AIRCRAFT ACCIDENT REPORT

BHNL/2015/08/12/F

Accident Investigation Bureau

Report on the Accident involving Bristow Helicopters (Nig.) Limited Sikorsky S-76C+ helicopter, Registration 5N-BGD at Latitude 6°31'54" N and Longitude 3°26'16" E, Oworonsoki, Lagos, Nigeria on 12th August, 2015

This report was produced by the Accident Investigation Bureau (AIB), Murtala Muhammed Airport, Ikeja, Lagos.

The report is based on the investigation carried out by the Accident Investigation Bureau, in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Civil Aviation Act 2006, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2016.

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of aircraft accident/serious incident investigations to apportion blame or liability.

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Accident Investigation Bureau believes that safety information is of great value if it is passed on for the use of others hence, readers are encouraged to copy or reprint for further distribution, acknowledging the Accident Investigation Bureau as the source.

Safety Recommendations in this report are addressed to the Regulatory Authority of the State (NCAA). This Authority ensures enforcement.

Printed in Nigeria for the Accident Investigation Bureau (AIB)

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accident Investigation Branch
AIB	Accident Investigation Bureau (The Bureau)
ATC	Air Traffic Controller
ATPL	Air Transport Pilot Licence
BATS	BGI Aviation Technical Services
C of A	Certificate of Airworthiness
CPL	Commercial Pilot Licence
CVR	Cockpit Voice Recorder
FAAN	Federal Airport Authority of Nigeria
FDR	Flight Data Recorder
ILS	Instrument Landing System
LOS	Lagos
MMA	Murtala Muhammed Airport
NAMA	Nigeria Airspace Management Agency
NCAA	Nigerian Civil Aviation Authority
NEMA	National Emergency Management Agency
PF	Pilot Flying
PM	Pilot Monitoring

QNH	Airfield Pressure corrected for sea level
VFR	Visual Flight Rules
VOR	Very High Frequency Omni-directional Range
WILCO	Will Comply

Aircraft Accident Report No.:	**BHNL/2015/08/12/F**
Registered Owners and Operator:	Bristow Helicopters Nig. Ltd
Models:	Sikorsky S-76C+
Manufacturers:	Sikorsky Aircraft Corporation, USA
Dates of Manufacture:	2003
Registration Number:	5N-BGD
Serial Numbers:	760540
Location:	Lat: 6° 31' 54" N and Long: 3° 26' 16" E, Oworonsoki, Lagos
Date and Time:	12th of August, 2015 at about 15:31hrs. *All times in this report are local time, equivalent to UTC+1 unless otherwise stated*

SYNOPSIS

Accident Investigation Bureau (AIB) was notified of the accident by the Nigerian Civil Aviation Authority (NCAA) at about 16:15hrs on 12th of August, 2015. Investigators were dispatched to Oworonsoki area of Lagos immediately. All relevant authorities were notified.

5N-BGD departed SEDCO Express oil rig at about 14:55hrs on 12th August, 2015 with 12 persons on board including two crewmembers and an endurance of one hour and thirty minutes maintaining 3,000 ft. The estimated arrival at Murtala Muhammed Airport (DNMM), Lagos was 15:36hrs according to the crew information before departure from the rig.

At about 15:31hrs, 5N-BGD, Sikorsky S-76C+, a domestic charter flight operated by Bristow Helicopters (Nig.) Limited, crashed into the Lagoon at Oworonsoki area of Lagos. Visual meteorological conditions prevailed at the time and a VFR flight plan was filed.

PThe helicopter experienced sudden uncommanded pitch up, yaw, and roll for about 12 seconds until it impacted water at about 15:31hrs. The pilots were neither able to make any form of distress call to ATC, SEDCO Express rig nor communicate with the passengers before impact.

Rescue Operation was swift, prompt and carried out by local fishermen who were in the area. There were six fatalities, including two crew members and six seriously injured passengers. The crew members were recovered the following day.

The helicopter was destroyed but there was no post-impact fire.

The investigation identified the following causal and contributory factors:

Causal Factor

The separation of the Forward Servo Clevis Rod Assembly from the bearing and Jam nut (Bell Crank Assembly) which is part of the Cyclic Control System responsible for stabilizing the attitude of the helicopter made the aircraft uncontrollable.

Contributory Factors

1. The absence of a secondary mechanical locking system (lock-pin or wire-lock) in the design of the Forward Servo Input Control Rod assembly contributed to the separation of the Forward Servo Clevis Rod from the bearing and Jam nut.

2. The wear that was prevalent at the forward servo clevis rod end fitting shank made the Jam nut rotate freely when force is applied.

One Safety Recommendation was made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 12th August, 2015 5N-BGD, Sikorsky S-76C+, a domestic charter flight operated by Bristow Helicopters (Nig.) Limited, on a round trip flight that originated from Lagos to an offshore SEDCO Express oil rig with two passengers and two crew on board. This was the first flight of the day; the helicopter did not re-fuel at the rig for the trip back to Lagos. Visual meteorological conditions prevailed at the time and a VFR flight plan was filed. The mobile drilling platform was located at Latitude 05° 40.9' N; Longitude 004° 23.56' E, and 85NM from Lagos.

5N-BGD departed SEDCO Express at about 14:55hrs with twelve persons on board including two crew members and an endurance of one hour thirty minutes. The helicopter was maintaining 3,000 ft and estimating Lagos at 15:36hrs. The Captain was the Pilot Flying (PF) while the First Officer was the Pilot Monitoring (PM).

The helicopter reported approaching 1,000 ft and estimating the field at 15:35hrs with 12 persons on board and an endurance of one hour plus ten minutes. The helicopter was cleared to 1,000 ft and to report field in sight.

At 15:30:19hrs, the helicopter reported field in sight. At 15:30:23hrs, the Tower instructed the pilot to report left downwind for runway 18L. The pilot acknowledged at 15:30:25hrs and that was the last transmission between the Tower and the crew.

The Flight Data Recorder indicated that at 1,000 ft and 120Kts, the helicopter experienced sudden uncommanded pitch up, yaw, and roll for about 12 seconds until it impacted the Lagoon at Oworonsoki area of Lagos at about 15:31hrs at GPS coordinate of Latitude 6° 31' 54" N and Longitude 3° 26' 16" E.

The two crew members and four of the ten passengers were fatally injured. The helicopter was destroyed and there was no fire outbreak.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	2	4	6	Nil
Serious	Nil	6	6	Nil
Minor	Nil	Nil	Nil	Nil
None	Nil	Nil	Nil	Nil
Total	2	10	12	Nil

1.3 Damage to Aircraft

The helicopter was destroyed.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Pilot Flying (Captain)

Nationality: American

Gender:	Male
Age:	37 years
Licence No.:	5419 ATPL (H)
Aircraft Ratings:	B206, B407, S76
Instrument Rating Validity:	17th September, 2015
Proficiency/ Recurrent Checks:	17th September, 2015
Medical Validity:	24th October, 2015
Total Flying Experience:	5,406:36hrs
On Type:	1,077:45hrs
Last 90 days:	112:10hrs
Last 28 days:	50:50hrs
Last 24 hours:	05:50hrs

1.5.2 Pilot Monitoring (First Officer)

Nationality:	Nigerian
Age:	26 years
Gender:	Male
Licence No.:	6617 CPL (H)
Aircraft Rating:	S76

Instrument Rating Validity:	15th May, 2016
Proficiency/Recurrent Checks:	15th November, 2015
Medical Validity:	31st March, 2016
Total Flying Experience:	808hrs
On Type:	570hrs
Last 90 days:	107:00hrs
Last 28 days:	35:20hrs
Last 24 hours:	04:00hrs

1.6 Aircraft Information

1.6.1 Aircraft Data

Type:	S-76C+
Serial No:	760540
Manufacturer:	Sikorsky Aircraft Corporation, USA
Year of Manufacture:	2003
Airframe time:	10,258:09hrs
Cycles:	Not Available

A-Check (50hrs) was carried out on the 10th of August, 2015 on the aircraft.

1.6.2 Engines

Engine Model: Turbomeca Arriel 2SI

No. 1

Serial No.: 20737TEC

Hours: 6414:37

Cycles: 7097((N1)/5313.2(N2))

No. 2

Serial No.: 20745TEC

Hours: 5815:49

Cycles: 5998.1((N1)/5235.3(N2))

Type of Fuel: Jet A1

1.6.3 Main Rotor

Main Rotor	**No. 1**	**No. 2**	**No. 3**	**No. 4**
Type	S-76C+	S-76C+	S-76C+	S-76C+
Serial No.	A086-03794	A086-04116	A086-00826	A086-03572
Time Since Overhaul	3814.45	2140.74	2950.47	4863.72

1.6.4 Tail Rotor

Tail Rotor	**No 1**	**No 2**
Type	S76C+	S76C|+
Serial No.	A245-00768	A245-00848
Total Rotor Hours	4204	4319.43

1.6.5 Forward Servo Clevis Rod Assembly and Bellcrank Assembly

Forward Servo Clevis Rod Assembly is part of the Cyclic Control System, which is responsible for stabilizing the attitude of the helicopter; the other servos are Aft Servo and Lateral Servo. These are all hydraulic servos that help move linkages to change blade pitch angles in the main and tail rotors.

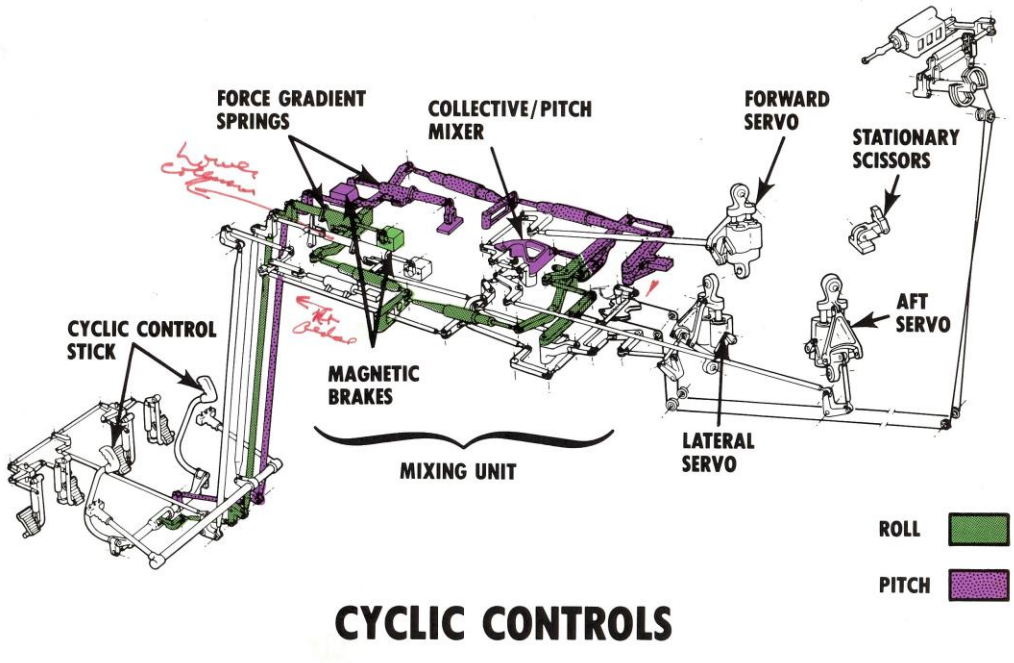

Figure 1: Cyclic controls

1.6.5 S-76 Maintenance

Maintenance actions that may involve Servo Clevis rod Assemblies removal or manipulation of pushrod length

- Main rotor rigging (either full or quick rigging)
- Flight control replacement (bell cranks, pushrods, push-pull tubes, rod ends)
- Main gearbox replacement
    - Last done on 3/9/2015, about 414 hours prior to accident.
- Primary servo (forward, lateral, aft) replacement
    - Aft and lateral servos were replaced coincident with main gearbox replacement (414 hours prior to accident).
    - Forward servo was not replaced during main gearbox replacement, and had been installed for about 1300 hours prior to accident.
- AFCS servo (trim and SAS servo) replacement
- PDTA (pedal damper/trim actuator) replacement

Scheduled inspections and maintenance actions that may allow for inspection of the pushrod

- 300-hour inspection
- 600-hour inspection
- 1500-hour inspection
- 12-month inspection
- Rotating scissors shimming (one of the side panels needs to be removed for this)

It was clear that during the Main Gearbox Replacement on the 9th March, 2015, the forward and aft servo clevis rods assemblies and associated bell crank assemblies were removed and replaced, this replacement was also at the 2 Year Inspection (C2Y).

The Engineers that performed the MGB replacement were invited for interview to ascertain their qualification and how the job was done according to the S-76 Main Gearbox Replacement Worksheet on Bristow Form No. S76/01 Issued 03/14.

1.7 Meteorological Information

Time:	1430 UTC
Wind:	200/09 KTS
Visibility:	10km
Weather:	NIL
Cloud:	Broken 360M
Temp./Dew point:	$29/22^0$ C
QNH:	1015hPa
Trend:	No Significant Weather

1.8 Aids to Navigation

ILS RWY 18L/18R	Serviceable
LAG VOR/DME	Serviceable

1.9 Communications

There was good communication between the aircraft and the tower before loss of contact. VHF 118.1 MHz Tower, 124.7MHz Radar and 121.9 MHz Lagos Ground were all serviceable at the time of the accident.

1.10 Aerodrome Information

The aerodrome doubles as both local and International Airport, with parallel runways 18L/36R and 18R/36L, it has 2,745m by 45m and 3,900m by 60m in length and width respectively, with an elevation of 135 feet; coordinates of N06 34.7, E003 19.4.

1.11 Flight Recorders

The Helicopter was fitted with a Solid-State Combined Cockpit Voice Recorder/Flight Data Recorder (CVR/FDR) and an additional separate CVR. The recorders were recovered in good condition from the Lagoon on the second day of the accident by professional divers, but the combined recorder had few punctures. The recorders were sent to Air Accident Investigation Branch (AAIB) UK for data download. During the download at the AAIB it was discovered that the combined Solid-State Voice/Flight Data recorder only contained information of the flight data while the separate Cockpit Voice Recorder contained audio data. However, they were both successfully downloaded and analysed.

The FDR plot indicates that the loss of cyclic control started 12 seconds before the helicopter impacted water.

Solid State Combined Voice/Flight Data Recorder

Model:	SCR 500-660
Part Number:	299402-0100
S/N:	02SRP156
Manufacturer:	British Aerospace System & Equipment (BASE)

Cockpit Voice Recorder

Model:	FA 2100
Part Number:	2100-1010-00
S/N:	000579228
Manufacturer :	L3 Communication

Figure 2: Solid-State Combined Voice/Flight Data Recorder

Figure 3: The Flight Recorders

Figure 4: Cockpit Voice Recorder

Figure 5: Flight Recorders immersed in fresh water for preservation

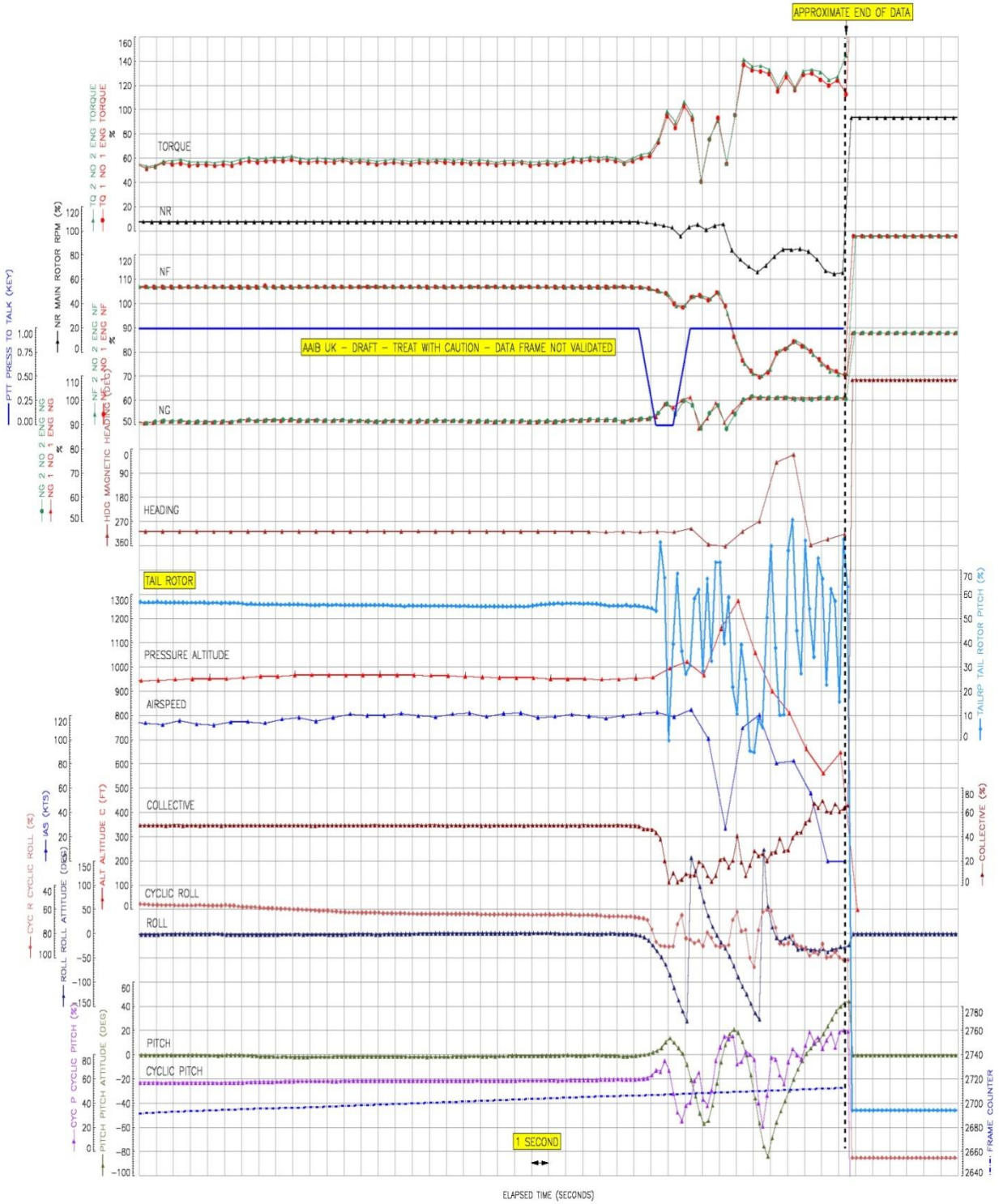

Figure 6: FDR Plot

1.12 Wreckage and Impact Information

The accident occurred in the shallow salty water of the Lagos Lagoon around Oworonsoki area with coordinates of Latitude 6° 31' 54" N and Longitude 3° 26' 16" E.

The wreckage scattered around the vicinity of the crash due to the impact forces with the water. The main wreckage was submerged except the destroyed floats that were hanging loose, still attached to the main wreckage that was visible on the surface of the Lagoon.

Figure 7: Helicopter Wreckage

Figure 8: The recovered parts being lifted onto the barge at the crash site

Figure 9: Parts of the destroyed tail rotor area

Figure 10: The Cockpit area of the wreckage

Figure 11: The crash site

1.13 Medical and Pathological Information

Toxicology test was not performed on the pilots since their remains were recovered the following day, due to the difficulties encountered by the local divers/rescue teams.

1.14 Fire

There was no fire outbreak.

1.15 Survival Aspects

Neither the crew nor the passengers had the opportunity to either inflate their respective life jackets or deploy the raft. The crew did not make a "MAY DAY" distress call, before the helicopter plunged/crashed into the salty waters, around Oworonsoki area of Lagos Lagoon at about 1531hrs. The crash site was at Latitude 6^{o} 31' 54" N and Longitude 3^{o} 26' 16" E.

According to eyewitness accounts, the rescue was prompt since there were local fishermen around the crash vicinity. One of the survivors provided a graphic account of how he was pulled out of the water by a fisherman.

Six passengers were rescued alive and four fatalities recovered same day. The pilots' bodies were recovered the next day fatally injured.

National Emergency Management Agency (NEMA) led the rescue team. Lagos State Emergency Management Agency (LASEMA) and Lagos State Waterways Authority (LASWA) played an important role. Other agencies included: NCAA, NAMA, Nigerian Police, Nigerian Air Force, Marine Navy-International, Nigerian Army, Indigo Drilling, Maritime Organization/International Transport Fund (IMO/ITF), FRSC, Civil Defence

Corps, Bristow Helicopters, Nigerian Maritime Administration and Safety Agency (NIMASA), Department of Petroleum Resources (DPR), Kick Against Indiscipline (KAI), The Press, etc, gave necessary support. Julius Berger Nig. Ltd played a vital role in the wreckage recovery from the Lagoon.

NEMA initially sent the rescued passengers to Gbagada General Hospital and Afolabi Medical Centre for first aid while the deceased were deposited at the Mainland Hospital morgue. The six survivors were later transferred to St. Nicholas Hospital and they were being treated for various serious injuries and were responding to treatment.

1.16 Tests and Research

During the preliminary investigation, the Bureau discovered that the Forward Main Servo Input Control Pushrod Assembly which is also called Forward Servo Clevis Rod and Bell crank Assembly failed. The Control Pushrod tube separated from Control rod end with the bearing and the Jam nut. The Jam nut was loose and was not seating against the Control Rod. See Figures 12 and 13.

These items were quarantined and later sent to National Transportation Safety Board (NTSB) Laboratory, USA; preliminary metallurgical examination of the Forward Main Rotor Servo Input Control Pushrod revealed that the separation was a pre-impact condition. ***The full report is attached as Appendix A.***

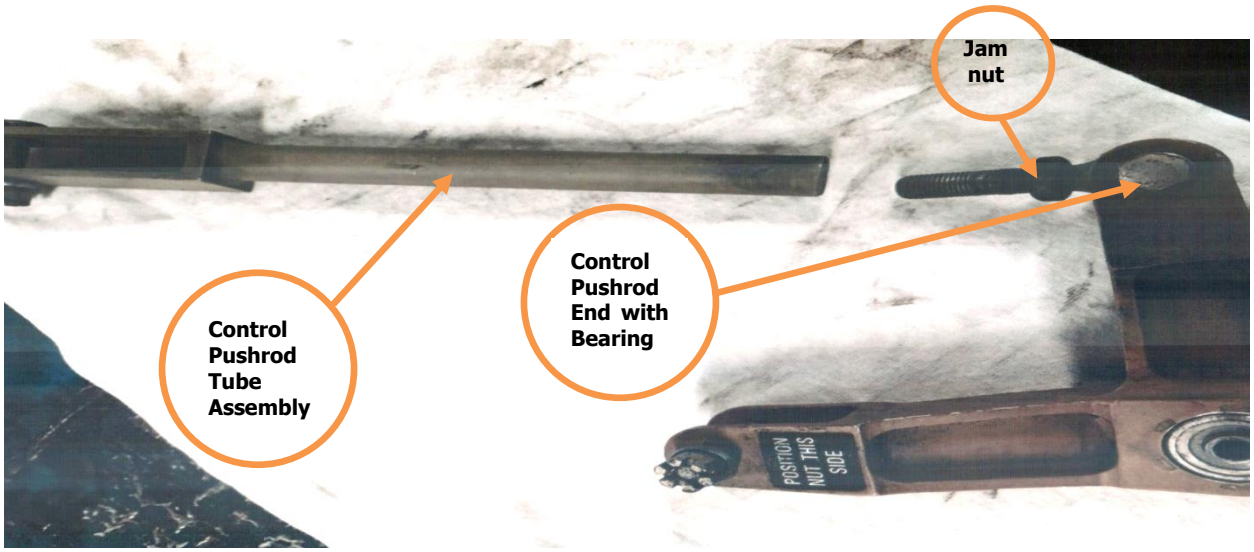

Figure 12: The control rod separated from bearing end and Jam nut

Figure 13: Control Pushrod tube separated from Control rod end with the bearing and the Jam nut (The separation of the Forward Servo Clevis Rod Assembly from the Bellcrank Assembly)

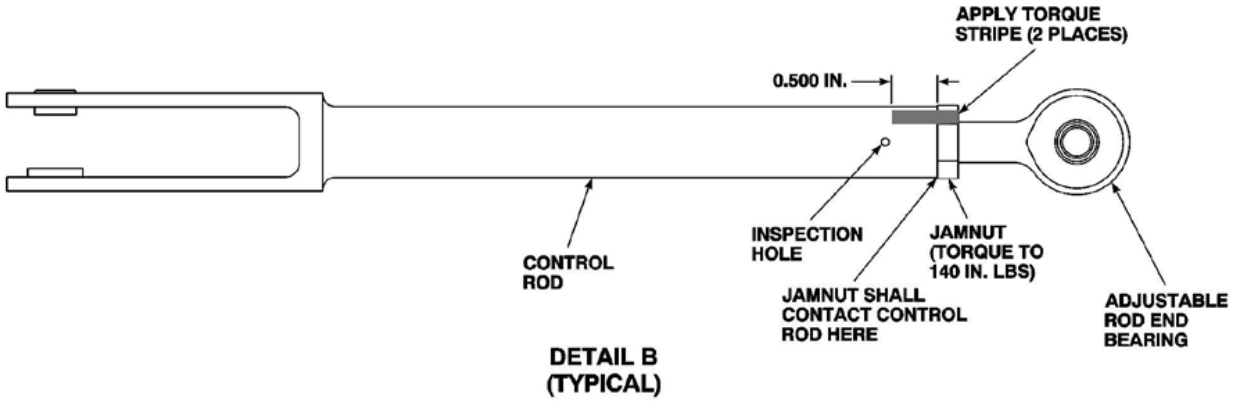

Figure 14: Control Pushrod Tube

The helicopter's engines were sent to the manufacturer's facility in France for examination. The results are available in sections 1.16.2

1.16.1 Pedal damper and Trim Actuator (PDTA)

The component was taken to Arkwin Industries in USA for analysis. The unit met the requirement of all tests performed. There was no reason to believe that the unit malfunctioned during flight. ***See Appendix B***.

1.16.2 Uncontained Engine damage

Field/Crash site examination of No. 2 Engine revealed damage associated with uncontained failure of internal components. The engines were sent to the manufacturer in France for detailed investigation with AIB investigators in attendance. ***See Fig. 15 below.***

Figure 15: Uncontained damage to Engine No. 2

1.16.2.1 Result of the Engine Teardown

1.16.2.1.1 Engine No. 1 Arriel 2S1 20737 Investigation

Particular findings during engine dismantling

- *Magnetic plugs: Nothing to report*
- *Module 1: Front engine attachment bent (screws broken and/or twisted). The splines of the coupling sleeve present tiny rubbing marks Torque meter shaft, nothing to report*
- *Module 2: No mechanical damage, presence of corrosion and salt.*
- *Module 3: No mechanical damage, presence of corrosion and salt. Presence of mineral debris downstream the HP turbine.*
- *Module 4: No mechanical damage, presence of corrosion and salt*
- *Module 5: Reduction gears seized by corrosion. Angular displacement of the nut in the over torque direction.*

Hydro Mechanical Unit (HMU) test on rig

- *Not applicable*

HMU disassembly

- *Considered as not necessary*

Conclusions

Engine Number 1 was in a general mechanical good condition. No anomaly found.

Most of the parts were found covered by corrosion due to stay in a salty water and the action of the ambient air since its recovery from the lagoon.

1.16.2.1.2 Engine No. 2 Arriel 2S1 20745 Investigation

Container opening

- *No seal presence*
- *No log book*
- *Transmission shaft put in the container*
- *Some broken blades found in the bottom of the container*

Engine main findings after container opening

- *Blade shedding confirmed*
- *Gas Generator seized*
- *Output shaft (Linked to Power Turbine seized)*
- *Bleed valve in open position*
- *Flector bent*
- *Exhaust distorted on its left side (internal side of the engine compartment)*

- *Impacts on the leading edge axial compressor blades*

Engine test on bench

- *Not applicable*

Particular findings during equipment removal

- *2 T4 probes wire cut*
- *Oil and fuel filters clogging indicator not visible*

Particular findings during engine dismantling

- *Magnetic plugs: MO5 magnetic plug: Fine dust (seems metallic) found;*
- *Module 1: Impact on the linking tube (rear part).Front engine attachment bent*

  (screws broken and/or twisted). Torque meter shaft, Angular displacement between reference and power shafts teeth. Spines of the transmission shaft (to the MGB) and spline of the coupling sleeve present rubbing marks.

- *Module 2: Axial compressor: Deep impacts on leading edge of the blades. Presence of parts of shell. No other mechanical damage, presence of corrosion and salt.*
- *Module 3: Centrifugal compressor and its diffuser: Some impacts on leading edge of the compressor and vanes of the diffuser. Presence of parts of shell. No othermechanical damage, presence of corrosion and salt.*
- *Module 4: Blade shedding phenomenon. All blades cut under the platform. Deep distortion of the free turbine support bearing. Important distortion of the containment shield. Free turbine disc complete and not damaged.*
- *Module 5: Module 5 casing has been found broken during its separation from the module 4. Angular displacement of the nut in the opposite at the over torque direction.*

Conclusions

- *Engine Number 2: The damage observed on the Modules 1, 2, 3, and 5, are consistent with an impact of the helicopter with the lagoon surface.*
- *Damage observed on the Module 4 are consistent with blade shedding phenomenon.*

Most of the parts were found covered by corrosion due to stay in salty water and then the action of the ambient air since its recovery from the lagoon.

1.17 Organizational and Management Information

1.17.1 Bristow Helicopters

Bristow Helicopters (Nig.) Limited, an affiliate of Bristow Group, is a player in the Nigerian oil and gas industry and has been in operation for more than 40 years. In the last eight years, Bristow Helicopters Nigeria ventured into deep-water helicopter services.

Bristow Helicopters operations include both the fixed wing and rotary wing; the company conducts all its operations in accordance with the approved NCAA Air Operators Certificate (AOC).

1.17.1.1 BGI Aviation Technical Services (BATS) Maintenance Organisation

BGI Aviation Technical Services (BATS) maintains Bristow Helicopters (Nig.) Limited aircraft. BGI Aviation Technical Services (BATS) is an Approved Maintenance Organisation (AMO) certified by NCAA.

With head office in G.R.A. Ikeja, Lagos, and a service office in the General Aviation Area of the Murtala Mohammed Airport, Ikeja, Lagos, which includes a fully equipped maintenance hangar and management offices, BATS provides aviation engineering and technical services to the Nigerian aviation market.

In addition, in Port Harcourt, the Company also owns a full maintenance hangar, in addition to its support facilities. BATS also operates from customer bases in Warri, Calabar, Eket, and Escravos.

Maintenance records revealed that BATS carried out work around the vicinity of the Main Servo area, during the S76 Main Gearbox (MGB) Replacement on the 9th of March, 2015. There were indications that, the Forward, Lateral and Aft Servo Clevis Rods and their Associated Bellcrank were removed during the replacement of the MGB.

However, in the course of the investigation, the discovery of the Control rod separation from the Bearing end and Jam nut of the Forward Servo Clevis Assembly and Bellcrank Assembly led to the decision taken by the Federal Aviation Administration (FAA) and Sikorsky Aircraft Corporation to issue Emergency Airworthiness Directives (EAD) and Alert Service Bulletin (ASB) respectively on the Main and Tail Rotor Servo Input Rod assembly as an interim safety action. This was to ensure the continued airworthiness and security of the assemblies. Bristow Helicopters Nig. Limited. had earlier issued two Technical Directives (TD) and three Alert Technical Directives (ATD) as interim safety actions. ***See Appendix C for details of the ASB, EAD, TDs and ATDs.***

1.17.2 Nigerian Civil Aviation Authority (NCAA)

The Nigerian Civil Aviation Authority (NCAA), in its role as the apex regulatory body, performs safety oversight on the activities of all Airlines, Approved Maintenance

Organisations, Airports, Airstrips, Heliports, Air Navigational Aids, Aviation Training Organisations and all Aviation personnel.

1.18 Additional Information

Four of the survivors gave the Bureau their various opinions/accounts of what they saw before, during, and after the crash. They were seated in all the rows available in the aircraft, one was sitting directly behind the captain, that is, on the first row, another was sitting in the middle row, the second sat on the left side of the aircraft, while the last two interviewed were seated in the last row, with one on the extreme end on the right hand side, while the other was seated on the second seat on the left hand side. Their accounts were similar as all of them asserted that the pilots did not talk to anybody but were seen trying to stabilize the aircraft before it plunged into the Lagoon.

One of the survivors, who gave a helping hand to another survivor, confirmed that "it all happened so fast".

Local fishermen were available for prompt rescue of the victims, and later helped in the recovery of crew personal belongings and some aircraft documents. However, professional divers were also engaged to recover the recorders and help in the recovery of the main aircraft wreckage.

The Local fishermen and other witness accounts were recorded as they all gave their various views of the accident.

The Police were in charge of security and controlling the crowd. The Police Station was used as the control centre for rescue team. Recovered items were first handed to the Police before they were handed over to the Bureau.

1.19 Useful or Effective Investigation Techniques

Nil.

2.0 ANALYSIS

2.1 The Crew

The crew were qualified to conduct the flight. There was no evidence of fatigue or any situation that could have impaired the safe operation of this flight. The nature of the accident made it almost impossible for the crew to salvage the aircraft. It took about 12 seconds from the beginning of the problem to impact with the Lagoon. The survivors (witnesses) confirmed seeing the crew trying to stabilize the aircraft before impact. The time available to the crew was not enough to do much before the aircraft impacted the Lagoon waters.

2.2 Forward Servo Clevis Rod and Bell crank or Main Rotor Servo Pushrod Assemblies

The cyclic control stick in the cockpit is where the input originates. The mixing unit, in the upper deck flight control compartment, combines all the pilot's control inputs and sends the appropriate output to the hydraulic servos that move the linkages to change blade pitch angles in the main and tail rotors.

The forward servo is connected to the collective/pitch mixer, which in-turn connects to the roll mixer in the mixing unit of the cyclic controls. These servos which control/move these linkages are effective as long as the hydraulic systems are not interrupted or all the servos are effectively in place.

However, the cause of this accident was the wear in the Forward Servo Clevis Rod end fitting shank found in the Main Rotor Servo Pushrod Assembly. The jam nut end fitting which fits into the rod end shank, rotated freely when turned by hand pressure. According to the Materials Laboratory Factual Report, the thread peaks at the middle

and upper end of the end fitting shank were smooth and rounded, consistent with wear. The wear was greatest near the middle of the shank on the outboard side of the end fitting and near the upper end of the shank on the inboard side of the threads. The Forward Servo Clevis Rod separated from the bearing and the Jam nut. The Jam nut was loose and was not seating against the Forward Servo Clevis Rod end. This situation made it impossible for inputs by the pilots to the cyclic control stick to be accepted or recognized by the mixing unit of the cyclic controls, which made the aircraft uncontrollable. Hence the display seen in the FDR plot, the aircraft displayed a continuous roll and pitch attitude problem for about 12 seconds before impacting the waters of the Lagoon; not giving the crew time to think out the problem or even an opportunity of making a MAY DAY call.

National Transportation Safety Board (NTSB) USA, Laboratory metallurgical examination of the Forward Servo Clevis Rod revealed that the separation was a pre-impact condition, that is, the separation existed before the impact and therefore, the cause of the accident.

2.3 BGI Aviation Technical Services (BATS)

BATS is charged with the maintenance of Bristow Helicopters (Nig.) Limited aircraft. There was indication that the Main Gear Box (MGB) was replaced on the 9th March, 2015 and specific components were removed to accomplish the Main Gear Box replacement. According to the S-76 Main Gearbox Replacement Worksheet on Bristow Form No. S76/01 Issued on 03/14. There were clear indications that the Forward Servo Clevis Rod and Left Servo Clevis Rods Assemblies were removed and reinstalled to gain access to the MGB. However, it is difficult to ascertain how the reinstallation was carried out. The signatures of the engineers and the inspectors who signed for the removal, re-installation and the duplicate inspections were recorded on the worksheet. According to

the worksheet, all tasks were duly signed off by the appropriate maintenance personnel. There were interviews conducted to determine the role they played during the removal and re-installation of these assemblies and to know what part they played in the whole Work Process.

2.4 The Flight Recorders

The Cockpit Voice Recorder (CVR) did not reveal anything of interest as the accident happened too fast and did not give the crew enough time to transmit even the mandatory "May Day" call. The survivors confirmed and corroborated that the pilots did not talk to anybody but were seen trying to stabilize the aircraft before plunging into the waters of the Lagoon.

However, the Flight Data Recorder (FDR) captured a lot of data that helped to reveal the attitude of the aircraft before, during and after the crash. The helicopter experienced sudden pitch up, then varying attitudes of yaw, roll and pitch for about 12 seconds until it impacted water at about 15:31hrs.

The initial airspeed was about 117kts; it suddenly increased to about 122kts, before decreasing to about 25kts and then rapidly increased 120kts before crashing into the Lagoon.

The initial pressure altitude before the accident was about 950 ft maintaining, the aircraft suddenly climbed to over 1,100 ft and back to 950 ft and climbed immediately before rapidly descending and eventually crashing into the Lagoon.

The helicopter impacted the water at pitch up angle of about 42^{o}, roll angle of about -20^{o} and airspeed of about 10kts.

2.5 Search and Rescue

There were witnesses that saw the aircraft plunge into the Lagoon; the search was easy since people were around the vicinity of the crash site.

The local fishermen were available to give the victims prompt rescue attention and later helped in the recovery of crew personal belongings and some aircraft documents. However, professional divers were later engaged to recover the recorders and helped in the recovery of the main aircraft wreckage.

One of the survivors provided a graphic account of how he was pulled out of the water by a fisherman. Six passengers were rescued alive and four fatally injured were recovered same day. The pilots' bodies were recovered the following day.

3.0 CONCLUSIONS

3.1 Findings

The investigation revealed the following:

1. The flight crew were licenced, medically fit and adequately rested to conduct the flight.
2. The crew and passengers' life vests were not activated.
3. The crew did not declare emergency.
4. There were twelve persons onboard including two crewmembers at the time of the accident.
5. The aircraft crashed into the Lagoon at the Oworonsoki area of Lagos State
6. There was no evidence of fire outbreak before and after the crash.
7. The life rafts on the helicopter were observed deflated and floating on the water but were not deployed.
8. The main wreckage of the helicopter was confined to a small area while other debris were scattered and floating around the crash site.
9. The main wreckage was submerged.
10. The helicopter was maintained in accordance with approved Maintenance program.
11. No records of any deferred defects in the tech log.
12. The Forward Servo Clevis Rod separated from the bearing and the Jam nut.

13. The Jam nut was loose and was not seating against the Forward Servo Clevis Rod end.

14. The rescue was promptly carried out by fishermen operating their boats around the crash site.

15. The surviving passengers reported the flight was normal until the helicopter suddenly spiralled, descended and impacted the waters.

16. Field examination suggested that No. 2 engine suffered an uncontained failure post impact.

17. The combined Solid-State Voice/Flight Data recorder only contained information of the flight data.

3.2 Causal Factor

The separation of the Forward Servo Clevis Rod Assembly from the bearing and Jam nut (Bell Crank Assembly) which is part of the Cyclic Control System responsible for stabilizing the attitude of the helicopter made the aircraft uncontrollable.

3.3 Contributory Factor

1. The absence of a secondary mechanical locking system (lock-pin or wire-lock) in the design of the Forward Servo Input Control Rod assembly contributed to the separation of the Forward Servo Clevis Rod from the bearing and Jam nut.

2. The wear that was prevalent at the Forward Servo Clevis Rod end fitting shank, which made the Jam nut rotate freely when force is applied.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendation 2018-001

Sikorsky Aircraft Corporation should redesign the affected control pushrod assembly by introducing wire lock or lock pins as safety features between the Jam nut and the Pushrod to enhance better security and safety.

SAFETY ACTIONS

The outcome of AIB preliminary investigation resulted in the following Safety Actions taken by Sikorsky, Federal Aviation Administration (FAA) and Nigerian Civil Aviation Authority (NCAA).

1. 1. On the 10th of September, 2015, Sikorsky Aircraft Corporation issued Alert Service Bulletin (ASB) 76-67-57 on all S-76 model helicopters equipped with Control Pushrod Assembly P/N 76400-0034-059 and 76400-00014-071.

   Purpose: "To perform a onetime inspection of installed Forward, Aft and Lateral Main Servo Input Control Pushrods and Jam nuts and Tail Servo Input Control Pushrods and Jam nuts for proper installation, condition and security followed by application of slippage mark on all Main and Tail Servo Input Control Pushrod Jam nuts".

   Compliance: "Compliance is essential. The instructions outlined herein shall be accomplished prior to next flight originating from a maintenance facility or not to exceed 5 flight hours from issue date of this ASB".

2. On the 14th September, 2015, The Federal Aviation Administration (FAA) issued Emergency Airworthiness Directives (EAD) 2015-19-51 to owners and operators of Sikorsky Aircraft Corporation model S-76A, S-76B, S-76C and S-76D helicopters. This was related to service information from Sikorsky issued Alert Service Bulletin No. 76-67-57 of 10th September, 2015.

3. The Nigerian Civil Aviation Authority (NCAA) issued an All Operator Letter (AOL 050, attached) to operators of the subject aircraft type, requiring their immediate compliance with requirements of the EAD 2015-19-51 and ASB 76-67-57. ***See Appendix D***

Figure 16: The recovered wreckage of the helicopter

Figure 17: The recovery barge

Figure 18: Professional divers during the wreckage recovery exercise

Figure 19: Local fishermen/rescuers at the crash site

Figure 20: Investigators, Search and Rescue personnel on recovery mission

APPENDICES

Appendix A: Materials Laboratory Factual Report

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

February 19, 2016

MATERIALS LABORATORY FACTUAL REPORT Report No. 15-111

A. ACCIDENT INFORMATION

Place	:	Lagos, Nigeria
Date	:	August 12, 2015
Vehicle	:	Sikorsky S-76C+
NTSB No.	:	DCA15WA171
Investigator	:	Chihoon Shin, AS-40

B. COMPONENTS EXAMINED

Forward, l clevis rod assemblies and associated bellcrank assemblies.

C. DETAILS OF THE EXAMINATION

Overall views of the forward, lateral, and aft servo clevis rod assemblies with associated bellcrank assemblies are shown in figures 1 through 3, respectively. The forward servo clevis rod was separated from the end fitting at the lower end of the assembly as shown in figure 1, and the end fitting remained attached to the bellcrank assembly. The lateral and aft servo clevis rod assemblies were intact, and each remained attached to its respective bellcrank as shown in figures 2 and 3.

1. Forward Servo Clevis Rod and Bellcrank Assemblies

The forward servo clevis rod assembly had identification marks on the flat of the clevis. The markings read "78286 ASSY", "?6400-00034-058", and "P MFR 8?781". (Throughout this report, the question marks in the part identification labels indicate portions of the label that were illegible.) The rod end fitting had part markings "F?8286SOCN38?D-00005-101", "MFR-73", and "(REP4M6-8FSK)EE". The jam nut had "AD" stamped on one of its flats. The rod end fitting attachment bolt had "SS27576-4-17" and "SPS14" marked on its head. Markings on the lower face of the bellcrank assembly read "7?8?ASS?-0950?", "P ALT MFR 575?", and "10/07/04".

Views of the forward servo clevis rod bellcrank assembly with attached rod end fitting are shown in figure 4. The rod end fitting did not move by light hand forces as-received. The upper end of the end fitting as-received was rotated inboard relative to the bellcrank plane of rotation (see upper image in figure 4). Additionally, the end fitting as-received was rotated clockwise, as viewed from below, relative to the transverse plane of the bearing attachment bolt (see left image in figure 4).

Closer views of the forward servo clevis rod end fitting shank are shown in figures 5 and 6. The threads were largely covered with black deposits. Isolated areas of orange oxide were present in some areas of the thread. Near the lower end of the shank adjacent to the jam nut, the thread valleys were filled with deposits. The length of the shank from the upper end to the first thread valley filled with deposits was 0.675 inch. Samples of the deposits within the threads were taken for compositional analysis as described later in this section.

The jam nut for the end fitting was located at the lower end of the shank. The upper face of the jam nut was located between 0.972 inch and 0.980 inch away from the upper end face of the end fitting shank. The jam nut rotated freely when manipulated by hand.

The thread peaks at the middle and upper end of the end fitting shank were smooth and rounded consistent with wear. The wear was greatest near the middle of the shank on the outboard side of the end fitting and near the upper end of the shank on the inboard side of the end fitting. Unlabeled brackets in figure 5 and 6 indicate areas of greatest wear in the threads.

The outer diameter of the end fitting threads was measured at three locations along the length of the shank, namely across worn threads at the upper end and middle of the shank and across unworn threads near the jam nut. At each location, the diameter was measured both in the forward/aft direction and in the lateral direction. The diameter in the worn portion ranged from 0.3656 inch in the lateral direction at mid-length to 0.3696 inch in the forward/aft direction at the upper end with an average outer diameter of 0.3682 inch within the worn area. Adjacent to the jam nut, the thread outer diameter measured 0.3712 inch in the forward/aft direction and 0.3709 inch in the lateral direction. The profile of the thread on the end fitting as viewed using an optical comparator matched the profile for a UNF 24 thread. An end fitting from an exemplar new forward servo clevis rod assembly had diameters ranging from 0.3709 inch to 0.3717 inch with an average of 0.3713 inch as measured at six locations comparable to those measured on the accident end fitting.

The force required to move the end fitting relative to the bellcrank assembly was measured using a Transducer Techniques Model HFG-45 handheld digital force gauge.[1] The bellcrank assembly was clamped within a padded vice, and force was applied at the upper end of the end fitting. Initially, the end fitting shank was pulled in the outboard direction and did not move with an applied force of up to 183 ounces. Next, the end fitting shank was pulled in the inboard direction, and the bearing moved at a load of 126 ounces. Next, the end fitting shank was pulled again in the outboard direction, returning to its original position with 80 ounces of force applied, but no further movement beyond the original position was apparent with applied loads of up to 444 ounces.

[1] Transducer Techniques, Temecula, California.

Next, the force was applied in the forward/aft direction. In the forward direction, movement was detected with 256 ounces of force. Finally, the end fitting was loaded in the aft direction, where movement initiated at 45 ounces and continued with increasing force up to 86 ounces.

After the load tests, the end fitting was disassembled from the bellcrank assembly, and the bearing outer race was cut at diametrically opposite sides using a Dremel cutting tool[2] to facilitate direct examination of the bearing components of the end fitting. Upon separation of the bearing, the balls and races appeared essentially free of grease. Orange-colored corrosion was noted on the balls and races. However, no evidence of spalling, pitting, or rotational damage was noted on the balls or races, indicating that the corrosion occurred after the bearing stopped operating.

Views of the lower end of the forward servo clevis rod are shown in figure 7. Black-colored deposits were observed in the internal threads and on the lower end surface around the threaded hole. A sample of the deposits in the threads was taken for further analysis.

Internal thread peaks in the lower portion of the hole appeared to be largely missing up to 0.654 inch from the lower end face. The hole at the lower end of the clevis rod was elongated toward one direction consistent with contact wear with the end fitting. Additionally, a lip of material was present on the lower face at the edge of the hole around nearly half the circumference on the elongated side of the hole as indicated with an unlabeled bracket in figure 7. At the opposite side of the clevis rod, the wall of the internal diameter was worn to a depth beyond the major diameter of the internal threads near the upper end of the damaged threads as indicated with a bracket in the lower image in figure 7.

The pattern of hole elongation from wear at the lower end of the rod and deeper wear on the opposite side of the hole near the upper end of the damaged thread region corresponded to the wear pattern observed on the inboard and outboard sides of the end fitting threads (bracketed areas in figures 5 and 6). The orientation of the clevis rod was not marked on the as-received part. However, the pattern of wear damage on the rod and end fitting was consistent with the clevis rod oriented as indicated in figure 7, and the rod is referenced in that orientation throughout the rest of the report.

The inside diameter of the of the internal threads measured near the lower end of the forward servo clevis rod measured approximately 0.378 inch in line with the inspection holes and measured approximately 0.375 inch measured perpendicular to the inspection holes. At the center of the elongated hole at the lower end of the clevis rod where the diameter was greatest, the inside diameter measured approximately 0.386 inch.

Next, a transverse cut was made near the lower end of the clevis rod followed by a longitudinal cut through the center of the end fitting attachment hole to expose the

[2] Robert Bosch GmbH, Gerlingen-Schillerhöhe, Germany.

internal threads of the clevis rod. A view of the sectioned pieces resulting from the cuts is shown in figure 8. Unlabeled brackets in figure 8 indicate the extent of worn threads at the lower end of the rod, and unlabeled arrows point to inspection holes, filled with black deposits, located within the worn thread area. A point micrometer was used to measure the remaining wall thickness at the location of greatest wear just above the inspection hole on the outboard half of the sectioned clevis rod, and the minimum wall thickness measured 0.103 inches.

The threads were cleaned using a soft-bristle brush with a solution of soap and water. Close views of the thread profiles after cleaning are shown in figures 9 and 10. The intact threads from the region indicated in figure 8 are shown in figure 9 and appeared to be well formed with no evidence of wear. The remaining thread profile in the worn area indicated in figure 8 is shown in figure 10. Most of the thread was missing.

The inside diameter of the clevis rod in the intact portion of the threads was measured using a FARO Quantum FaroArm[3] coordinate measuring device fitted with a hard probe having a 3-millimeter sphere at the tip. To measure the inside diameter, the probe was touched to the intact threads such that the ball rested in a stable position touching two adjacent thread peaks, and points were collected with CAM2Q software[4] around the circumference on the outboard half of the threaded hole. A cylinder form was then fitted to the points to obtain a preliminary measurement. Next, the distance between adjacent corners where the 3-millimeter probe contacted the thread peaks was measured using a Keyence VHX-2000 microscope,[5] and the distance between thread peaks measured 0.029 inch. By calculation, the surface of a 3-millimeter sphere would extend up to 0.00094 inch past the thread peaks spaced 0.029 inch apart. Therefore, the preliminary inside diameter measured using the probe tipped with a 3-millimeter sphere was reduced by 0.0019 inch to obtain the diameter at the thread peaks. The resulting inside diameter in the intact portion of the threads measured by the above method was 0.339 inch.

The forward servo clevis rod was analyzed to determine composition, hardness, and conductivity. The rod was prepared for testing by grinding an area of the clevis to remove paint and machining marks on the surface. Composition was then determined using a Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer, which identified the material as aluminum alloy 7075. Conductivity measured 39.8% IACS, and hardness measured 84.7 HRBW. The composition was consistent with the specified material. Although conductivity was slightly higher than the range specified on the engineering drawing for the clevis rod, hardness was consistent with typical values expected for the specified alloy and temper.[6,7]

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[3] FARO Technologies, Inc., Lake Mary, Florida.
[4] FARO Technologies, Inc., Lake Mary, Florida (2010).
[5] Keyence Corporation of America, Elmwood Park, New Jersey.
[6] Aerospace Structural Metals Handbook, CINDAS/USAF CRDA Handbooks Operation, Purdue University, West Lafayette, Indiana (1995).
[7] Matweb.com accessed November 12, 2015.

Deposits collected from the forward servo clevis rod internal threads and the corresponding end fitting external threads were analyzed in a scanning electron microscope (SEM) using energy-dispersive x-ray spectroscopy (EDS). Typical spectra obtained from the EDS analysis are shown in figures 11 and 12. High peaks of carbon, oxygen, aluminum, and cadmium were typically found in wide-area scans of the deposits with smaller peaks of iron, chromium, silicon, and magnesium. Small peaks of sodium and chlorine were also frequently present. An SEM image using backscattered electrons[8] of a typical debris sample is shown in figure 13. In the internal thread sample, some particles had relatively low oxygen peaks compared to the aluminum peak such as the particle shown in figure 14 with a corresponding EDS spectrum shown in the lower position in figure 12. The long curled shape of the particles combined with the observed EDS spectrum was consistent with a remnant of thread material from the clevis rod internal threads.

2. Lateral Servo Clevis Rod and Bellcrank Assemblies

An overall view of the lateral servo clevis rod assembly with attached bellcrank assembly is shown in figure 2. Identification markings "78286 ASSY", "76400-00034-058", and "MFR 8F781" were observed on the rod clevis face. Markings "ALT MAT", "MFR 2Z106", and "FEB 24 1999" were marked on the lower side of the bellcrank assembly, and "78286-76400-09502" and "-106-046 ASSY" was marked on the inboard face of the outboard leg.

Views of the lateral servo clevis rod bellcrank assembly with attached rod end fitting are shown in figure 15. The clevis rod rotated freely in the forward and aft directions through a limited angle but did not rotate in the lateral direction. The upper end of the lateral servo clevis rod assembly as received was displaced inboard relative to the rotational axis of the bellcrank assembly (displacement angle shown in the upper image in figure 15). Additionally, the end fitting as-received was rotated clockwise, as viewed from below, relative to the transverse plane of the bearing attachment bolt (see left image in figure 15).

Remnants of yellow torque paint were observed on the lower end of the lateral servo clevis rod, but no torque paint was observed on the adjacent jam nut. The inspection hole in the clevis rod was blocked consistent with sufficient end fitting thread engagement. Approximately 4 to 5 threads were exposed on the end fitting shank below the jam nut. The total length of the lateral clevis rod assembly as measured between centers of the attachment points was approximately 8.956 inches.

The force required to move the end fitting relative to the bellcrank assembly was measured using a Transducer Techniques Model HFG-45 handheld digital force gauge. The bellcrank assembly was clamped within a padded vice, and force was applied at

[8] SEM images produced using a backscatter detector in composition mode have contrast that is associated with atomic weight of the elements in the image. Areas with elements having higher atomic weights appear as a relatively lighter shade of gray compared to areas having elements with lower atomic weights.

the lower end of the clevis on the lateral servo clevis rod. Initially, the rod was pulled in the outboard direction, and sudden free movement occurred at an applied load of 3.86 pounds. Next, the force required to cause rotation in the forward direction was measured, and rotation was detected with a force of 4.42 pounds applied at the lower end of the clevis.

Next, the lateral servo clevis rod assembly was disassembled from the bellcrank assembly to facilitate torque testing of the jam nut. A marker was used to draw a longitudinal reference line across the lower end of the clevis rod, the jam nut, and the end fitting to mark the installed position of the jam nut relative to the other components of the assembly. Using a digital torque wrench, the torque required to back the jam nut away from the installed position was 127 pound inches. The torque required to return the jam nut to its original position was 66 pound inches. The torque required to back the jam nut away the second time was 33 pound inches. When the jam nut was then returned to finger-tight, it was approximately 1/12 of a turn away from its original position.

After the torque tests were complete, the end fitting was unscrewed from the lateral servo clevis rod as shown in figure 16. Black semi-liquid deposits were observed on the threads of the end fitting, on the internal threads of the clevis rod, and on the mating faces between the jam nut and the clevis rod. A swab of the deposit was sampled for further analysis using EDS, and the resulting spectrum is shown in figure 17. The deposit showed a high peak of carbon with smaller peaks of oxygen, aluminum, and cadmium. Additionally, smaller peaks of sodium, magnesium, silicon, sulfur, and chlorine were present. According to the engineering drawing for the lateral servo clevis rod, an anti-seize compound is applied to the threaded joint of the assembled clevis rod assembly.

External threads on the end fitting and corresponding internal threads on the lateral servo clevis rod were intact and showed no evidence of wear damage. The outer diameter of the end fitting threads measured 0.3722 inch. The internal threads of the clevis rod had an inside diameter of 0.335 inch.

The lateral servo clevis rod was analyzed to determine composition, hardness, and conductivity. The rod was prepared for testing by grinding an area of the clevis to remove paint and machining marks on the surface. Composition was then determined using a Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer, which identified the material as aluminum alloy 7075. Conductivity measured 39.8% IACS, and hardness measured 84.3 HRBW.

3. Aft Servo Clevis Rod and Bellcrank Assemblies

An overall view of the aft servo clevis rod assembly with attached bellcrank assembly is shown in figure 3. Identification markings “78286 ASSY”, “76400-00034-058”, and “P MFR 8F781” were observed on the rod clevis face. Markings “78286/76400-09502-104”, “-044 ASSY MFR 3S611”, and “F/L 301918 “P” “ALT”” were vibrapeened on the lower surface.

Views of the aft servo clevis rod bellcrank assembly with attached rod end fitting are shown in figure 18. The upper end of the lateral servo clevis rod assembly as received was rotated downward in the direction opposite from its as-installed upward position (see left image in figure 18 and overall image in figure 3). In this report, references to up and down for the aft clevis rod are as installed on the helicopter as opposed to the as-received position. Additionally, the end fitting as-received was rotated counterclockwise, as viewed from above, relative to the transverse plane of the bearing attachment bolt (see upper image in figure 18). Initially, the clevis rod rotated freely in the forward and aft directions through a limited angle. However, as the bellcrank was repositioned during the visual examination, the weight of the rod was sufficient to overcome the resistance to movement, and the rod began to rotate completely about the attachment bolt axis with little resistance.

Remnants of yellow torque paint were observed on the lower end of the aft servo clevis rod, but no torque paint was observed on the adjacent jam nut. The inspection hole in the clevis rod was blocked consistent with sufficient end fitting thread engagement. Approximately 7 to 8 threads were exposed on the end fitting shank below the jam nut. The total length of the lateral clevis rod assembly as measured between centers of the attachment points was approximately 9.260 inches.

The force required to move the end fitting relative to the bellcrank assembly was measured using a Transducer Techniques Model HFG-45 handheld digital force gauge. The bellcrank assembly was clamped within a padded vice, and force was applied at the lower end of the clevis on the lateral servo clevis rod. The rod was pulled in the outboard direction, and movement was detected at an applied load of 1.23 pounds. Force measurements to produce movement of the bearing about the axis of the attachment bolt were not completed due to the limited resistance to movement in that plane.

Next, the aft servo clevis rod assembly was disassembled from the bellcrank assembly to facilitate torque testing of the jam nut. A marker was used to draw a longitudinal reference line across the lower end of the clevis rod, the jam nut, and the end fitting to mark the installed position of the jam nut relative to the other components of the assembly. Using a digital torque wrench, the torque required to back the jam nut away from the installed position was 83 pound inches. The torque required to return the jam nut to its original position was 72 pound inches. The torque required to back the jam nut away the second time was 39 pound inches. When the jam nut was then returned to finger-tight, it was approximately 1/12 of a turn away from its original position.

After the torque tests were complete, the end fitting was unscrewed from the aft servo clevis rod as shown in figure 19. Black semi-liquid deposits were observed on the threads of the end fitting, on the internal threads of the clevis rod, and on the mating faces between the jam nut and the clevis rod. A swab of the deposit was sampled for further analysis using EDS, and the resulting spectrum is shown in figure 20. The

deposit showed a high peak of carbon with smaller peaks of oxygen, aluminum, and cadmium. Additionally, smaller peaks of sodium, silicon, sulfur, chlorine, and nickel were present. As with the other servo clevis rods, an anti-seize compound is applied to the threaded joint of the assembled aft servo clevis rod assembly.

External threads on the end fitting and corresponding internal threads on the aft servo clevis rod were intact and showed no evidence of wear damage. The outer diameter of the end fitting threads measured 0.3731 inch. The internal threads of the clevis rod had an inside diameter of 0.335 inch.

The lateral servo clevis rod was analyzed to determine composition, hardness, and conductivity. The rod was prepared for testing by grinding an area of the clevis to remove paint and machining marks on the surface. Composition was then determined using a Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer, which identified the material as aluminum alloy 7075. Conductivity measured 39.2% IACS, and hardness measured 84.1 HRBW.

4. Exemplar Forward Servo Clevis Rod Assembly

According to torque requirements noted in the Sikorsky maintenance manual for the S-76 series helicopters, "Jamnuts shall be tightened 1/6 to 1/3 turn from point where a sharp rise in torque is felt." An exemplar forward servo clevis rod assembly was used to install a jam nut using these instructions. In the torque tests of the exemplar assembly, the threads were dry with no anti-seize compound.

At the start of the test, the exemplar end fitting was threaded into the exemplar clevis rod to an extent such that the inspection hole was blocked. During installation, the end fitting threaded freely into the clevis rod, and the jam nut rotated freely on the end fitting threads. Then the jam nut was threaded into place until it was finger tight against the clevis rod. The positions of the centers of the flats on the jam nut were marked on the lower end of the clevis rod so that each mark would represent approximately 1/6 of a turn.

Next, the end fitting was clamped in a padded vice, and the jam nut was rotated to 1/12 of a turn while holding the clevis end of the rod in place with locking pliers. Rotating the jam nut 1/12 of a turn required 160 pound inches of torque. Then the jam nut was rotated in the opposite direction, requiring 105 pound inches of torque to break away.

The jam nut was then retightened to finger tight, which returned it to the test start position. The jam nut was then turned to 1/6 of a turn, requiring 188 pound inches of torque. The jam nut was then rotated in the opposite direction, which required 105 pound inches of torque to break away.

Next the jam nut was rotated back to finger tight. However, the finger tight position was now moved approximately 1/12 of a turn from the original start position. From this new start position, the jam nut was rotated 1/6 of a turn, which required

204 pound inches of torque. The jam nut was then rotated slightly in the opposite direction, which required was 77 pound inches of torque.

Without returning to the finger tight position, the torque was then reapplied to rotate 1/3 of a turn from the second finger-tight start position, which required 254 pound inches of torque. The torque required to rotate the jam nut in the opposite direction from this point was 121 pound inches.

Once the clamping force was released, the jam nut could not be rotated by hand. Corners on the flats of the jam nut were deformed. The torque wrench was applied to continue rotating the jam nut in the releasing direction, and the measured prevailing torque was 22 pound inches. When the jam nut was then rotated toward the tightening direction, the prevailing torque was 17 pound inches.

The end fitting was removed from the clevis rod. As the end fitting was removed, it rotated freely within the clevis rod. No evidence of thread damage was noted in the clevis rod threads or in the end fitting threads engaged in the clevis rod.

Figure 1. Forward servo clevis rod and bellcrank assemblies as received showing the outboard side of the bellcrank assembly.

Figure 2. Lateral servo clevis rod and bellcrank assemblies as received showing the outboard side of the assemblies.

Figure 3. Aft servo clevis rod and bellcrank assemblies as received showing the inboard side of the assemblies. Directional arrows point to the orientation of the bellcrank assembly. As installed, the clevis rod assembly extends upward from the bellcrank assembly.

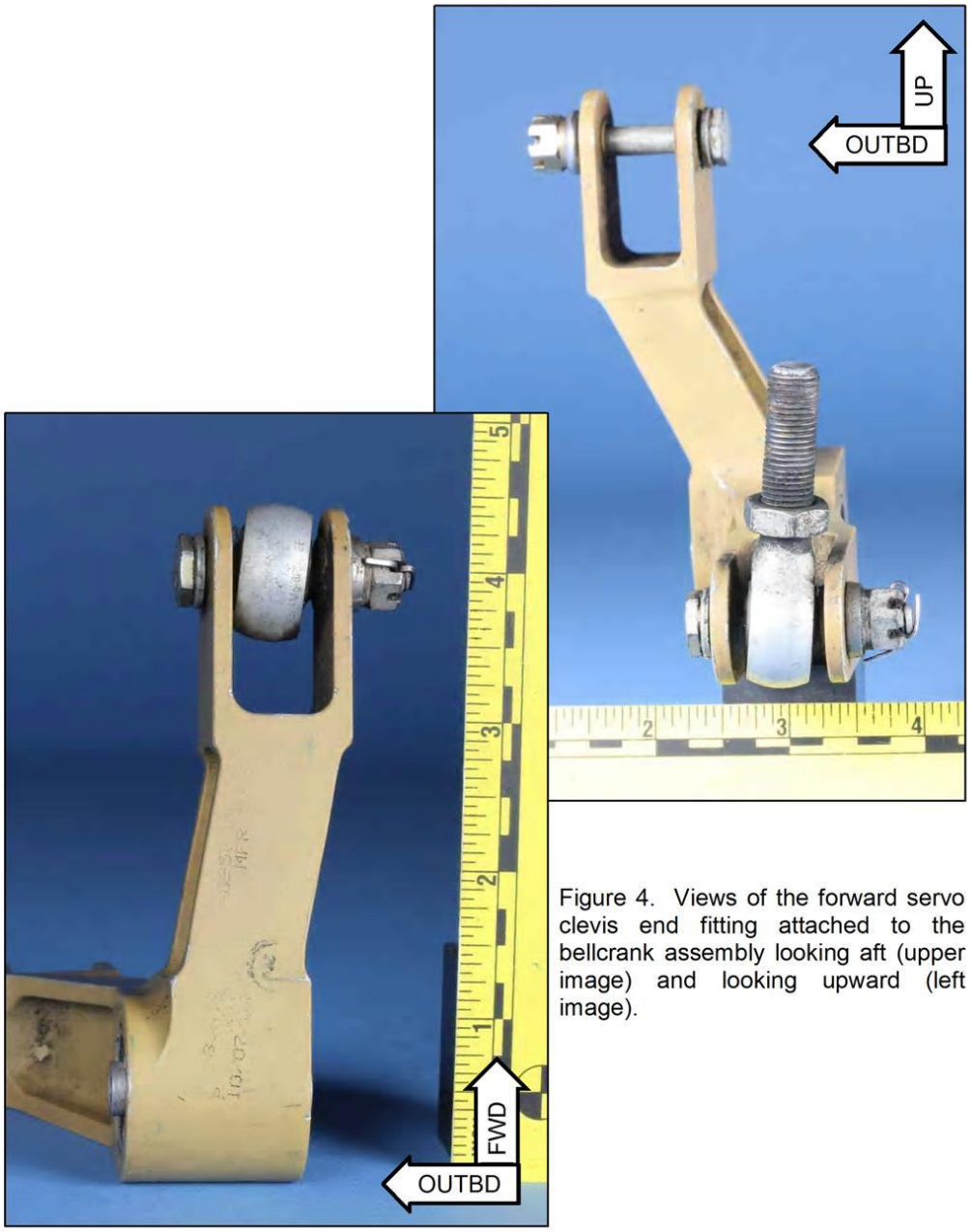


Figure 4. Views of the forward servo clevis end fitting attached to the bellcrank assembly looking aft (upper image) and looking upward (left image).

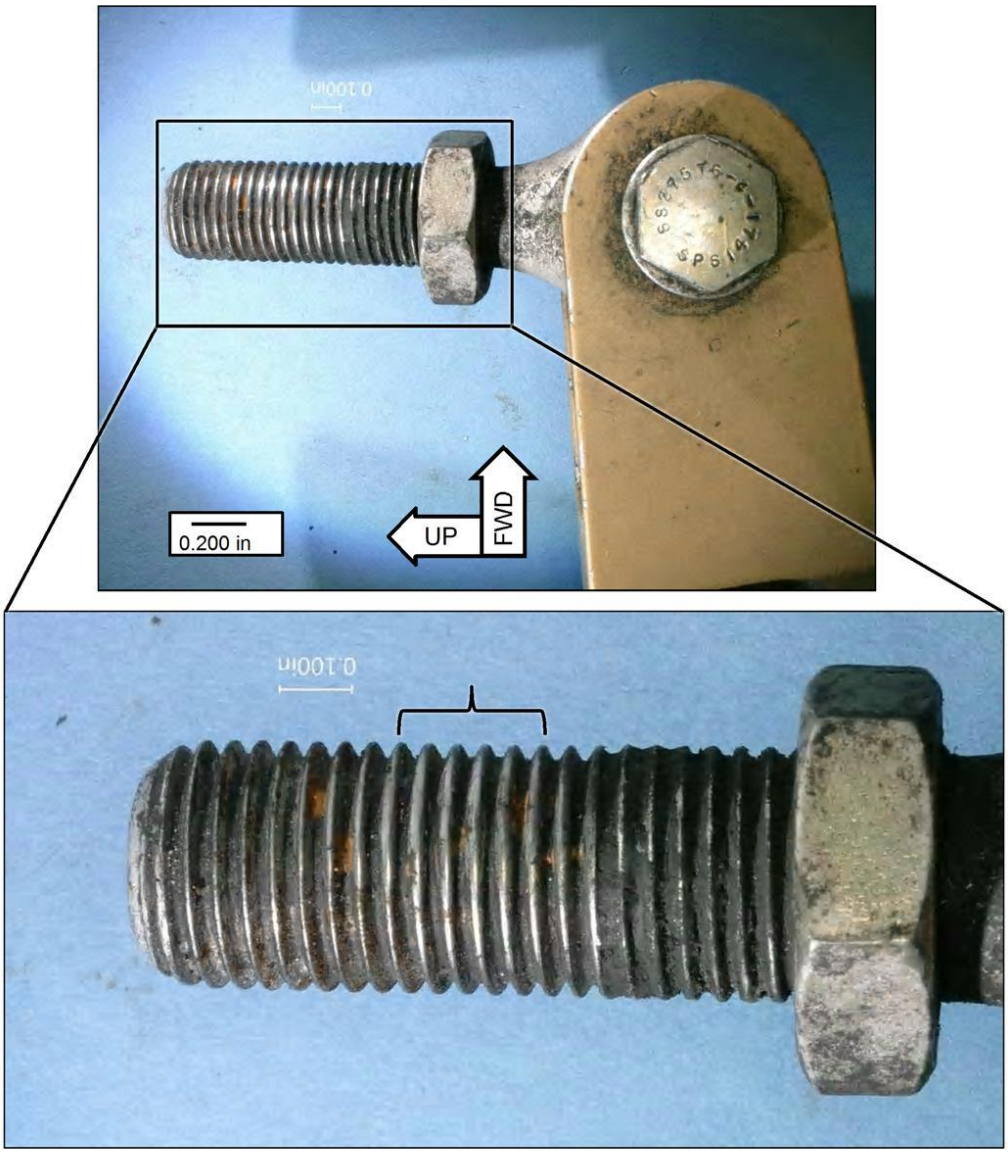


Figure 5. Close view of the forward clevis servo end fitting, outboard side. An unlabeled bracket indicates an area with greater thread wear.

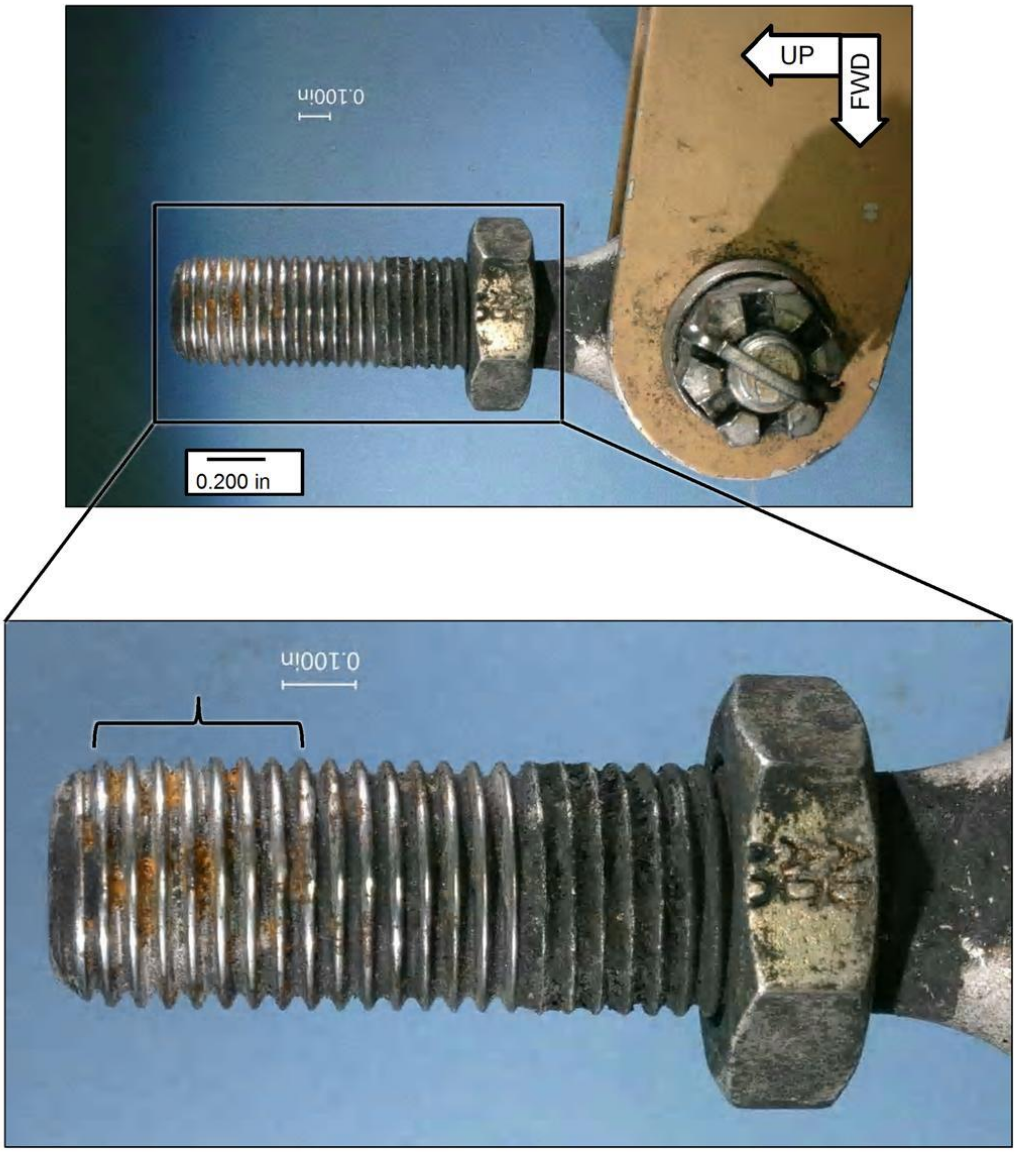


Figure 6. Close view of the forward clevis servo end fitting, inboard side. An unlabeled bracket indicates an area with greater thread wear.

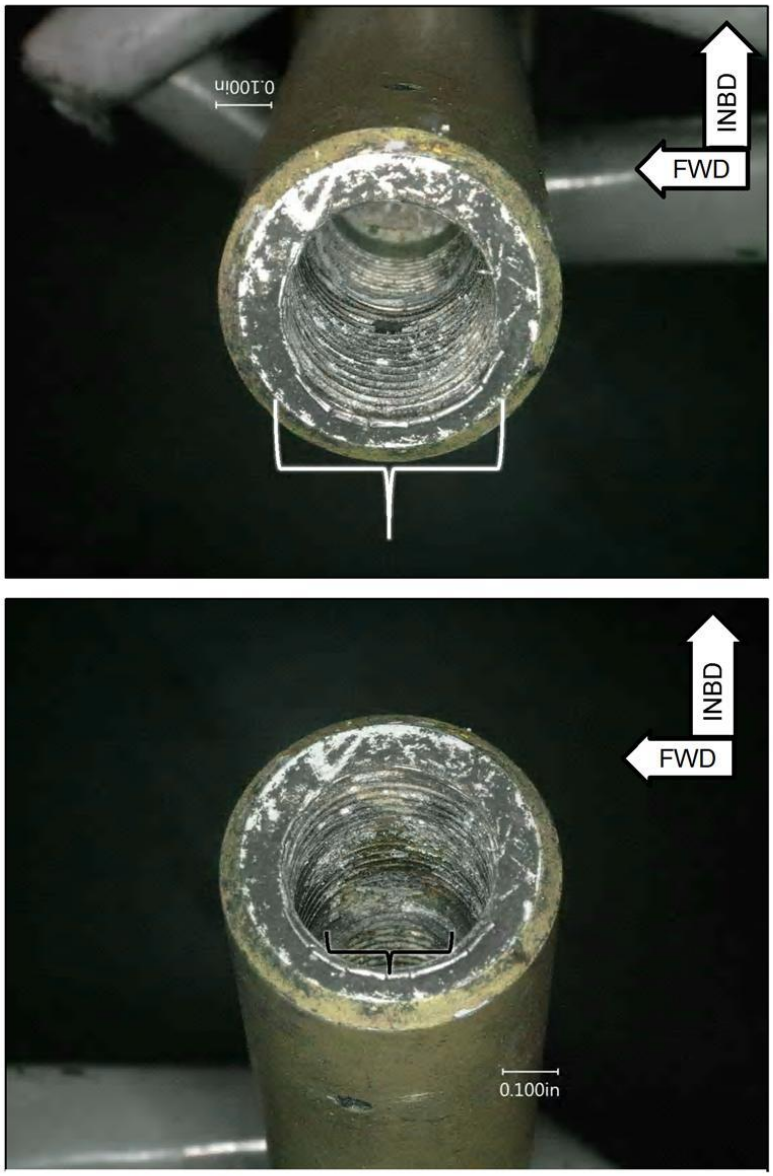


Figure 7. Views of the lower end of the forward servo clevis rod showing worn internal threads on the outboard side (upper image) and inboard side (lower image) of the rod. Unlabeled brackets indicate areas where wear was greatest on each side.

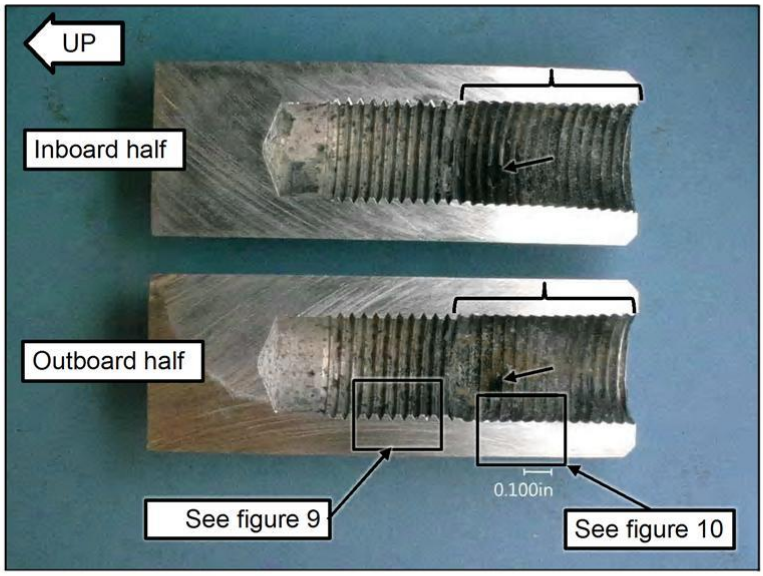


Figure 8. Direct view of the internal threads of the forward servo clevis rod after sectioning. Unlabeled brackets indicate the depth of worn threads, and unlabeled arrows indicate the locations of the inspection holes. Closer views of thread profiles in the boxed areas are shown in the figures indicated.

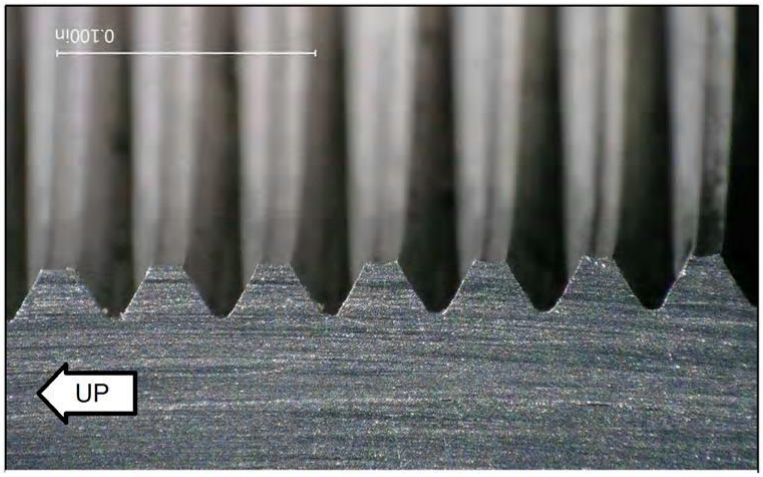


Figure 9. Internal thread profile of intact threads in the area of the forward servo clevis rod indicated in figure 9.

Figure 10. Internal thread profile of worn threads in the area of the forward servo clevis rod indicated in figure 9.

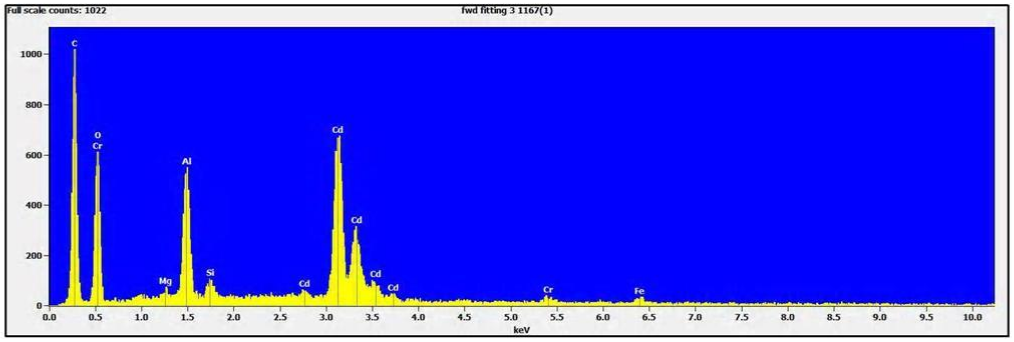


Figure 11. Typical EDS spectrum for samples of the black deposit collected from the forward servo clevis rod end fitting. An image of the deposit that produced this spectrum is shown in figure 13.

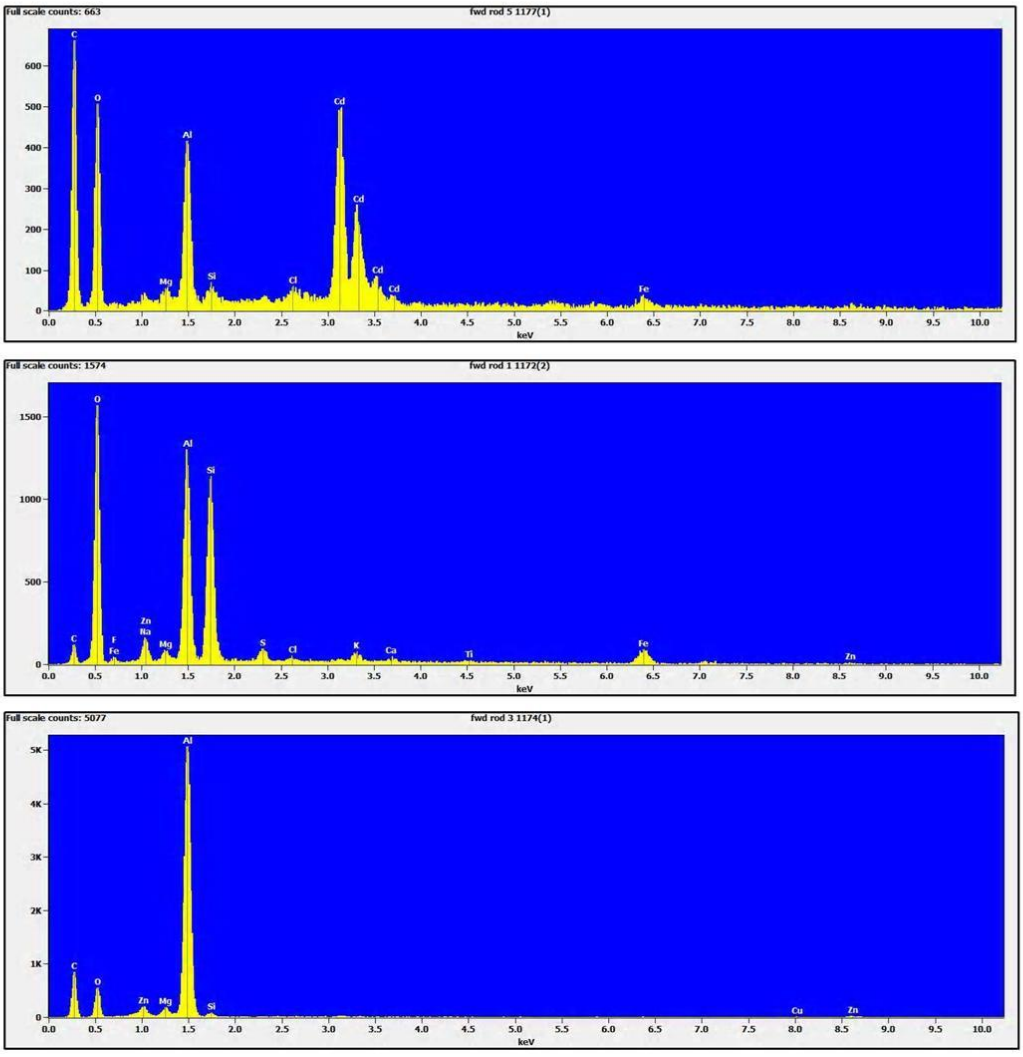


Figure 12. Typical EDS spectra obtained from deposits collected from the internal threads of the forward servo clevis rod. The upper spectrum is an overall area scan at low magnification. The middle spectrum is an area at higher magnification where a particle with a high silicon peak covered a large portion of the scan area. The lower spectrum was taken from a long segment of metal consistent with an internal thread remnant (see figure 14).

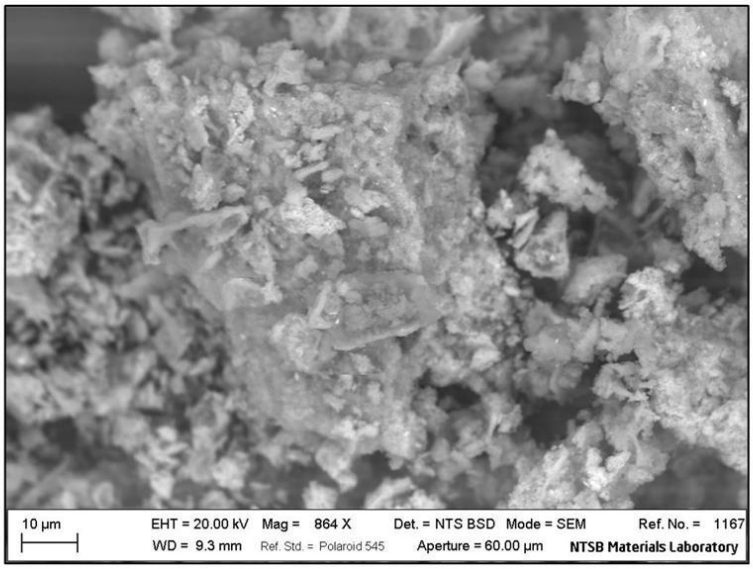


Figure 13. SEM image using backscattered electrons showing a typical deposit sampled from the forward servo clevis rod producing the spectrum shown in figure 11.

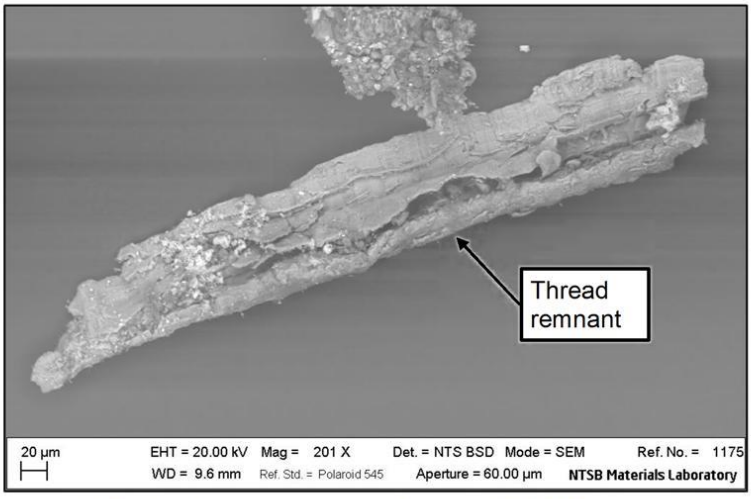


Figure 14. SEM image using backscattered electrons showing a clevis rod internal thread remnant obtained from the deposits sampled from the forward servo clevis rod.

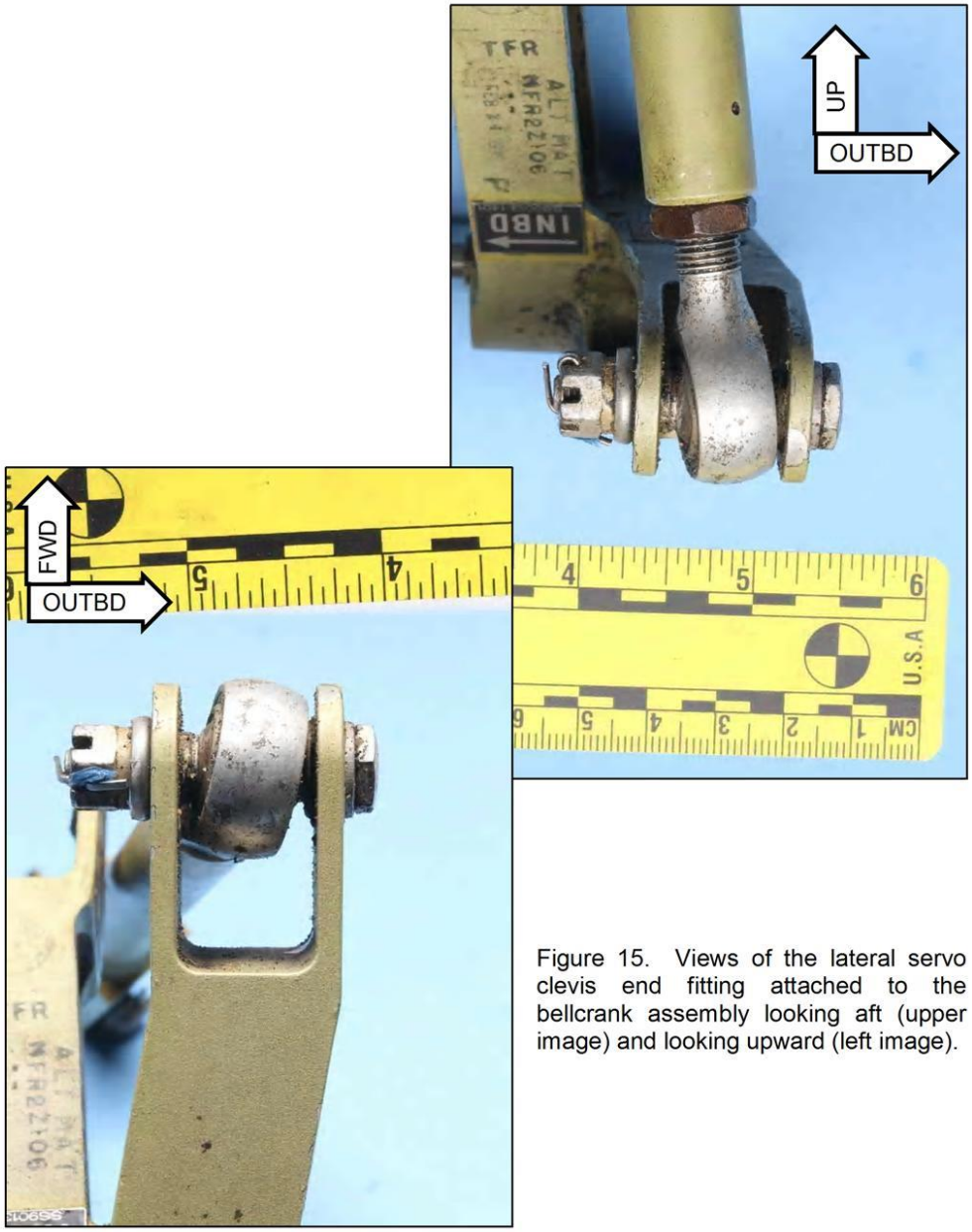


Figure 15. Views of the lateral servo clevis end fitting attached to the bellcrank assembly looking aft (upper image) and looking upward (left image).

Figure 16. Lower end of the lateral servo clevis rod assembly after the end fitting was disassembled from the rod.

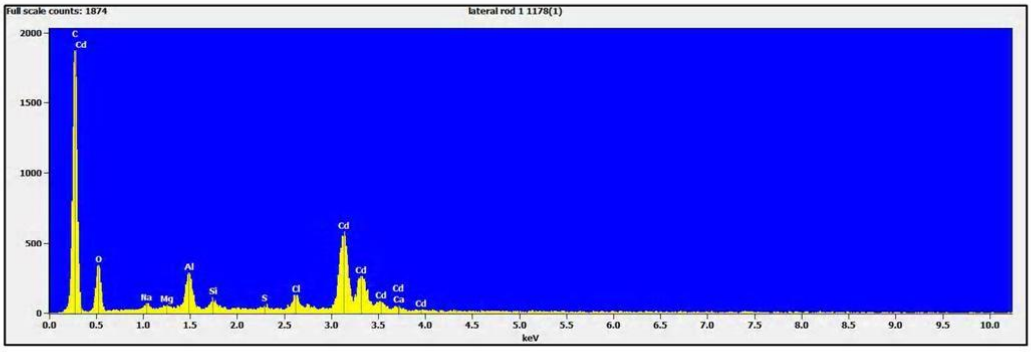


Figure 17. Typical EDS spectrum of black material sampled from the lateral servo clevis rod end fitting threads.

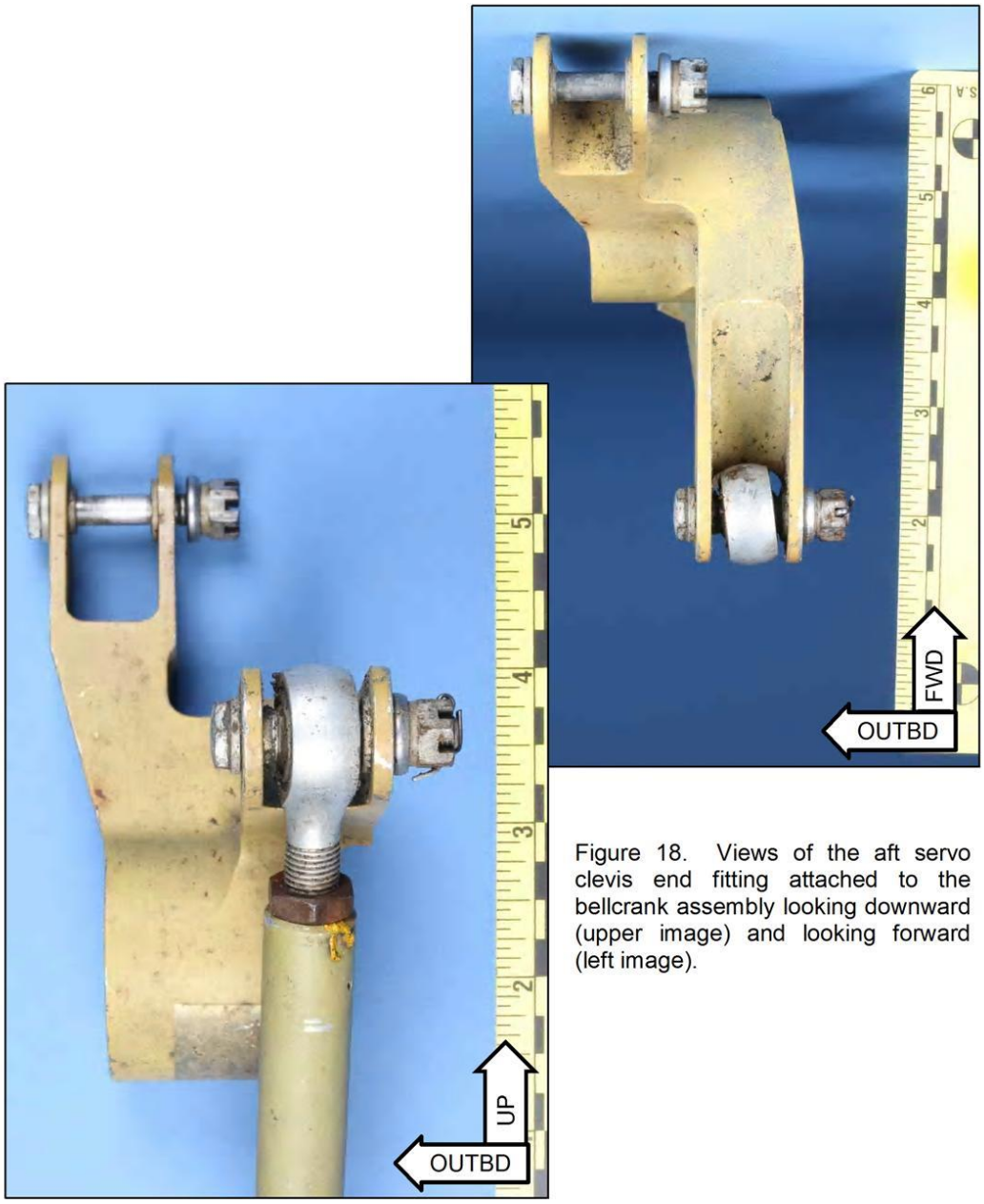


Figure 18. Views of the aft servo clevis end fitting attached to the bellcrank assembly looking downward (upper image) and looking forward (left image).

Figure 19. Lower end of the aft servo clevis rod assembly after the end fitting was disassembled from the rod.

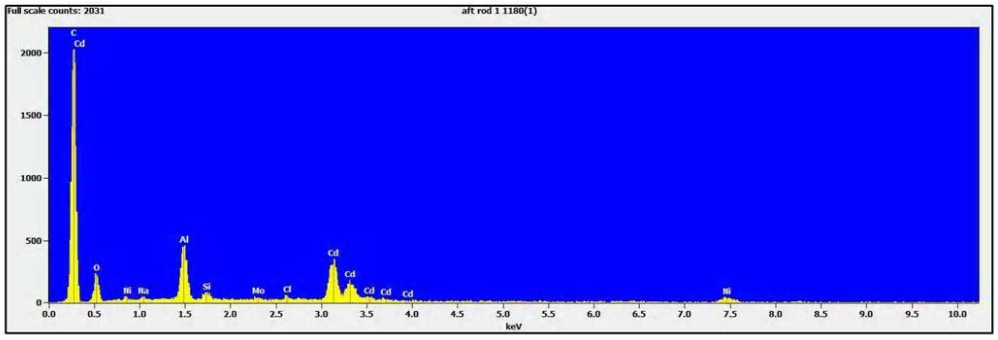


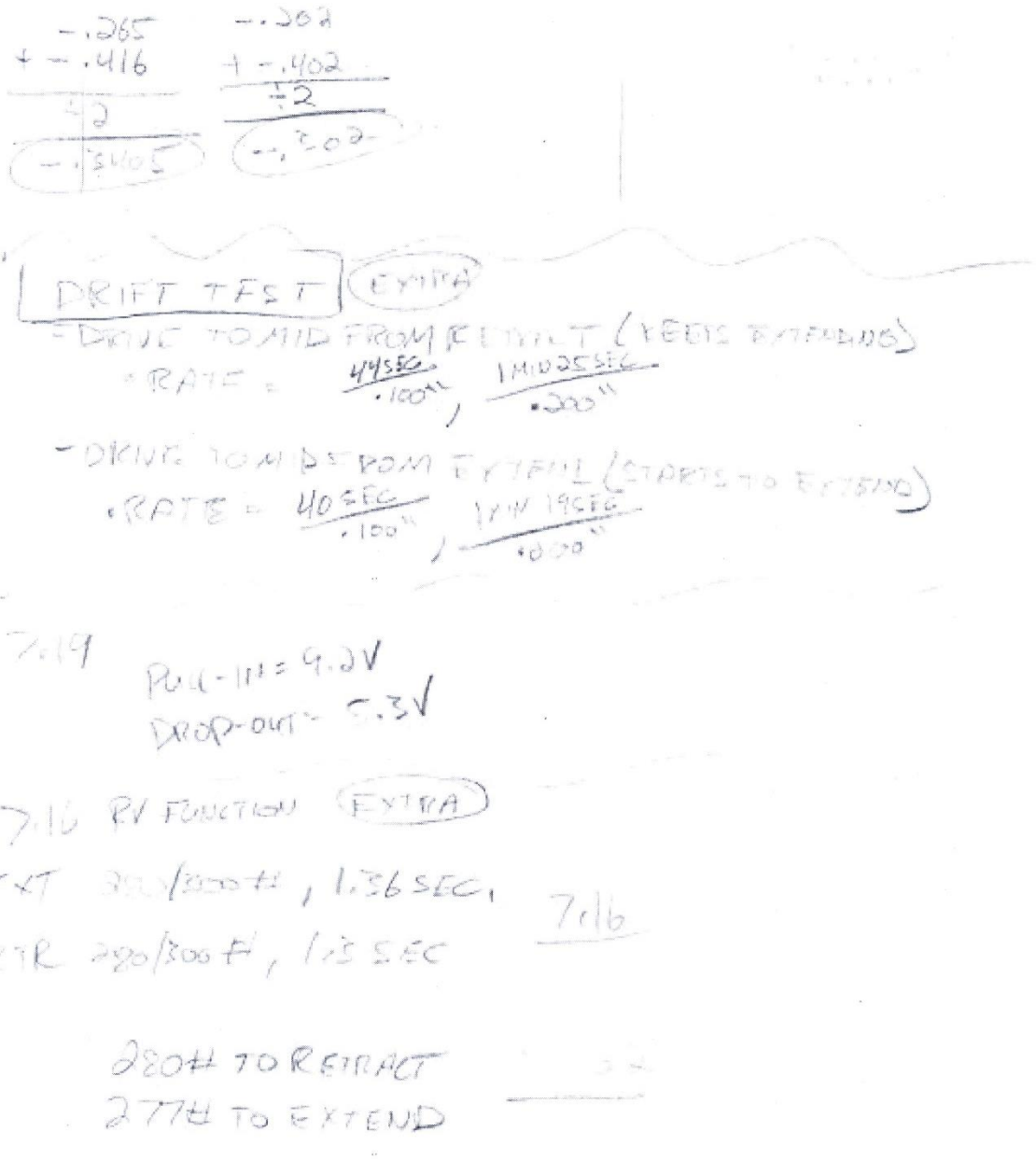
Figure 20. Typical EDS spectrum of black material sampled from the aft servo clevis rod end fitting threads.

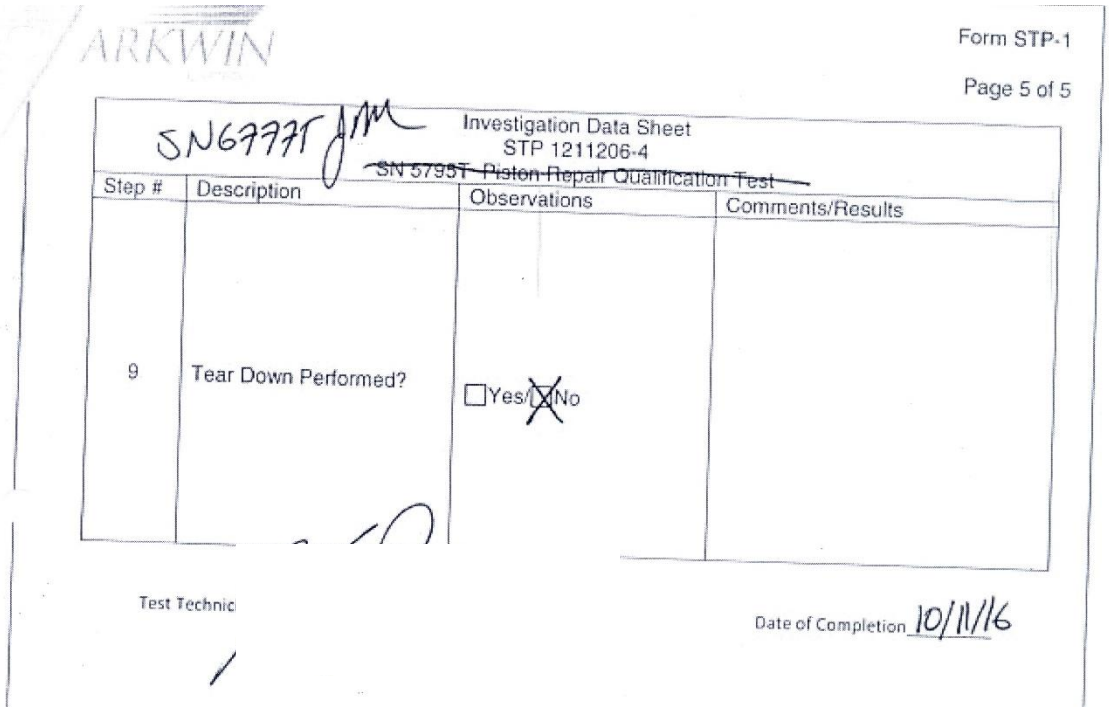
Appendix B

SN 6777T

Investigation Data Sheet
STP 1211206-4
SN 5795T Piston Repair Qualification Test

Description	Observations	Comments/Results
Record RA Data & photograph	☑ Confirmed (6777T) SN	- PICTURES TAKEN - NO FLUID FOR SAMP FROM UNIT IN BOX - CLEAN ID OF BEARIN W/ BRUSH TO FIT AT - UNITS/LBS - FLUID COLLECTED (3 BOTTLES
Performed Testing Per Modified ATP Para 7.6	☑ Pass/☐ Fail 150 cc/min TRIM 2cc cc/MIN DRAWING	
Performed Testing Per Modified ATP Para 7.3.3/7.13	☐ Pass/☐ Fail	
Performed Testing Per Modified ATP Para 7.7	☑ Pass/☐ Fail 58 lb	START AT 58 67 . 0
Performed Testing Per Modified ATP Para 7.8	☑ Pass/☐ Fail 20 lb	
Performed Testing Per Modified ATP Para 7.15	☑ Pass/☐ Fail 7.9/8 seconds	
Performed Testing Per Modified ATP Para 7.18 & 7.19	☑ Pass/☐ Fail .227 mA -.302 BIAS (.09 - .20)	1st -.227 -.550 +.323


-.265
+-.416
÷2
-.3405
-.302
+-.402
÷2
-.202
DRIFT TEST
EXTRA
- DRIVE TO MID FROM RETRACT (FEELS EXTENDING)
- RATE = 44SEC/.100", 1MIN25SEC/.200"
- DRIVE TO MID FROM EXTEND (STARTS TO EXTEND)
- RATE = 40SEC/.100", 1MIN 19SEC/.200"
7.19
PULL-IN = 9.2V
DROP-OUT = 5.3V
7.16 RV FUNCTION
EXTRA
EXT 280/300 ft, 1.36 SEC,
RTR 280/300 ft, 1.25 SEC
7.16
280# TO RETRACT
277# TO EXTEND



ARKWIN

Form STP-1

Page 5 of 5

SN6777T

Investigation Data Sheet
STP 1211206-4
~~SN 5795T Piston Repair Qualification Test~~

Step #	Description	Observations	Comments/Results
9	Tear Down Performed?	☐Yes/☒No	

Test Technic

Date of Completion 10/11/16

ARKWIN INDUSTRIES INC.

Form STP-1

Page 1 of 5

Special Test Procedure STP 1211206-4

STP#	STP1211206-4	Prepared by:	S. Mangone	Date:	12/30/15
Program:	S-76	STP Revision:-		Revision Date:	
End Items:	1211206-017				
Source:	☐ Customer Directed	☒ Arkwin Internal		☐ Other	
Purpose:	Investigate flight incident on S-76 helicopter (PN 1211206-017, SN 5795T)				
Test Procedure or Description (attach documents as needed)					

Background

Pedal Damper and Trim Actuator (PDTA) 1211206-017 SN 5795T was involved in a flight incident overseas. On 12th August, about 1531hrs, 5N-BGD, Sikorsky S-76C+, a domestic chartered flightoperated by Bristow Helicopters Ltd (Nigeria), crashed into the Lagoon at Oworonshokiarea of Lagos. The 2 flight crewmembers and 4 of the 10 passengers were fatallyinjured. The helicopter was destroyed and there was no fire. The unit along with the wreckage of the aircraft was submerged in the lagoon for an extended period of time. Water damage is to be expected.

Test Methodology

In lieu of performing a standard acceptance test as defined in the CMM or Acceptance Test procedure ATP 1211206, a series of special tests will be used to evaluate the PDTA. These tests are intended to evaluate various performance aspects of the PDTA with minimal impact on any potential evidence contained within the unit. Tests such as proof pressure (which requires removal and replacement of various components), dielectric testing etc. will not initially be performed. Instead, passive tests intending on evaluating the condition of the unit will be performed. Depending on the results of testing, a teardown and visual inspection will be performed at the discretion of the team investigating this unit.

1. Record data from unit receipt. Note date received, RA number, and Serial number onto the datasheet. Photograph packaging and exterior condition of damper. Note any evidence of damage or any other points of interest.
2. Open hydraulic ports on unit and attempt to retrieve a fluid sample. Install in unit in Test Fixture T2557-17. Using a beaker, capture return flow for a fluid sample once pressure is applied to the supply port. Cycle the unit 5 times and capture the fluid to prevent contaminates from entering the test stand. Figure 1 provides a visual outline for the testing that is to be performed in steps 3 through 8. Attach ATP data sheet to STP with applicable data filled out upon completion of testing.

Note: If any ATP testing requires removal of any non-critical piece parts or if investigators/engineers deem it necessary to remove any piece parts, photographs shall be taken before removal and after to document condition.

ARKWIN INDUSTRIES INC.

Form STP-1

Page 2 of 5

3. Conduct testing in accordance with ATP1211206 paragraph 7.6.
4. Conduct testing in accordance with ATP1211206 paragraph 7.3.3. Note Paragraph 7.3.3 includes instructions to conduct testing per paragraph 7.13
5. Conduct testing in accordance with ATP1211206 paragraph 7.7
6. Conduct testing in accordance with ATP1211206 paragraph 7.8
7. Conduct testing in accordance with ATP1211206 paragraph 7.18 & 7.19 in order to evaluate the servo valve and solenoid.
8. After completion of testing, at the discretion of the investigators/engineering team, a teardown may be performed if deemed necessary. If teardown is performed, photograph condition of all relevant parts and surfaces.
9. Lay out parts and await further instruction from NTSB.

ARKWIN INDUSTRIES INC.

Form STP-1

Page 3 of 5

SN 5795T INVESTIGATION

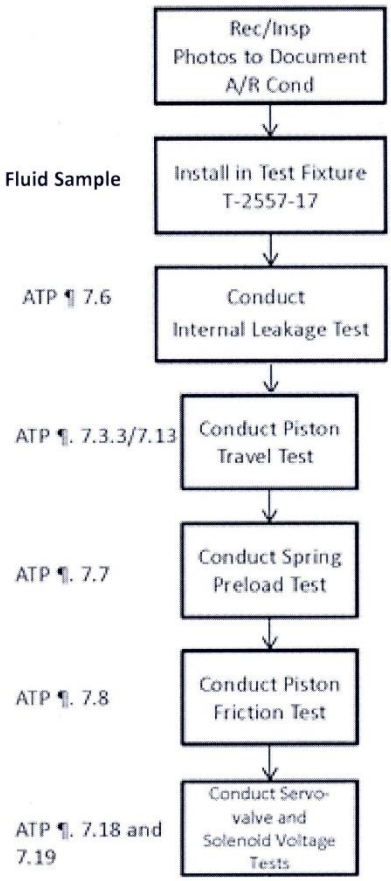


Figure 1 – Investigation Flow Chart

ARKWIN INDUSTRIES INC.

Form STP-1

Page 4 of 5

Investigation Data Sheet STP 1211206-4 SN 5795T Piston Repair Qualification Test			
Step #	Description	Observations	Comments/Results
1	Record RA Data & photograph	☐Confirmed	
3	Performed Testing Per Modified ATP Para 7.6	☐Pass/☐Fail _____ cc/min	
4	Performed Testing Per Modified ATP Para 7.3.3/7.13	☐Pass/☐Fail	
5	Performed Testing Per Modified ATP Para 7.7	☐Pass/☐Fail _____ lb	
6	Performed Testing Per Modified ATP Para 7.8	☐Pass/☐Fail _____ lb	
7	Performed Testing Per Modified ATP Para 7.15	☐Pass/☐Fail _____ seconds	
8	Performed Testing Per Modified ATP Para 7.18 & 7.19	☐Pass/☐Fail _____ mA	

ARKWIN INDUSTRIES INC.

Form STP-1

Page 5 of 5

Investigation Data Sheet STP 1211206-4 SN 5795T Piston Repair Qualification Test			
Step #	Description	Observations	Comments/Results
9	Tear Down Performed?	☐Yes/☐No	

Test Technician_____ Date of Completion_____

Accident Investigationat ARKWIN Industries on October 11, 2016

Purpose:

Investigate flight incident on S-76 Helicopter

End Item:

ARKWIN Industries Inc. Pedal Damper and Trim Actuator (PDTA)

Serial No. 6777T, Part No. 1211206-017

Special Test procedure:

ARKWIN Industries STP 1211206-4

Investigation Summary:

- Arkwin Industries provided brief overview of accident, scope and objective.
- Shipping Box opened and visual inspection.
    - Unit visually inspected for damage (unit intact, no damage, no lock wire cut)
    - Serial Number (6777T) verified on nameplate
    - No fluids were released upon removing the unit from its packaging since the caps were off prior to shipping
        - A hydraulic fluid sample from the unit when removed from helicopter was not provided in the shipping box.
    - Visible salt deposit on connector pins
    - Bearing exhibited salt water corrosion.
        - Bearing liner (Teflon) seemed to be falling out and the bearing was also not moving
        - Visible rust and pitting
    - Unit was last serviced 4th quarter of 2013

- Lab Testing
    - Bearing wouldn't accept the ATP Pin for load test due to corrosion/debris
        - Pin was able to be inserted after cleaning out with brush
    - Unitturned on
        - Unit cycled normally when hydraulic pressure was applied
        - 3 bottles of hydraulic fluid was collected for testing
    - Performed tests per ARKWIN's STP 1211206-4 by ARKWIN personnel
        - Paragraph 7.18.1 of the STP had to be repeated after not meeting the requirement.

- This was due to operator error in adjustment of the potentiometer
- Unit passed all tests performed.
- Sikorsky, ARKWIN, and FAA elected not to perform the test in Step #4 ATP paragraphs 7.3.3/7.13 on the Investigation Data Sheet. This was a long duration test and would have not provided any additional data.

- Sikorsky requested tests over and above Arkwin's STP
  - Drift Test
    - Drive to Mid from Retract (Keeps extending) – PASS
    - Drive to Mid from Extend (Starts to extend) – PASS
  - Relief Valve Test
    - Extend Time – PASS
    - Retract Time - PASS

Conclusion:

Unit met requirements of all tests performed- there was no reason to believe the unit malfunctioned during flight

ARKWIN Industries Report:

ARKWIN will have their report out for comment by the end of next week (10/2116)

- This was due to operator error in adjustment of the potentiometer
- Unit passed all tests performed.
- Sikorsky, ARKWIN, and FAA elected not to perform the test in Step #4 ATP paragraphs 7.3.3/7.13 on the Investigation Data Sheet. This was a long duration test and would have not provided any additional data.

- Sikorsky requested tests over and above Arkwin's STP
  - Drift Test
    - Drive to Mid from Retract (Keeps extending) – PASS
    - Drive to Mid from Extend (Starts to extend) – PASS
  - Relief Valve Test
    - Extend Time – PASS
    - Retract Time - PASS

Conclusion:

Unit met requirements of all tests performed- there was no reason to believe the unit malfunctioned during flight

ARKWIN Industries Report:

ARKWIN will have their report out for comment by the end of next week (10/2116)

Appendix C: Bristow Technical Directives

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	110

Subject:	**Post-accident physical inspections**
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Description: Following the accident in Nigeria on 12th August, as a precautionary measure, the following enhanced inspection review is required.

Compliance: Prior to first flight on or after the 14th August 2015

Action: Carry out the following inspections;

Airframe;

- Tail Rotor Blade Spar – Carry out a 25H inspection of the Tail Rotor Blade Spar IAW Composite Material Manual SA 4047-76-5, 65-20-00, Table 201. (If any ambiguity is found then progress to 500 hr borescope inspection IAW 65-21-00 paragraph 4)
- Carry out a detailed visual inspection of the complete flying control system, including all control rods, cables, bearings, bellcranks, support levers, fittings and torque shafts
- Carry out a Quick Rig of the Main Rotor IAW MM 67-00-00, para 2
- Carry out a Quick Rig of the Tail Rotor IAW MM 67-00-00, para 3
- Carry out a detailed visual inspection of the TRDS, bearings and bearing supports IAW MM 66-40-00, para 3.
- Without disassembly, carry out an inspection of the Flexible Couplings IAW MM 66-40-01, para 2A.
- Carry out a lightning strike check IAW ALIR 05-50-03 General 4
- Carry out a general inspection of the aircraft for any signs of FOD damage
- Carry out a detailed visual inspection of the Horizontal Stabilizer attachment fittings and the support structure.
- Carry out a detailed visual inspection of the Transmission and Engine Cowlings.

Compiled by:	Rick Bergeron	Vetted by:	David Moore		
Date:	13 August 2015	TD No.:	S76	- 05 -	110

Page 1 of 3 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	110

Subject:	**Post-accident physical inspections**
Effectivity:	**All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)**

Engines:

- Carry out general visual Inspection of the engine for FOD damage. If any evidence of FOD is noted carry out task IAW MM 71-02-03-280-801.
- Carry out general visual inspection of the engines for lightning strike. If any evidence of a lightning strike is noted carry out task IAW MM 71-02-04-280-801.

Report any finding to Fleet Support.

List of Attachments:	

Recurring	☐ Yes ☒ No	**IFS Mod**	☒ Yes ☐ No	**E.L.A. Affected**		☐ Yes ☒ No	
Weight and Balance	☐ Yes ☒ No	**WEIGHT**		**MOMENT**			

Additional Information:

NOTE;
This Alert TD is produced in tandem with Alert TD S76-05-111 and forms the first part of the return to service post Lagos Nigeria Incident.

Compiled by:	Rick Bergeron	Vetted by:	David Moore		
Date:	13 August 2015	TD No.:	S76	- 05 -	110

Page 2 of 3 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	110

Subject:	Post-accident physical inspections
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Technical Directive Acknowledgement – Americas & Bristow Academy ONLY

Base:	A/C Reg.No.:
Ser.No.:	A/C TT:
Date:	Name:
A and P:	(PRINT)
Technical Signature:	
To GOM personnel:	On completion please return this sheet to ARA Fleet Support department.
To BRISTOW ACADEMY personnel:	On completion please return this sheet to Ms Krista Norman (Titusville).

ANY ADDITIONAL INFORMATION REQUIRED:

Compiled by:	Rick Bergeron	Vetted by:	David Moore		
Date:	13 August 2015	TD No.:	S76	- 05 -	110

Page 3 of 3 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	111

Subject:	**S76 Fleet review of Aircraft Airworthiness documentation post incident in Lagos, Nigeria**
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Description:
Following an incident in Lagos Nigeria, as a precautionary measure, all Aircraft Airworthiness documentation, with respect to local NAA variances, is to be subject to an enhanced inspection review for the following;

- Applicability
- Compliance
- Correctness

Compliance:
Prior the first flight on or after the 14th August 2015.

Action:
Review all S76 variant documentation with respect to the follow directives and their governing NAAs for the last 12 months from the date at the bottom of this form;

- Airworthiness Directives
- ASBs and EASBs
- SBs
- Concessions/ variances issued
- Modifications
- Incidents e.g. lightning strikes, tail strike, heavy landing, etc.
- Weight and Balance history including any significant changes.
- Repairs (outside of SRM)
- Review of HUMS data for last 14 days

Depending on the location of the Aircraft, this check may be carried out by ARC, CASS or other local Airworthiness nominated personnel and the confirmation that this process has been performed should be emailed to the Engineering/Maintenance manager or EIC responsible for each aircraft and a copy attached to the paperwork.

List of Attachments: None

Recurring	☐ Yes ☒ No	**IFS Mod**	☒ Yes ☐ No	**E.L.A. Affected**		☐ Yes ☒ No	
Weight and Balance		☐ Yes ☒ No	**WEIGHT**		**MOMENT**		

Compiled by:	Rick Bergeron	Vetted by:	David Moore		
Date:	13 August 2015	TD No.:	S76	- 05 -	111

Page 1 of 2 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76C Series	Number:	S76	- 05 -	111

Subject:	S76 Fleet review of Aircraft Airworthiness documentation post incident in Lagos, Nigeria
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Additional Information:
NOTE;
This Alert TD is produced in tandem with Alert TD S76-05-110 and forms the second part of the return to service post Lagos Nigeria Incident.

Technical Directive Acknowledgement – Americas & Bristow Academy ONLY

Base:	A/C Reg.No.:
Ser.No.:	A/C TT:
Date:	Name:
A and P:	(PRINT)
Technical Signature:	
To GOM personnel:	On completion please return this sheet to ARA Fleet Support department.
To BRISTOW ACADEMY personnel:	On completion please return this sheet to Ms Krista Norman (Titusville).

ANY ADDITIONAL INFORMATION REQUIRED:

Compiled by:	Rick Bergeron	Vetted by:	David Moore		
Date:	13 August 2015	TD No.:	S76	- 05 -	111

Page 2 of 2 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76	Number:	S76	- 05 -	113

Subject:	Post-accident physical inspections
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Description: This TD extends the detail of some inspections initially required under TD S76-05-110. The cause of the recent S76 accident still remains unknown. We remain vigilant and are carrying out a further detailed inspection of the flight control system, specifically as indicated below.

Compliance: At next maintenance opportunity within the next 25 flight hours and no later than 30th August 2015.

Action: Carry out the following inspections;

- Remove race car forward fairing and main gearbox side panels to facilitate inspection.
- Carry out a detailed visual inspection of the flying control system from point A to the main rotor servos (point B) ref diagram on page 2. Inspection shall include visual and tactile inspection of control rods for security, damage, cracking, distortion; correct locking of jam nuts (check for tightness) and correct safety of adjustable rod ends (check thread engagement using tell-tale inspection hole, 0.020" locking wire cannot pass through inspection hole) and correct fitment of control bolts including cotter pins. Ref AMM 67-14-00.
- Inspect all bellcranks for security, condition and correct locking.
- Refit removed panels after inspection.

Report any finding to Fleet Support.

List of Attachments:	

Compiled by:	Russell Gould	Vetted by:	John Cloggie		
Date:	22 August 2015	TD No.:	S76	- 05 -	113

Page 1 of 3 (TD Acknowledgment page - for Americas ONLY)

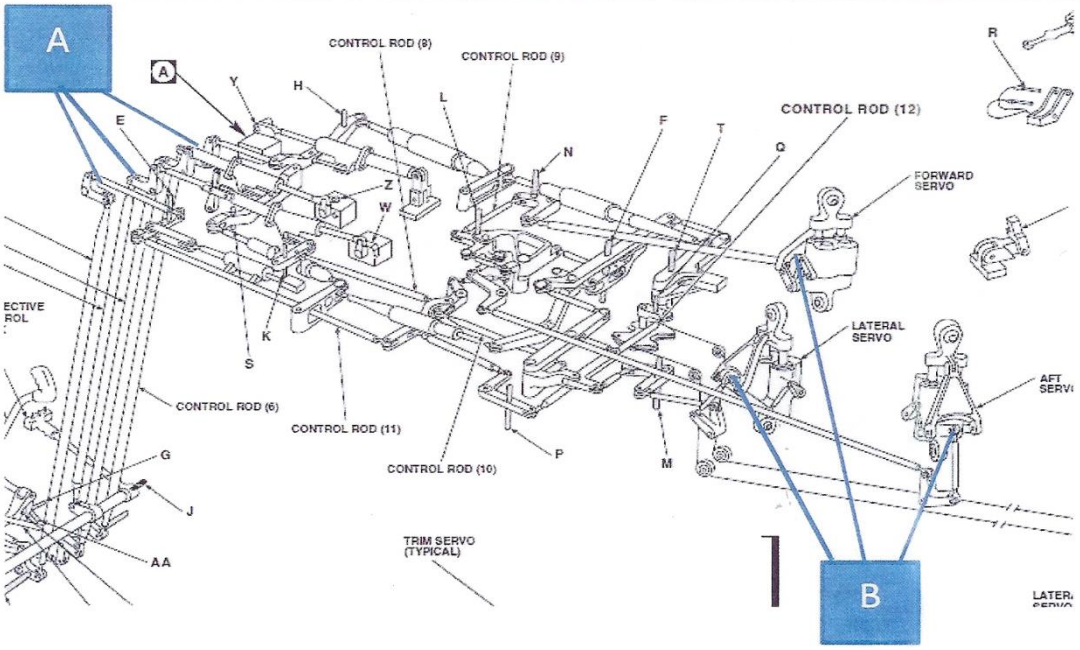
Technical Directive

Type:	S76	Number:	S76	- 05 -	113

Subject:	Post-accident physical inspections
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Recurring	☐Yes ☒No	IFS Mod	☒Yes ☐No	E.L.A. Affected	☐Yes ☐No
Weight and Balance	☐Yes ☒No	WEIGHT		MOMENT	

Additional Information:



Compiled by:	Russell Gould	Vetted by:	John Cloggie		
Date:	22 August 2015	TD No.:	S76	- 05 -	113

Page 2 of 3 (TD Acknowledgment page - for Americas ONLY)

Technical Directive

Type:	S76	Number:	S76	- 05 -	113

Subject:	Post-accident physical inspections
Effectivity:	All S76 variants in Bristow Global Fleet (operating aircraft, stored and held for sale)

Base:	A/C Reg.No.:
Ser.No.:	A/C TT:
Date:	Name:
A and P:	(PRINT)
Technical Signature:	
To GOM personnel:	On completion please return this sheet to ARA Fleet Support department.
To BRISTOW ACADEMY personnel:	On completion please return this sheet to Ms Krista Norman (Titusville).

ANY ADDITIONAL INFORMATION REQUIRED:

Compiled by:	Russell Gould	Vetted by:	John Cloggie		
Date:	22 August 2015	TD No.:	S76	- 05 -	113

Page 3 of 3 (TD Acknowledgment page - for Americas ONLY)

Appendix D: FAA Emergency Airworthiness Directive

FAA
Aviation Safety

AIRWORTHINESS DIRECTIVE

www.faa.gov/aircraft/safety/alerts/
www.gpoaccess.gov/fr/advanced.html

DATE: September 14, 2015
AD #: 2015-19-51

This emergency airworthiness directive (EAD) 2015-19-51 is being sent to owners and operators of Sikorsky Aircraft Corporation Model S-76A, S-76B, S-76C, and S-76D helicopters.

Background

This EAD was prompted by an accident of a Sikorsky Aircraft Corporation Model S-76C helicopter. During preliminary investigation, a failed servo input control pushrod (pushrod) assembly was identified. Separation of the pushrod tube and the control rod end with bearing was found. This EAD requires inspecting the main rotor (M/R) forward, aft, and lateral pushrod assemblies, the tail rotor (T/R) pushrod assembly, and the jamnuts, and applying slippage marks across the pushrod tubes and jamnuts. These EAD actions are intended to prevent loss of M/R or T/R flight control and subsequent loss of control of the helicopter.

FAA's Determination

We are issuing this EAD because we evaluated all the relevant information and determined the unsafe condition described previously is likely to exist or develop in other products of these same type designs.

Related Service Information

Sikorsky issued Alert Service Bulletin No. 76-67-57, Basic Issue, dated September 10, 2015 (ASB), which specifies a one-time inspection of the M/R forward, aft, and lateral pushrod assemblies, the T/R pushrod assembly, and the jamnuts for proper installation, condition, and security. If a pushrod or jamnut does not meet criteria specified in the inspection, the ASB specifies replacing the assembly. The ASB also specifies applying two slippage marks across each M/R and T/R pushrod tube and jamnut. Further, the ASB references the applicable maintenance manual for a new recurring inspection of the slippage marks.

EAD Requirements

This EAD requires, within five hours time-in-service, inspecting each M/R and T/R pushrod assembly by inspecting the position of the control rod end in the pushrod tube. If the lockwire passes through the inspection hole, this EAD requires replacing the pushrod assembly. If the lockwire does not pass through the inspection hole, this EAD requires inspecting the jamnut to determine seating position against the pushrod and whether the jamnut can be turned with finger pressure. If the jamnut is not seated against the pushrod or is loose, this EAD requires replacing the pushrod assembly. This EAD also requires, both for those pushrod assemblies that are replaced and for those that pass the inspections, applying two slippage marks across each M/R and T/R pushrod tube and jamnut.

Interim Action

We consider this EAD interim action as the accident investigation is ongoing. If additional action is later identified, we might consider further rulemaking.

Authority for this Rulemaking

Title 49 of the United States Code specifies the FAA's authority to issue rules on aviation safety. Subtitle I, Section 106, describes the authority of the FAA Administrator. "Subtitle VII, Aviation Programs," describes in more detail the scope of the Agency's authority.

We are issuing this rulemaking under the authority described in "Subtitle VII, Part A, Subpart III, Section 44701, General requirements." Under that section, Congress charges the FAA with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority because it addresses an unsafe condition that is likely to exist or develop on products identified in this rulemaking action.

Adoption of the Emergency Airworthiness Directive (EAD)

We are issuing this EAD under 49 U.S.C. Sections 106(g), 40113, and 44701 according to the authority delegated to me by the Administrator.

2015-19-51 **Sikorsky Aircraft Corporation:** Directorate Identifier 2015-SW-065-AD.

(a) Applicability

This EAD applies to Model S-76A, S-76B, S-76C, and S-76D helicopters with main rotor (M/R) servo input control pushrod (pushrod) assembly part number (P/N) 76400-00034-059 or tail rotor (T/R) pushrod assembly P/N 76400-00014-071 installed, certificated in any category.

(b) Unsafe Condition

This EAD defines the unsafe condition as a loose jamnut. This condition could result in failure of a pushrod assembly, loss of M/R or T/R flight control, and subsequent loss of control of the helicopter.

(c) Effective Date

This EAD is effective upon receipt.

(d) Compliance

You are responsible for performing each action required by this EAD within the specified compliance time unless it has already been accomplished prior to that time.

(e) Required Actions

Within five hours time-in-service:

(1) Inspect each pushrod end to determine whether a 0.020 inch diameter lockwire can pass through the inspection hole.

(i) If the lockwire passes through the inspection hole, replace the pushrod assembly.

(ii) If the lockwire does not pass through the inspection hole, inspect the jamnut to determine whether it is seated against the pushrod and whether it can be turned with finger pressure. If the jamnut is not seated against the pushrod or can be turned with finger pressure, replace the pushrod assembly.

(2) Apply two slippage marks across each pushrod tube and jamnut as follows:

(i) Clean the area where a slippage mark is to be applied.

(ii) Apply two slippage marks across the pushrod tube and jamnut, parallel and on opposite sides of each other. Each slippage mark must extend at least 0.5 inch onto the pushrod tube and must not cover the inspection hole. Figures 2 and 4 of Sikorsky Alert Service Bulletin No. 76-67-57, Basic Issue, dated September 10, 2015, illustrate slippage marks across a pushrod tube and jamnut.

(f) Alternative Methods of Compliance (AMOCs)

(1) The Manager, Boston Aircraft Certification Office, FAA, may approve AMOCs for this EAD. Send your proposal to: Blaine Williams, Aerospace Engineer, Boston Aircraft Certification Office, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, Massachusetts 01803; telephone (781) 238-7161; email blaine.williams@faa.gov.

(2) For operations conducted under a 14 CFR part 119 operating certificate or under 14 CFR part 91, subpart K, we suggest that you notify your principal inspector, or lacking a principal inspector, the manager of the local flight standards district office or certificate holding district office, before operating any aircraft complying with this EAD through an AMOC.

(g) Additional Information

(1) For further information contact: Blaine Williams, Aerospace Engineer, Boston Aircraft Certification Office, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, Massachusetts 01803; telephone (781) 238-7161; email blaine.williams@faa.gov.

(2) For a copy of the service information referenced in this AD, contact: Sikorsky Aircraft Corporation, Customer Service Engineering, 124 Quarry Road, Trumbull, CT 06611; telephone 1-800-Winged-S or 203-416-4299; email sikorskywcs@sikorsky.com.

(h) Subject

Joint Aircraft Service Component (JASC) Code: 2700, Flight Control System.

Issued in Fort Worth, Texas, on September 14, 2015.

Acting Directorate Manager, Rotorcraft Directorate,
Aircraft Certification Service.

Appendix E: Sikorsky Alert Service Bulletin

Sikorsky
A United Technologies Company

Sikorsky Aircraft Corporation
6900 Main StreetP.O. Box 9729
Stratford, Connecticut 06615-9129
(203) 386-4000

S-76®HELICOPTER

ALERT SERVICE

BULLETIN

ASB 76-67-57

Basic Issue ▪ September 10/15

SUBJECT: FLIGHT CONTROLS – Main and Tail Rotor Servo Input Control Pushrods – One-Time Inspection and Application of Slippage Mark

Section 1. PLANNING INFORMATION

A. Effectivity — All S-76 model helicopters equipped with control pushrod assemblies, Part Number (P/N) 76400-00034-059 and 76400-00014-071, delivered as of the issue date of this Alert Service Bulletin (ASB).

B. Purpose — To perform a one-time inspection of installed forward, aft and lateral main servo input control pushrods and jamnuts and tail rotor servo input control pushrods and jamnuts for proper installation, condition, and security followed by application of slippage mark on all main and tail rotor servo input control pushrod jamnuts.

C. Description — Helicopter is prepared for maintenance. The forward, aft, lateral main servo input control pushrod part numbers are verified. Main servo input control pushrod hardware is inspected. Slippage mark is applied to main rotor input control pushrod jamnut.Tail rotor servo input control pushrod part numbers are verified. Tail rotor servo input control pushrod hardware is inspected. Slippage mark is applied to tail rotor servo input control pushrod jamnut. Helicopter is returned to service.

Section 1. PLANNING INFORMATION (Continued)

NOTE: Only main rotor servo input control pushrod P/N 76400-00034-059 shall be used. Main rotor servo input control pushrod P/N 76400-00034-056 was removed from service in accordance with ASB 76-67-46. Verify ASB 76-67-46 has been completed prior to starting this ASB.

D. Compliance Compliance is essential. The instructions outlined herein shall be accomplished prior to next flight originating from a maintenance facility or not to exceed 5 flight hours from issue date of this ASB.

E. Approval Inspection Item.

F. Manpower (Estimated)

Task	No. of Men	No. of Hours	Man-Hours*
Inspection of main servo input control pushrod**	1	0.5	0.5
Inspection of tail rotor servo input control pushrod**	1	0.5	0.5
Total Man-Hours			1.0

*Estimate does not include time required to prepare helicopter or return it to flight status or time to remove input control pushrods and inspect if required.

**Estimate does not include removal and installation of input control rods.

G. Tooling

None.

H. Weight and Balance

Not affected.

I. Electrical Load Data

Not affected.

J. Software Load Data

Not affected.

K. References

(1) Models A, B, & C, refer to applicable Maintenance Manual, Chapter/Section 53-20-02.

(2) Models A, B, & C, refer to applicable Maintenance Manual, Chapter/Section 53-30-02.

(3) Models A, B, & C, refer to applicable Maintenance Manual, Chapter/Section 67-15-02.

Section 1. PLANNING INFORMATION (Continued)

(4) Models A, B, & C, refer to applicable Maintenance Manual, Chapter/Section 67-20-00.

(5) Model D, refer to Maintenance Manual, SA S76D-AMM-000, Task 53-70-05-900-802.

(6) Model D, refer to Maintenance Manual, SA S76D-AMM-000, Task 53-70-08-900-801.

(7) Model D, refer to Maintenance Manual, SA S76D-AMM-000, Task 67-15-02-900-804.

(8) Model D, refer to Maintenance Manual, SA S76D-AMM-000, Task 67-20-05-900-801.

L. Publications Affected

(1) Temporary Revision No. 5-205 against Maintenance Manual, SA 4047-76-2-1, Chapter/Section 5-20-00 is issued concurrently with this ASB.

(2) Temporary Revision No. 5-181 against Maintenance Manual, SA 4047-76B-2-1, Chapter/Section 5-20-00 is issued concurrently with this ASB.

(3) Temporary Revision No. 5-187 against Maintenance Manual, SA 4047-76C-2-1, Chapter/Section 5-20-00 is issued concurrently with this ASB.

(4) Temporary Revision No. 67-17 against Maintenance Manual, SA S76D-AMM-000, Chapter/Section 67-15-02 is issued concurrently with this ASB.

(5) Temporary Revision No. 67-18 against Maintenance Manual, SA S76D-AMM-000, Chapter/Section 67-20-05 is issued concurrently with this ASB.

(6) Temporary Revision No. 5-37 against Maintenance Manual, SA S76D-AWL-000, Chapter/Section 5-20-00 is issued concurrently with this ASB.

M. Attachment

None.

Section 2. MATERIAL INFORMATION

A. Basis for Material Data

Per helicopter.

B. Bill of Material

None.

C. Consumable Material

WARNING

OBSERVE ALL CAUTIONS AND WARNINGS ON CONTAINERS WHEN USING CONSUMABLES. WHEN APPLICABLE, WEAR NECESSARY PROTECTIVE GEAR DURING HANDLING AND USE. IF A CONSUMABLE IS FLAMMABLE OR EXPLOSIVE, MAKE CERTAIN CONSUMABLE AND ITS VAPORS ARE KEPT AWAY FROM HEAT, SPARK AND FLAME. MAKE CERTAIN FIREFIGHTING EQUIPMENT IS READILY AVAILABLE PRIOR TO USE. FOR ADDITIONAL INFORMATION ON TOXICITY, FLASHPOINT AND FLAMMABILITY OF CHEMICALS, CONSULT YOUR MEDICAL PEOPLE OR THE MANUFACTURER OF THE CONSUMABLE.

Qty	Nomenclature	Part Number	Source
AR	Sentry Seal	F-1000 or equivalent	(1)
AR	Epoxy Polyamide Coating	MIL-PRF-22750 or equivalent	(1)
AR	Trichloroethane	O-T-620 or equivalent	(1)

(1) Available through normal supply channels.

Section 3. ACCOMPLISHMENT INSTRUCTIONS

WARNING

WHEN ANY COMPONENT OF ANY FLIGHT CONTROL SYSTEM IS DISCONNECTED, REMOVED AND REINSTALLED OR REPLACED, A RIGGING CHECK MUST BE MADE TO BE SURE THAT CONTROL RANGES ARE WITHIN SPECIFIED LIMITS.

A. Prepare helicopter for inspection.

(1) Turn off all helicopter electrical and hydraulic power.

(2) Engage rotor brake.

(3) Remove main rotor fairing. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 53-20-02, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 53-70-08-900-801.)

(4) Remove tail rotor fairing. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 53-30-02, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 53-70-05-900-801.)

B. Perform inspection of main rotor servo input control pushrod assembly (76400-00034-059) as follows (Refer to Figure 1):

(1) Verify forward, aft, and lateral main servo input control pushrod P/N (76400-00034-059).

(2) Check adjustable rod-end of control pushrod assembly (76400-00034-059) to make sure rod-end threads pass inspection hole (witness hole). (Refer to Figure 2.)

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)

(a) Verify a 0.020 inch diameter piece of lockwire cannot pass through inspection hole. (Refer to Figure 2.)

1. If lockwire passes through inspection hole, remove pushrod assembly (76400-00034-059) and replace with serviceable unit. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 67-15-02, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 67-15-02-900-804). Apply slippage mark on replacement unit. Proceed to step B. (4)

2. If lockwire does not pass through inspection hole, proceed to step B.(3).

(3) Visually inspect jamnut, make sure it is seated against the control pushrod. (Refer to Figure 2.)

(a) Using finger pressure check jamnut for looseness. If jamnut is loose or not seated, remove pushrod assembly (76400-00034-059) and replace with serviceable unit. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 67-15-02, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 67-15-02-900-804.) Apply slippage mark on replacement unit. Proceed to step B. (4).

(b) If jamnut is not loose and seated, proceed to next step.

(4) Apply slippage mark to all main rotor servo input control pushrod jamnuts as follows (Refer to Figure 2):

(a) Clean areas where slippage mark is to be applied with trichloroethane (O-T-620 or equivalent).

NOTE: Make sure slippage mark is not applied over inspection hole.

(b) Using epoxy polyamide coating (MIL-PRF-22750 or equivalent) or Sentry Seal (F-1000 or equivalent), apply slippage mark to jamnut in (two places) 180 degrees apart.

(c) Slippage mark shall extend a minimum of 0.500 inch on the control rod.

C. Perform inspection of tail rotor servo input control pushrod assembly (76400-00014-071) as follows (Refer to Figure 3):

(1) Verify tail rotor servo input control pushrod P/N (76400-00014-071).

(2) Check adjustable rod-end of control pushrod assembly (76400-00014-071) to make sure rod-end threads pass inspection hole (witness hole). (Refer to Figure 4.)

(a) Verify a 0.020 inch diameter piece of lockwire cannot pass through inspection hole. (Refer to Figure 4.)

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)

1. If lockwire passes through inspection hole, remove pushrod assembly (76400-00014-071) and replace with serviceable unit. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 67-20-00, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 67-20-05-900-801). Apply slippage mark on replacement unit. Proceed to step C. (4).

2. If lockwire does not pass through inspection hole, proceed to step C.(3).

(3) Visually inspect jamnut, make sure it is seated against the control pushrod. (Refer to Figure 4.)

(a) Using finger pressure check jamnut for looseness. If jamnut is loose or not seated, remove pushrod assembly (76400-00014-071) and replace with serviceable unit. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 67-20-00, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 67-20-05-900-801.) Apply slippage mark on replacement unit. Proceed to step C. (4).

(b) If jamnut is not loose and seated, proceed to next step.

(4) Apply slippage mark to tail rotor servo input control pushrod jamnut as follows (Refer to Figure 4):

(a) Clean areas where slippage mark is to be applied with trichloroethane (O-T-620 or equivalent).

NOTE: Make sure slippage mark is not applied over inspection hole.

(b) Using epoxy polyamide coating (MIL-PRF-22750 or equivalent) or Sentry Seal (F-1000 or equivalent), apply slippage mark to jamnut in (two places) 180 degrees apart.

(c) Slippage mark shall extend a minimum of 0.500 inch on the control rod.

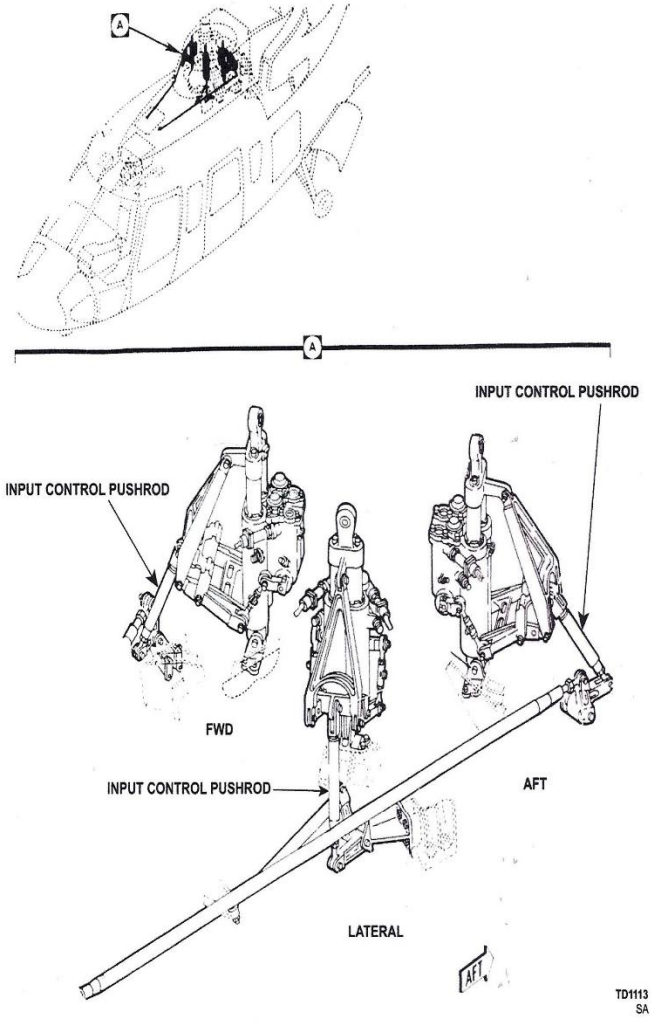
D. Install main rotor fairing. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 53-20-02, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 53-70-08-900-801.)

E. Install tail rotor fairing. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 53-30-02, or Model D, Maintenance Manual, SA S76D-AMM-000, Task 53-70-05-900-801.)

F. Review and comply with newly established recurring inspection of Main and Tail Rotor Servo Input Control Pushrods at next interval. (Refer to Models A, B & C, applicable Maintenance Manual, Chapter/Section 5-20-00, or Model D, Maintenance Manual, SA S76D-AWL-000, Chapter/Section 5-20-00).

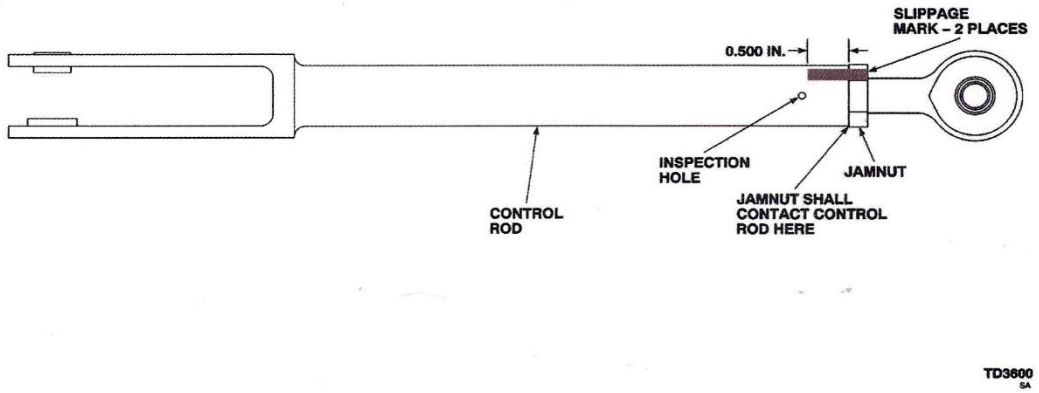
G. Return helicopter to Service.

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)



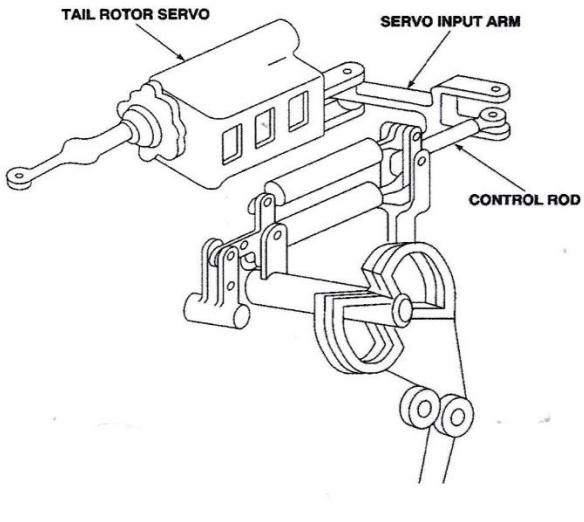
MAIN ROTOR SERVO INPUT CONTROL PUSHRODS
FIGURE 1

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)



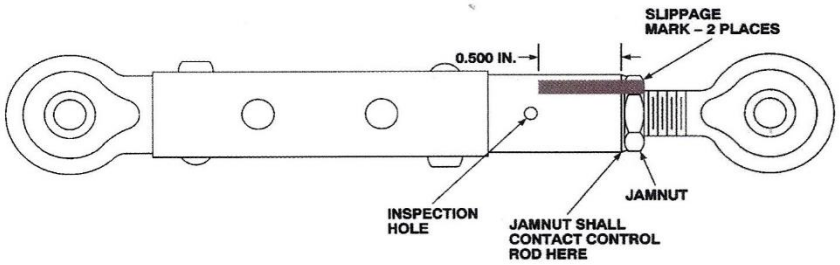
MAIN ROTOR SERVO INPUT CONTROL PUSHROD (76400-00034-059)
JAMNUT INSPECTION HOLE (WITNESS HOLE) AND SLIPPAGE MARK LOCATION
FIGURE 2

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)



TAIL ROTOR SERVO INPUT CONTROL PUSHRODS
FIGURE 3

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)



TAIL ROTOR SERVO INPUT CONTROL ROD (76400-00014-071)
JAMNUT INSPECTION HOLE (WITNESS HOLE) AND SLIPPAGE MARK LOCATION
FIGURE 4

Section 3. ACCOMPLISHMENT INSTRUCTIONS (Continued)

H. Record of compliance:

(1) Make helicopter logbook entries to show compliance with this ASB as follows:

(a) Make helicopter level logbook entry on form SA7343-15 (Aircraft ASB and CSN Release Signoff).

(b) When ASB modifies a component that can be removed from this helicopter:

1. Make component log card entries on forms SA7343-22 (Aircraft Component Log Cards) and SA7343-21 (Component Log Cards), as applicable.

2. If a component modified by this ASB does not have a log card and the ASB does not create one, then annotate compliance on the next higher assembly that the component belongs to which does have a log card.

NOTE: If access to www.Sikorsky360.com is unavailable, complete attached ALERT SERVICE BULLETIN COMPLIANCE RECORD CARD and return it to Sikorsky Aircraft Corporation.

(2) Make an appropriate electronic compliance entry in the E-Notification section at www.Sikorsky360.com. Refer to User Guide located on the www.Sikorsky360.com/E-Notification Search page.

Appendix F: NCAA All Operator Letter (AOL 050)

NCAA

NIGERIAN CIVIL AVIATION AUTHORITY

P.M.B. 21029, 21038, IKEJA-LAGOS.

ALL OPERATORS LETTER (AOL 050)

Circular Ref:	NCAA/DAWS/AD.1104/AOL 050/Vol.I
Date:	15th September, 2015
To:	All Sikorsky Model S76 Helicopter Owners/Operators
From:	Directorate of Airworthiness Standards
Attn:	Accountable Manager / Quality Assurance Manager

SUBJECT: **FAA EMERGENCY AIRWORTHINESS DIRECTIVE (EAD) 2015-19-51**

The Federal Aviation Administration (FAA) has issued an Emergency Airworthiness Directive (EAD) 2015-19-51 on Sikorsky Aircraft Corporation S-76A. S-76B, S-76C and S-76D Helicopters: Main Rotor (M/R) Failed Servo Input Control Pushrod Assembly.

The attached EAD is hereby forwarded to all owners and operators of S76 Model Helicopters registered in Nigeria for immediate compliance within the specified compliance time in the EAD unless it has already been accomplished prior to that time.

All owners and operators are hereby required to submit evidence of compliance to the Principal Maintenance Inspector (PMI) in charge of their airlines within 48hrs of compliance.

Treat as very urgent.

Director, Airworthiness Standards
For: Director General

Corporate Headquarters: Nnamdi Azikwe Int'l Airport, Domestic Wing, Abuja.
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Licencing: +234 (1) 7739972; Operations: +234 (1) 4714339; Switch Board: +234 (1) 7610036, +234 (1) 7610037.
Email: info@ncaa.gov.ng Website: www.ncaa.gov.ng