# Bearing failure of the ACC helical two-stage gearbox

## Gear box data:

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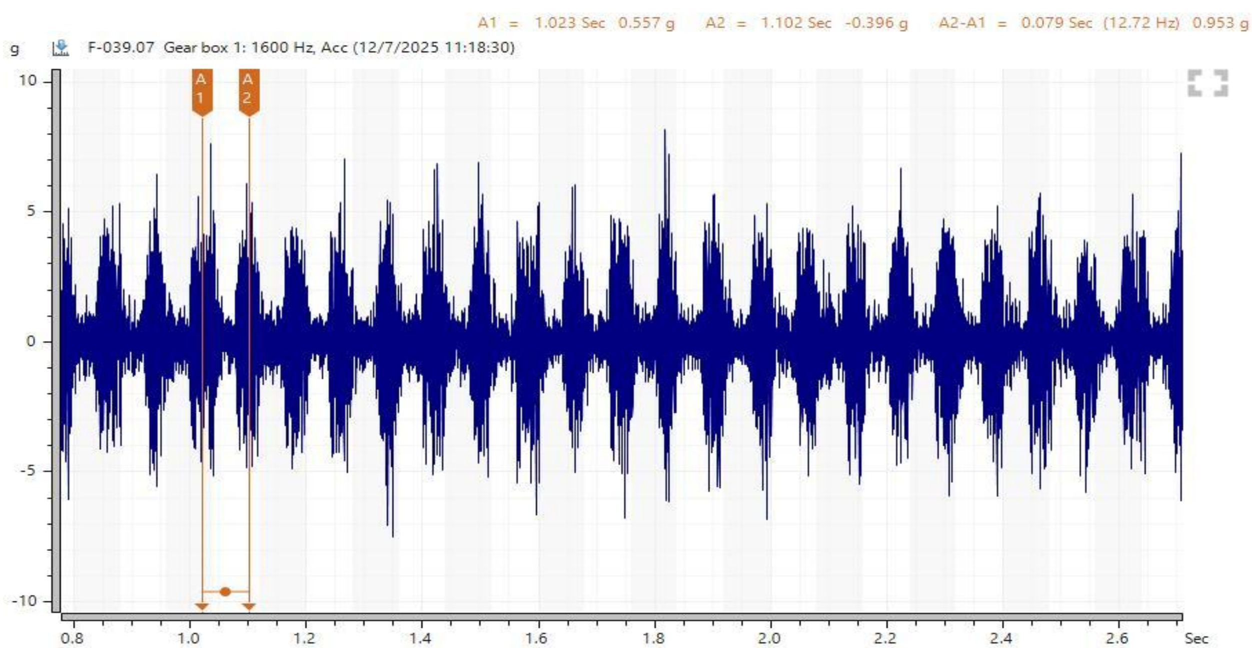
|---|---|
| ***Equipment Name*** | ***ACC Fan gear box*** |
| ***Gear box Type*** | ***MACC08*** |
| ***Speed*** | ***750,1500RPM*** |
| ***Motor type*** | ***Weg*** |
| ***Power*** | ***6.6 KV*** |
| ***BRG For Gear box*** | ***IMS: 30230, 32318.***<br>***LSS: 32036X, 32318.***<br>***HSS:33217, 32314*** |
| ***BRG for motor*** | ***DE: 6319 C3, NDE: 6316 C3*** |

## Vibration analysis:

- High impact & modulation around 12.5 Hz



## ➢ Inner race bearing frequency appeared in velocity FFT.


### <u>Finding:</u>

After the gear box to check, we found the lower bearing inner race of HSS damaged and outer races burnt.


- ## Visual Inspection:

The teardown inspection revealed severe surface damage on both the inner and outer bearing races. The raceways showed extensive spalling and pitting, characterized by flaked material and rough, fractured surfaces rather than smooth wear. The inner race exhibited a large, spalled area within the primary load zone, while multiple pitted regions were observed on the outer race. This damage is typical of rolling contact fatigue and indicates an advanced failure stage, suggesting the bearing continued operating after defect initiation. Metallic debris was present in the oil, and the race surfaces were dull and rough, consistent with degraded rolling contact and progressive vibration increase.

- Most Probable Root Causes as **ISO 15243**:
  - **Inadequate Lubrication / Lubricant Distress:**

Lubrication issues are a common cause of bearing failure and are likely a contributing factor in this case. Although ISO VG 220 oil is generally suitable for gearbox applications, inadequate oil supply, improper viscosity at operating temperature, oil degradation, or contamination can lead to insufficient lubrication. Loss of the oil film results in metal-to-metal contact, increasing contact stress and initiating surface fatigue. Additionally, contaminated oil containing wear particles or dirt can cause abrasive damage and surface-initiated spalling. Overall, insufficient, or degraded lubrication likely accelerated bearing surface damage and fatigue failure.

  - **Contamination and Cleanliness Issues:**

Contamination is a critical contributor to bearing failure. Metal wear particles, dirt ingress, or inadequate filtration can introduce abrasive debris into the lubricant, damaging raceway surfaces and disrupting the lubrication film. These surface defects act as stress concentrators, promoting early fatigue cracking and spalling. Poor contamination control, often linked with lubrication deficiencies, is therefore a likely root cause of the observed bearing damage.

- **Excessive Load or Duty Cycle Stress:**

  Operation beyond design limits, such as excessive torque, shock loading, or frequent start–stop cycles, can impose stresses exceeding the bearing's fatigue limit and accelerate spalling. High loads combined with marginal lubrication further increase damage by reducing oil film thickness and promoting metal-to-metal contact.

- **Preload and Installation Corrections:**

Bearing housing and shaft fits should be inspected for defects, and the replacement bearing must be installed using proper tools and procedures to avoid preload or damage., Correct bearing type and internal clearance must be ensured to accommodate thermal and operating conditions, thereby preventing uneven loading and premature spalling.

- **Structural Resonance or Vibration Amplification**

  It is less likely because the structure does not preserve vibration and the ACC fan construction includes a vibration protection sensor.

The failure was likely caused by a combination of causes. Lubrication and contamination issues, together with probable wrong preload, resulted in localized high loads that caused surface fatigue. As the damage advanced, increased vibration and dynamic loading accelerated bearing degeneration, leading to rolling contact fatigue failure.

- Most Probable Root Causes as ISO 15243 assessment comparison:
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| Potential Cause | Failure Mechanism | Typical Indicators | Relevance to this Case | Assessment |
|---|---|---|---|---|
| **Inadequate Lubrication / Lubricant Distress** | Insufficient or degraded oil film causes metal-to-metal contact, leading to high contact stress and surface fatigue (spalling). | Spalling on raceways, elevated vibration, metallic debris in oil, increased temperature. | ISO VG 220 oil used, but evidence of surface fatigue and debris suggests possible oil degradation, poor delivery, or film breakdown. | **Low likelihood** |
| **Contamination and Cleanliness Issues** | Abrasive particles damage raceway surfaces, create stress raisers, and initiate surface-initiated fatigue and spalling. | Pitting, abrasive marks, early spalling, contaminated oil, filter loading. | Presence of metallic debris and spalling patterns strongly indicate contamination contributing to fatigue initiation. | **High likelihood** |
| **Excessive Load or Duty Cycle Stress** | Loads exceeding bearing fatigue limit accelerate subsurface and surface fatigue; oil film collapses under high stress. | Accelerated spalling, high vibration, damage at load zones. | Gearbox operates at high speed with possible transient or shock loads; combined with lubrication issues, this could accelerate failure. | **Medium likelihood** |
| **Preload / Improper Installation** | Incorrect fits or preload cause uneven internal load distribution, edge loading, and localized high stresses. | Localized spalling, abnormal wear patterns, shortened bearing life. | After checking the bearing clearance of the HSS, we found that it should be +0.5 to +0.10 mm, but it is compression -.05 mm, indicating the incorrect preload for this type of bearing. | **High likelihood** |
| **Structural Resonance or Vibration Amplification** | Resonance amplifies dynamic forces acting on bearing, increasing fatigue damage. | Broad vibration amplification, resonance peaks, looseness symptoms. | Considered less likely due to ACC fan design and presence of vibration protection sensors; no indication of sustained resonance. | **Low likelihood** |

## ➢ Corrective action:

- Implement routine oil analysis to monitor contamination, viscosity, and wear debris.
- Ensure proper oil flow to bearings and clean oil passages.
- Confirm correct bearing type and internal clearance for the bearing application and adjusted as OEM.
- Include bearings in a regular vibration condition monitoring program.

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