Safer, Stronger, Smarter Networks

Turbine Bearing Failure Case Study

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Analytical Facilities

Oil Diagnostics Labs
Switchgear, Transformers & Tap Changers

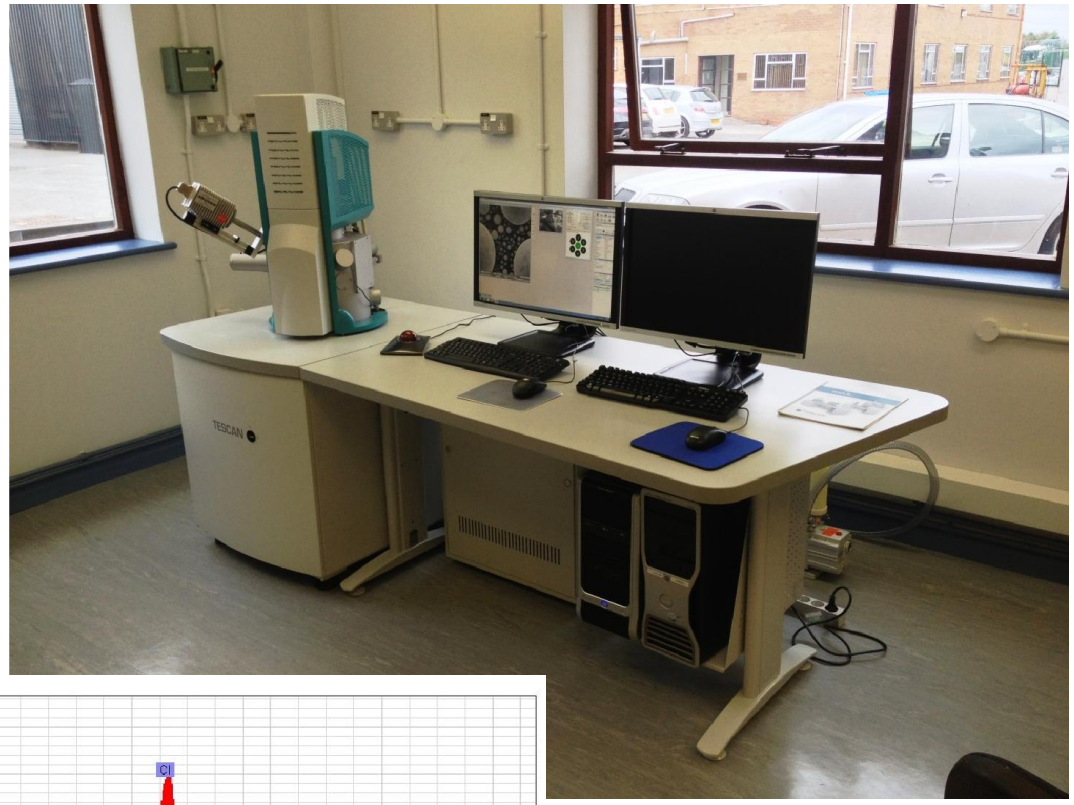
- Moisture
- Acidity
- Breakdown Voltage
- Filtration
- DGA

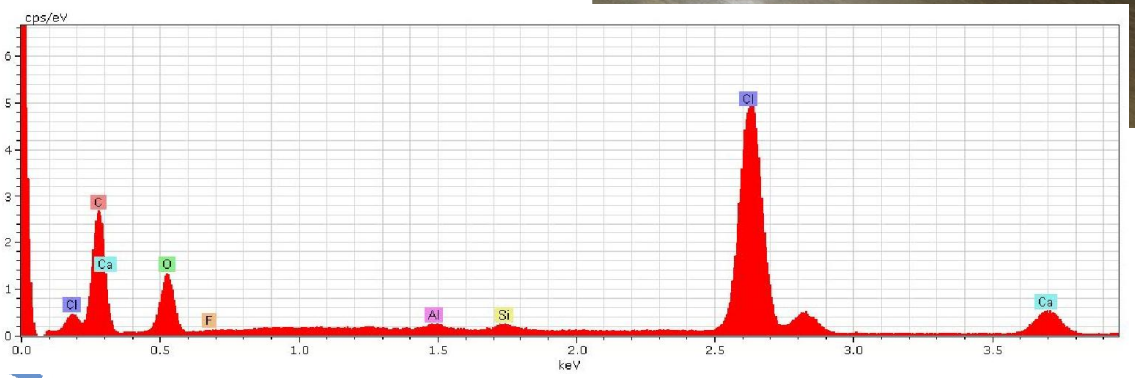
Analytical Facilities

- Optical Microscopy
  - Low Powered Optical Microscope (64x)
  - High Powered Optical Microscope (1000x)
  - Image Analysis

Analytical Facilities

- Scanning Electron Microscopy (SEM)
  - TESCAN (1,000,000x)
  - Bruker Energy Disersive X-ray Analysis (EDAX) – Elemental Analysis





Analytical Facilities

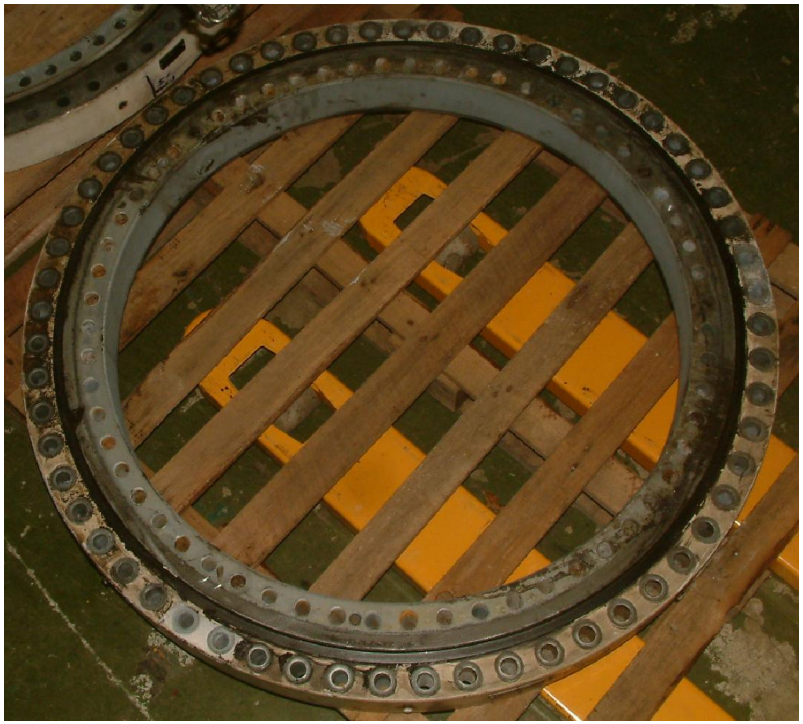
- Mechanical Testing
  - Tensile Testing Machine (5kN & 250kN)
  - Torsion Testing
  - Vickers Hardness
  - Surface Roughness Assessment

The asset

- Blade bearings
- In service for 10 years
- Protective coverings – off for unknown period
- 4-point contact ball bearing system
- Induction hardened raceway – leave a ‘soft’ spot
- Maintenance period – every 6 months
- Actual maintenance - unknown

The issue

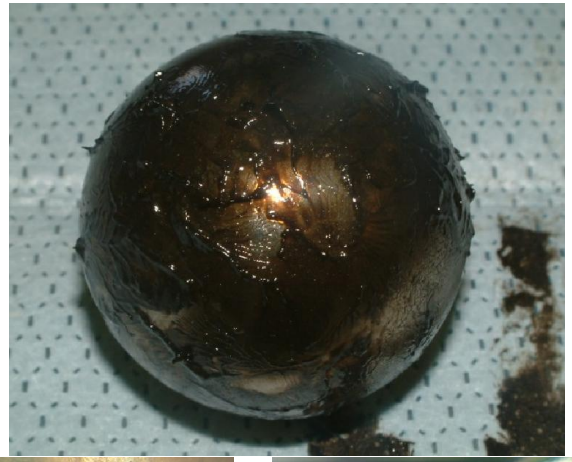
- Multiple pitch errors across one site
- Vibration of the turbines
- Seizing of 2 of the blades on 1 turbine
- Possible more seizing across site

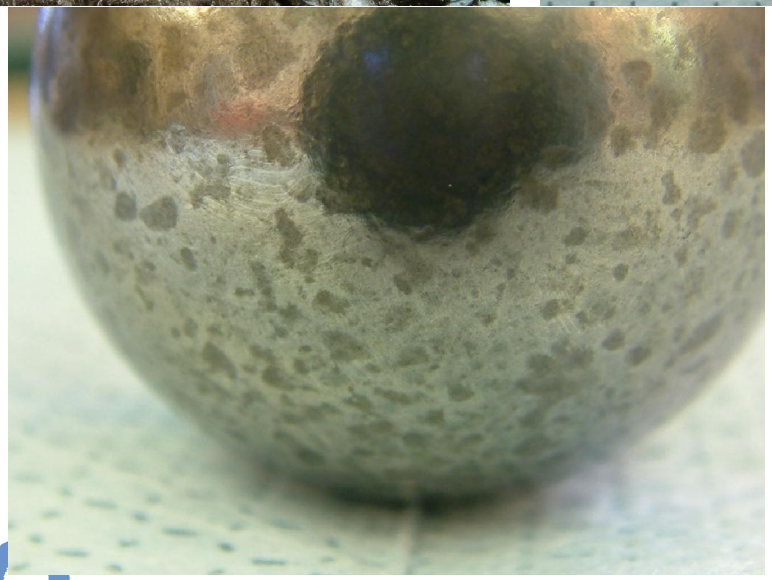
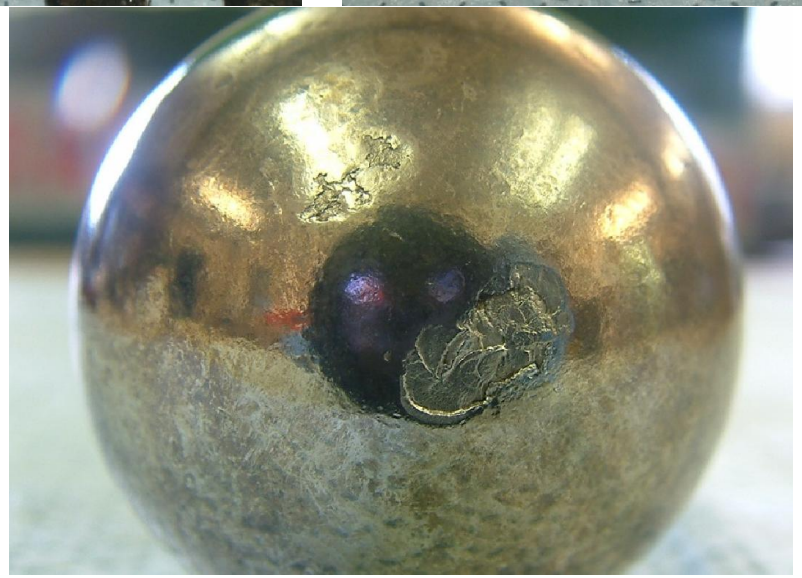


Dismantling & Inspection

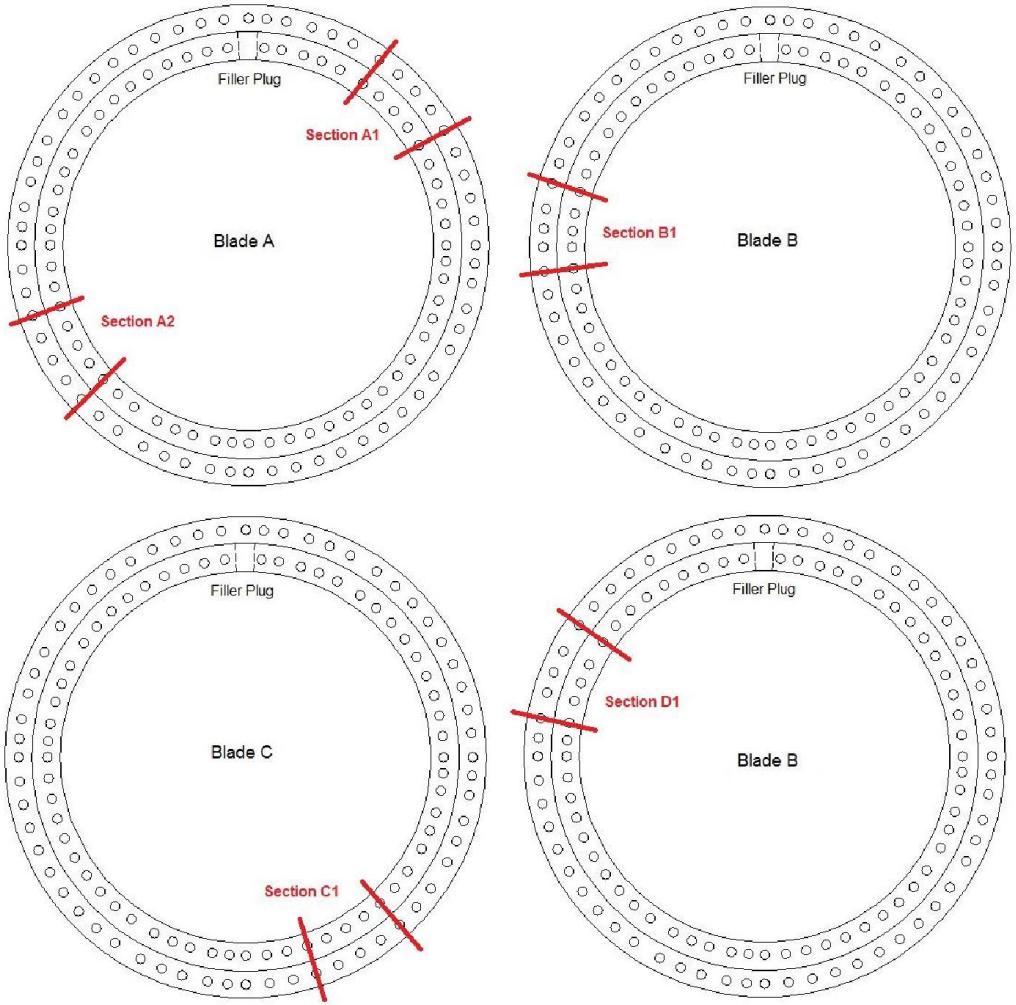
- General external condition
- Gasket assessment & removal
- Water ingress assessment
- Filler plug removal
- Ball bearing removal & conditioning
- Sectioning
- Raceway and cage assessment
  - Outer and inner ring
- Grease assessment
  - General condition
  - Elemental analysis

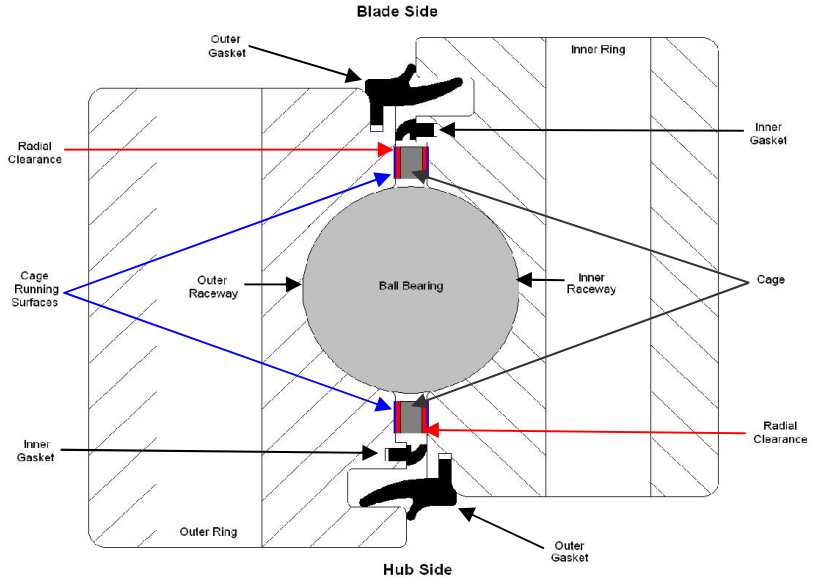
Ball bearing condition

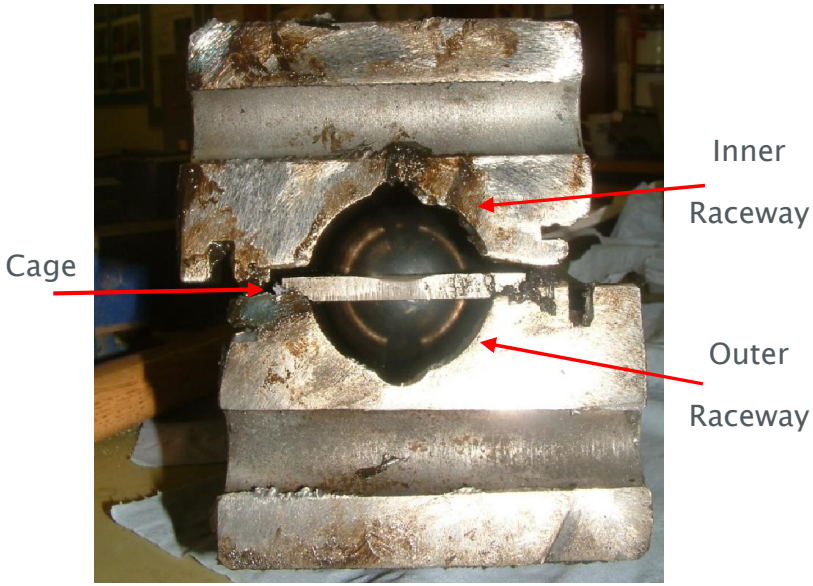



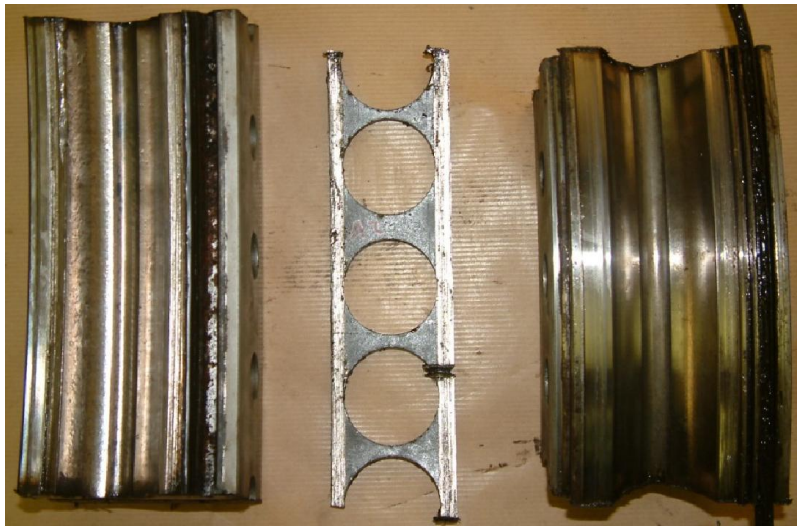
Sectioning

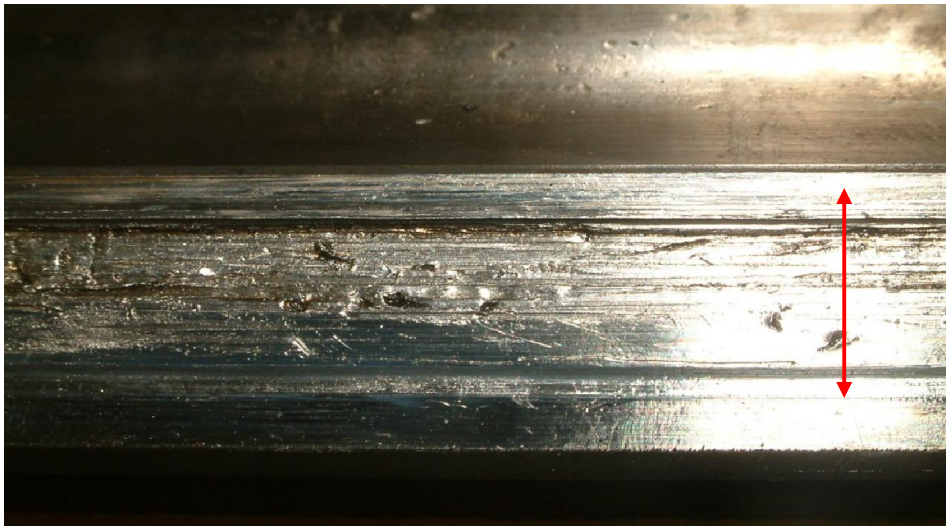

Filler Plug
Section A1
Blade A
Section A2
Filler Plug
Section B1
Blade B
Filler Plug
Blade C
Section C1
Filler Plug
Section D1
Blade B

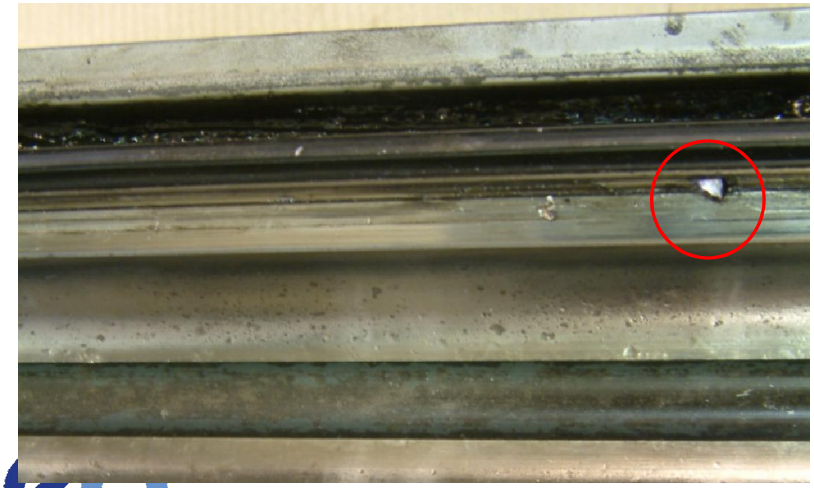

Blade Side
Outer Gasket
Inner Ring
Inner Gasket
Radial Clearance
Cage Running Surfaces
Outer Raceway
Ball Bearing
Inner Raceway
Cage
Inner Gasket
Radial Clearance
Outer Ring
Outer Gasket
Hub Side

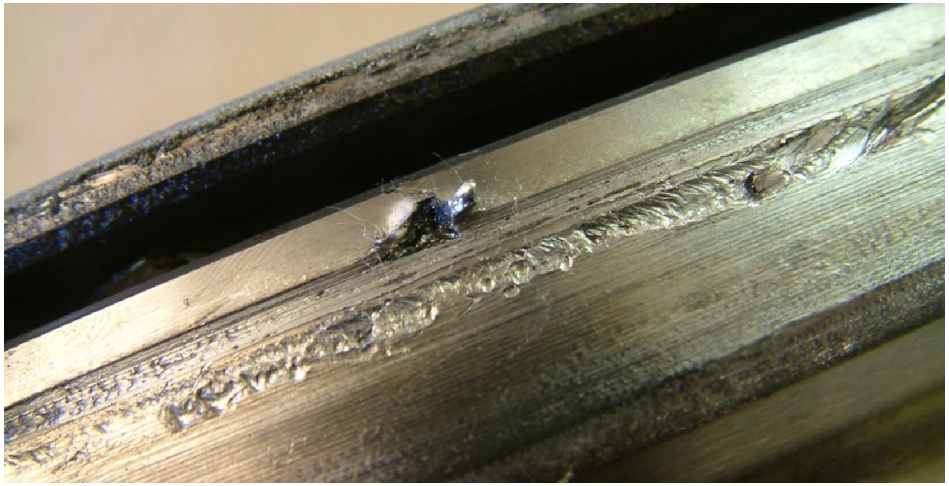

Cage
Inner Raceway
Outer Raceway

Cage running surface

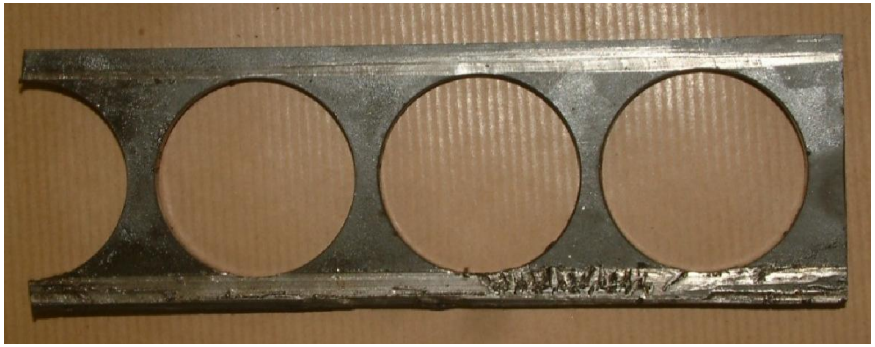


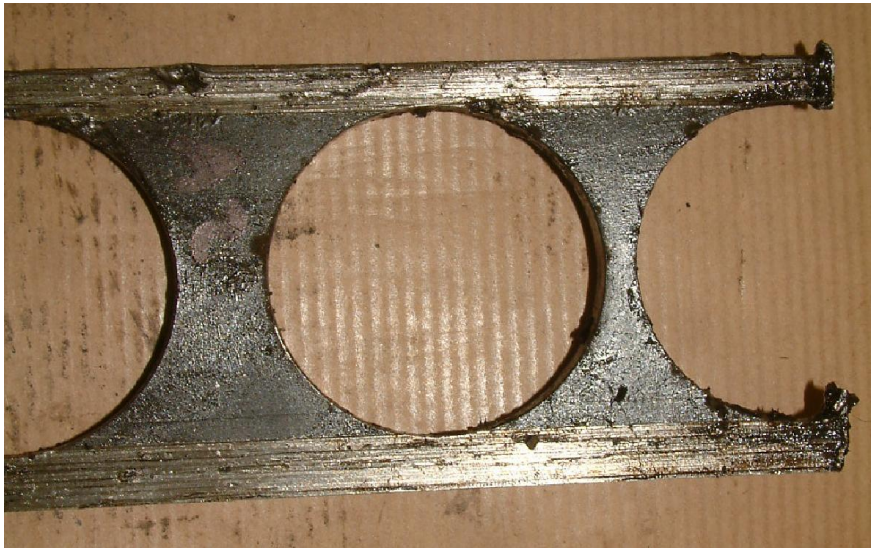


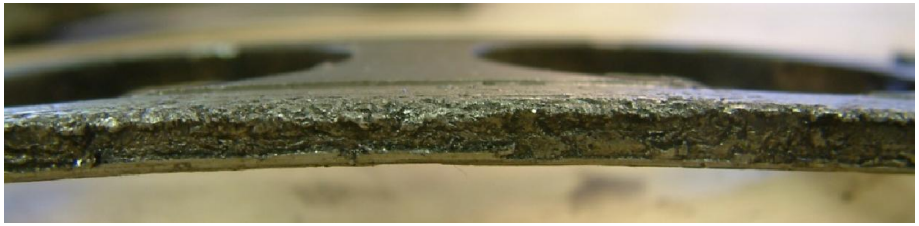


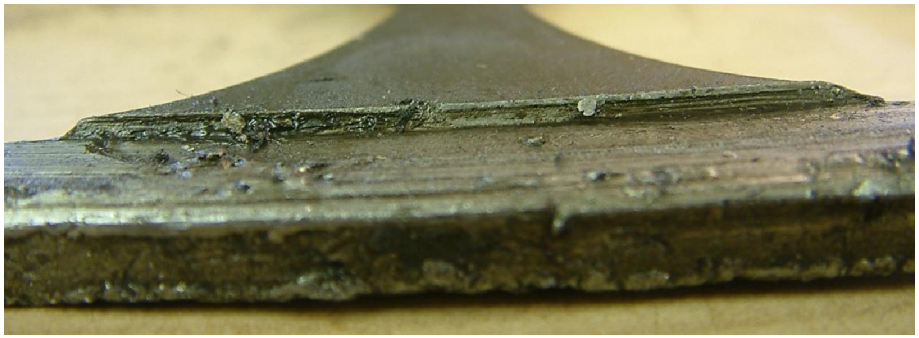


Cage condition



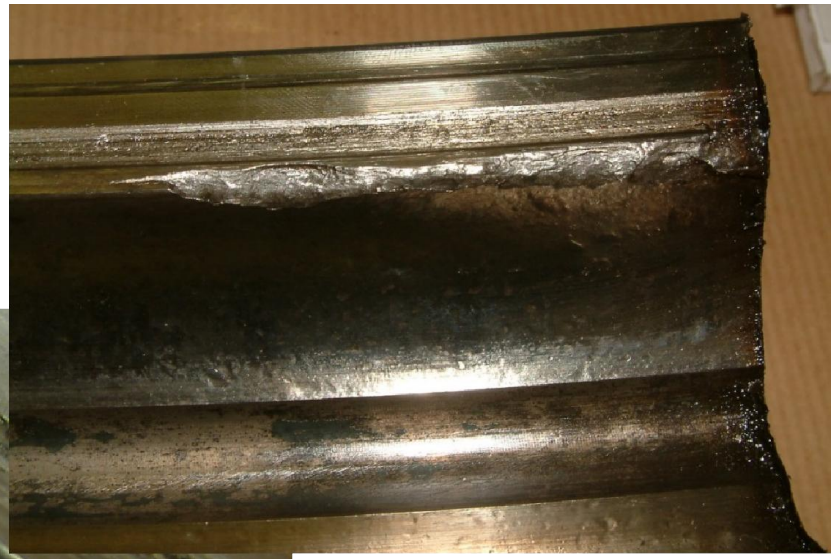






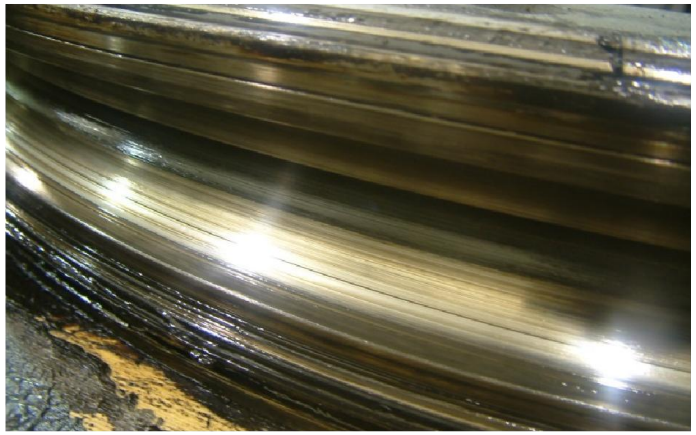
Dismantling & Inspection

- Indentations – Material debris from cage/running surface
- Spawling of the raceway and raceway breakup



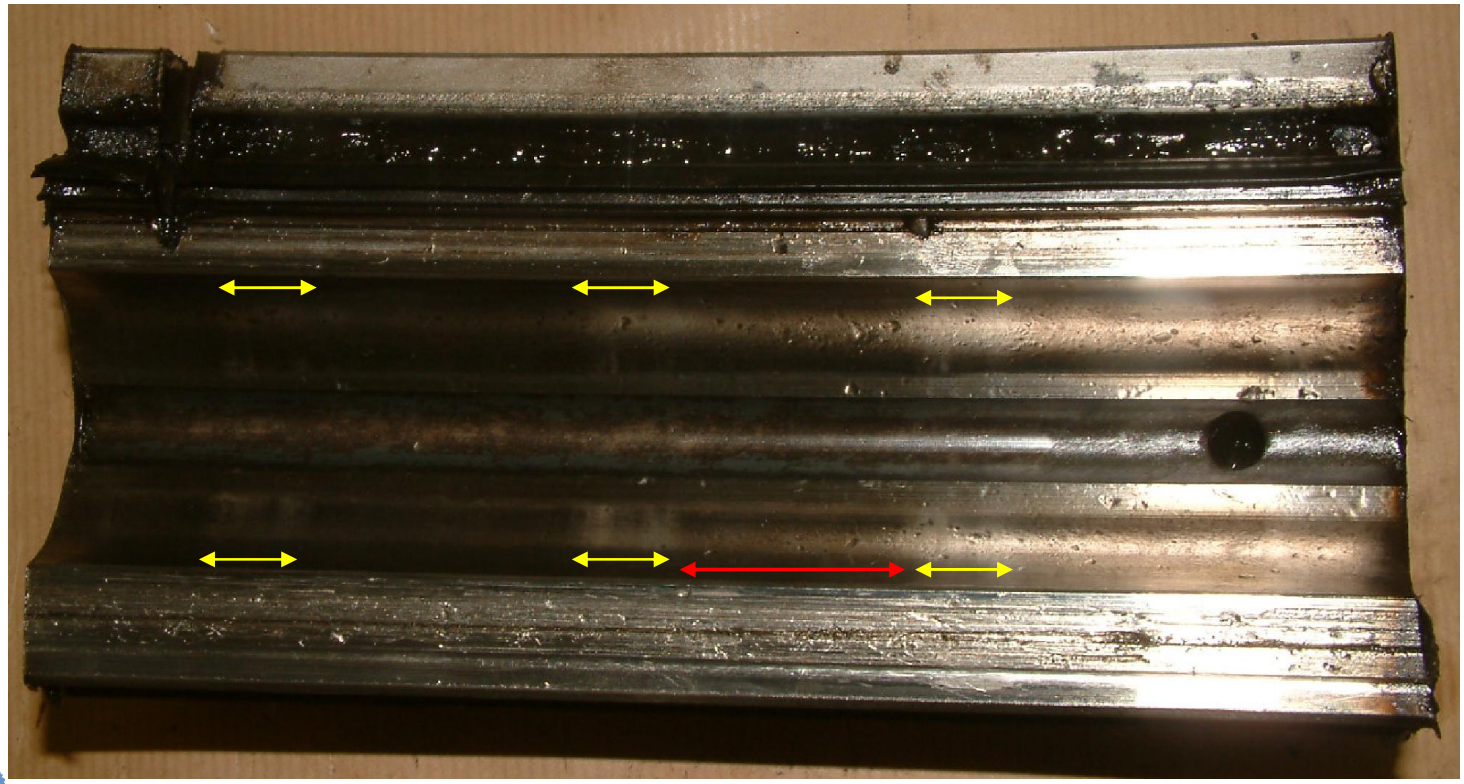
Raceway degradation

- Rolling contact fatigue
  - Material indentations
  - Lack of/poor lubrication
  - Sliding motion of ball bearings



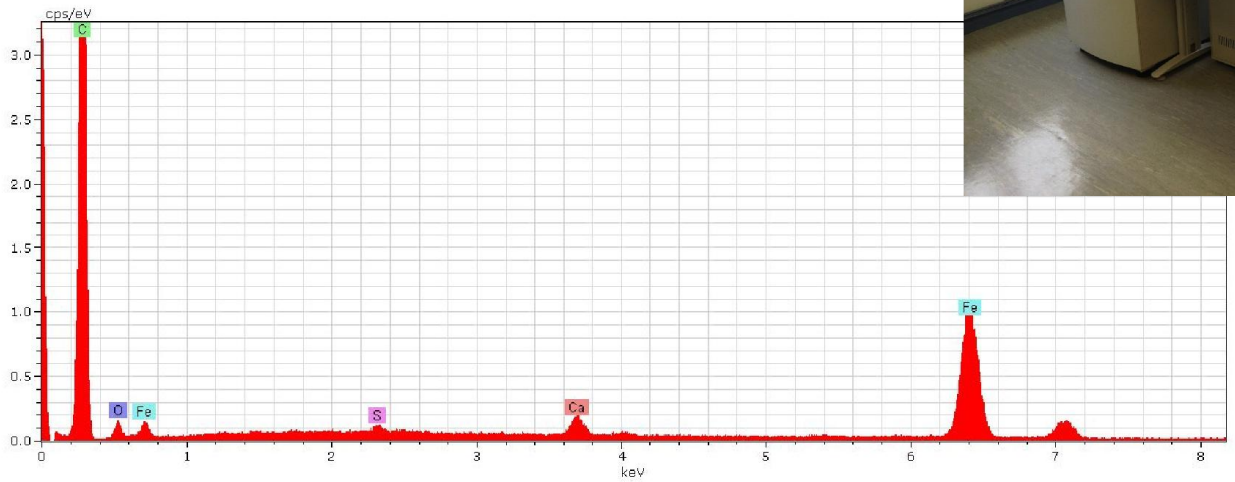
Raceway degradation

- Low level vibration corrosion – False brinelling
  - Caused by micro movements under cyclic vibration
  - No significant wear or corrosion present



Grease assessment

- Reasonable condition
  - Dark, fluid, slightly thickened suggesting aging
  - Some but not significant levels of material debris
- Elemental analysis
  - Iron (Fe) present



Summary

- Good external and gasket condition
- Evidence of water ingress – rusting
  - Weather protection not in place
- Reasonable grease condition – small amounts of metal particulate
  - Suggests grease has been changes recently
- Cage and running edge wear – severe scoring and material loss
  - Caused by sliding friction and material debris – inadequate lubrication and radical clearance
- Severe raceway degradation & breakup
  - Indentation damage caused by material debris/inadequate lubrication
  - No significant degradation around 'soft' spot region 0 indicating failure was not due to the surface hardening or installation processes
  - Evidence of false brinelling – bearing vibration has occurred, could be secondary due to spawling and raceway breakup
- Route cause
  - Poor/inadequate lubrication or inadequate maintenance policy

Asset Management

- Implications
  - Installation practices
  - Maintenance practices
  - Condition assessment
  - Monitoring
- Considerations
  - Maintenance – grease sample, metallic particulate analysis
  - Permanent online monitoring
  - Vibration detection
  - Torque, lubrication quality & temperature detection
  - Automatic grease systems

Thank you

For further information

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