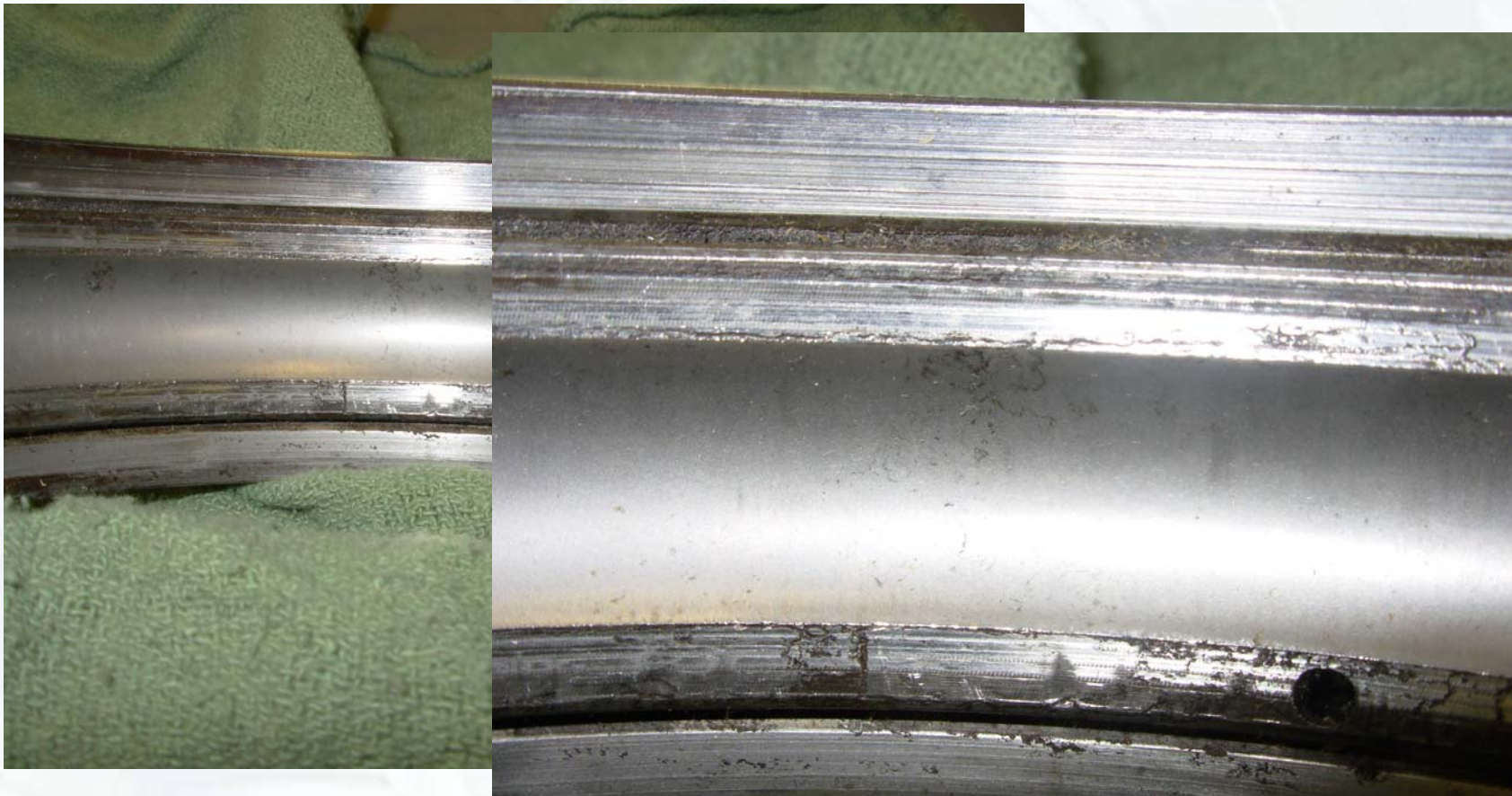
- Heavy wear, pitting and fragment indentation



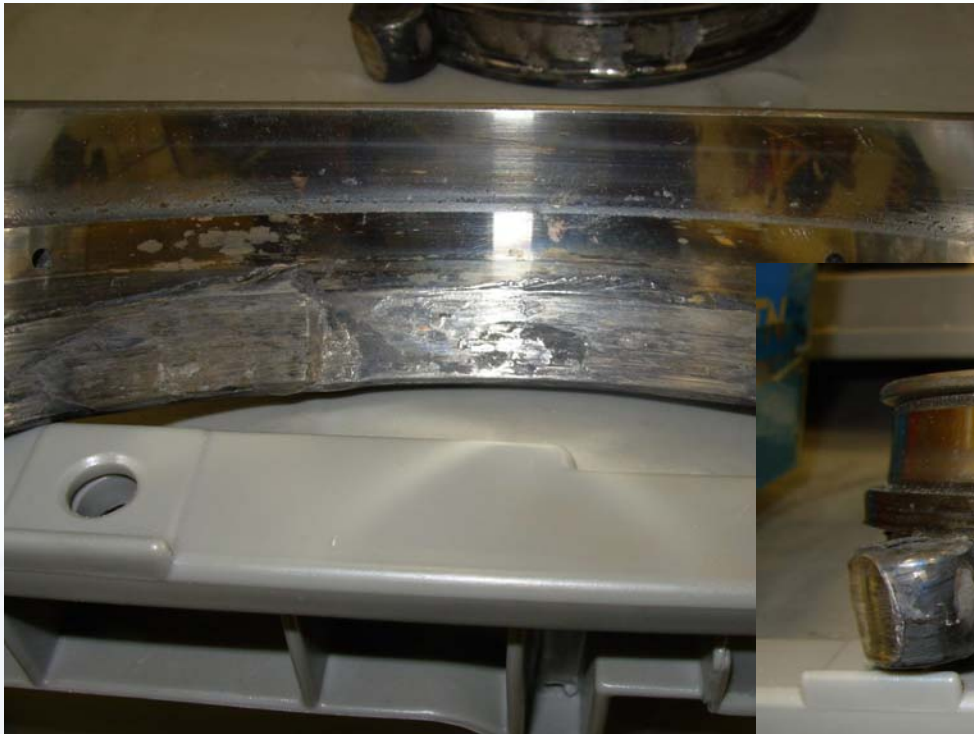
Fragment indentation



- Abrasive wear



- Heat and discolouration



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- Symptom: Heat discolouration
- Cause: Environment; improper grease choice; loss of lubricant; contamination
- Secondary symptoms: Spalling; water etching; spalling; fragment indentation; ...
- Other causes for heat discolouration: Preload; cross-loading; thrust loading; excessive loading

- Fretting corrosion



Failure analysis

- Lubrication issues are generally not the root cause but a secondary symptom.
- Keep a sample of the lube.
- Get the full story.
- Relubricate when possible and on time.

