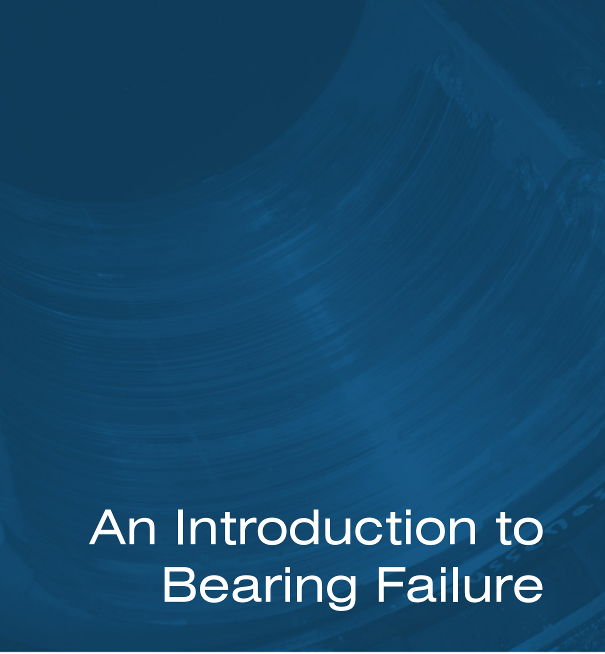
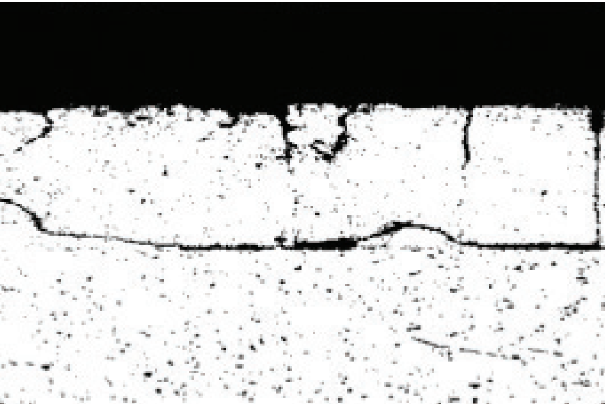


An Introduction to Bearing Failure

Total Shaft Solutions

www.osborne-engineering.com

Fatigue



Symptoms

- Hairline cracks in the whitemetal surface around the area of applied load
- Surface cracks cannot propagate into the harder backing material so turn sideways along bond line leading to sections of whitemetal detaching

Causes

- Excessive dynamic loads
- Overheating causing a reduction in fatigue strength
- Misalignment
- High Levels of vibration
- Poor localised repairs

Corrective Actions

- Eliminate causes of dynamic load
- Review bearing alignment
- Increase load carrying capacity
- Consider bearing materials with higher resistance to dynamic loads

Fatigue

Loss of Oil Film

Symptoms

- Polished band across some or all of surface
- No evidence of overload on pivots or housing
- No excessive wiping of whitemetal

Causes

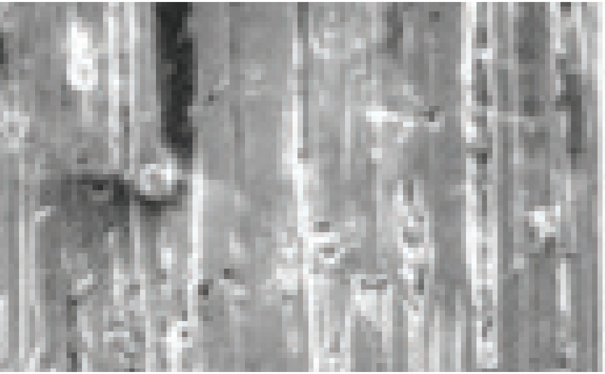
- Insufficient lubricant supply to bearing
- Inappropriate lubricant type (viscosity, temperature)
- Deflect or distortion of journal pads or collars
- Excessive loads during start up

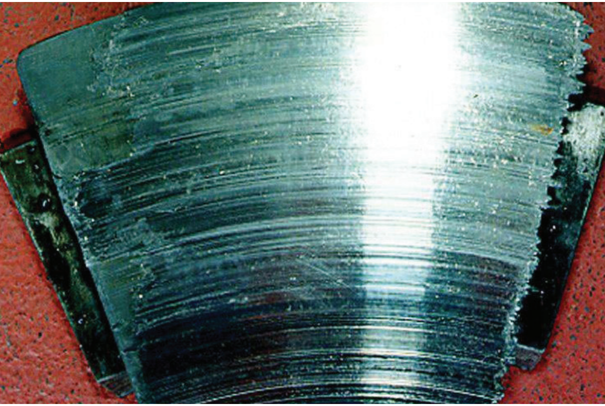
Corrective Actions

- Check and modify lubricant supply and type
- Check collars and pads for flatness and squareness
- Check for possible overloading

Loss of Oil Film

Scoring / Erosion





Symptoms

- Score marks in surface following the direction of motion
- Erosion wear of surface roughening / dulling of the surface

Causes

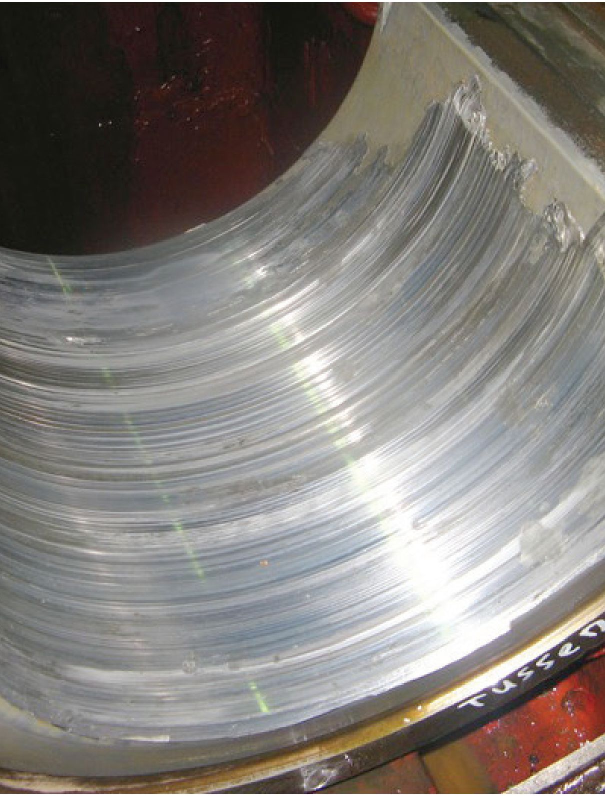
- Scoring due to contaminant particles larger than the minimum film thickness embedded into the whitemetal layer
- Erosion caused by large quantities of small particles in the lubricant smaller than the oil film thickness typically located near to oil entry point
- High velocity lubricant flow
- Atmospheric contamination via seals or breathers
- Could lead to complete failure due to reduced oil films and a reduction in the load carrying capacity

Corrective Actions

- Repair damaged running surfaces
- Clean lubricant and flush surfaces before restarting
- Replace and check correct filtration is being used

Scoring / Erosion

Overload / Wiping



Symptoms

- Circumferential movement (wiping) of whitemetal
- Heavy scoring
- Pivots show flattening or indentation
- Re-solidification of whitemetal deposited in oil grooves

Causes

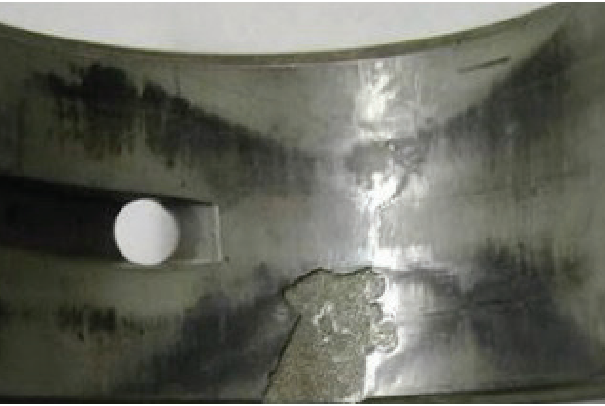
- Excessive load above design duties
- Failure of the Hydrodynamic oil film
- Oil inlet temperature too high
- Incorrect oil grade used
- Loading applied into oil grooves
- Inadequate clearances

Corrective Actions

- Reassess bearing design inputs and operating loads
- Reduce load on bearings
- Increase load carrying capacity
- Consider higher load bearing design such as off-set pivot

Overload / Wiping

Misalignment



Symptoms

- Polishing pattern on one side or localized area of babbitt surface
- Localised severe wear
- High localised temperature
- Fatigue failure in diagonally opposed areas in top and bottom halves

Causes

- Load concentration on one area of bearing. Due to geometry misalignment
- Axial mismatch between journal and bearing centre lines
- Misalignment of bearing housing or shaft
- Journal deflection under load

Corrective Actions

- Re-align bearings
- Switch to a more misalignment tolerant design such as, tilting pad, equalised thrust or self aligning bearings

Misalignment

Overheating

Symptoms

- Oil varnish / lacquer build up in hot areas
- Possible local cracking and movement of whitemetal
- Discolouration of steel

Causes

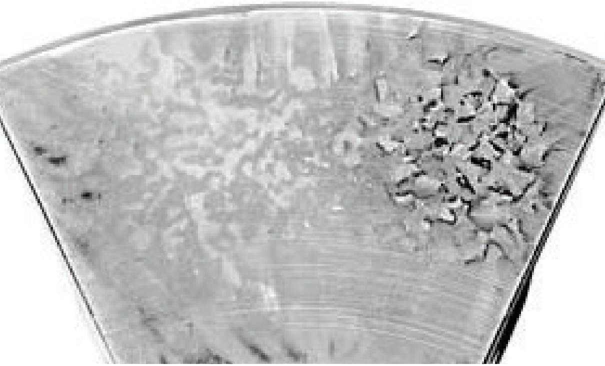
- Over speed / excessive load
- Loss of oil film due to varnish build up
- Oil inlet temperature too high
- Insufficient bearing clearance
- Failure of cooling / insulation mechanism

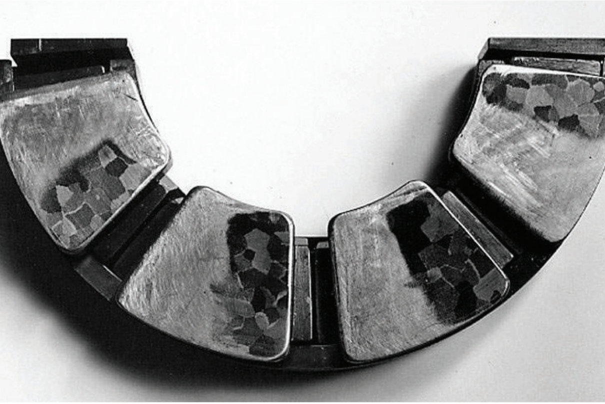
Corrective Actions

- Reduce oil inlet temperature
- Review cooling / insulation mechanism
- Change to a more heat stable lubricant
- Increase oil flow
- Increase load carrying capacity

Overheating

Thermal Ratcheting





Symptoms

- Marble type relief pattern on whitemetal surface. Typically more noticeable on trailing (hotter) part of bearing
- Crack formation between grains

Causes

- Repeated thermal cycling triggering anisotropic thermal expansion of tin crystals within the whitemetal
- Uneven thermal expansion of tin based whitemetal
- Switching from lead to tin based whitemetal

Corrective Actions

- Review alloy composition to reduce grain size
- Where possible minimize thermal cycling

Thermal Ratcheting

Wire Wool Damage

Symptoms

- Very heavy scoring of the whitemetal surface in short time period
- Hard scabs of material embedded into the whitemetal surface

Causes

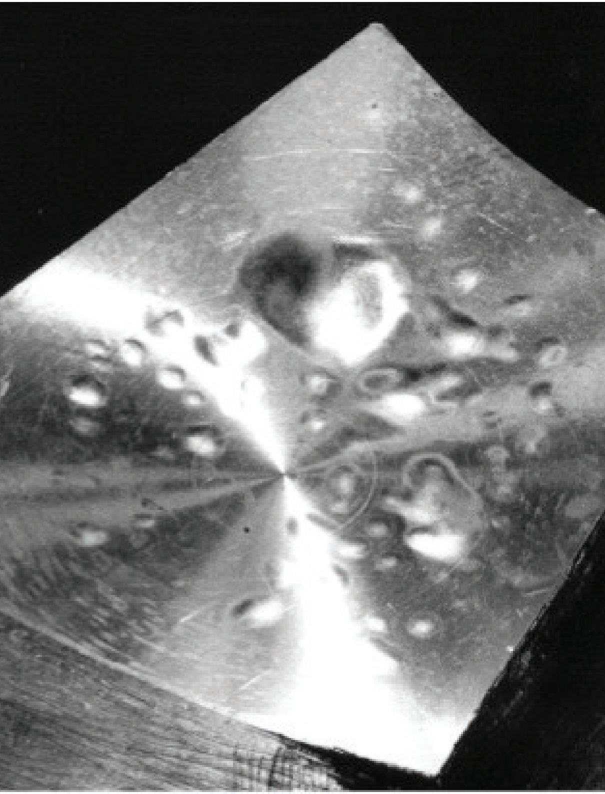
- Failure initiated by small particles of dirt embedding into the bearing surface
- Shaft material containing chromium or manganese in the region of 2% - 14% are incompatible with whitemetal
- Long tern exposure to water in oil can lead to scab formation (tin oxide)
- Most aluminium bronzes are incompatible with whitemetal

Corrective Actions

- Change journal or collar material to mild steel
- Hard chrome surface in contact with whitemetal

Wire Wool Damage

Hydrogen Blisters



Symptoms

- Blister under the whitemetal layer
- Can become visible following long periods of storage or operation

Causes

- Hydrogen within the mild steel diffuses out to the bond line then becomes trapped, breaking the mechanical bond

Corrective Actions

- Degas steel prior to use through thermal or vacuum treatment
- Repair blistered surfaces
- Avoid hydrogen sources during manufacture

Hydrogen Blisters

Electrical Pitting

Symptoms

- Numerous uniform pits concentrated in discrete areas
- Frosted appearance in pitted area
- Pitting concentrated to areas with lowest oil film thickness (least insulation)
- Damage will be present on both the bearing and shaft

Causes

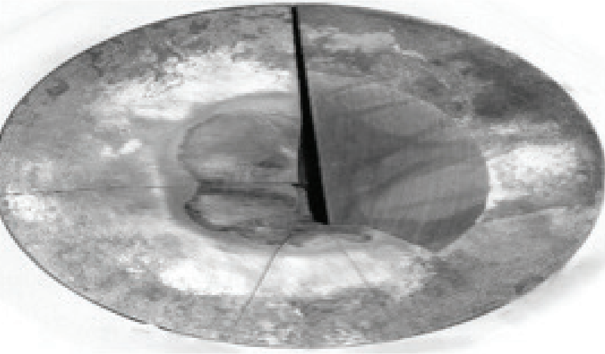
- Poor insulation allowing electrostatic arcing between the shaft and bearing
- Electromagnetic currents from rotating shaft
- Water in oil or film cavitation disrupts insulating effect of the oil

Corrective Actions

- Grounding of shaft currents
- Insulation of bearings
- Replace lubrication oil and flush housing to remove water content

Electrical Pitting

Pivot Damage / Fretting



Symptoms

- Wear and erosion of contact surfaces
- Discolouration around contact area
- Cracks or fractures to highly loaded pivot point
- Flattened pivot area

Causes

- Fretting caused by vibration of machinery
- Overload of pads
- Insufficient pivot contact area to support load

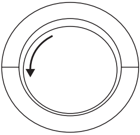
Corrective Actions

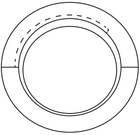
- Repair existing pivots
- Reduce the load on the pivots or increase the pivot radius to support higher loads
- Minimise external vibrations

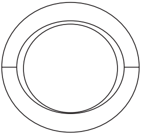
Pivot Damage / Fretting

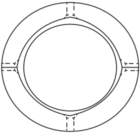
Typical Parameters

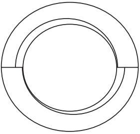
Type	Typical Peripheral Speeds	Typical Surface Pressure	Stiffness / Dampening
Plain Journal bearing	0 – 30 m/sec	0.2 – 4.0 MPa	* *****
Pressure Dam bearing	0 – 40 m/sec	0.2 – 3.5 MPa	** ****
Lemon Bored bearing	25 – 70 m/sec	0.2 – 3.5 MPa	** ****
Offset Bored bearing	20 – 90 m/sec	0.2 – 3.5 MPa	*** ****
Four lobed journal bearing	30 – 90 m/sec	0.1 – 1.5 MPa	*** *
Tilting journal pad bearing	30 – 100 m/sec	0 – 3.0 MPa	***** ****

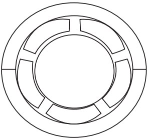

Plain Journal Bearing


Pressure Dam Bearing


Lemon Bore Bearing


Four Lobe Bearing


Offset Halves Bearing


Tilting Journal Pads

Unit from	Sum	Number	Unit to
in	x	25.4	mm
ft	x	0.3048	metres
1μm (micron)	0	10^{-6}m	39.37μins
in^2	x	6.4516	cm^2
cm^2	x	100	mm^2
in^2	x	6.4516	mm^2
tons	x	2240	lbf
tons	x	9.96	kN
kgf	x	9.81	N
lbf	x	4.45	N
kN	x	224.8	lbf
kN	x	102	Kgf
kN	x	1000	N
kN	x	100	daN
lb/in^2	x	0.0703	Kg/cm^2
lb/in^2	x	6.895	kN/m^2
MPa	x	1000	KN/m^2
MPa	x	10.2	Kg/cm^2
MPa	x	145	lb/in^2
bar	x	100	kN/m^2
bar	x	14.5	lb/in^2
hp	x	0.745	kW
litres	x	0.2642	U.S.gallons
litres	x	0.22	gallons
ft/sec	x	0.3048	m/sec

Unit Conversions

oel group

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