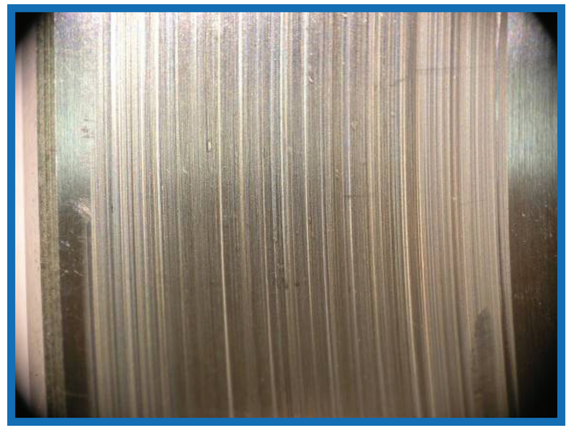
# Failure Modes

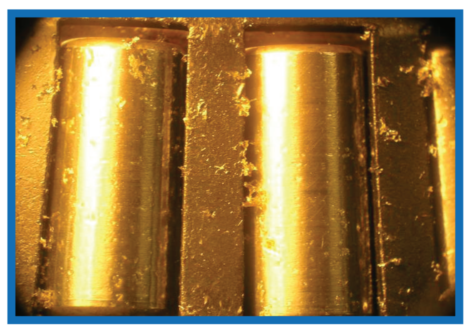
## Grooving

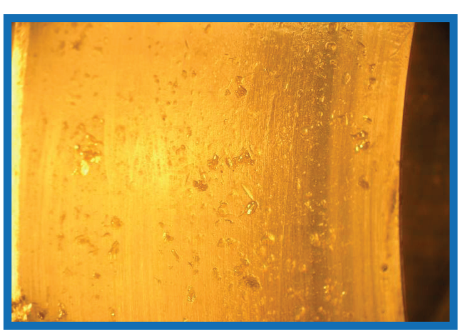
- Grooving occurs when hard contaminants enter the bearing and get wedged in the cage and cut grooves in the rollers.
- Particles can also get caught between rollers and cut grooves in the bearing races.
- The damage is permanent and will lead to early bearing failure.

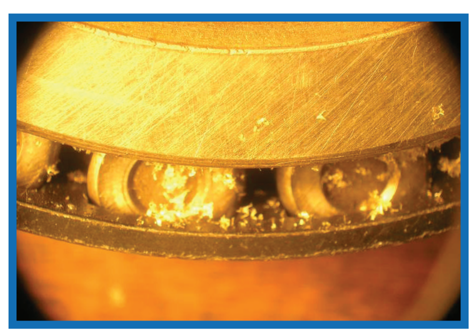


## Pitting and Contaminants

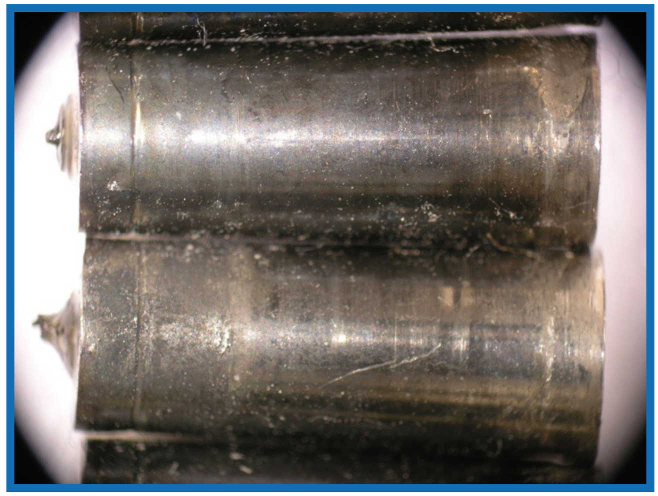
- Pitting is damage that is also caused by foreign material such as dirt or metal particles entering the bearing.
- The most likely source of these particles are improperly cleaned housings.
- Even light pitting may lead to eventual bearing failure. Caution should be taken to evaluate whether lightly damaged parts should be returned to service.
- Excessive contaminants and resulting raceway pitting.







# Excessive Abrasive Wear from Contaminants

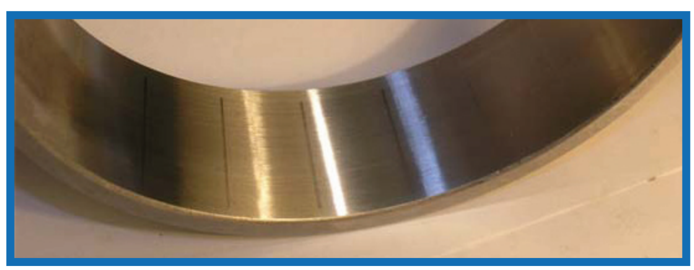


- Extremely contaminated environments will cause excessive wear to the point of wearing down roller ends as shown here. Bearing life is severely reduced in this situation.
- Abrasive wear occurs when a hard rough surface slides across a softer surface.
- Damage caused by lubricant-borne particles in rolling/sliding contacts can severely reduce the operational life of ball and roller bearings.
- Lubricant supplies frequently contain such contaminating particles, either generated from within the machinery itself or incorporated into the fluid from the surroundings.

# Etching from Moisture Contamination

- When water is allowed to enter the bearing assembly and mix with the system lubricants, a chemical reaction can cause surface etching as shown above.

# Frictional Corrosion

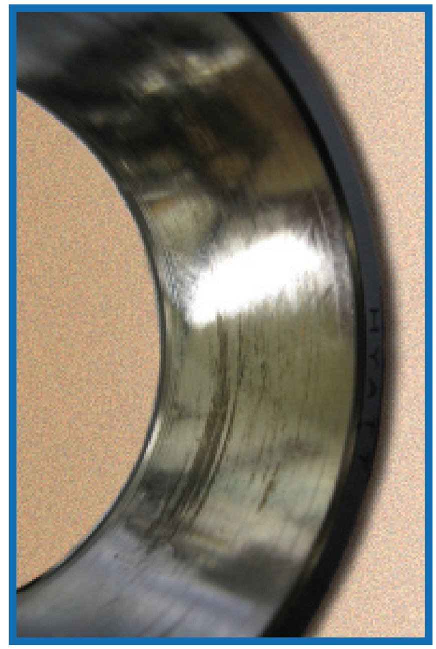


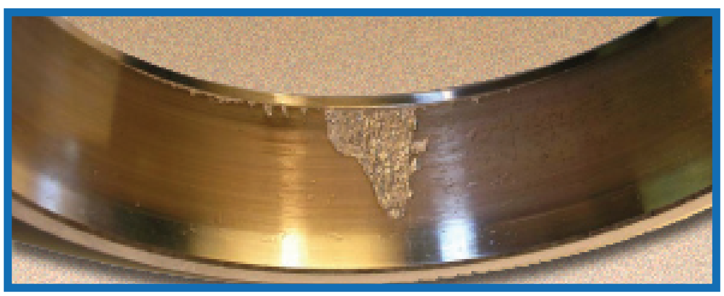
- Small vibrations will cause the bearing rolling pathway surfaces to rub together when the bearing is not rotating, such as when an assembly with installed bearings are shipped.
- The rubbing eventually leads to surface oxidation and a failure initiation point.
- Properly installed bearings with correct clearance and lubrication can alleviate this.

# Operating Conditions

## Misalignment

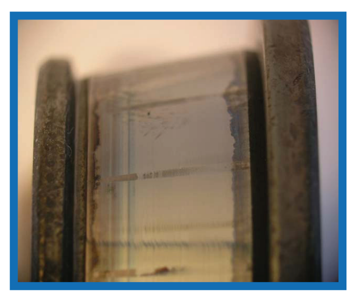
- Misalignment caused by installtation forces the centerline of the inner bearing race (cone) to operate at a slight angle to the centerline of the outer race (cup).
- This causes the load to be unevenly distributed creating greater than expected stress at one end of the rolling surfaces.
- Eventually, this will lead to surface spalling and premature failure as shown.
- The unexpected forces caused by misalignment can extend outside of the bearing, influencing the bearing mating components and causing other unexpected and uneven wear. In the photos shown here, a misalignment condition has caused wear between the cone bore and shaft outer diameter and caused the bore to have a polished appearance.





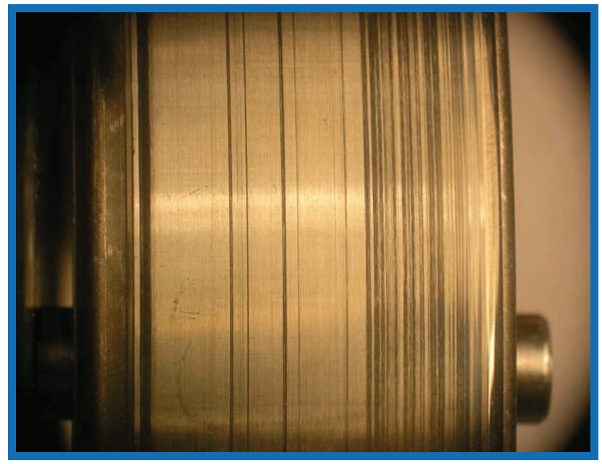
## Static Overload

- Static overload of a stationary bearing from either load or shock will produce true brinelling or permanent plastic deformation at the rolling element and raceway contact points.
- Excessive preload, improper installation, or improper handling can all cause this condition.
- This will lead to premature failure.



# Outer Diameter Damage

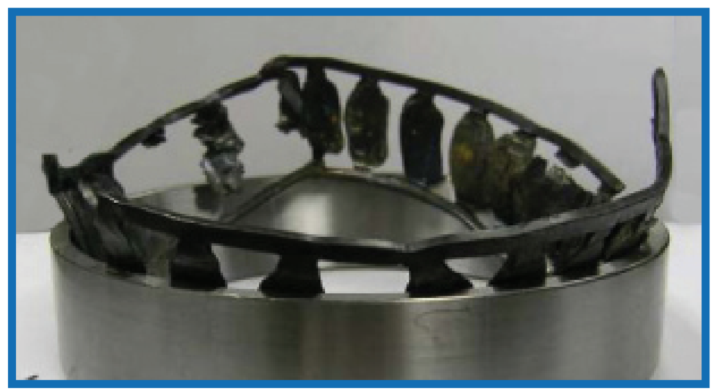
- In these photos, grooves and heavy wear on the outer diameter of the cup indicate that the cup was spinning inside the housing/hub. This condition is most often caused by improper fits or misalignment.

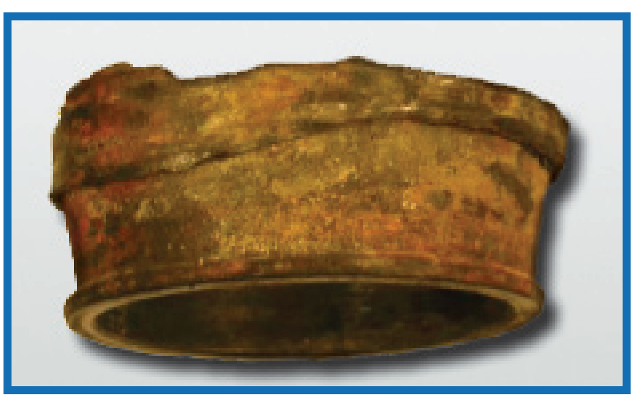


# Effects of Lubrication Starvation

- Lack of lubrication in fully loaded bearings will cause prompt and severe failure. Improper maintenance, installation, and poor sealing are several root causes.

- In addition to the destruction of the roller separator pictured above, overheating due to high friction will affect all bearing components.

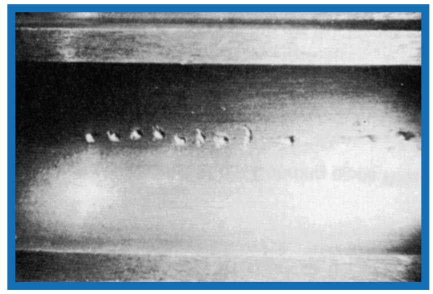


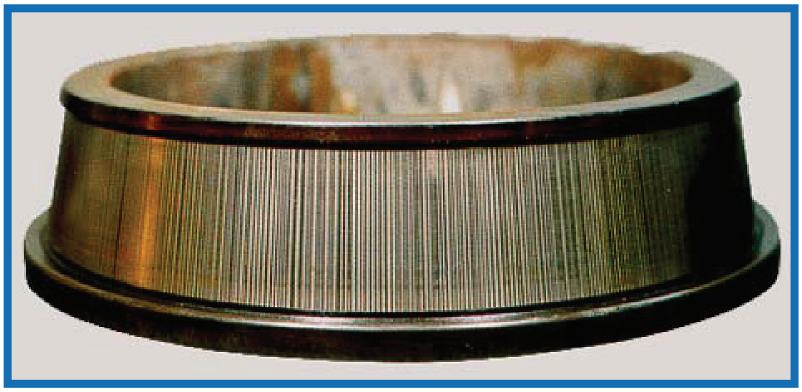


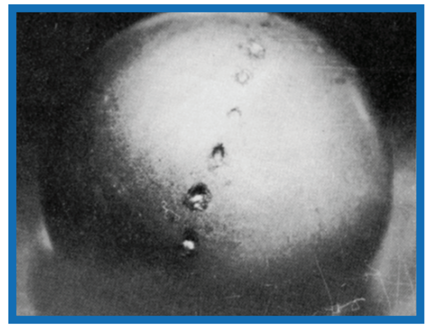
# Effects of Electrical Current

- Due to small internal clearances in the bearing, electrical current can arc between component surfaces causing rolling surface pitting. This will eventually lead to failure.

- Proper grounding techniques should be employed to avoid current passing through bearings.

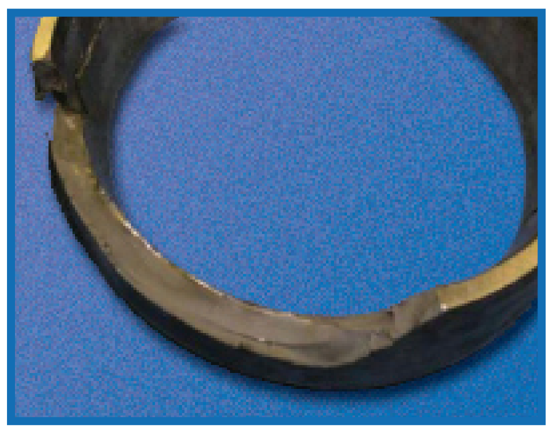






# Fracture

- Excessive preload, high shock loads, poor handling and extreme thermal conditions can lead to component fracture.



## Failure Modes

- ISO 15242:2004(E) is a comprehensive document on Bearing Failure Analysis. Almost all bearing failure modes can be classified into one of these six categories:

| | | |
|---|---|---|
| Fatigue | Wear | Corrosion |
| Plastic Deformation | Fracture | Electrical Erosion |

## Failure Causes

- Almost all bearing failure causes can be classified into one of these five categories:

| | | |
|---|---|---|
| Lubricant | Mounting | Handling |
| Application Design | Operating Condition | |

# Lubricant Based Failure Causes

- All bearings need proper lubrication to function properly. Lubrication must be correctly selected, be applied to the correct quantity level, be clean, monitored, and maintained correctly.

| | Insufficient Lubricant | Excessive Lubricant | Incorrect Viscosity | Inadequate Quality | Contamination |
|---|---|---|---|---|---|
| Increased Wear | ✓ | | ✓ | ✓ | ✓ |
| Tracks | | | | | ✓ |
| Scores | | | | | ✓ |
| Material Smearing | ✓ | | ✓ | ✓ | |
| Scratches | ✓ | | ✓ | ✓ | |
| Hot Running | ✓ | ✓ | ✓ | ✓ | |
| Pitting | ✓ | | ✓ | ✓ | ✓ |
| Spalling | ✓ | | ✓ | ✓ | ✓ |
| Rust | | | | ✓ | ✓ |
| Cage Fracture | ✓ | | ✓ | | |
| Indentations | | | | | ✓ |
| Thermal Cracks | ✓ | | ✓ | ✓ | |

# Operating Condition Based Failure Causes

- Operating conditions must be carefully considered when choosing the proper bearing and determining the bearing's expected life.

| | Excessive Speed | Excessive Load | Frequently Fluctuating Loads | Vibration | Passage of Electrical Current |
|---|---|---|---|---|---|
| Increased Wear | ✓ | ✓ | ✓ | ✓ | |
| Scores | | | ✓ | | |
| Material Smearing | ✓ | ✓ | ✓ | ✓ | |
| Fluting | | | | | ✓ |
| Chatter Marks | | | | ✓ | |
| Hot Running | ✓ | ✓ | | | |
| Pitting | ✓ | ✓ | ✓ | ✓ | ✓ |
| Spalling | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fretting (Rust) | | | | ✓ | |
| Fracture Cracks | | ✓ | | ✓ | |
| Cage Fracture | ✓ | | ✓ | ✓ | |
| Indentations | | ✓ | | | |
| Thermal Cracks | | ✓ | | | |

# Bearing Mounting Based Failure Causes

- Incorrect mounting practices can severely shorten bearing life

| | Faulty Electrical Insulation | Incorrect Mounting | Incorrect Heating | Misalignment |
|---|---|---|---|---|
| Increased Wear | | | ✓ | ✓ |
| Scratches | | ✓ | | ✓ |
| Fluting | ✓ | | | |
| Hot Running | ✓ | | | |
| Pitting | ✓ | ✓ | | ✓ |
| Spalling | ✓ | ✓ | | ✓ |
| Electrical Craters | ✓ | | | |
| Fracture Cracks | | ✓ | | |
| Cage Fracture | | ✓ | | |
| Deformation | | ✓ | ✓ | ✓ |
| Indentations | | ✓ | | |
| Thermal Cracks | | | ✓ | |

| | Undesirable preload | Impact | Inadequate fixing | Uneven seating Surface | Incorrect Seating fit |
|---|---|---|---|---|---|
| Increased Wear | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tracks | ✓ | ✓ | ✓ | ✓ | ✓ |
| Smearing | | | ✓ | | |
| Hot Running | ✓ | | | | ✓ |
| Pitting | ✓ | | ✓ | ✓ | ✓ |
| Spalling | ✓ | | ✓ | ✓ | ✓ |
| Fretting (rust) | | | | ✓ | ✓ |
| Fracture Cracks | ✓ | | ✓ | ✓ | |
| Cage Fracture | ✓ | ✓ | | | |
| Deformation | ✓ | ✓ | ✓ | ✓ | ✓ |
| Thermal Cracks | ✓ | | ✓ | | ✓ |

# Application Design Based Failure Causes

- Proper bearing selection, along with the components they are mounted to, will enhance bearing life.

| | Incorrect Bearing Selection | Unsuitable Adjacent Components |
|---|---|---|
| Smearing | ✓ | ✓ |
| Scratches | ✓ | ✓ |
| Hot Running | ✓ | ✓ |
| Fretting (rust) | ✓ | ✓ |
| Fracture Crack | ✓ | ✓ |
| Cage Fracture | ✓ | ✓ |
| Spalling | ✓ | ✓ |

# Bearing Handling Based Failure Causes

- Bearing handling, storage, and transportation should follow proper guidelines to avoid rolling surface damage.

| | Incorrect Bearing Storage | Vibration During Transportation |
|---|---|---|
| Scratches | | ✓ |
| Corrosion (rust) | ✓ | |
| Fretting (rust) | | ✓ |
| Indentations | | ✓ |