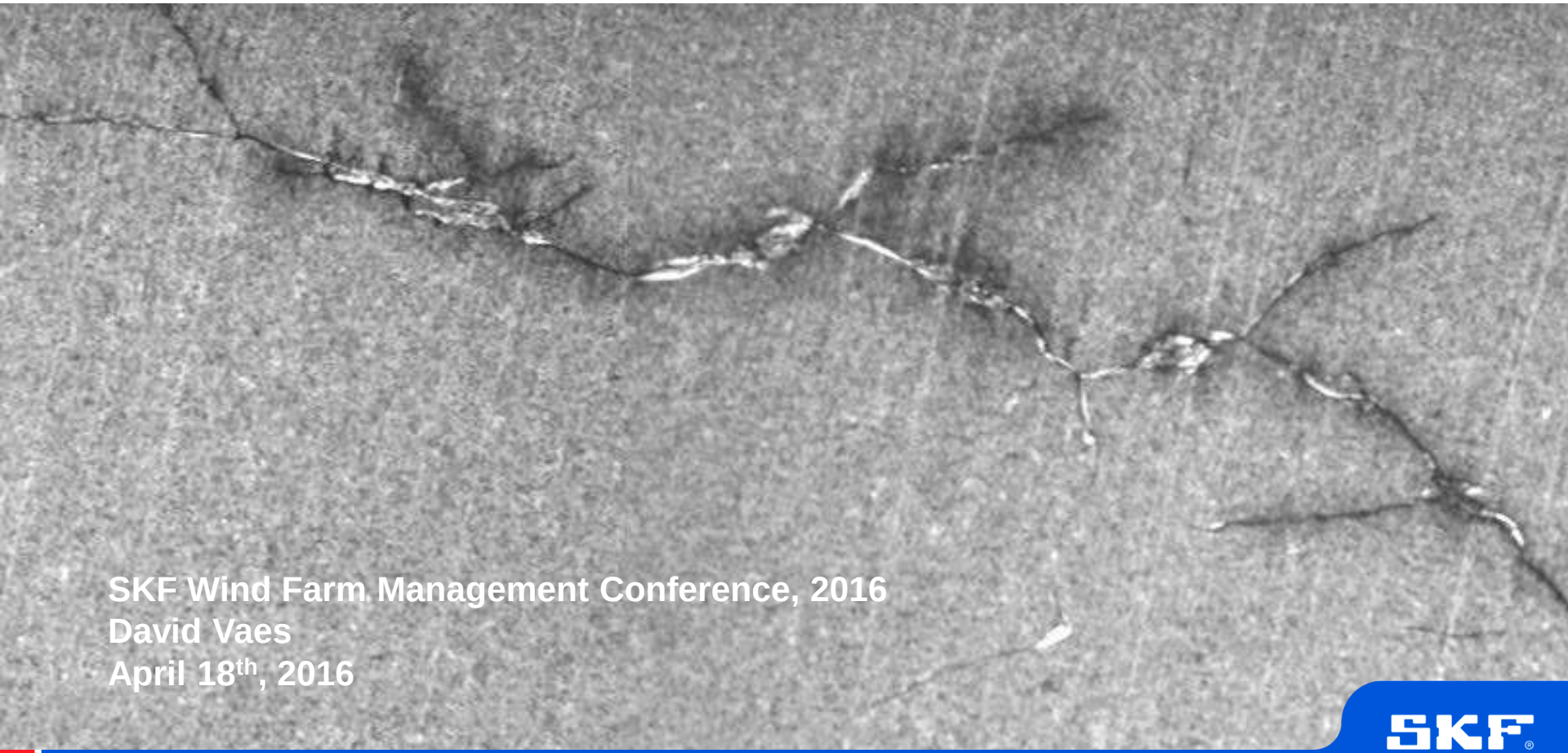
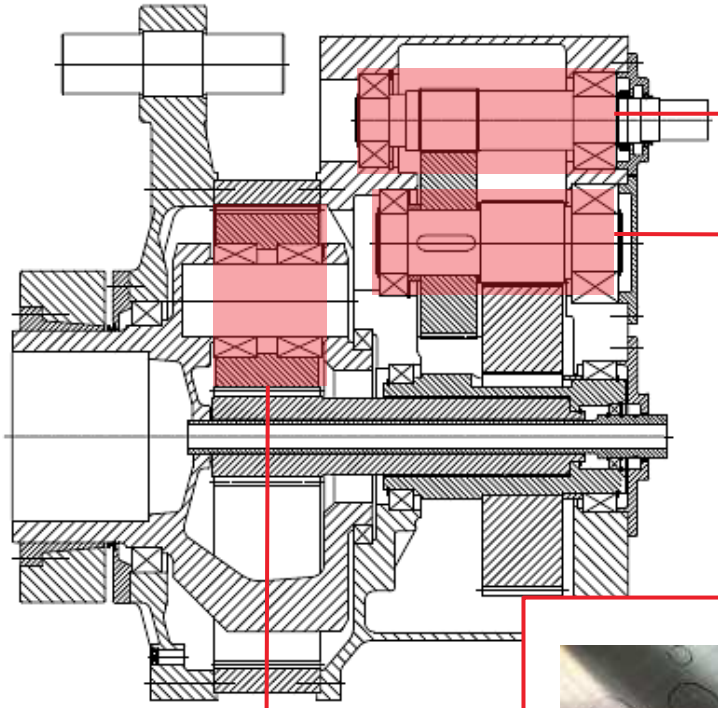
Premature bearing failures in wind turbine gear units

Drivers and counter measures

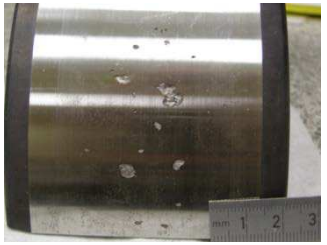


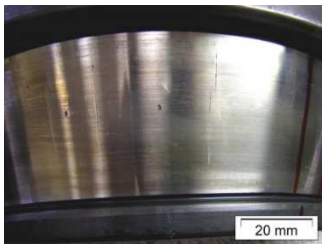
SKF Wind Farm Management Conference, 2016
David Vaes
April 18th, 2016

Critical bearing positions



Early cracks have occurred commonly within the first 1-3 years of operational time, or at less than 10% of the calculated rating life.





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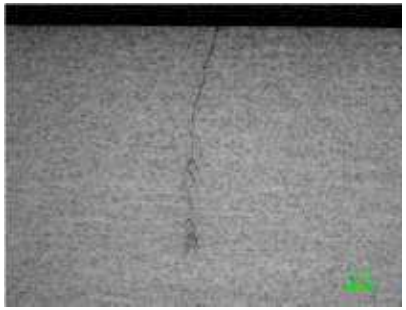
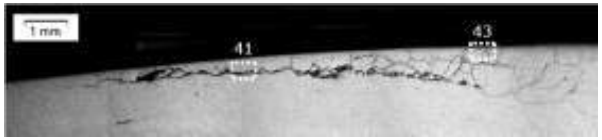
Crack appearance depending on heat treatment

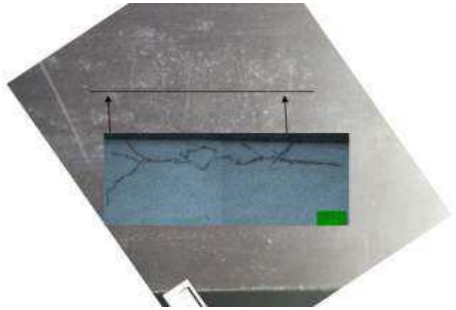
Through hardened as well as case carburized can fail!



Martensite
+50 to +100 MPa
Tensile at surface



Bainite
–50 to –100 MPa
Compressive at surface



Case carburized
–100 to –200 MPa
Compressive at surface

Through hardened

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White etching cracks – a symptom of bearing failures

White etching areas are created around cracks due to crack face rubbing

➔ *White etching areas are a symptom of the failure and not the root cause*

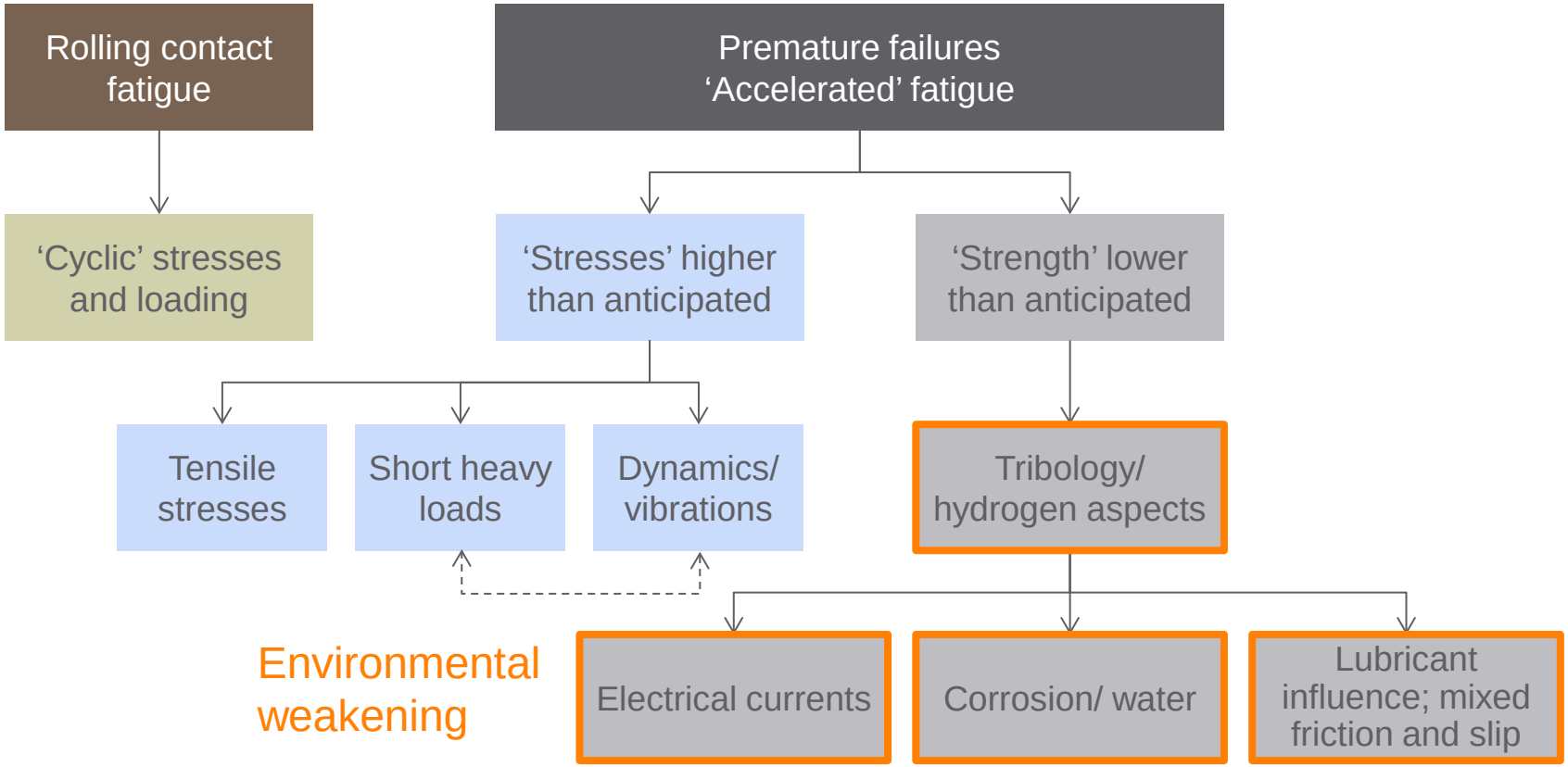
Focus should be on understanding the drivers and counter measures of the premature failures

- Why are cracks initiated much faster in premature failing bearings?
- How to make bearing system more robust?

White etching crack in large TRB rolling contact fatigue test

© SKF Group

Premature bearing failures: understanding the drivers



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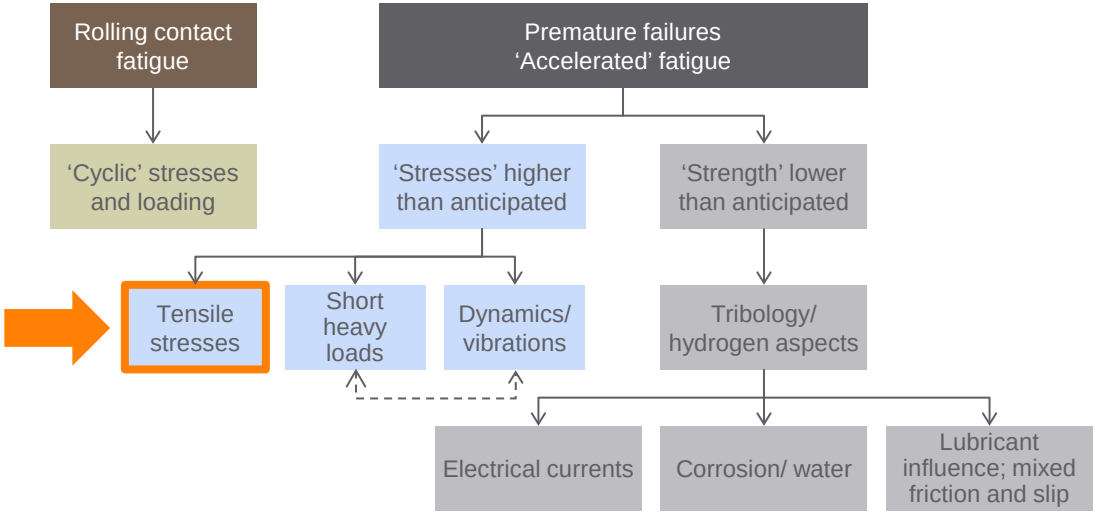
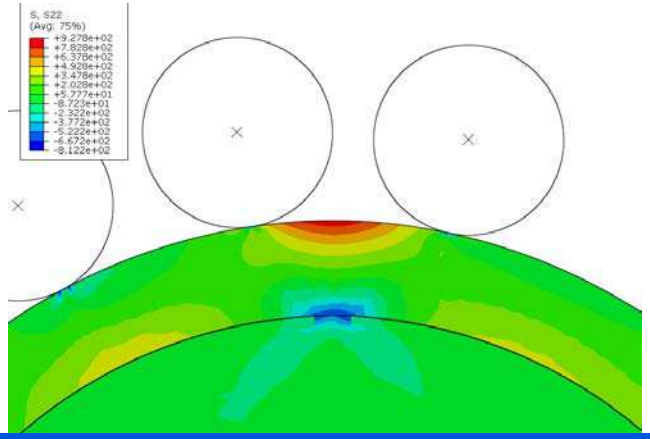
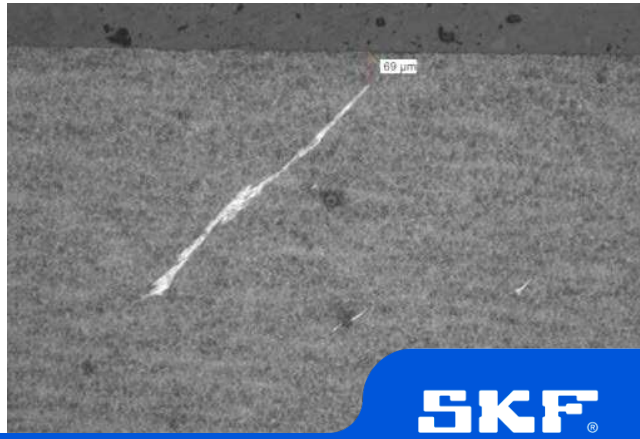
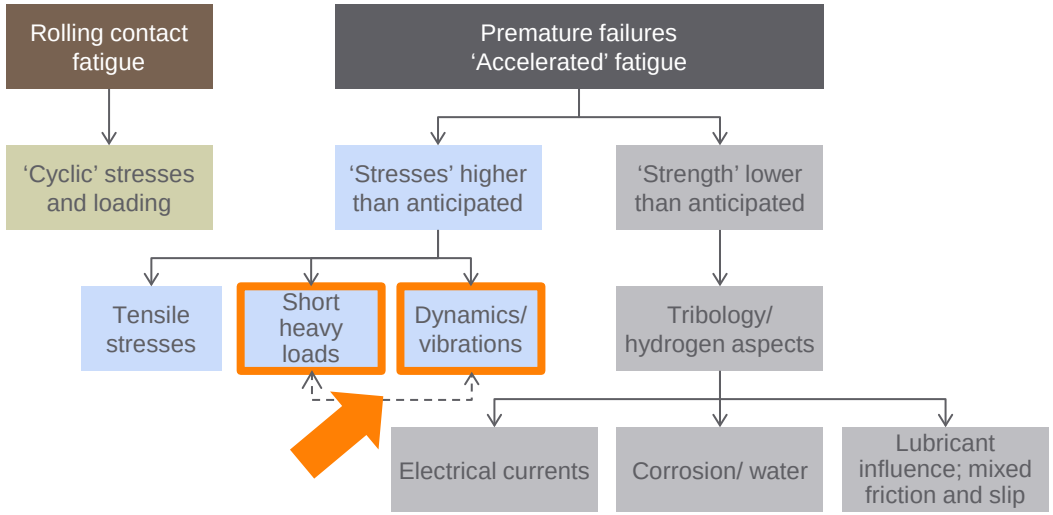
SKF test results – Tensile stresses

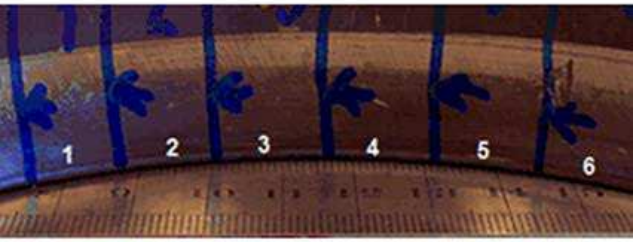




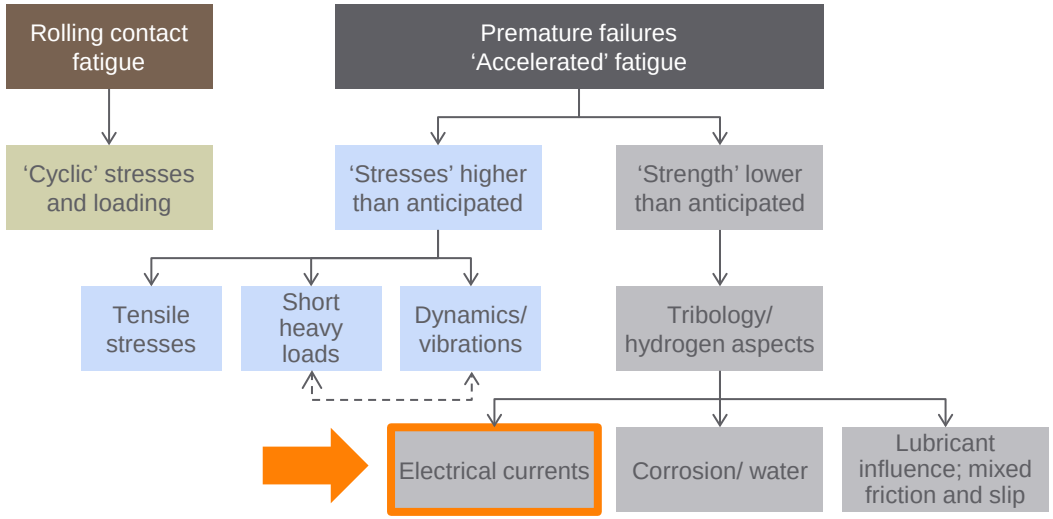


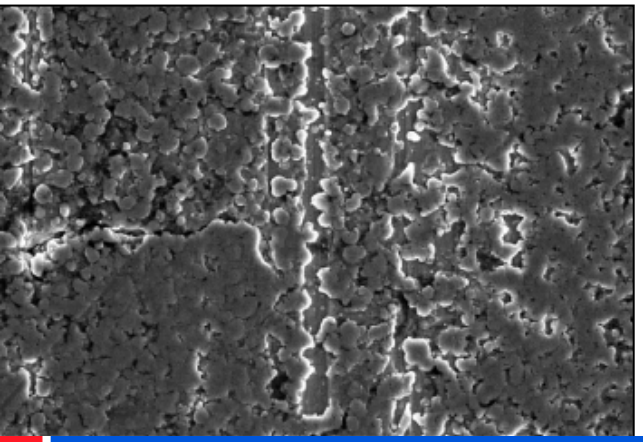
SKF test results – Short heavy loads and dynamics/vibrations

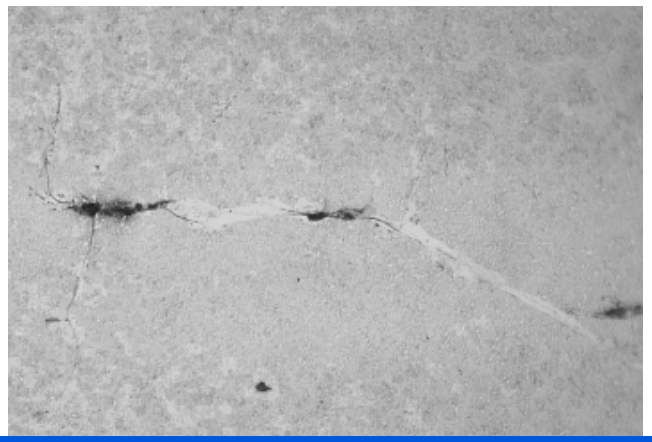


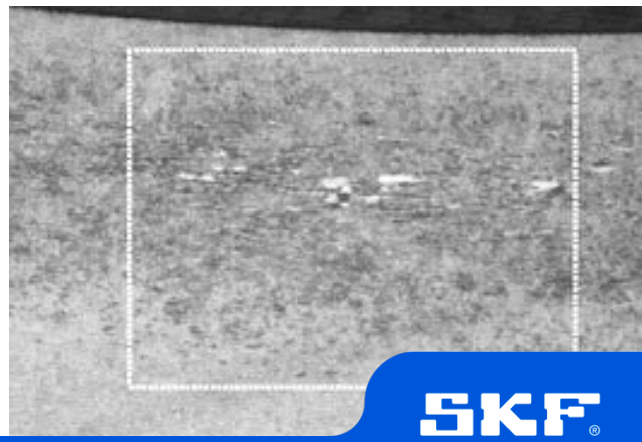


SKF test results – Electrical currents

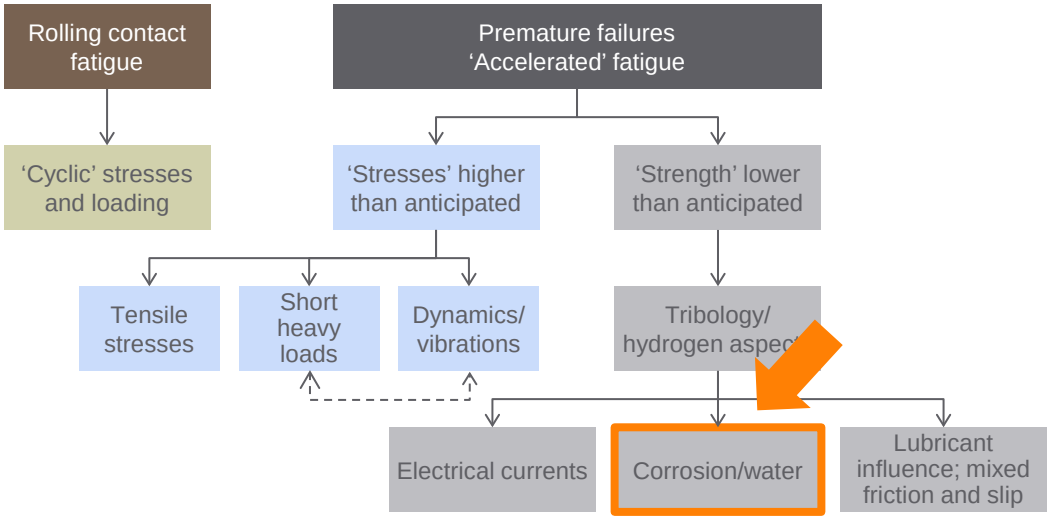


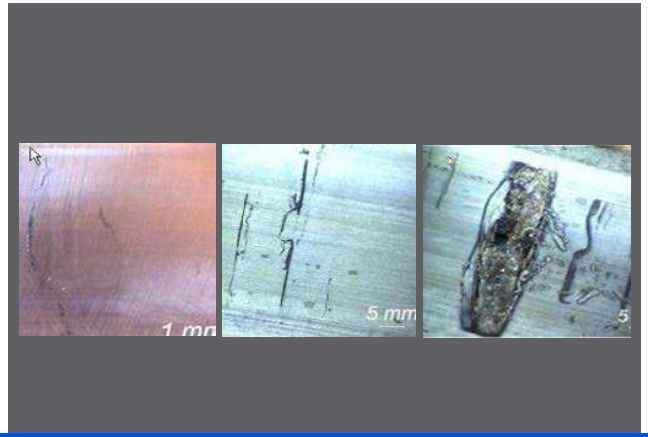


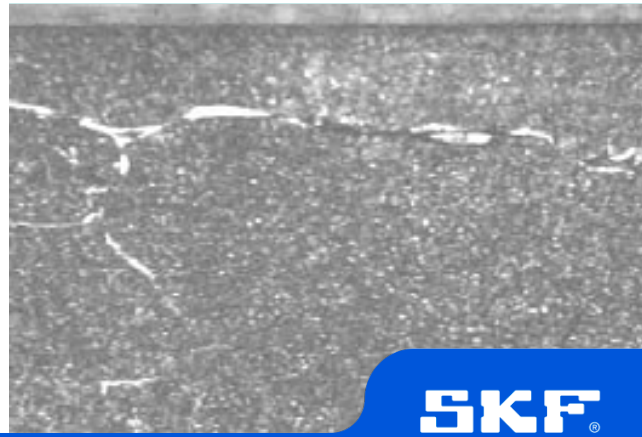




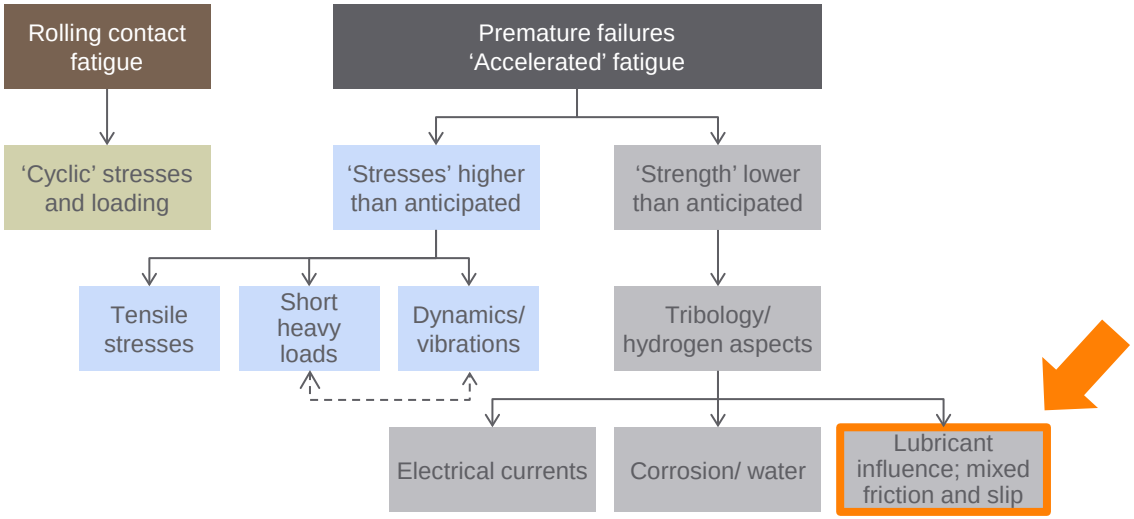
SKF test results – Corrosion/water

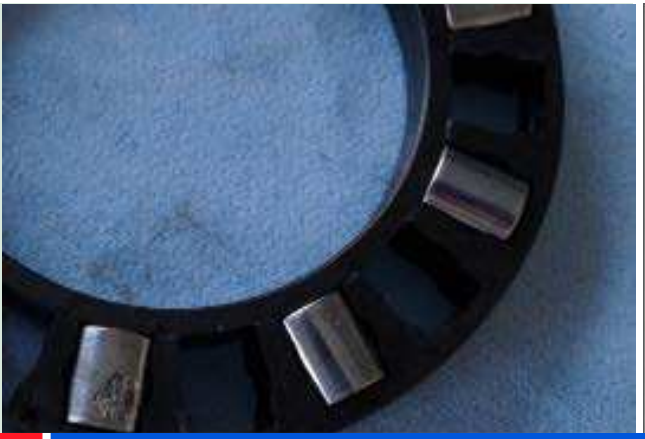


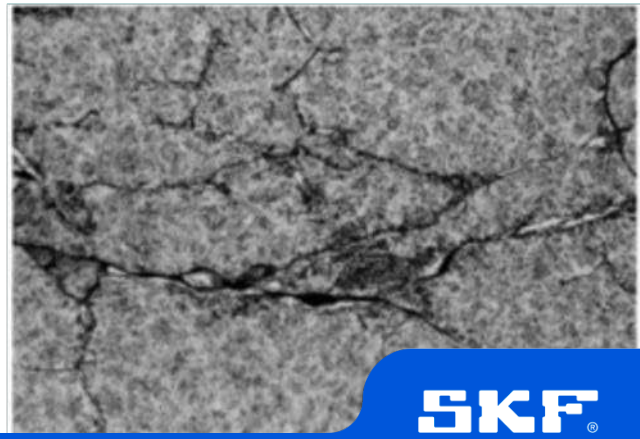




SKF test results – Lubricant influence







Understanding premature failures

White etching areas (WEA) in white etching cracks are a consequence not a root cause!

- Cracks come first, then WEAs
- WEAs are created by crack phase rubbing (possibly supported by chemical effects when lubricant enters)

Drivers for premature failures are identified and supported by test results:

- **Local stresses** (short time high loads, structural stresses)
- **Environmental weakening** (mixed friction & lubrication influence, moisture corrosion, stray currents)

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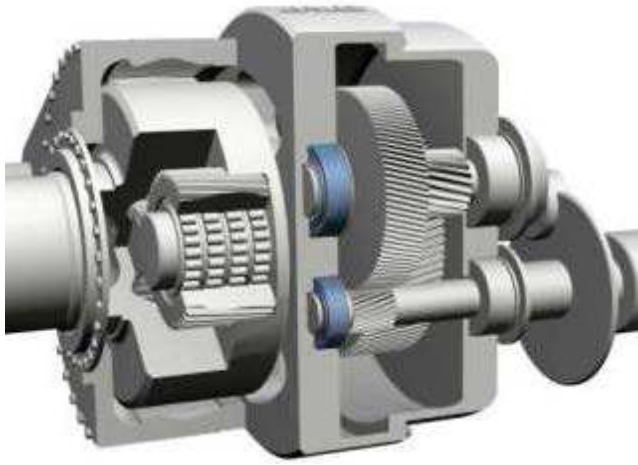
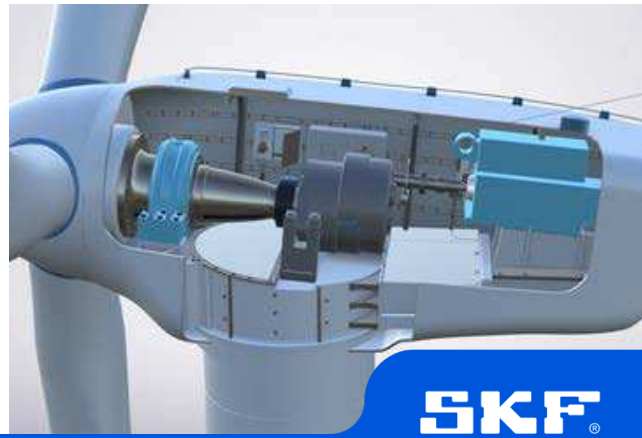
Each failure is “unique”

- The exact combination of influencing factors that explain the failures in different bearing positions in wind gear units is not yet understood
- “The root cause” does not exist and each failure case needs to be reviewed in the light of the corresponding operating conditions
- However countermeasures can be identified to counter the known drivers.





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Overview of counter measures

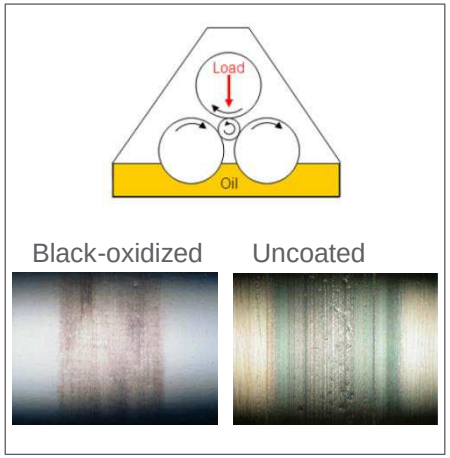
Drivers	Bearing system	Bearing
“Stresses” higher than anticipated (Tensile stress, short heavy loads)	• Bearing arrangement • Bearing support • Limit housing deformations • Clearance / preload setting • Verify loads extreme events (incl. grid events)	• High compressive residual stresses • Cleaner steel
Environmental weakening (Corrosion, electrical current, mixed friction and lubricant)	• Limit water in oil • Limit humidity during standstill • Transport and mounting • Avoid stray current • Limit vibrations	• SKF Black Oxide • Case carbonitriding • VC444 (very high costs) • Insocoat, hybrid bearings (related to electrical erosion)

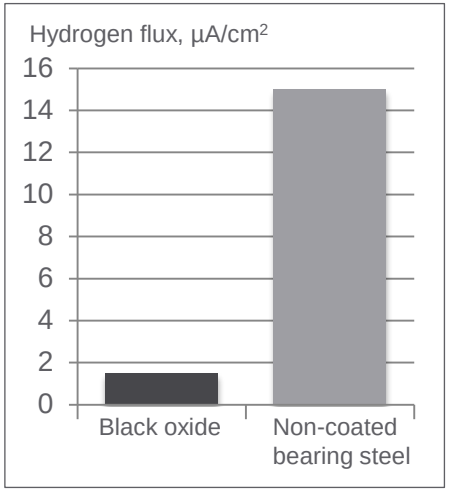
© SKF Group

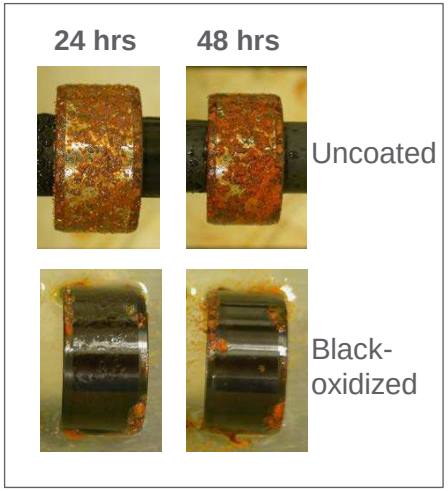
SKF black oxide increases robustness

Advantages of SKF black oxide

- Improves running-in properties and reduces friction
- Improved resistance against smearing damage
- Better performance in low lubrication conditions
- Reduced risk of chemical attack from aggressive oil additives on the bearing steel
- Increased oil and grease adhesion
- Enhanced corrosion resistance
- Reduced chance of hydrogen generation & permeation in the bearing steel







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Strong field experience with SKF black oxide

More than 140 000 SKF black oxide bearings supplied to the gearbox market

- With significant volumes since 2008
- Largely applied on CRB, however possible for all bearing types
- 99% through hardened rings and rollers
- On all positions in gearbox
- Applied in all turbine sizes
- Supplied in various sizes

To date SKF black oxide has no known “serial” issue with premature failures (< 50 ppm)

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®