CUSTOMER SERVICE REPORT

EXAMPLE REPORT

Report prepared for:

Stowe Mtn. Resort

Project/Quote #:

23-012

Project Description:

Emergency Repair of Failed Output Bearings & Gearbox Overhaul

Report prepared by:

Dan Droegkamp

LONE WOLF
GEARBOX SPECIALTIES

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Project #: 23-012	**Start of Service:** 1-2-23	**End of Service:** 1-6-23
Customer Name: Stowe Mountain Resort		
Main Contact: Mark Fletcher		

SERVICE WORK INFO

Work Description: Emergency Repair of Failed Output Bearings and Majority Gearbox Overhaul		
Reason for Work: Leaking output seals indicating contaminated oil from failing bearings		
Lift Name: Overeasy Gondola	**Hours at Time of Service:** 6,166	
Gearbox Make: Poma/Kissling	**Gearbox Model:** KPU-350/SB-500HW	**Gearbox S/N:** 69493
Work Completed by: Dan Droegkamp	**Ratio:** 48.16:1	

SERVICE WORK DETAILS

Scope of Work:

- Rig & remove haul rope from bullwheel
- Rig & remove bullwheel lowering to the ground
- Disassemble all gearbox sections
- Disassemble, clean, inspect, and replace all bearings in both planetary assemblies
- Disassemble, clean, inspect, and replace all bearings seals, bushings etc. in the right angle input assembly
- Remove and replace output bearings, seal bushing, and seals with new
- Investigate and evaluate main failure(s) and likely causes
- Reassemble all and operate lift inspecting running

Status After Service:

- Oil needs to be added to the gearbox to the proper level
  - This needs to be checked and added when the gearbox has sat for awhile and the oil is cold (ideally in the morning before any operations)
- Oil flow, bearing/gearbox temperatures, and vibrations need to be regularly monitored at all times, but especially with the initial operations.
- The oil should be filtered or changed mid-season AND post-season due to the extreme levels of contamination from the bearing failures.

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SERVICE WORK DETAILS

Remarks:

- The haul rope rigging and terminal dismantling was carried out prior to Lone Wolf's arrival by Leitner-Poma of America East and Stowe Mtn. Resort Lift Maintenance Department

- The majority of the gearbox disassembly was also carried out prior to Lone Wolf's arrival in preparation for the gearbox overhaul repair.

- There was an extreme amount of contaminants found inside the gearbox contaminating all oil, oil lines, cavities, cooler, etc.
  - The best possible attempts were made to flush out all contaminants as possible

- The Bullwheel bushings were tack welded in place to help keep them in the bullwheel during any necessary removals of the bullwheel in the future.
  - The bushings measured an adequate interference fit to the output shaft of +.002"

- The hollow shaft bearing outer races had a slightly loose fit in the housing very likely due to operating in the high levels of contaminated oil.
  - The lower race was installed with a retaining compound Loctite 648
  - The upper race fit was helped by installing with Loctite 573 to help reduce further vibrations and deterioration of this housing fit.

- The level of deterioration with the bearing failures made it very difficult to determine a possible culprit of the cause of the failure.
  - The obvious condition of the deterioration of mainly the lower bearing is a direct result of contamination. This is a byproduct of the failure. The contamination grew exponentially during operating and settled in the lower and larger output bearing causing that bearing to exponentially deteriorate and continue to add to the contamination
  - One possible cause of the initial damage is foreign material got into the bearing and caused damage to the bearing, which resulted in increased wear during operations.
  - Another possible cause of the initial damage is electrical arcing from a high-voltage ground fault. Either lightning or other source of high-voltage current passed through the bearings and arced causing damage eventually leading to the levels of bearing failure/break-down that was found upon disassembly.
    - Regardless, the electrical system within AND surrounding the ski lift drive should be thoroughly investigated for proper grounding throughout.

- See final page #15 for summary of all bearings changed during this emergency service work
  - All bearings etc. changed in addition to the failed bearings were done proactively in relation to the high level of abrasive debris contamination that had ran through the gearbox for an undetermined amount of time.
  - This would definitely shorten the life expectancy of all other components therefor the main components were also changed out at this time, and everything flushed/cleaned to the best of our abilities.

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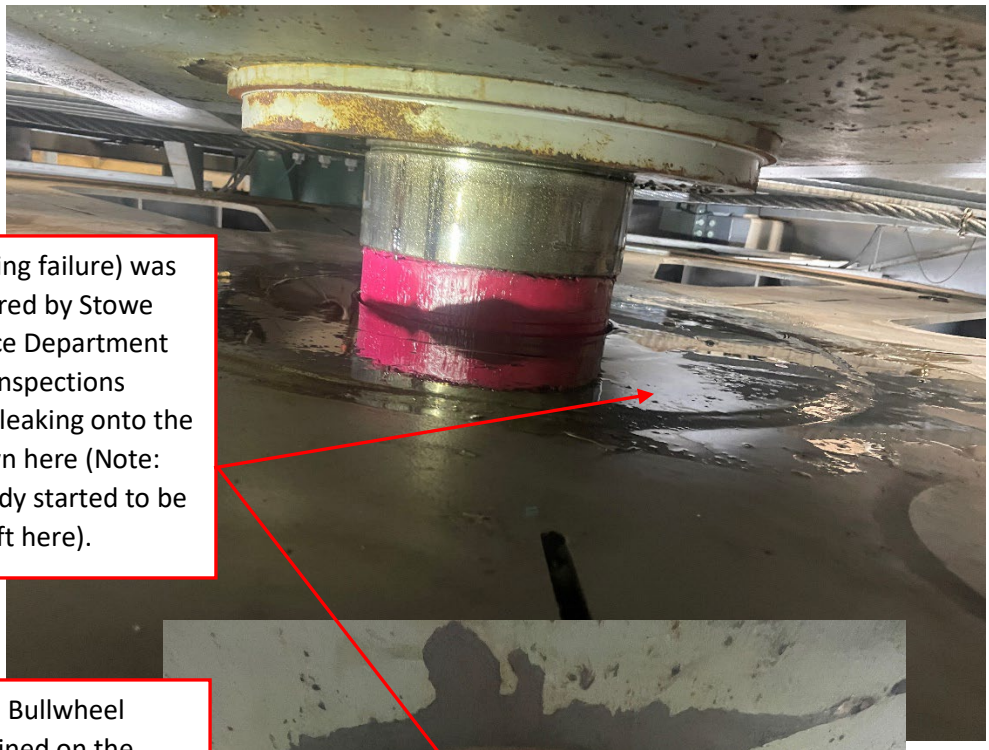
SERVICE WORK DETAILS



The issue (bearing failure) was initially discovered by Stowe Lift Maintenance Department during regular inspections noticing the oil leaking onto the bullwheel shown here (Note: bullwheel already started to be pressed off shaft here).

Also Note: The Bullwheel Bushings remained on the shaft during the Bullwheel removal. This should not happen, but the bushings were able to be removed intact, and reinstalled to the bullwheel.

- The Bushings were then fully cooled and measured confirming a proper interference fit to the Output Shaft of 0.002."
- The bushings were tack welded into the Bullwheel to facilitate future Bullwheel removal (to help them stay in the Bullwheel as they are supposed to).

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The majority of the lower rollers in the lower bearing were crooked due to the extreme level of failure in the bearing roller cage. The lower cage was mostly deteriorated allowing the rollers to excessively move around.

Bearing cage pieces

There were extremely high levels of contaminants found during disassembly.

- A lot of brass “glitter” from the output bearing roller cages breaking down
- Parts of the lower bearing cage that had worn completely off and were loose in the bearing exponentially breaking down adding to the contamination

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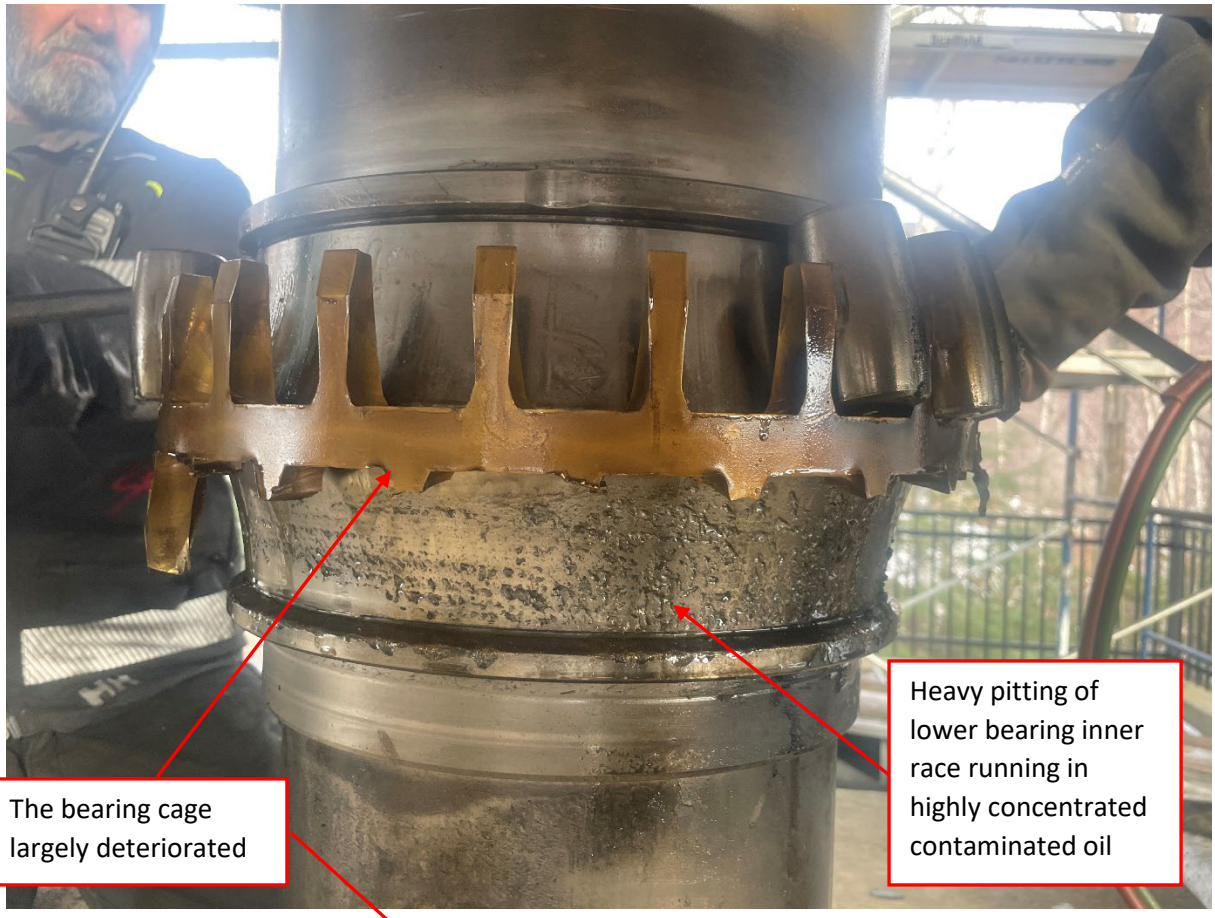

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Inner race of the lower bearing
(main failure bearing)

Possible evidence of foreign debris damage initiating bearing break-down failure.

(significant indication noted at roller area)

Outer race of the lower bearing
(main failure bearing)

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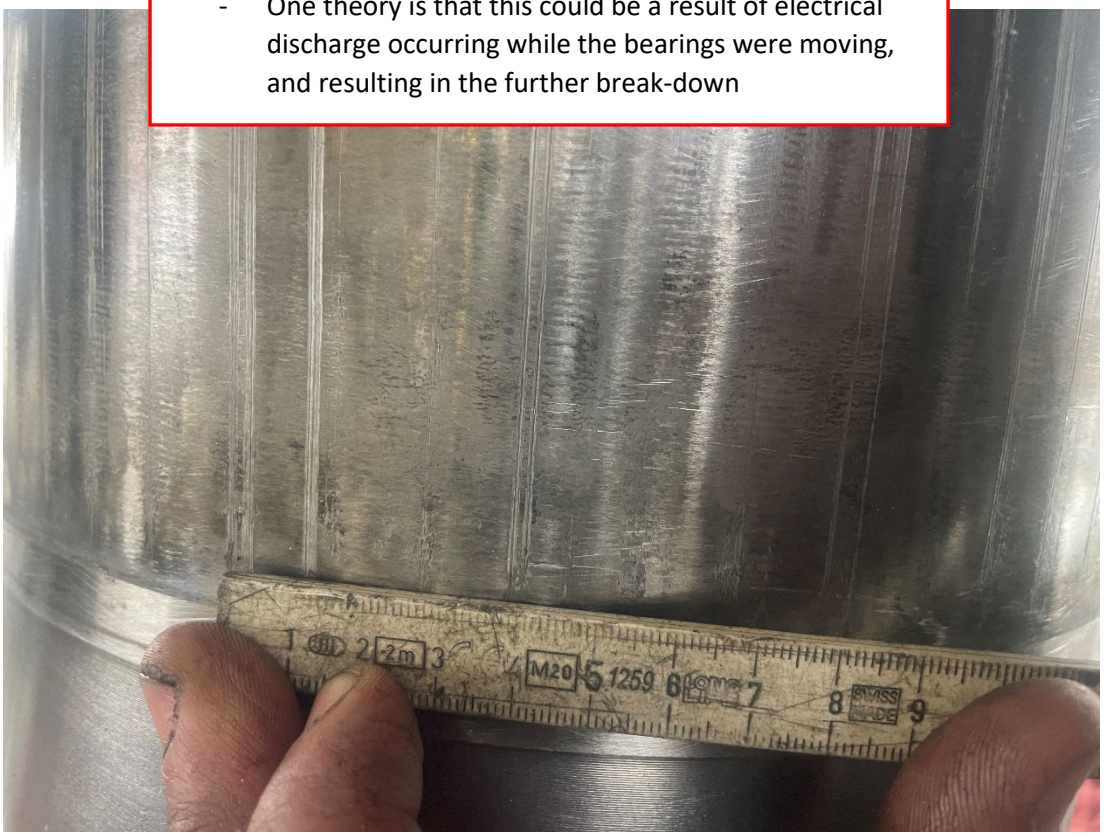
The Output Shaft had very consistently spaced debris scoring after removal of the large (lower) bearing inner race.

- One theory is that this could be a result of electrical discharge occurring while the bearings were moving, and resulting in the further break-down



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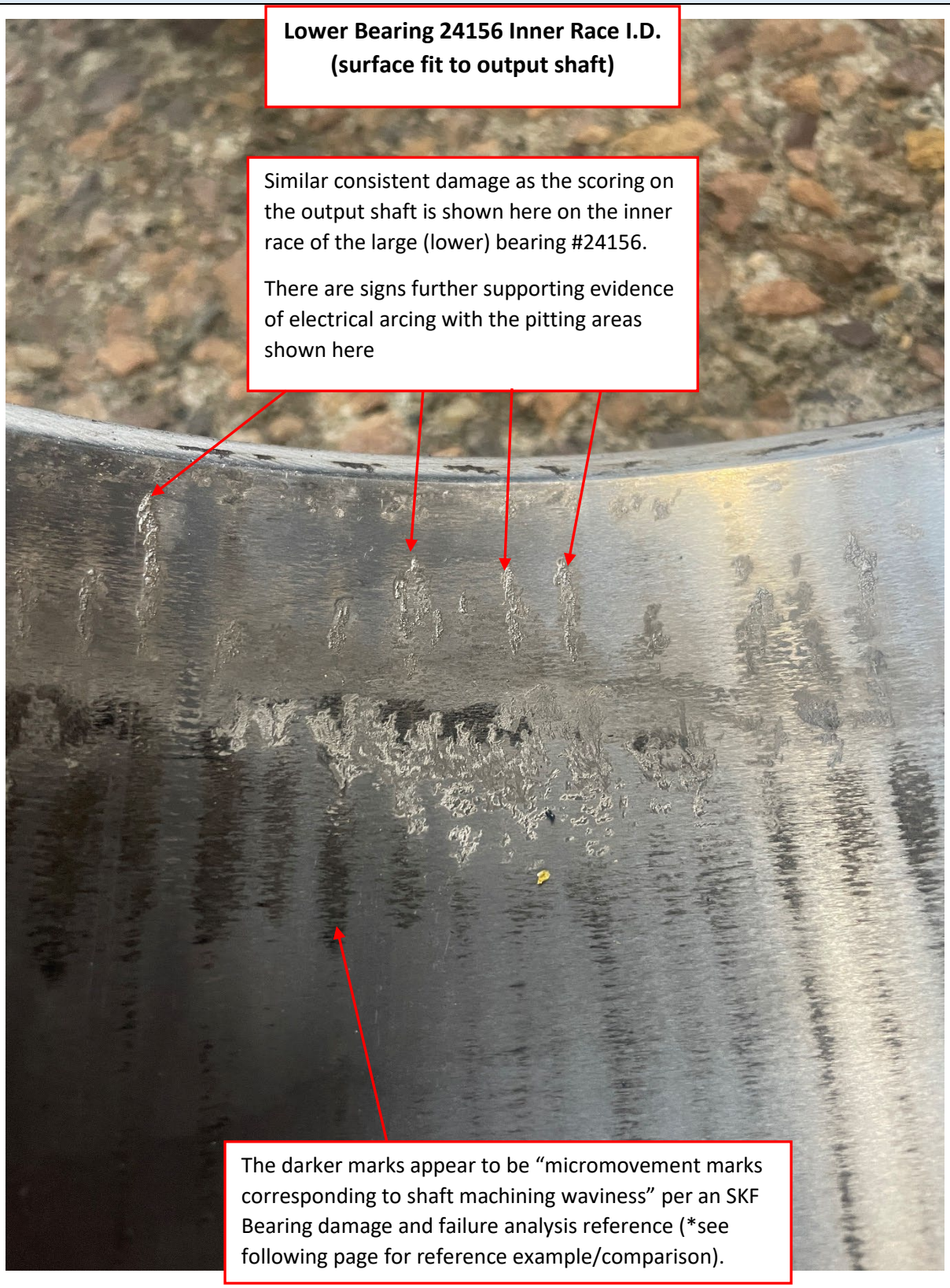
SERVICE WORK DETAILS

Lower Bearing 24156 Inner Race I.D. (surface fit to output shaft)

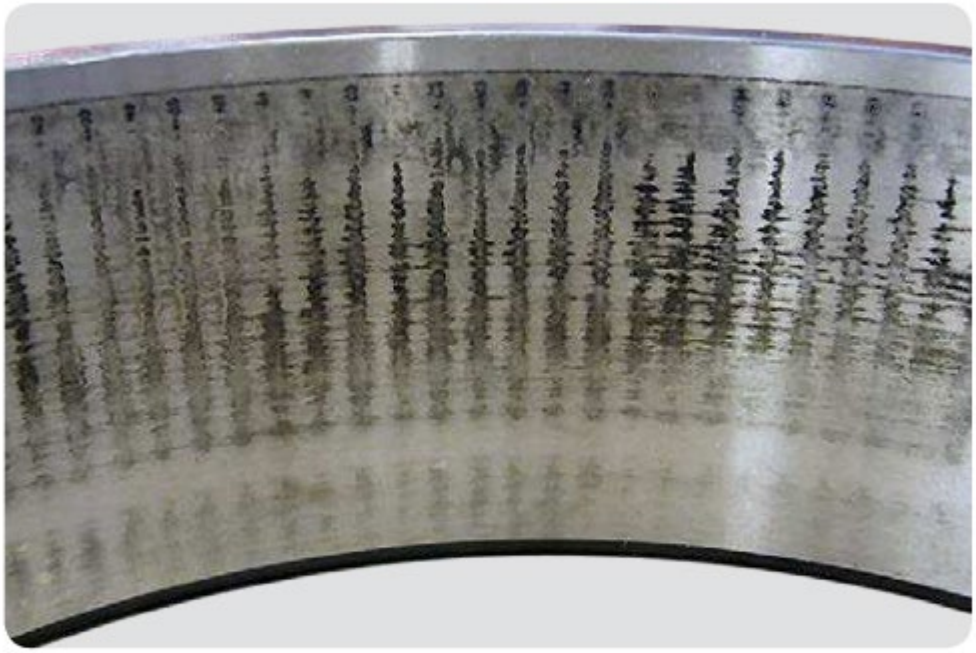


Similar consistent damage as the scoring on the output shaft is shown here on the inner race of the large (lower) bearing #24156.

There are signs further supporting evidence of electrical arcing with the pitting areas shown here

The darker marks appear to be “micromovement marks corresponding to shaft machining waviness” per an SKF Bearing damage and failure analysis reference (*see following page for reference example/comparison).

5 Damage and actions



Tapered roller bearing inner ring
Micromovement marks corresponding to shaft machining waviness

SKF "Bearing Damage and Failure Analysis"

Reference Link:

https://www.skf.com/binaries/pub12/Images/0901d1968064c148-Bearing-failures---14219_2-EN_tcm_12-297619.pdf

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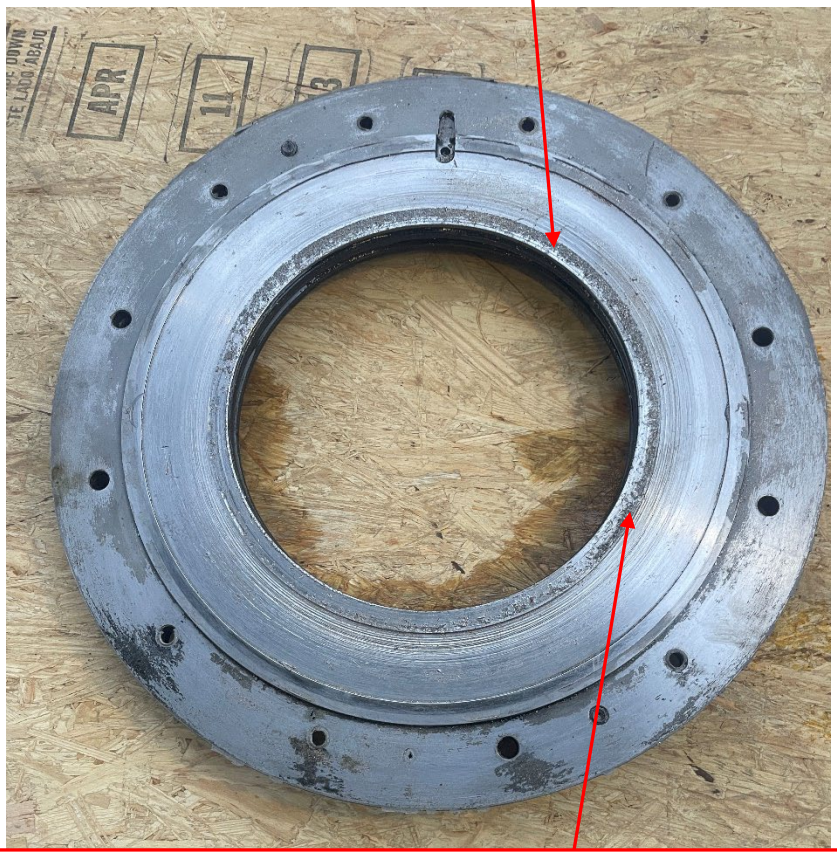

The Output Seal Plate was found to have cosmetic damage from all of the abrasive debris settling and running against the seal plate face shown here.

- This was cleaned up and is of no further concern.
- This abrasive debris is the direct reasoning that the output seals started to leak oil, as it damaged the seals.

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Bullwheel Reinstallation

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Shown here is the final high-speed gear contact pattern with a backlash of 0.30mm

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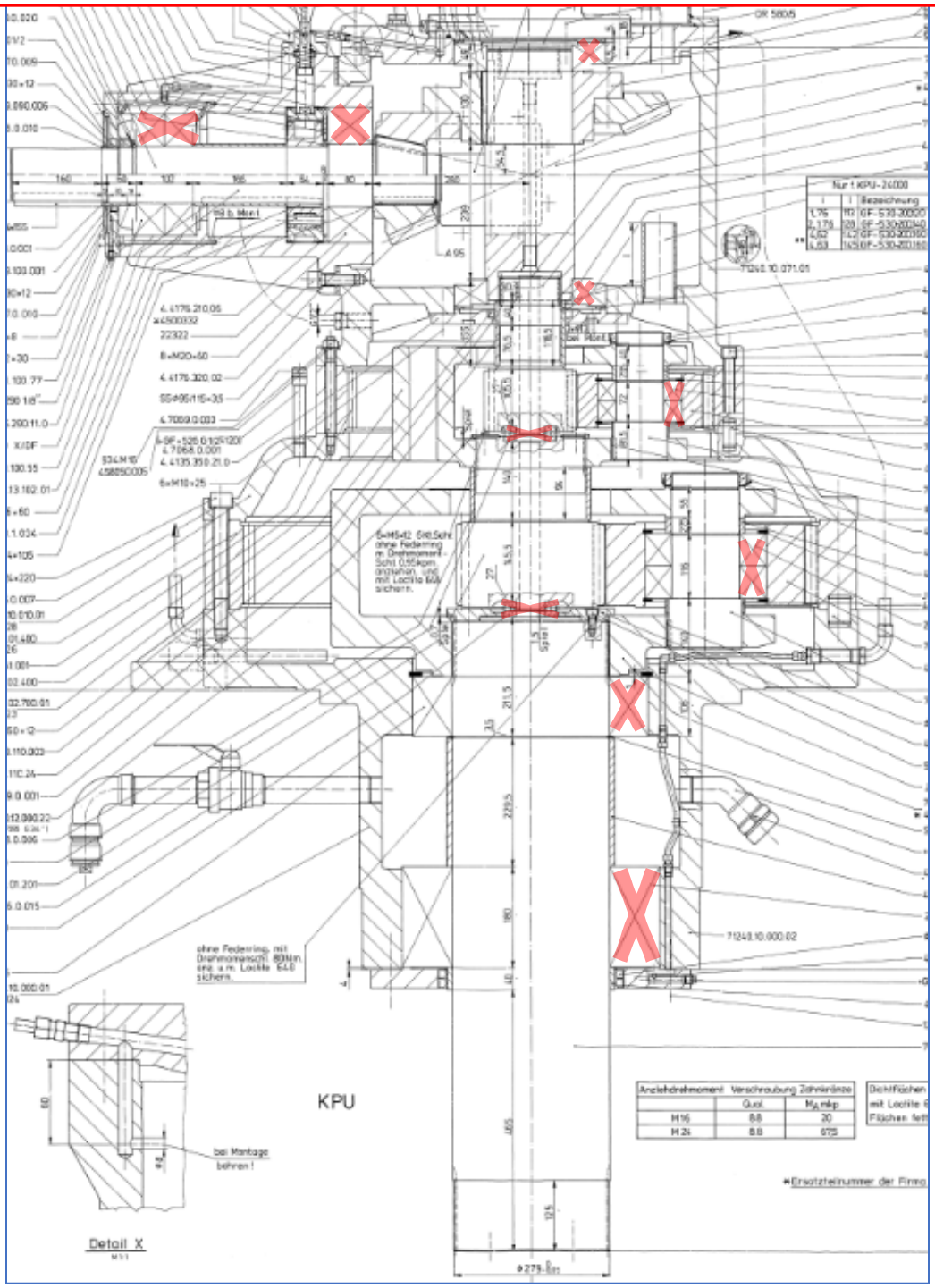
SERVICE WORK DETAILS

In Summary the Bearings Changed are Marked Below with a Red X

(*also, related seals, bushings, etc. changed)

(**The auxiliary bearings on either side were not changed. Just the main high-speed input components)



END OF REPORT