



June 4, 2026

Mitchell Rasmussen
Investigator-in-Charge
Office of Aviation Safety
National Transportation Safety Board
222 West 7th Avenue, Room 216, Box 11
Anchorage, Alaska 99513

Re: Jack Harter Helicopters' Party Submission re: MD Helicopter 369E/500E Accident; February 27, 2024; Kekaha, Hawaii; NTSB Investigation No. ANC24LA017

Dear Mr. Rasmussen:

The purpose of this letter is to provide our proposed findings to the National Transportation Safety Board ("NTSB") regarding the accident investigation and final report in this matter, in accordance with Title 49 Code of Federal Regulations ("CFR") Section 831.14. Jack Harter Helicopters ("JHH") appreciates the opportunity to submit these comments, as well as the professional and collaborative environment amongst all parties throughout this investigation. These cooperative efforts demonstrate our common commitment to aviation safety.

I. INTRODUCTION

On February 27, 2024, an MD Helicopter 500E was on a routine sightseeing flight along the north shore of Kauai. Around 1:40 pm, the pilot suddenly smelled smoke and immediately changed course to a nearby beach which JHH has previously designated as an emergency landing zone. Shortly after changing course, the pilot heard a loud "pop" sound followed by an automatic engine out warning tone.

The pilot immediately lowered the collective and conducted an autorotation to the smaller, but closer, Honopu beach. The helicopter successfully touched down on Honopu Beach, but then pitched forward in the sand and rolled to the right, causing substantial damage to the tail boom, fuselage, and main rotor system. All passengers and the pilot were able to evacuate. One passenger suffered serious injuries and the pilot and three passengers suffered minor injuries.

Subsequent investigation revealed the inner race splined shaft in the overrunning clutch subassembly had fractured.

II. DISCUSSION

JHH prioritizes safety in all aspects of our operations. We thoroughly reviewed the available information produced by the NTSB investigation, and discuss below several issues that we believe are relevant to the NTSB's ultimate analysis of the facts and circumstances of this incident.

A. Inapplicability of Airworthiness Directive 90-19-02

There has been some confusion as to whether the FAA's Airworthiness Directive (AD) 90-19-02 applied to the accident helicopter at the time of the accident. It does not.

The FAA issued AD 90-19-02 effective October 5, 1990. While the applicability of this AD is to all model 369 series helicopters equipped with a cargo hook, the compliance text cannot be accomplished on the accident helicopter due to the limitations in the AD itself.

The AD contains three primary instructional paragraphs.

Paragraph (a)

Paragraph (a) requires operators to take two actions within 300 hours time in service: first, remove overrunning clutch assemblies P/N 369A5350-BSC, -601, or -603, if installed; and second, install overrunning clutch subassembly P/N 369A5350-41 into whichever of those assemblies is installed, or alternatively, replace the overrunning clutch assemblies with P/N 369A5350-605.

The accident helicopter already had an overrunning clutch assembly P/N 369A5350-605 installed, so Paragraph (a) does not apply to it.

Paragraph (b)

Paragraph (b) requires, in relevant part, inspection of the overrunning clutch assembly P/N 369A5350-605 at 300-hour intervals, and specifies three parts within the overrunning clutch assembly, the condition of which must be inspected: the race inner clutch, P/N 369A5353-3; the race outer clutch, P/N 369A5352; and the sprag assembly, P/N 369D25351. No mechanic could legally sign off the AD without inspecting those three specified parts.

While the overrunning clutch assembly in the accident helicopter is P/N 369A5350-605, as specified in the AD, the overrunning clutch subassembly in the accident helicopter is a newer version, P/N 369A5350-51, which does not contain the race outer clutch, P/N 369A5352 which is identified in the AD. Therefore, it is impossible to comply with Paragraph (b) in that one of the three parts specifically called out for inspection does not exist in the accident helicopter and thus cannot be inspected.

Accordingly, Paragraph (b) does not apply to the accident helicopter.

Paragraph (c)

Finally, Paragraph (c) requires one-time replacement of sprag assemblies, P/N 369D25351 and P/N 369A5364, with an airworthy part on or before reaching 1,800 hours total time in service. The accident helicopter's maintenance records show this replacement was already accomplished on August 27, 2019 before it reached 1,800 hours total time in service.

Therefore, Paragraph (c) does not apply to the accident helicopter.

Because none of the substantive paragraphs in AD 90-19-02 apply, it is factually inaccurate to say this AD applied to the accident helicopter.

B. Evidence of Premature Wear in Other Bearings

In July 2024, during routine maintenance of another helicopter, JHH maintenance staff noticed the grease in the helicopters' overrunning clutch output bearing (PN 369A5362) had unexpectedly changed color. JHH removed the entire clutch assembly, including the suspected bearing, from service before it reached its service life limit (1800 hours). A "Service Difficulty Report" was filed with the FAA via the "Service Difficulty Reporting Service" (<https://sdrs.faa.gov/>) A copy of the service difficulty report is provided with this submission as Attachment A.

The removed clutch had been installed on the helicopter for 1475.3 hours since it was overhauled. The "on-condition" output bearing in the clutch has no service life limit. The company that overhauled the clutch replaced the output bearing with a new bearing during the overhaul process. The clutch in the accident aircraft and the clutch removed from the second helicopter due to the finding of discolored grease on the output bearing were overhauled within a relatively short time of each other.

JHH engaged R.J. Waldron & Co. Ltd. (Waldron), a respected aviation forensics and failure analysis laboratory, to conduct analysis of the clutch removed from the second helicopter. Waldron's analysis revealed the clutch's output bearing had prematurely reached its end of life and the sprag assembly (PN 369D25351) showed wear beyond serviceable limits. The condition of this bearing could not be detected without destructive testing that was authorized by JHH.

Because JHH was concerned with the possibility that other output bearings could fail in-service, JHH notified the NTSB (via email on October 14, 2024) about this suspected bearing and provided a copy of the Waldron analysis report. A copy of the Waldron report is provided with this submission as Attachment B.

Disappointingly, the NTSB declined to investigate further. The NTSB cited the fact that the output bearings are not serialized by the manufacturer, which would make tracking individual bearings difficult.

Although the output bearings are not serialized, there are only a limited number of manufacturers and suppliers, and with the NTSB's resources and investigative authority, it would be possible to determine the origins of the suspect bearings and look for additional problematic bearings. If this investigation

determined that the failed bearing from the accident aircraft and the bearing in the second helicopter were from the same manufacturer and production lot, further analysis of the bearing from the second helicopter would seem to be warranted to determine if the bearing materials met manufacturing specifications.

JHH continues to urge the NTSB to investigate the possibility of overrunning clutch output bearings in active service helicopters flying in the national airspace system that may be experiencing wear at rates faster than expected and could fail catastrophically before they exceed their intended life.

III. PROPOSED FINDINGS

- Training of the pilot was current, exceeded the requirements of Part 135, and he was properly qualified and certified for the flight.
- Pilot fatigue does not appear to have been a factor in the accident.
- The helicopter was maintained in reference to all applicable maintenance manuals.
- Jack Harter Helicopters performed maintenance (greasing of the clutch output bearing) at shorter intervals than those required by the manufacturer.
- All maintenance entries in the airframe and engine logbooks were properly signed off.
- The maintenance procedures used by Jack Harter Helicopters did not contribute to this accident.
- While FAA Airworthiness Directive 90-19-02 did apply generally to the make and model of the accident helicopter, the configuration of the overrunning clutch assembly in the accident helicopter at that time made compliance impossible.

IV. PROPOSED RECOMMENDATIONS

JHH proposes the following Safety Recommendations:

To MD Helicopters:

1. Revise your manuals to remove confusing or unclear language related to aircraft and component inspection and maintenance. Currently, the Handbook of Maintenance Instructions (HMI) refers technicians to the Component Overhaul Manual (COM) for some of the processes and limitations related to the inspection and maintenance of individual aircraft components. Clear and concise instructions for the inspection and maintenance of individual aircraft components should be in specific HMI locations. Similarly, clear and concise instructions for overhauling individual aircraft components should be in specific COM locations

2. Consider using a serialized bearing for the output bearing and add an “hours in-service” life limit of 1800 hours or less rather than utilizing an “on-condition” limit.

To the Federal Aviation Administration:

1. Amend AD 90-19-02 to make it clear which clutches in the MD369/500 series are affected by the AD.
2. Issue an Airworthiness Directive to operators of helicopters which contain sprag assemblies, P/N 369D25351, and require periodic inspection to check for accelerated wear, or replacement.

V. CONCLUSION

Jack Harter Helicopters is committed to excellence in all aspects of our operations. The company has a robust safety culture, sound training programs for its pilots and mechanics, and well-proven operational procedures. These factors played a significant role in ensuring that our pilot successfully maneuvered the helicopter to a safe landing, saving his passengers from serious injury or worse.

We thank the NTSB for its work and the opportunity to contribute to this investigation. We appreciate the shared commitment to flight safety evidenced by the collaborative investigative approach displayed by all parties to the investigation.

We are grateful for the trust our customers and employees place in us every day.

Sincerely,

A black rectangular redaction box covering the signature of Casey Riemer.

Casey Riemer
Special Projects Manager
Party Coordinator to NTSB investigation

Service Difficulty Report

1. Submitter Information

(a) Unique Control #: 2024FA0000495 (b) Difficulty Date: 07/09/2024
 (c) Registration #: 842JH (d) Submitter Type: E - CARRIER PART 135
 (e) Submitter Designator: (f) Submission Date: 7/12/2024 3:24:57 PM

2. Codes

(a) Operator Designator : (b) Operator Type : General Aviation
 (c) JASC/ATA Code : 6300
 (d) Stage of Operation : IN - INSP/MAINT
 (e) How Discovered : V - Visual
 (f) Nature of Condition : O - OTHER
 (g) Precautionary Procedures: K - NONE
 (h) FAA Region : HI (i) District Office : HI
 (j) Flight Number :

3. Major Equipment Identity

	Manufacturer	Model	Serial Number	Total Time	Total Cycles
(a) Aircraft	MD HELICOPTERS	369E	0020E	23947.7	21423
(b) Engine	ROLLS ROYCE	250 C20B	cae837090	16771.7	
(c) Propeller					

4. Problem Description

During aircraft inspection an aircraft mechanic questioned discoloring of the overrunning clutch output bearing grease. The bearing did not demonstrate any abnormal play or roughness. The clutch had the correct amount of oil installed. It was decided to disassemble the clutch assembly. It appeared the forward bearing was rotating in the outer race housing. Unofficial measurement of the outer race had it over limits. Metal particles were found in the remaining oil in the bottom of the outer race housing. The part was removed from service for further inspection.

5. Specific Part or Structure Causing Difficulty

(a) Part Name : Clutch sub assembly (b) Manufacturer's Name : MD Helicopters
 (c) Part Number : 369A5350-51 (d) Serial Number : CAC9923
 (e) Part Condition: MAKING METAL (f) Part/Defect Location: Zone 100
 (g) Total Time : (h) Total Cycles :
 (i) Time Since : 1475.3 OVERHAUL

6. Component/Assembly That Includes Defective Part

(a) Component Name: overrunning clutch (b) Manufacturer's Name : MD Helicopters
 (c) Part Number : 369A5350-605 (d) Serial Number : CAC9923
 (e) Model Number : (f) Location :
 (g) Total Time : (h) Total Cycles :
 (i) Time Since : 1475.3 OVERHAUL

7. Structure Causing Difficulty

(a) Body or Fuselage Station - From/At: To:
 (b) Water Line - From/At: To:
 (c) Crack Length : (d) Number of Cracks:
 (e) Stringer - From/At: To:
 (f) Butt Line - From/At: To:
 (g) Wing Station - From/At: To:
 (h) Structural Other: (i) Corrosion Level :

----- End Of Report -----



WALDRON

FORENSIC ENGINEERING • FAILURE ANALYSIS

EXAMINATION REPORT

HUGHES 369D OVERRUNNING CLUTCH EXAMINATION



Re: Hughes 369D Overrunning Clutch
Examination

Prepared for: Jack Harter Helicopters
4231 Ahukini Road
Lihue, HI
USA 96766

Attention: Chris Hoesel

Report Date 3 September 2024

Principal Author
Sepehr Gerami, MASc PEng
RJ Waldron & Co.

1 Introduction

Jack Harter Helicopters (JHH) forwarded to R J Waldron and Company (RJW) parts and used grease (Mobil 28) and oil (Mobil 387) samples from an over-running clutch assembly from a Hughes 369D helicopter (PN 369A5350). The unit was removed from service when routine inspection detected possible “heat decoloring” of the grease, and what appeared to be rotation of the “forward bearing” in its housing. cursory measurement of the over-running clutch “outer race” raised concerns over excessive wear. It was requested that RJW examine the over-running clutch parts and the samples of the used over-running clutch lubricants for overheating, heat damage, and excessive wear.

The following parts from the overrunning clutch sub-assembly (PN 369A5350-51, CAC9923) were forwarded to RJW:

- 369A5361-BSC Overrunning Clutch Output Ball Bearing
- 369A5362-BSC Overrunning Clutch Forward Sprag Ball Bearing
- 369D25351-BSC Overrunning Clutch Sprag Assembly
- 369A5363-BSC Overrunning Clutch Aft Sprag Ball Bearing
- W1593-018 Wave Washer
- 369A5352-5 Overrunning Clutch Outer Race, Serial Number 005570-0474
- 369A5366-BSC Overrunning Clutch Bearing Retainer
- 369A5355-BSC Overrunning Clutch Bearing Carrier
- 369A5367-BSC Bearing Sleeve Spacer
- 369A5360-BSC Spacer Washer
- 369A5358-BSC Lock Washer
- 369A5365-3 Bearing Retainer Nut

The sprag clutch assembly “inner race” (PN 369A5353-3) was not included in the shipment, as it was removed for serviceable transfer.

The overrunning clutch sub assembly was last overhauled by California Aero Components (CAC).

Service history records for the overrunning clutch sub-assembly beginning in 2019 were provided with the above parts. These included JHH records as well as CAC records.

2 Documents Provided/ Relied Upon

- [1] MD Helicopters Component Overhaul Manual PN 369A5350, Section 63-10-10, Reissue 1 Revision 1
- [2] Jack Harter Helicopters Component Historical Record – MDHI Overrunning Clutch PN 369A5350-51 SN CAC9923 – 6 January 2020 through 8 July 2024.

- [3] California Aero Components FAA Authorized Release Certificate W.O. 4940 R.O. 114871X, Overrunning Clutch PN 369A5350-51 SN CAC9923
- [4] California Aero Components Discrepancy Forms – Component PN 369A5350-51 SN CAC9923, Work Order 4940
- [5] California Aero Components DN/HN Checklist, W.O. 4940 Customer R.O. 114871X
- [6] California Aero Components Discrepancy Forms – Component PN 369A5350-51 SN CAC9923, Work Order 9124
- [7] California Aero Components DN/HN Checklist, W.O. 9124 Customer R.O. 127539

3 Over-running Clutch History

The overrunning clutch history beginning in 2019, as reported in the records provided, was as follows:

<i>Date</i>	<i>Hours Since Last Overhaul</i>	<i>Action</i>
3 Sep 2019	1788.1	Overhauled at California Aero Components (CAC), work order 4940. The record of inspection and work completed stated the following: • Outer race (PN 369A5352-5 SN 005570-0474) splines worn beyond book limits – installed new outer race (SN 5304-10044) • Sprag cage (PN 369D25351 SN 7879) worn beyond book limits and no info on hook times – installed new sprag assembly (PN369D25351 SN 9898) • Bearing balls (PN 369A5361) scored – installed new bearing (PN 369A5361) • Bearing (PN 369A5362) spins rough – installed new bearing (PN 369A5362) • Spacer sleeves (PN 369A5367) received scored – installed new spacer sleeves
6 Jan 2020	0	Installed on Jack Harter Helicopters (JHH) aircraft SN 0454E at 17255.8 airframe hours
8 April 2022	1754.5	Removed from aircraft at 19010.3 airframe hours by JHH. Records include note that states, “requires overhaul.”
12 May 2022	1754.5	Overhauled at CAC, work order 9124. The record of inspection and work completed stated the following: • Bearing (PN 369A5362) received spalling – installed new bearing • Sleeve spacer (PN 369A5367) received with OD scored – installed new sleeve spacer • Sprag assembly (PN 369D25351 SN9898) received with cages scored – installed new sprag assembly (PN 369D25351 SN 10319)
15 April 2023	0	Installed 15 April 2023 on JHH aircraft SN 0020E at 22472.4 airframe hours
8 July 2024	1475.3	Removed from aircraft at 24272.4 airframe hours by JHH. Records include note that states, “suspect upper bearing outer race wear.” Disassembled by JHH, removed inner race (PN 369A5353-3) for serviceable transfer.

4 Examination

Figure 1 shows an exploded parts diagram of the overrunning clutch, clipped from the manufacturer overhaul manual. The part numbers for the components shown are listed in Figure 2.

Figure 3 and Figure 4 show the overrunning clutch components as received at RJW.

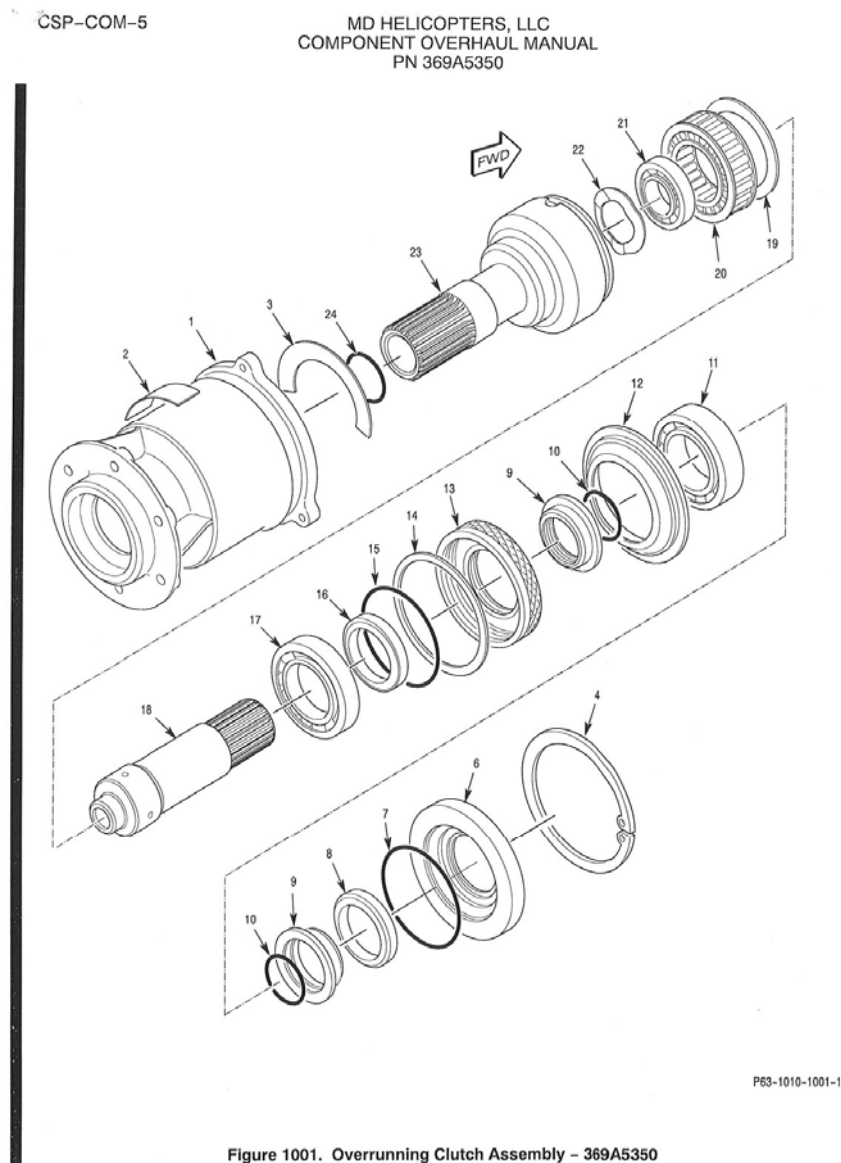


Figure 1001. Overrunning Clutch Assembly - 369A5350

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Figure 1 - Exploded parts diagram of the overrunning clutch assembly, taken from the manufacturer's overhaul manual

CSP-COM-5 MD HELICOPTERS, LLC COMPONENT OVERHAUL MANUAL PN 369A5350									
I L Fig. L No. No.	Item No.	Part Number	Description	Qty. per Assy.	Used on Code	Model / Serial No. From - To			
1001	1	369A5350-603	Overrunning Clutch Assembly Ref. CSP-IPC-4, Chapter 71, for NHA	REF	A	D 0001-SUBS E 0001-00439 FF 0001-00081			
	2	369A5350-605	Overrunning Clutch Assembly Ref. CSP-IPC-4, Chapter 71, for NHA	REF	B	E 0040-SUBS FF 0002-SUBS FF 0002-SUBS			
	1	369A5351-5	• Housing, Clutch Main (Aluminum)	1					
	2	369A5369-BSC	• Plate, Overrunning Clutch Identification Replaced by 369A5369-3	REPL	A				
	2	369A5369-3	• Plate, Overrunning Clutch Identification Replaced by 369A5369-5	REPL	B				
	2	369A5369-5	• Plate, Overrunning Clutch Identification Replaces 369A5369-BSC	1					
	3	369A5370-BSC	• Plate, Overrunning Clutch Contoured Identification (Aluminum) Replaces 369A5370-3	REPL					
	3	369A5370-3	• Plate, Overrunning Clutch Contoured Identification (Aluminum) Replaced by 369A5370-5	REPL					
	3	369A5370-5	• Plate, Overrunning Clutch Contoured Identification (Aluminum) Replaces 369A5370-BSC	1					
	4	M5002-315	• Ring, Retaining	1	B				
	5	369A5350-51	• Sub-Assembly, Clutch (Preferred Part)	1		E 0018-SUBS FF 0002-SUBS			
	5	369A5350-41	• Sub-Assembly, Clutch (Preferred Part) Replaces 369A5350-51	ALTN		D 0147-SUBS E 00324-00518 FF 00070-00091			
	5	369A5350-11	• Sub-Assembly, Clutch Replaced by 369A5350-21	REPL	A				
	5	369A5350-21	• Sub-Assembly, Clutch Replaced by 369A5350-31	REPL		D 0001-01226 E 0001-00210 FF 0001-00041			
	5	369A5350-31	• Sub-Assembly, Clutch Replaced by 369A5350-41	REPL	A	D 0127-01346 E 0002-SUBS FF 00042-00069			
	6	369A5366-BSC	• Retainer, Overrunning Clutch Bearing (Aluminum)	1					
	7	M832481-035	• O-Ring	1					
	8	369A5368-BSC	• Seal, Overrunning Clutch Oil Use with Item 5, 369A5350-11	1	A				
	8	369A5368-3	• Seal, Overrunning Clutch Oil Use with Item 5, 369A5350-31 / -41 / -51	1					
	9	369A5367-BSC	• Sleeve, Spacer Bearing (Corrosion-Resistant Steel)	2					
	10	M832481-026	• O-Ring	2					
	11	369A5361-BSC	• Bearing, Overrunning Clutch Ball Output	1					
	12	369A5355-BSC	• Carrier, Overrunning Clutch Bearing (Aluminum)	1					

CSP-COM-5 MD HELICOPTERS, LLC COMPONENT OVERHAUL MANUAL PN 369A5350									
I L Fig. L No. No.	Item No.	Part Number	Description	Qty. per Assy.	Used on Code	Model / Serial No. From - To			
1001	13	369A5365-BSC	• Nut, Bearing Retainer (Aluminum) Use with Item 5, 369A5350-11 / -21 / -31	1					
	13	369A5365-3	• Nut, Bearing Retainer (4340 Steel) Use with Item 5, 369A5350-41 / -51	1					
	14	369A5358-BSC	• Washer, Lock (4130 Steel)	1					
	15	M832481-141	• O-Ring	1					
	16	369A5368-BSC	• Seal, Overrunning Clutch Oil	1					
	17	369A5362-BSC	• Bearing, Overrunning Clutch Forward Sprag Ball	1					
	18	369A5353-BSC	• Race, Clutch Inner (9310 Steel) Use with Item 5, 369A5350-11 / -21 / -31	1					
	18	369A5353-3	• Race, Clutch Inner (4130 Steel) Use with Item 5, 369A5350-41 / -51	1					
	19	369A5360-BSC	• Washer, Spacer (4130 Steel)	1					
	20	369A5364-BSC	• Spring Assembly, Clutch Replaced by 369D2531-BSC	REPL					
	20	369D2531-BSC	• Spring Assembly, Overrunning Clutch Use with Item 5, 369A5350-31 / -41 / -51	1					
	21	369A5303-BSC	• Bearing, Overrunning Clutch Alt Sprag Ball	1					
	22	W1593-018	• Washer, Wave Use with Item 5, 369A5350-51	1					
	23	369A5352-BSC	• Race, Clutch Outer Use with Item 5, 369A5350-11 / -21 / -31 / -41	1					
	23	369A5352-5	• Race, Clutch Outer Use with Item 5, 369A5350-51	1					
	24	MS29561-017	• Packing, Preformed	1					

CSP-COM-5

MD HELICOPTERS, LLC
COMPONENT OVERHAUL MANUAL
PN 369A5350

CSP-COM-5

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PN 369A5350

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Figure 2 – Part numbers corresponding to parts illustrated in Figure 1, taken from the manufacturer's overhaul manual

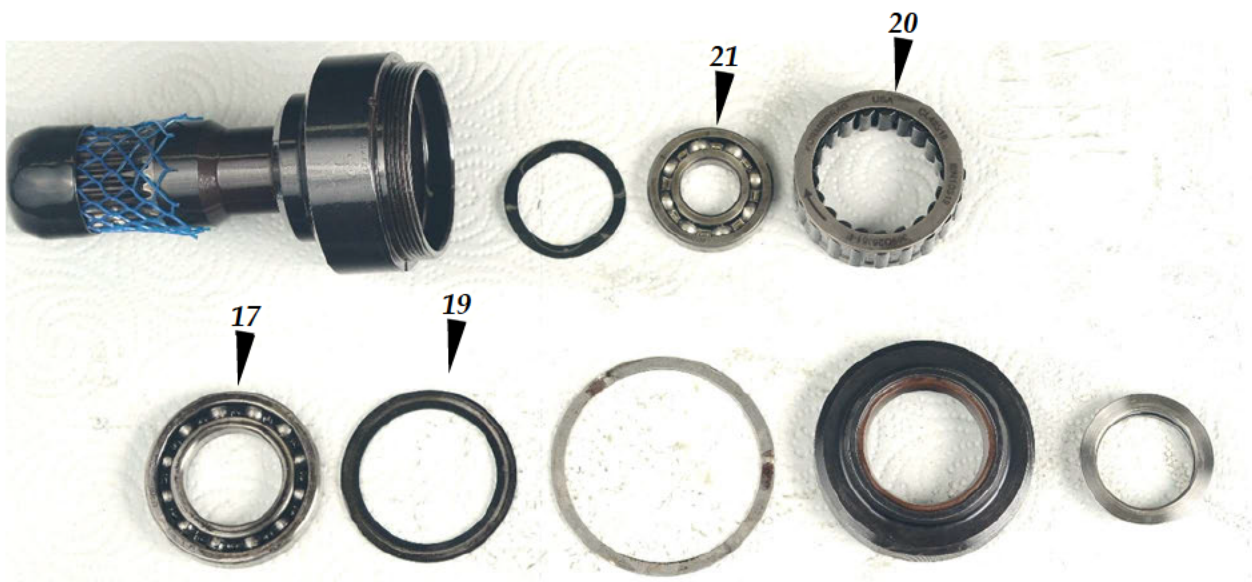


Figure 3 – Overrunning clutch sub-assembly

4.1 The outer race did not show any damage

Measurement of the outer race bore dimensions showed that they remained within the tolerances stated in the overhaul manual. No scoring or other damage was observed on the bore surfaces. Wear was observed on the outer race splines. The outer race spline dimensions were not measured.

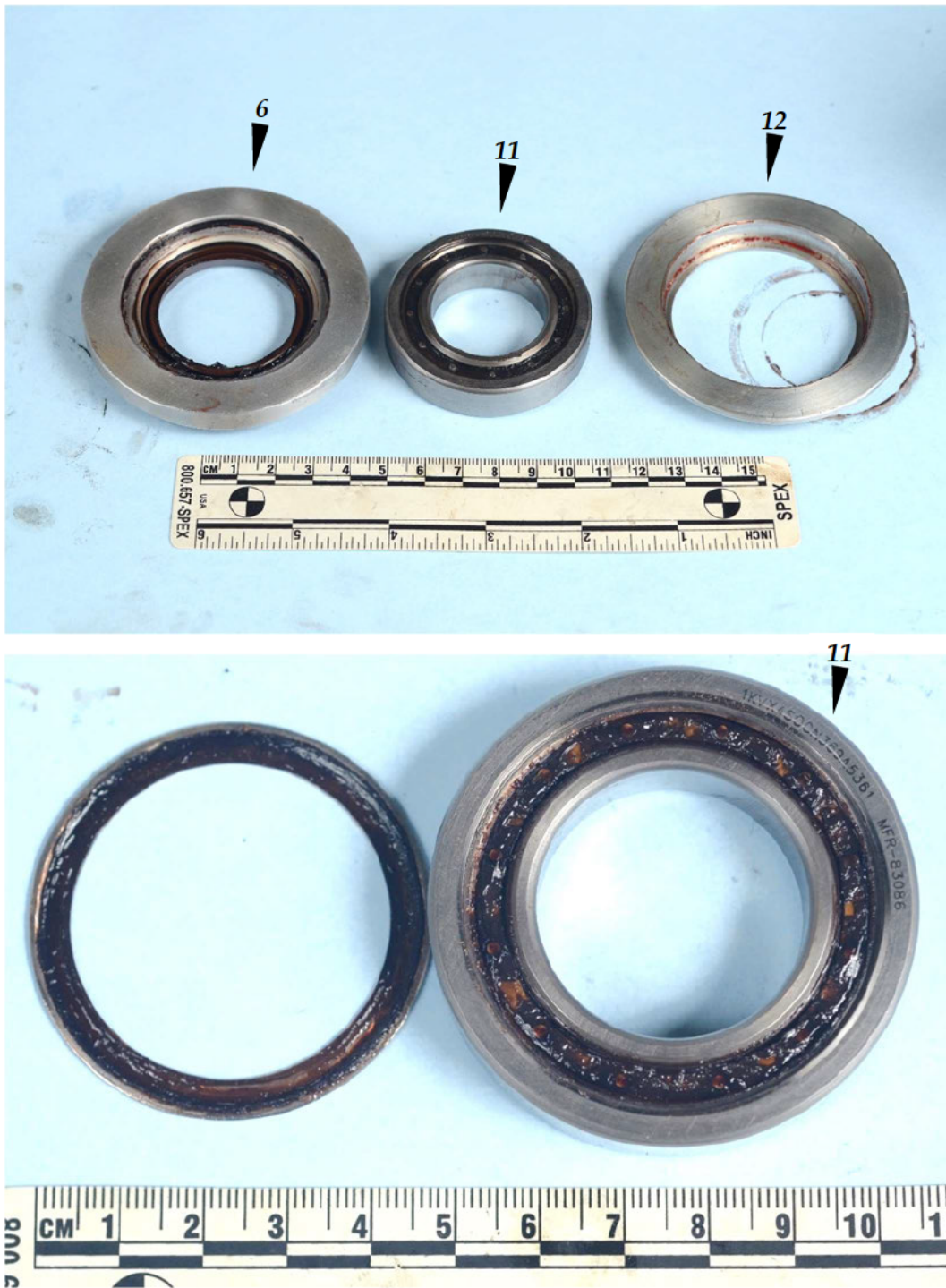


Figure 4 – Outer bearing retainer, outer bearing, and outer bearing carrier, and – items 12, 6, and 6 in Figure 1, PNs 369A5366-BSC, 369A5361-BSC, and 369A5355-BSC respectively.

4.2 Visual examination of the sprag clutch assembly revealed wear that was beyond the allowable limits in the overhaul manual.

Figure 5 shows a photograph of the sprag clutch assembly after ultrasonic cleaning in solvent (acetone). The part number and serial number, visible in the photograph, agreed with the records provided (PN 369D25351-BSC, SN 10319).

Closer examination of the sprag assembly showed heavy wear on the cage, well beyond the 0.102 mm or 0.004 in maximum depth stated in Table 503 of the overhaul manual. Figure 7 and Figure 8 show a photograph and an optical microscope image of the wear on the cage.

The sprags showed wear, especially noticeable on their inner load surfaces. One sprag showed flaking of the Formchrome surface treatment. See Figure 9.

The sprags had freedom of movement and there was no binding. No corrosion was observed. The retainer springs were sound and there were no chips or cracks in the components. However, the assembly was worn beyond serviceable limits.

The spacer/washer – item 19 in Figure 3, 369A5360-BSC – was scored on its surface (see Figure 6). Similar scoring was observed on the contacting face of the sprag cage (see Figure 5). This was consistent with relative movement between the parts in the presence of wear debris.



Figure 5 - Sprag Assembly, part number 369D25351-E (BSC)



Figure 6 – Spacer/washer, part number 369A5360-BSC



Figure 7 - Wear on sprag cage

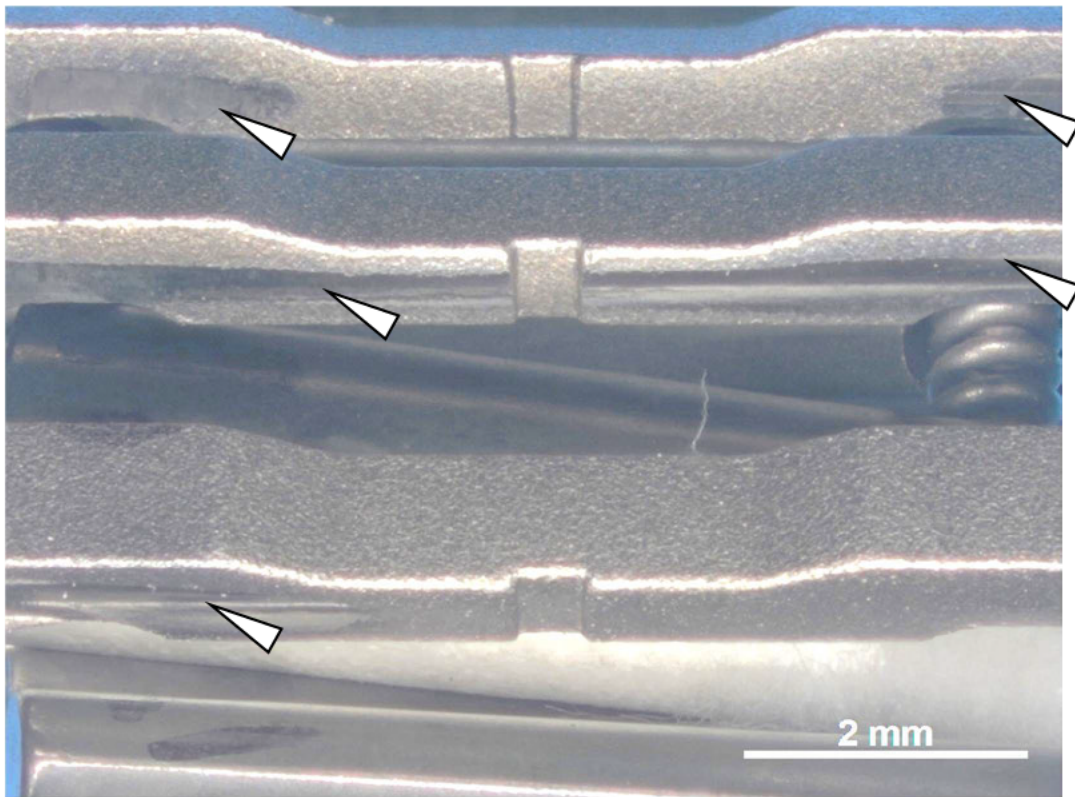


Figure 8 - Optical microscope image of wear on sprag clutch cage (indicated)



Figure 9 - Sprag assembly, showing flaking of the Formchrome surface treatment on one of the sprags, and wear on sprag load areas.

4.3 All three bearings turned freely and smoothly

The overrunning clutch ball bearings – items 17 and 21 in Figure 3 and item 11 in Figure 4 – turned freely and smoothly. They did not have excessive play.

Examination of the outer bearing retainer and outer bearing carrier – items 6 and 12 in Figure 4 – did not reveal evidence of the bearing “spinning” in as suspected by JHH. Similarly, the output bearing outer surface did not show evidence of relative movement between the bearing outer ring and the carrier and retainer.

4.4 EDS Analysis of Metallic Debris in Sprag Clutch Oil

The samples of used sprag clutch oil extracted by JHH were passed through a fine filter and washed with acetone. The washed debris were then analyzed using Energy Dispersive X-ray Spectroscopy (EDS) in a scanning electron microscope (EDS) for elemental composition. A representative X-ray energy spectrum is shown in Figure 10. The micron-scale debris consisted of copper, iron, and chromium. These elements were present in the bearing components. Other elements detected included calcium, silicon, and aluminum, which were likely present as dust (contamination).

It was concluded that the metallic debris were wear particles from the sprag clutch components.

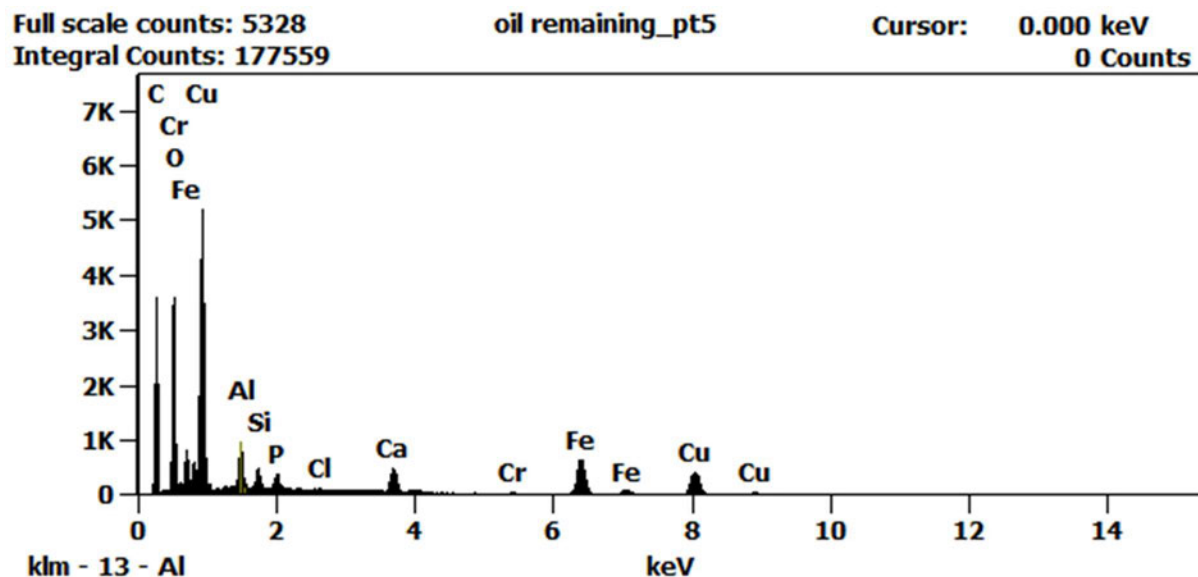


Figure 10 - Representative X-ray energy spectrum for debris found in sprag clutch oil

4.5 FTIR analysis of the darkened grease from the overrunning clutch output ball bearing did not indicate overheating of the lubricant

As can be seen in Figure 4, the grease in the output bearing (PN 369A5361-BSC) was dark, with a brown colour rather than the expected red colour of Mobil 28 grease. The discolouration of the grease led JHH to suspect overheating in the bearing.

The used grease from the output bearing was analyzed using absorbance total reflection Fourier transform infrared (ATR-FTIR) spectroscopy. A sample of fresh Mobil 28 grease was also analyzed for comparison. Additionally, samples of Mobil 28 grease heated for 2 hours at 225 °C and 250 °C were analyzed. The infrared (IR) absorbance spectra thus obtained are shown in Figure 11.

Over-heating and consequent oxidation of the grease would be expected to produce changes to the IR absorbance spectrum in the 1500 cm⁻¹ to 1750 cm⁻¹ wavenumber range. These changes can be observed in Figure 11, in the spectra for the samples of grease heated to 225 °C and 250 °C – compare these to the spectra for the fresh grease. There was no similar change in the spectra for the sample of used grease collected from the overrunning clutch output bearing. The FTIR analysis results did not indicate oxidation of the used grease from the overrunning clutch bearing.

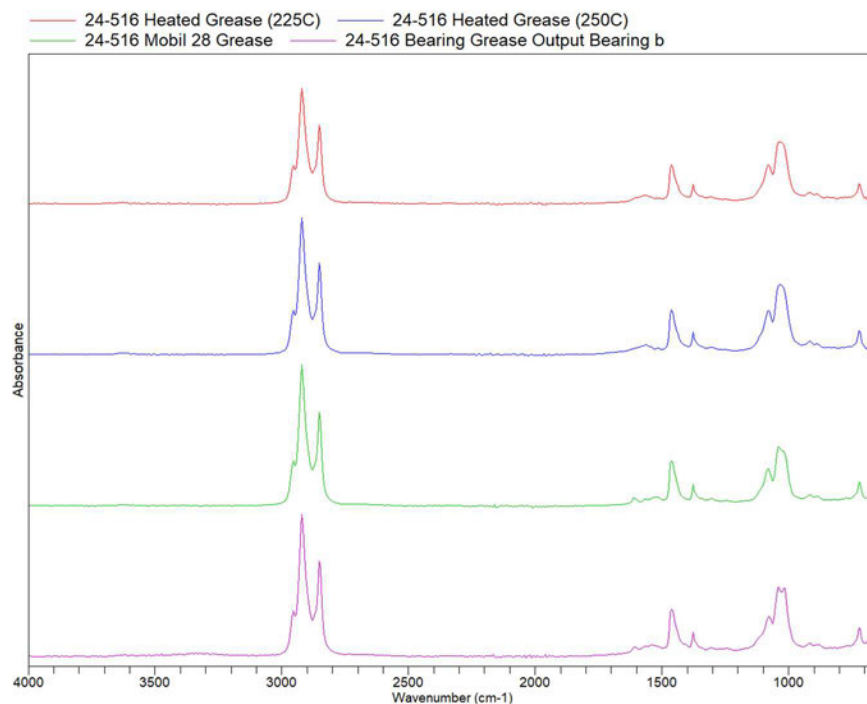


Figure 11 – FTIR analysis results (IR absorbance spectra)

Violet: Used grease sample from overrunning clutch output bearing

Green: New Mobil 28 grease

Blue: New Mobil 28 grease heated to 225 °C for 2 hours

Red: New Mobil 28 grease heated to 250 °C for 2 hours

4.6 Internal Examination of Output Bearing Showed Evidence of Rolling Fatigue
To further investigate the darkening of the output bearing grease, the bearing was cut open to allow examination of its rolling surfaces.

The bearing rolling surfaces showed wear patterns showing “pear skinning” and flaking/spalling. The flaking remained in its initial stage. Figure 12 through Figure 14 show scanning electron microscope images of the rolling surface on the outer ring of the outer bearing. The appearance of the worn surface and the flaking were typical of rolling contact fatigue. Rolling contact fatigue often appears at the end of the bearing life but can occur prematurely under excessive loads.

It was further observed that the bearing wear pattern was axially offset to one side of the ball path on the outer rings. This indicated the presence of an axial load on the bearing.

There were no visual indications of the bearing overheating (discolouration).

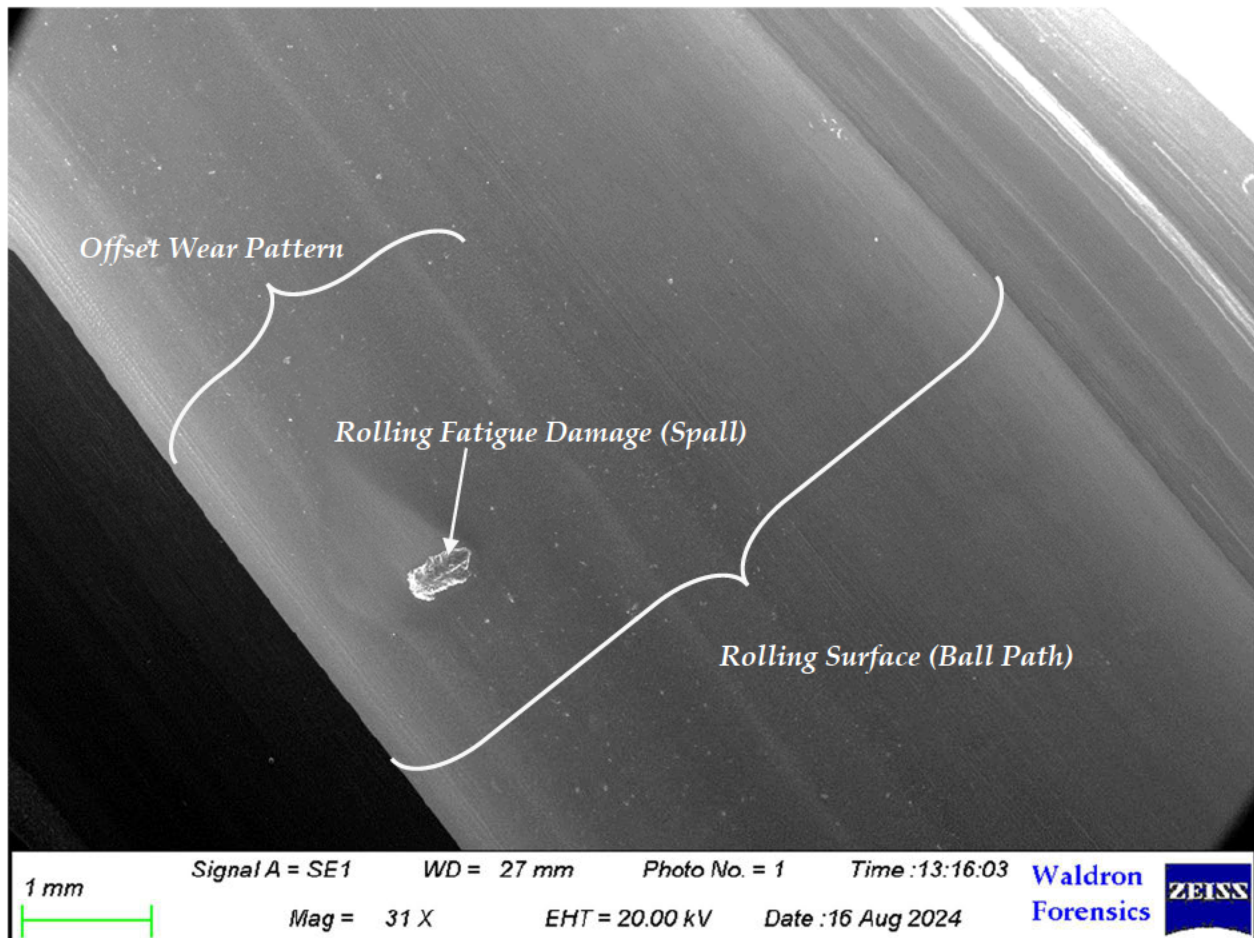


Figure 12 – Scanning Electron Microscope of Outer Bearing Outer Ring Running Surface

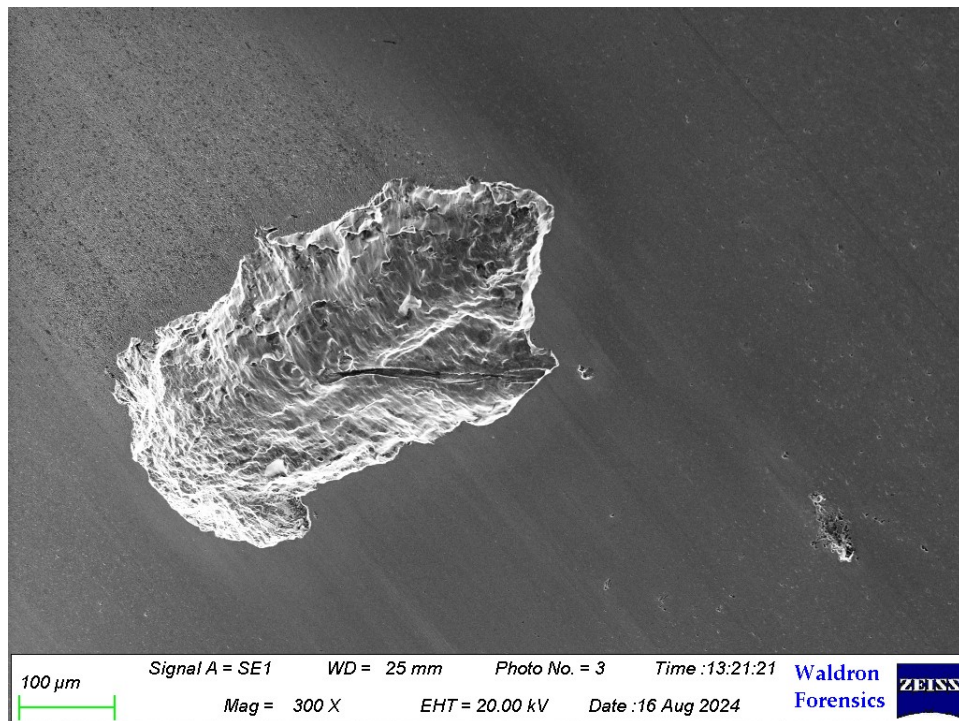


Figure 13 – Higher magnification of rolling fatigue flake/spall found on the outer ring ball path of the output bearing

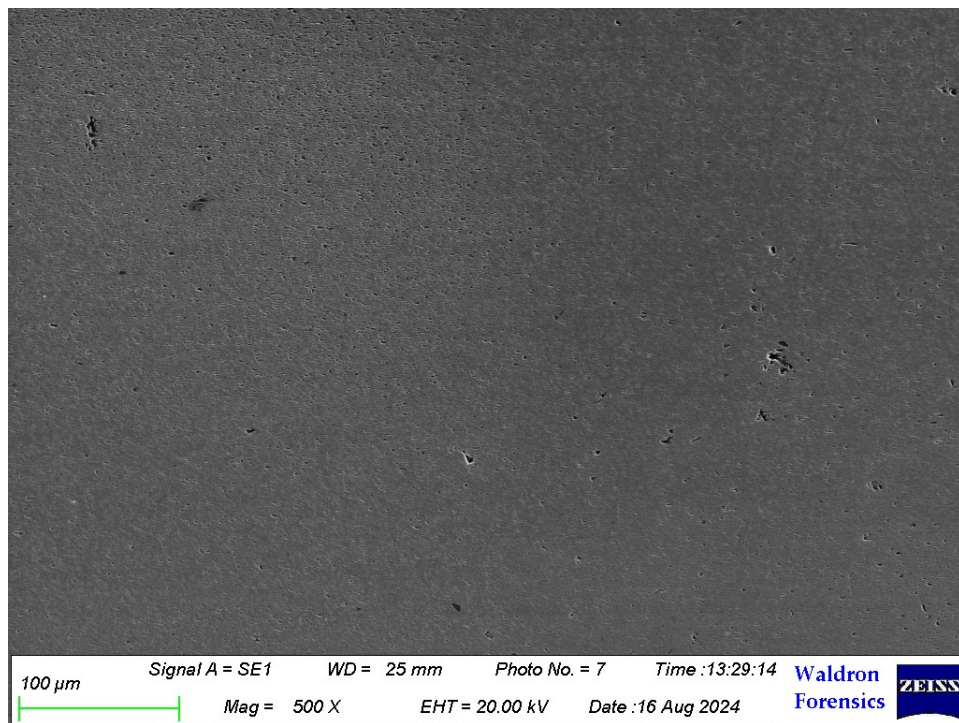


Figure 14 – High magnification image of the surface in the worn area of the outer ring ball path of the output bearing

5 Summary and Conclusions

My observations can be summarized as follows:

- The outer race (PN 369A5352-5 5570-0474) did not appear worn. The outer race bore dimensions were within tolerances stated in the MD Helicopters overhaul manual.
- The sprag assembly (PN 369D25351-BSC, SN 10319) showed wear beyond serviceable limits. Wear was greatest on the sprag cage.
- The spacer/washer separating the sprag assembly and the face of the sprag cage were scored, consistent with relative movement in the presence of debris.
- Metallic debris was present in the sprag clutch oil. EDS analysis showed that it was wear debris from the sprag clutch components as well as external contamination (dust).
- FTIR analysis of grease samples from the output bearing did not show evidence of oxidation normally associated with bearing overheating. The bearing itself had no visual indications of overheating.
- Examination of the output bearing and the output bearing retainer and carrier did not reveal any visible evidence of the bearing “spinning” in the retainer/carrier.
- Visual and microscopic examination of the output bearing running surfaces (balls, inner and outer rings) showed evidence of rolling fatigue, including “pear skinning” flaking/spalling.
- The wear pattern on the output bearing outer ring was offset to one side, indicating the presence of an axial load.

To conclude:

- I found no evidence of “spinning” or overheating in/on the output bearing.
- Darkening of the overrunning clutch oil was associated with wear debris generated in the clutch components, including the sprag clutch cage, and possibly the bearings.
- Darkening and discolouration of the output bearing grease was associated with wear debris from the output bearing.
- The output bearing was at end of life, with evidence of rolling fatigue including spalling and pear skinning. Rolling fatigue is not unusual at the end of the bearing life, however it can occur prematurely under excessive service loads.