AIRCRAFT ACCIDENT REPORT

PAAN/2012/10/27/F

Accident Investigation Bureau

Report on the Accident Involving Pan African Airlines Nigeria Limited (PAAN), Bell 206 L4 Helicopter with Registration 5N – BFF, At Chevron Okan Production Platform, Escravos Offshore, Delta State which occurred on 27th October, 2012.

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

The report is based upon the investigation carried out by 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.
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.

Readers are advised that Accident Investigation Bureau investigates for the sole purpose of enhancing aviation safety. Consequently, Accident Investigation Bureau reports are confined to matters of safety significance and should not be used for any other purpose.

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

Recommendations in this report are addressed to the regulatory Authorities of the state (NCAA). It is for this authority to ensure enforcement.

Contents

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AOC: - Air Operator's Certificate

ASB: - Alert Service Bulletin

CECO: - Chandler Evans Control System

CLR: - Clear

CMM: - Component Maintenance Manual

CPM: - Crucible Particle Metallurgy process

CSN: - Cycles Since New

ELT: - Emergency Locator Transmitter

FAA: - Federal Aviation Administration

FCU: - Fuel Control Unit

FOD: - Foreign Object Damage

GPECS: - Goodrich Pump and Engine Control Systems

GPS: - Global Positioning System

HF: - High Frequency

hPa: - Hecto Pascal (Unit of pressure)

IIC: - Investigator –in –Charge

MFP: - Main Fuel Pump

MHz: - Mega Hertz (Unit of frequency)

NAC: - National Airways Corporation

NCAA: - Nigerian Civil Aviation Authority

PAAN: - PAN African Airlines Nigeria Limited

PTG:	- Power Turbine Governor
QAR:	- Quick Access Recorder
QNH:	- The Atmospheric Pressure at Mean Sea Level
RR:	- Rolls –Royce
SB:	- Service Bulletin
TBO:	- Time Between Overhaul
TECS:	- Triumph Engine Control System
TSN:	- Time Since New
TSO:	- Time Since Overhaul
UTC:	- Universal Time Co-ordinated
	Nigerian Time (UTC+1)
VHF:	- Very High Frequency
Wx:	- Weather

Aircraft Accident Report No:	**PAAN/2012/10/27/F**
Registered Owner and Operator:	PAN African Airlines, Nigeria (PAAN) Limited
Aircraft Type and Model:	Bell 206 L4
Nationality:	Nigerian
Registration:	5N-BFF
Location:	Chevron Okan production Platform, Escravos Offshore, Delta State. Coordinates: N05°33.49' E005° 04.61'
Date and Time:	27th October, 2012 at about 1607hrs. *(All times in this report are local time equivalent to UTC + 1) unless otherwise stated*

Synopsis

The accident involving 5N–BFF belonging to PAN African Airlines Nigeria Limited was reported to Accident Investigation Bureau on 27th October, 2012 at about 1733hrs through its emergency telephone lines. All relevant authorities were notified. Two Investigators were subsequently dispatched to the crash site.

The Bell 206 L4 helicopter with registration number 5N-BFF was assigned to work with the South Operations Assistant for the Meji Shutdown and repair operations. At 1500hrs, after working for a while at Meji Field, the aircraft

was deployed to work at Delta field. It landed at OKAN, refueled and proceeded to work at the field. Essentially, South Field Operations comprise OKAN Field, DELTA Field and MEJI Field.

The pilot made several landings on many helidecks within the Delta field and returned to OKAN production platform at about 1602hrs. The aircraft took off from the platform for final departure to Escravos base at about 1607hrs. The pilot stated that just as the aircraft took off and cleared the helideck, he noticed that the engine had stopped. He entered autorotation, promptly deployed the floats and made a precautionary ditching.

The aircraft landed hard on water following which the windscreen were completely shattered but the inflated floats kept the helicopter afloat on water. However, the centre float on the starboard side did not fully inflate causing the helicopter to tilt to the right. The three passengers and the pilot exited the aircraft through the left door unto the port floats assembly. A supply boat which was working at the same platform at the time helped evacuate the passengers and crew into safety before it capsized.

The investigation identified the following:

Causal Factor

Failure of the main fuel pump, resulting from wearing of the fuel pump main drive shaft external splines, which mate with the internal splines of the pump driver gear with a consequent fuel starvation, flame-out and engine loss of power.

Contributory Factor

Material compositions of the improved main fuel pump, which allowed excessive differential wear between the main drive shaft and the driver gear.

Three (3) safety recommendations were made.

1.0 Factual Information

1.1 History of Flight

On the 27th October, 2012 a Pan African airlines Bell 206 L4 helicopter with registration number 5N-BFF was assigned to work with the South Operations Assistant for the MEJI Shutdown and repair operations.

At 1500hrs, after working for a while at MEJI Field, the aircraft was deployed to work at Delta field. It landed at OKAN, refueled and proceeded to work at the field. Essentially, South Field Operations comprise OKAN Field, DELTA Field and MEJI Field.

The pilot made several take-offs and landings on several helidecks within the Delta field and returned to OKAN production platform at about 1602hrs. The aircraft took off from the platform for final departure to Escravos base at about 1607hrs.

The pilot stated that just as the aircraft took off and cleared the helideck, he noticed that the engine had stopped. He entered autorotation, promptly deployed the floats and made a precautionary ditching.

The aircraft landed hard on water, which resulted in the shattering of the windscreen. The inflated floats kept the helicopter afloat. However, the centre segment of the starboard float did not fully inflate causing the helicopter to tilt to the right. The three passengers and the pilot exited the aircraft through the left door unto the port float assembly. A supply

boat which, was working at the same platform at the time helped evacuate the passengers and crew into safety before it capsized.

The accident occurred offshore around the Chevron OKAN production platform with latitude N05°33.49' and longitude E005° 04.61'at 1607hrs.
The accident occurred in daylight.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	1	3	Nil

1.3 Damage to Aircraft

The aircraft was substantially damaged.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Pilot in Command

Nationality:	Irish
Gender:	Male
Age:	42 yrs
Licence No.:	6088(H)

Aircraft Ratings:	Single Engine; part 1: Bell 206, Bell 407
Instrument Rating:	None
Proficiency Check:	
Bell 206	1st September, 2012 valid until 28th February, 2013
Bell 407	2nd September, 2012 valid until 1st March, 2013
Medical Certificate:	9th August, 2012 valid until 9th February, 2013
Total Flying Experience:	4830.8hrs
On Type:	811.6hrs
Last 90 days:	179.2hrs
Last 28 days:	83.3hrs
Last 24 hrs	4.7hrs

1.6 Aircraft Information

Type:	Bell 206 L4
Year of Manufacture:	2002
Serial No.:	52273
Registration:	5N-BFF
Total Airframe Time:	12243.8hrs
Cycles/Landings:	103244
Certificate of Airworthiness Validity:	26th March, 2013
Certificate of Registration:	25th April, 2007

1.6.1 Engine

Type:	Turbo shaft 250 – C30P
Manufacturer:	Rolls - Royce
Serial No.:	CAE – 895745
Time Since New:	8103hrs, 8mins
Cycle Since New:	16799 cycles as at 26th October, 2012

Type of fuel used is Jet A1.

1.7 Meteorological Information

The weather forecast obtained from Escravos Tower on the day of the accident was as follows:

Time	:	**0650 UTC**
Wind	:	200/09
Weather	:	Nil
Visibility	:	10km
Cloud	:	Nil
Temp/Dew	:	26/26^{o}C
QNH	:	1009 hPa

The actual available weather information to the pilot at the time of the accident was as follows:

Time	:	**1507 UTC**
Wind	:	360/05
Weather	:	Nil
Visibility	:	Unlimited
Cloud	:	High Overcast
Temp/Dew	:	26°C/Nil
QNH	:	1009 hPa
Light Conditions	:	Day

1.8 Aids to navigation

The conditions of the navigation aids at Escravos Tower on the day of the accident were as follows:

131.7 MHz main/standby radios	:	'Serviceable'
121.5 MHz ELT Monitor	:	'Serviceable'
HF Radio	:	'Serviceable'
Davis Wx Eqpt.	:	'Serviceable'
Aldis Lamp	:	'Serviceable'
AD rotating beacon	:	'Serviceable'
Airfield Lighting System:	:	'Serviceable'
Phones 73755 and 73732	:	'Serviceable'
Walkie Talkies (2)	:	'Serviceable'

The helicopter was also fitted with an on-board GPS.

1.9 Communications

There was good communication between the aircraft and the platforms base.

1.10 Aerodrome Information

The accident occurred on OKAN Production Platform, which is a Chevron offshore facility. The platform has two helidecks located in the Atlantic Ocean on co-ordinates N05°33.49', E005° 04.61' with elevations 90ft and 60ft, size D17m and D13m respectively. The helicopter took off from the lower deck. The production platform is equipped with communication facilities such as VHF 131.70 for communicating between it and Escravos Tower. It has a refueling capability with fuel dump located at the top deck as well as helideck edge lights. The direct distance between the platform and Escravos terminal is about 7.3 nautical miles. See fig 1.10a to 1.10b below.

Fig.1.10a: Picture showing the Lower Deck of OKAN Production Platform where the Helicopter took off.

Fig.1.10b: picture showing the relative positions of the two helidecks of OKAN Production Platform

1.11 Flight Recorders

The Helicopter was not equipped with a Flight Data Recorder or Cockpit Voice Recorder neither was it required by law to be installed.

However, the aircraft was fitted with the Quick Access Recorder (QAR) also known as Appareo Data Card and GPS module.

APPAREO DATA CARD

Part Number	: 104030-000005
S/N	: Not Available
Date Code	: Not Available
Manufacturer	: SanDisk

GPS MODULE

Part Number	: 011-00506-10
S/N	: GNC420
Date Code	: Not Available
Manufacturer	: Garmin International, Inc. Olathe, KS USA

1.12 Wreckage and impact information

The helicopter took-off from the lower deck of OKAN production platform and just as it cleared the helideck, the engine flamed-out. The pilot immediately entered autorotation and inflated the floats, just as the helicopter hit the water surface with substantial force.

At the time of impact the windscreen shattered completely. The floats were inflated sufficiently to keep the helicopter afloat although the centre segment of the starboard float did not fully inflate causing the chopper to tilt approximately 30 degrees to the right.

After the aircraft's occupants were evacuated, the helicopter rolled completely and was fully submerged with the skid facing skyward although the floats were still inflated and could be seen on the water surface.

1.13 Medical and Pathological Information

The pilot and passengers were taken to Chevron Hospital, Escravos for medical examination after the accident. The pilot tested negative to all drugs substance and alcohol. Similarly, the passengers were examined and immediately discharged to go and rest since no one sustained serious injuries. See fig 1.13 below.

Chevron Hospital
ESCRAVOS

October 27 2012

Confidential

Result of Drug and Alcohol Testing

Name of Subject: [redacted]

Company: PAAN AVIATION

Indication for test: Helicopter Accident

Test Date: 10/27/2012

BREATH ALCOHOL CONCENTRATION [BAC] = 0.00%

Substances tested for	Result
Tetrahydrocannabinol (THC) (Marijuana)	Negative
Morphine	Negative
Cocaine	Negative
Benzodiazepines	Negative
Barbiturates	Negative
Amphetamines	Negative

Summary of results:

Tested Negative to all drugs substance and alcohol

[redacted]

Signed Physician Date 10/27/2012

Fig. 1.13

1.14 Fire:

There was no fire outbreak.

1.15 Survival Aspects

The rescue operation was promptly carried out by the crew of a supply boat to OKAN production platform, which was about 100m away from the ditched helicopter. The accident was survivable in that there was a liveable volume for the helicopter occupants. The impact force was absorbed by the floats

that were immediately deployed by the pilot following the loss of power from the engine.

The four occupants were evacuated to safety from the sinking helicopter to the supply boat with the aid of lifelines thrown to them. They were later conveyed to Escravos by a rescue boat and subsequently taken for medical examination. See figures 1.15a and 1.15b below.

Fig.1.15a: Picture Showing the Rescue Operation being carried out.

Fig.1.15b: picture showing the crew of the supply boat (Rescuers) and the capsized helicopter.

1.16. Test and Research

1.16.1 Engine Teardown

A Rolls-Royce Air Safety Investigator conducted an engine examination at National Airways Corporation (Rand Airport, Germiston, South Africa) and Greystones Accessories Shop (Durban, South Africa) on 28th and 29th August

2013 respectively. The examination was under the direction of and supervised by the Nigerian AIB IIC. The engine was removed from the sealed shipping box and placed in a turnover stand and completely disassembled under the direction of the Nigerian AIB IIC. External damage was limited to salt water corrosion on the engine and accessories, with extensive penetration damage through the gearbox housing. The fuel pump, manufactured by Triumph Engine Control Systems (TECS), was sent to TECS in West Hartford, CT USA for further examination. The detailed component examination was conducted on 16th October 2013 under the supervision of the Nigerian AIB IIC and a Rolls-Royce Air Safety Investigator. See figure 1.16a below.

Fig.1.16a: picture showing the containerized engine as receieved at NAC facility in Johannesburg, South Africa.

1.16.2 Summary of Findings

The fuel pump main drive shaft external splines, which mate to the internal splines of the pump driver gear, were severely worn. The wear was significant enough to decouple the fuel pump main drive shaft from

the pump driver gear, which provides fuel to the engine. The subsequent loss of pressurized fuel to the engine resulted in a flameout and loss of power during flight. The cause of the fuel pump main driveshaft wear is under investigation by the fuel pump supplier, the Triumph Engine Control System (TECS) and Rolls-Royce engineering. See figures 1.16b, 1.16c, 1.16d, 1.16e and 1.16f below.

Fig.1.16b: Picture showing Fuel Pump Main Drive Shaft prior to removal from Fuel Pump.

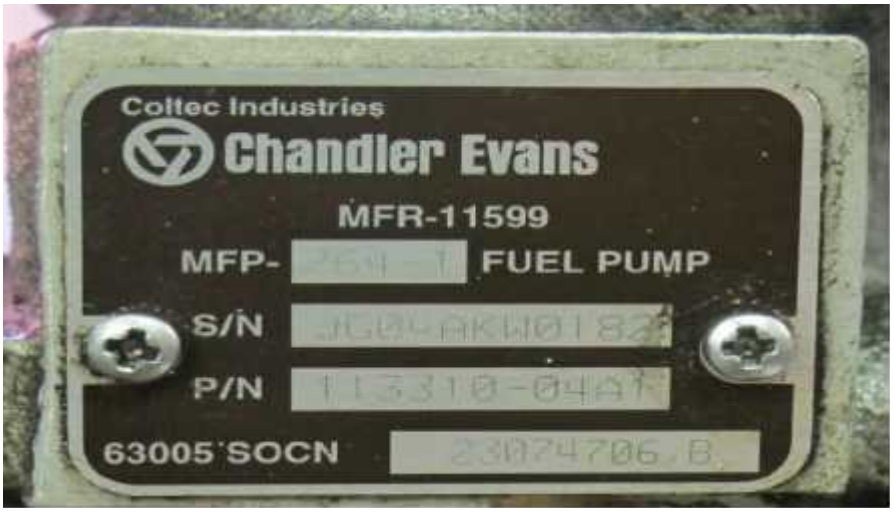


Fig. 1.16c: Photograph showing the Fuel Pump Data Plate


Fig.1.16d: Picture Showing Fuel Pump Main Drive Shaft after removal

Fig.1.16e: picture showing the Magnified View of Fuel Pump Main Drive Shaft Splines Wear

Fig 1.16f: Picture showing the Magnified View of Fuel Pump Driver Gear internal splines

The detailed report of the engine manufacturer and the fuel pump supplier is attached in Appendix C and D respectively.

1.16.3 Results of Fuel Samples Analysis

Fuel samples were taken from the Chevron fuel storage facilities at Okan Platform as well as the tank of the incident helicopter and sent to a reputable laboratory for analysis. Except for the Sulphur, Mercaptans content, which marginally exceeded the limit of 0.003% mass by 0.0009%, all other properties including contaminants and lubricity were within limits. See Appendix H and I for details.

1.17 Organizational and Management Information:

1.17.1 Operator (PAAN)

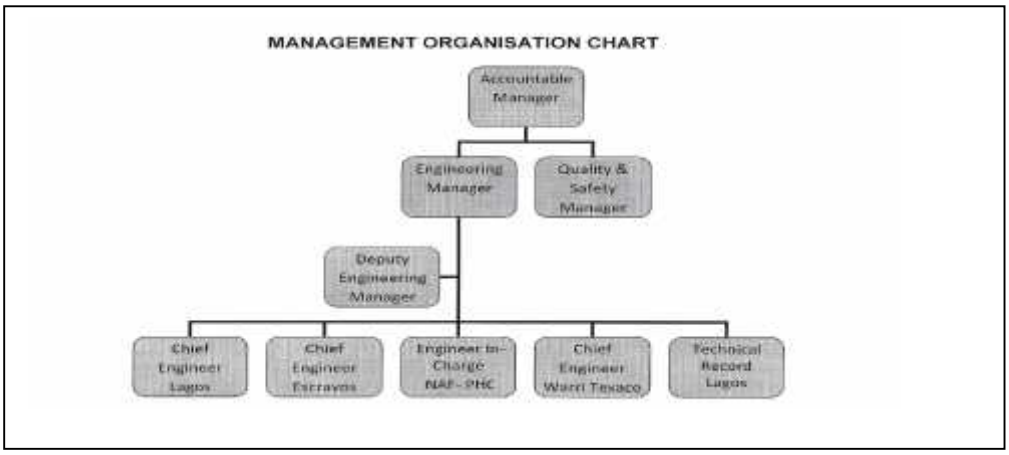
Pan African Airlines (Nigeria) Ltd. (PAAN) is an indigenous Nigerian aviation transportation supplier incorporated in April 1961. Pan African is headquartered at Murtala Muhammed Airport in Lagos. Facilities there include a fully equipped maintenance hangar, management offices and dedicated training facilities. In Lagos and Port Harcourt the company also has access to purpose-built passenger terminal facilities that serve both offshore personnel and VIP passengers.

The company also operates from customer bases in Warri and Escravos. It has modern fleet of fixed-wing aircraft and helicopters.

Pan African's current rotary wing fleet includes Bell 412's, Bell 407's and Bell 206's, all of which are contracted to support the offshore oil and gas industry.

The figure below is the PAAN engineering management organization chart showing the line of reporting and responsibility.

1.17.1.1 Engineering Management Structure



The Engineering Management Organisation Chart showing the lines of reporting and responsibility.

- *The Engineering Manager and Quality & Safety Manager report directly to the Accountable Manager.*
- *The Quality & Safety Manager has oversight responsibility for all areas of operations.*
- *Deputy Engineering Manager shall assist the engineering Manager in his duties and deputize for him when he is absent.*
- *Chief Engineers have day to day responsibilities for supervision of Line / Base /Workshop maintenance activities for their respective bases.*
- *Chief Engineers report through the Engineering Manager to the Accountable Manager.*

- *Technical Records reports through the Engineering Manager to the Accountable Manager and has the responsibility of keeping track of all technical recording, control, management and storage of all aircraft maintenance, component and equipment records*

1.17.1.2 PAAN's Maintenance Records Keeping

The investigation revealed a discrepancy in the organization's maintenance records on the main fuel pump as it affects the component's overhaul interval.

Section 9.3.2.8 of the Nig.CARs stipulates the responsibilities of an AOC holder regarding maintenance records as follows:

(a) Each AOC holder shall ensure that a system has been established to keep, in a form acceptable to the Authority, the following records:

(1) The total time in service (hours, calendar time and cycles, as appropriate) of the aircraft and all life-limited components;

(2) The current status of compliance with all mandatory continuing airworthiness information;

(3) Appropriate details of alterations and repairs to the aircraft and its major components;

(4) The time in service (hours, calendar time and cycles, as appropriate) since last overhaul of the aircraft or its components subject to mandatory overhaul life;

(5) The current aircraft status of compliance with the maintenance programme; and

(6) The detailed maintenance records to show that all requirements for signing of a maintenance release and airworthiness release have been met.

Compliance and Oversight actions on the above Nig.CARs section could have been implemented by relevant organizations.

1.17.2 Triumph Engine Control Systems, LLC (TECS)

TECS manufactured the engine-driven pump installed on the crashed helicopter. It is an FAA approved Air Agency with certificate number SF3R839L empowered to operate an approved REPAIR STATION. The organization was previously called Chandler Evans Control Systems Division of Coltec Industries and has been original equipment and builds to print manufacturer of aircraft and engine accessories since 1938.

In mid 2002, coupled with other corporate activities, Chandler Evans' name was revised to Goodrich Pump and Engine Control Systems, Inc., a division of Goodrich Corporation. In March 2013, Goodrich Pump and Engine Control changed its name to what is now known as Triumph Engine Control Systems, LLC; under the Triumph Group, Inc.

On 8th April, 2004, TECS known then as Goodrich Pump and Engine Control Systems, Inc. issued a Service Bulletin with the following heading:

Goodrich Pump & Engine Control Systems, Inc. Model MFP-263/MFP-264 Used on Rolls – Royce Model 250 Series II and III and IV Engines.

Introduction of New Configuration Pumps to Increase the Pump Service Life. (See Appendix G)

Maintenance records showed that this SB was implemented when the pump returned to TECS for overhaul in 2008. Also, the Rolls–Royce service bulletin dated 7th April, 2004 was incorporated during the overhaul whereas the component was shipped out newly from TECS on 30th April, 2004.

The new gears were made from Crucible Particle Metallurgy process (CPM-10V) and the main draft shaft was made from H-11 tool steel, hot work steel that is represented by its excellent impact toughness.

1.17.3 Rolls-Royce Corporation

Rolls-Royce is a Power Systems company, which has been providing power for aircraft, ships and land applications for more than a hundred years. The company is known for manufacturing aero engines that power many of the world's most advanced passenger jets, like the new Airbus A350 and the Boeing 787 Dreamliner.

In 1995, Rolls-Royce acquired the Allison Engine Company in Indianapolis, USA. The engine under investigation was originally manufactured by Allison. Rolls-Royce Corporation is headquartered in the United Kingdom but has regional offices across the world including the United States of America.

On 21st August, 1997 and 7th April, 2004, Allison Engine Company (Rolls-Royce) issued an alert commercial engine bulletin and a service bulletin respectively. See Appendix E and F.

The latter service bulletin had a low compliance code in spite of very poor service experiences.

1.17.4 Federal Aviation Administration

The Federal Aviation Administration (FAA) is the national aviation authority of the United States. An agency of the United States Department of Transportation, it has authority to regulate and oversee all aspects of American civil aviation. The Federal Aviation Act of 1958 created the organization under the name Federal Aviation Agency. The agency adopted its current name in 1966 when it became a part of the U.S. Department of Transportation.

FAA has safety oversight responsibilities on both the Rolls–Royce Corporation and the Triumph Engine Control Systems. The technical aspects of the applicable bulletins to the engine under this investigation were approved by FAA.

1.18 Additional information.

Nil.

1.19 Useful or effective investigation techniques.

Nil.

2.0 Analysis

2.1 The Event

5N-BFF was assigned to work with the South Operations Assistant for the MEJI Shutdown and repair operations. At 1500hrs, after working for a while at MEJI field, the aircraft was deployed to work at DELTA field. It landed at OKAN, refueled and proceeded to work at the field.

The pilot made several takeoffs and landings on different helidecks within the DELTA field and returned to OKAN production platform at about 1602hrs. The aircraft took off from the platform for final departure to Escravos base at about 1607hrs. The pilot stated that just as the aircraft took off and cleared the helideck, he noticed that the aircraft engine had stopped/flamed-out. He entered autorotation, promptly deployed the floats and made a precautionary ditching.

The aircraft landed hard on water following which the windscreen were completely shattered but the inflated floats kept the helicopter afloat on water before the occupants were rescued.

The Pilot handled the emergency professionally by putting the aircraft into autorotation and subsequent ditching.

The rescue operation was swift and prompt with little or no injuries to occupants. The supply boat within the vicinity facilitated the rescue operation.

2.2 Results of Engine and Components Teardown

2.2.1 Engine Observations

The engine examination was conducted at National Airways Corporation (NAC) in Rand Airport, Germiston, South Africa. The results is as indicated below:

Severe spline damage was noted on the fuel pump driveshaft. The result of this damage could be a loss of pressurized fuel to the engine and subsequent power loss.
No other engine anomalies, which would contribute to a power loss were noted during the examination. The engine damage observed was consistent with post event salt water intrusion and subsequent corrosive attack.

The engine was removed from the sealed shipping box and placed in a turnover stand and completely disassembled under the direction of the Nigerian IIC. External damage was limited to salt water corrosion on the engine and accessories, with extensive penetration damage through the gearbox housing. Neither the N1 nor the N2 systems turned.

Based on the engine teardown report, it was evident that the core engine was not a factor in the accident. This necessitated the need for engine components/accessories examination.

The detailed engine examination result is attached in Appendix C.

2.2.2 Components Examination

Examination and analysis of the engine components; the Fuel Control Unit (FCU), the Power Turbine Governor (PTG), Main Fuel Pump (MFP) and Fuel Nozzle were carried out at Greystones Aviation Components in Durban, South Africa. Greystones is an approved Honeywell repair station in South Africa.

The fuel nozzle was bench tested and met two of four fuel flow test points and all spray angle requirements. The two fuel flow test point deviations were minor and not considered contributory to the event. The fuel nozzle was then disassembled and appeared normal with the exception of the corrosion resulting from immersion in salt water.

The input drive shaft to the PTG turned freely. The PTG was disassembled and no internal failures were noted to the drive and spool bearings. Salt water corrosion was noted in various orifices, which were clogged. The flyweights and spring were normal in appearance.

The FCU also displayed internal corrosion consistent with salt water intrusion. The flyweights, bearings, springs and shaft appeared normal.

The fuel pump driveshaft "ratcheted" when turned by hand. Normally, it is not possible to turn the fuel pump driveshaft due to the pump configuration. The corresponding output splines, which turn the FCU input shaft, were not coupled with the drive shaft as designed. The fuel pump driveshaft was then removed and severe spline wear was noted.

The fuel pump was not further disassembled but the unit whole was shipped back to the supplier (Triumph Engine Controls, Hartford, CT, USA) for further analysis.

2.3 Main Fuel Pump Investigation Result

Investigation of the main fuel pump conducted at the Triumph Engine and Control Systems facility revealed that all teeth of the male spline on the main drive shaft which mates with the female spline of the pump driver gear were completely worn away over approximately two thirds of their length. However, the mating spline of the pump driver gear showed little to no wear, and appeared in near pristine condition. A measurement under wires of this spline yielded a value of 0.1902 in., only slightly below the new part print limit of 0.1926 in.

Subsequent metallurgical evaluations of the main drive shaft and associated driver gear confirmed the chemical composition of the drive shaft to be typical of the required H-11 tool steel per AMS 6487 and the gear to be typical of the required CPM-10V per TECS specification CEPS 534. Core hardness, nitride case depth, and case hardness of the gear was found to be acceptable.

No defects or abnormalities were observed in the microstructure of the parts, which appeared typical of the required CPM-10V and H-11.

2.3.1 Excessive Differential wear of the main fuel pump parts

According to the metallurgical evaluations of the main drive shaft, this is part of the pump assembly and the driver gear and also part of the gear assembly, the former is made from H-11 tool steel while the latter is made from CPM -10V. Whereas all teeth of the male spline on the main drive shaft, which mates with the female spline of the pump driver gear were completely worn out over approximately two thirds of their length, the mating spline of the pump driver gear showed little or no wear, and appeared in near pristine condition.

2.3.2 H-11 Tool Steel versus CPM -10V Tool Steel.

H-11 Tool Steel

*According to Next Generation Metals Inc., **H-11 Tool Steel** is a hot work steel that is represented by its excellent impact toughness. It consists of less vanadium than the commonly used H-13 hot work tool steel. This gives it the higher toughness, with some reduction in wear resistance and temper resistance. H-11 is deep-hardening, air-hardening steel that gives minimal size change during heat treatment. It also has super resistance to thermal fatigue cracking (heat checking) and superb resistance to gross cracking and thermal shock when water cooled in service. Experts will recommend H-11 for hot tooling applications where maximum resistance to cracking is required.*

Chemical Properties

Element	*min*	*max*
Carbon	*0.38*	*0.43*
Manganese	*0.20*	*0.40*
Silicon	*0.80*	*1.00*
Phosphorus	*-*	*0.015*
Sulfur	*-*	*0.015*
Chromium	*4.75*	*5.25*
Molybdenum	*1.20*	*1.40*
Vanadium	*0.40*	*0.60*
Nickel	*-*	*0.25*
Copper	*-*	*0.35*

Specifications:

UNS T20811, AMS 6437, AMS 6485, AMS 6487, ANS 6488, ASTM A-681, FED QQ-T-570, SAE J437, SAE J438, SAE J467, AISI 610, ASTM A-579, MIL-S-47262

Applications:

Hot punches, die casting dies, hot shear blades, forging dies, hot gripper dies and extrusion tooling.

H-11 is used for highly stressed structural parts such as aircraft landing gear.

CPM – 10V Tool Steel

CPM 10V is a unique tool steel made by the Crucible Particle Metallurgy Process, according to Crucible Industries. It is designed with a tough, air hardening base analysis with added high Carbon and vanadium for exceptionally good wear resistance, Warmwork tooling applications.

The exceptional wear resistance and good toughness of CPM 10V makes it an excellent candidate to replace carbide and other highly wear resistant materials in cold work tooling applications, particularly where tool toughness is a problem or where cost effectiveness can be demonstrated.

Typical Chemistry

Carbon	*2.45%*
Manganese	*0.50%*
Silicon	*0.90%*
Chromium	*5.25%*
Vanadium	*9.75%*
Molybdenum	*1.30%*
Sulphur	*0.07%*

Typical Applications

Punches & Dies for Blanking, Piercing, Forming and Cold Extrusion

Knives for Slitting, Shearing, Trimming, etc.

Granulator/Pelletizer Blades

Nozzles, Screw Tips, Barrel Liners, etc. for Plastic Injection Molding Equipment

Powder Compaction Tooling

Woodworking Tools Wear Parts

Considering the chemical composition of the CPM -10V steel with a far higher percentage of carbon and vanadium as compared with the H -11 steel, it may be expected that the main draft shaft made from the H -11 steel would wear faster than the pump driver gear made from CPM -10V steel. Also, since analysis of the fuel used on the aircraft indicated that contaminants and lubricity were within limits, it is very unlikely that fuel was a factor in this occurrence. AIB has it on record that a similar pump with the same part number 23074706 had its main shaft splines completely sheared at 2133.4 hours TSN.

2.4 Rolls – Royce Service Bulletins and the Main Fuel Pump Historical Service Record

Maintenance records indicated that the failed main fuel pump installed on the helicopter was manufactured by Goodrich Pump and Engine Control Systems now Triumph Engine Control Systems. The component was shipped out of TECS as a new component with part number 113310-03A1 on 30th April, 2004. Before then, on 21st August, 1997, Allison, now acquired by

Rolls Royce issued an Alert Commercial Engine Bulletin to cover similar engine models to the one under investigation with the title: **ENGINE, FUEL AND CONTROL – CECO ENGINE DRIVEN FUEL PUMP – INTERNAL SPLINE INSPECTION.**

The ASB required the applicable customers to remove the CECO fuel pump installed on their aircraft and check the internal spline backlash. The reason was that: *A number of Chandler Evans (CECO) fuel pumps have been found with badly worn internal drive shaft splines at relatively low hours.*

The ASB was allocated compliance code 2 and was to be implemented within 25 hours following receipt of the bulletin and every 100 hours thereafter until further notice.

On 7th April, 2004, Rolls–Royce issued another Commercial Engine Bulletin titled: **ENGINE, FUEL AND CONTROL – GOODRICH ENGINE DRIVEN PUMP IMPROVED DRIVE SHAFT DURABILITY.**

The SB adequately covered the engine model installed on the helicopter and the reason for issuing it was that "*New fuel pumps are released that incorporate various product improvements*". These improvements "eliminate the need for repetitive spline inspections". The fuel pump assembly was to be replaced with reference to the overhaul maintenance manual in order to accomplish the SB but it was given a code 7, which made the compliance optional.

Although the main fuel pump did not fail in service during the first overhaul inspection period, given the unpleasant service experience of the earlier models of the component, it would have been expected that compliance with the SB be made mandatory. Upon compliance, the SB required that the component be re-identified by changing the Rolls - Royce part number from 23070460 to 23074706.

The component was newly supplied to the operator with old part number 23070460 on 30th April, 2004 whereas the Rolls – Royce SB which required the change of the fuel pump assembly was issued on 7th April, 2004; a date before the component was shipped out of TECS facility. However, maintenance records showed that the SB was incorporated in 2008 when the component returned to TECS for overhaul.

2.5 Goodrich (TECS) Service Bulletin and the Main Fuel Pump Historical Service Record

Goodrich (TECS) issued the service bulletin 73 -3 on 8th April, 2004 entitled:

Goodrich Pump & Engine Control Systems, Inc. Model MFP – 263/MFP -264

Used on Rolls – Royce Model 250 Series II and III and IV Engines

Introduction of New Configuration Pumps to Increase the Pump Service Life

The above SB affected the engine model and hence, the pump installed on the helicopter. The reason for the SB was "To introduce a new configuration fuel pump incorporating a new material pump gear assembly. This change is being introduced to increase the pump service life, especially in harsher operating environments". The work required by this bulletin

consists of incorporating a new pump gear assembly. The compliance was to be accomplished when the component returned for depot level maintenance. Upon compliance, it was to be re–identified by changing the part number from 113310-03A1 to 113310-04A1.

Maintenance records showed that the component returned to TECS for overhaul on 5th August, 2008 and the overhauled component was shipped out of TECS to the operator on 10th September, 2008. The SB 73–3 was incorporated during this overhaul and the component re–identified accordingly.

The new gears were reportedly made from an improved, more durable material (CPM-10V), and it was this change to gear material which constituted the configuration change from 113310-03A1 to 113310-04A1.

2.6 Quality and Safety Department/Manager

According to PAAN Management Organization Chart and responsibilities, the Quality and Safety Manager reports to the Accountable Manager. He has oversight responsibility for all areas of operations of the company including the technical records.

On 29th January, 2009, the overhauled component was installed on 5N – BFV, one of the helicopters in the operator's fleet.

The time remaining to the next maintenance requirement (TBO) was recorded then as 3000 hours on the component card. But, the Bell 206 L4

maintenance programme adopted by PAAN stipulates 3500 hours as the overhaul inspection period (TBO) for the failed CECO fuel pump. 3000 hours TBO is more restrictive than the manufacturer's 3500 hours and would have prevented this accident had it been applied because the main fuel pump failed at 3,176 hours TSO.

3.0 Conclusions

3.1 Findings

3.1.1. The pilot was properly licensed and qualified to conduct the flight.

3.1.2. The pilot had 811.6 hrs on type as at the time of the occurrence.

3.1.3. There were four souls on board.

3.1.4. The certificate of release to flight was duly signed by the appropriate personnel.

3.1.5. The aircraft had a valid Certificate of Airworthiness (C of A).

3.1.6. The aircraft had been maintained in accordance with approved Maintenance Programme.

3.1.7. A phase 4 inspection check was completed on the 1st October, 2012 at 12139.3 flight hours and 102370 cycles and the Certificate of Release to Service/Maintenance Statement was duly issued.

3.1.8. The phase 4 inspection carried out in accordance with Bell 206 L4 Series Maintenance Programme on the fuel pump was to "visually inspect fuel pump and external filter for obvious damage and leaks".

3.1.9. A 50 hrs inspection was carried out on the 20th October, 2012.

3.1.10. The engine with serial number CAE – 895745 installed on the aircraft was transferred from another aircraft in the operator's fleet (5N-BFV) at 17,999.2 hrs on 4thOctober, 2012.

3.1.11. The main fuel pump installed on the aircraft was supplied to Rolls Royce by Triumph Engine Control Systems (TECS) based in Hartford Connecticut, USA.

3.1.12. The pump was shipped from TECS to Bristow Nigeria as a new component (part number 113310-03A1) on 30th April, 2004.

3.1.13. On 5th August, 2008 at 3478.6 hrs TSN, it was returned to TECS for overhaul and upgrade to a new part number 113310-04A1. Records indicated that the main driveshaft and gear set were replaced during this overhaul.

3.1.14. On the 9th October, 2008, the overhauled component was shipped back to Nigeria for a return to service at a TSN of 3,478.6 hrs; TSO of 0.0 hrs.

3.1.15. On 29th January, 2009, the overhauled component was installed on 5N – BFV, one of the helicopters in the operator's fleet. The time remaining to the next maintenance requirement (TBO) was recorded as 3,000 hrs on the component card. But, the Bell 206 L4 maintenance programme adopted by PAAN stipulates 3,500 hrs as the overhaul inspection period (TBO) for the failed CECO fuel pump.

3.1.17. On the 27th October, 2012, the engine driven fuel pump failed in service during an offshore operation in Escravos at a TSN of 6,654.6 hrs and TSO of 3,176 hrs.

3.1.18. Laboratory analysis of the fuel used on the helicopter indicated that the level of contaminants and lubricity were within limits.

3.1.19. AIB has it on record that a similar pump with the same part number 23074706 had its main shaft splines completely sheared at 2,133.4 hrs TSN.

3.1.20. There was no evidence from maintenance records on the component to show that any other maintenance work was performed on it outside of TECS.

3.1.21. On the day of the accident, the pilot had made several uneventful take-offs and landings on many helidecks within the Delta field and returned to OKAN production platform at about 1602hrs.

3.1.22. The aircraft took off from the platform for final departure to Escravos base at about 1607hrs. The engine stopped/flamed out shortly after the helicopter cleared the platform.

3.1.23. The rescue operation was promptly carried out at 1608hrs by the crew of a supply boat (Bourbon Adelaide) operating at an approximate distance of 100m to the ditched helicopter.

3.1.24. At 1650hrs, the accident victims were transferred to a surfer boat enroute to Escravos base.

3.1.25. The pilot tested negative to drugs substance and alcohol tests at Chevron Hospital in Escravos.

3.2 Causal factor

Failure of the main fuel pump, resulting from wearing of the fuel pump main drive shaft external splines, which mate with the internal splines of the pump driver gear with consequent fuel starvation, flame-out and engine loss of power.

3.3 Contributory factor

Material compositions of the improved main fuel pump, which allowed excessive differential wear between the main drive shaft and the driver gear.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendations 2015-005

FAA should ensure that TECS review the material compositions of the assemblies of its MFP 264 – 1 main fuel pump to prevent excessive differential wear between the parts.

4.2 Safety Recommendations 2015-006

FAA should ensure that TECS reviews the Time Between Overhaul of its MFP 264–1 main fuel pump downward from 3,500 hrs and communicate same to affected operators while the component is being improved upon.

4.3 Safety Recommendations 2015-007

NCAA should intensify its safety oversight functions on PAAN to ensure proper maintenance record keeping by the operator.

APPENDIX C

Rolls-Royce

Engine Investigation Report

Model 250-C30P

Rolls-Royce
Model 250-C30P
Engine CAE 895745

Bell 206L4
Registration: 5N-BFF

Pan African Airlines

[redacted]
Air Safety Investigator

Accident date: 27 October 2012
Engine investigation date: 28/29 August 2013
Component Investigation Date: 16 October 2013
Report date: 8 January 2014

Report Enclosures:

Report Narrative

Appendix A, Engine Examination Photographs

Appendix B, Fuel Nozzle Flow Results

Background Information:

On 27 October 2012, a Bell 206L4 was taking off from an off-shore oil platform near Escravos, Nigeria, when the engine lost power. The pilot performed an autorotation to the water and evacuated safely with three passengers. The aircraft was secured to a recovery vessel but overturned in the water. The engine was removed and shipped to a Rolls-Royce Authorized Maintenance Facility in South Africa for examination. The author did not view the aircraft or go to the accident site.

A Rolls-Royce Air Safety Investigator conducted an engine examination at National Airways Corporation (Rand Airport, Germiston, South Africa) and Greystones Accessories Shop (Durban, South Africa) on 28 and 29 August 2013 respectively. The examination was under the direction of and supervised by the Nigerian AIB IIC.

The fuel pump, manufactured by Triumph Engine Control Systems (TECS), was sent to TECS in West Hartford, CT USA for further examination by request of the Nigerian AIB IIC. The detailed component examination was conducted on 16 October 2013 under the supervision of the Nigerian AIB IIC and a Rolls-Royce Air Safety Investigator.

Engine Observations:

The engine was removed from the sealed shipping box and placed in a turnover stand and completely disassembled under the direction of the Nigerian AIB IIC. External damage was limited to salt water corrosion on the engine and accessories, with extensive penetration damage through the gearbox housing. Neither the N1 nor the N2 systems turned.

All external lines and fittings were tight when checked by hand. A pneumatic leak check was conducted with no leaks observed in either the control lines or associated fittings. Each line was tested individually, as internal blockages within the power turbine governor prevented pressurization of the entire system. All of the air lines were visually inspected upon removal with no cracks or anomalies noted. Several of the lines exhibited internal residue which was consistent with salt water immersion. The Pc air filter was inspected and was not clogged.

Both the upper and lower magnetic chip detectors displayed a gray sludge similar in appearance to deteriorated magnesium. No metallic debris was noted on the detectors. The gearbox was disassembled and significant deterioration from salt water intrusion was observed. However, the power and accessory gear trains were intact with no missing teeth or obvious pre-event anomalies noted. The oil pressure and scavenge lines as well as the pressure filter bowl contained oil. The oil pressure filter element was free of debris. The freewheeling unit was removed and operated as designed.

The turbine shafting was continuous and the turbine bearings turned with much resistance. Salt water was noted throughout the gas path; however, no indications of FOD were present. All of the turbine wheels and nozzles were intact with no evidence of high temperature operation. The combustion liner inner surface was consistent with an even burn pattern and the outer combustion case was normal in appearance.

No FOD or contact witness marks were observed on the compressor impeller or corresponding shroud. The spur adapter gearshaft and #2 bearing were intact and corroded, while the #1 bearing was normal in appearance. The compressor scroll, internal turning vanes and the air discharge tubes displayed surface corrosion consistent with salt water immersion. The right discharge tube exhibited oil staining on the forward, upper surface. The compressor bleed valve was disassembled with no anomalies noted.

The Fuel Control Unit (FCU) and fuel pump were intact. The maximum fuel flow adjustment on the FCU was set to 2nd intermediate, which is appropriate for this application. Fuel was noted within the lines between the FCU and pump. The throttle input shaft was frozen in the fly position. The Power Turbine Governor (PTG) exhibited no damage and the input drive shaft turned freely. The FCU, PTG, pump, and fuel nozzle were hand-carried by the IIC to Greystones in Durban, South Africa for analysis. The author, IIC, and a manager from National Airways Corporation attended the exam at Greystones.

Controls Analysis and Testing (Greystones, Durban, South Africa 29 August 2013):

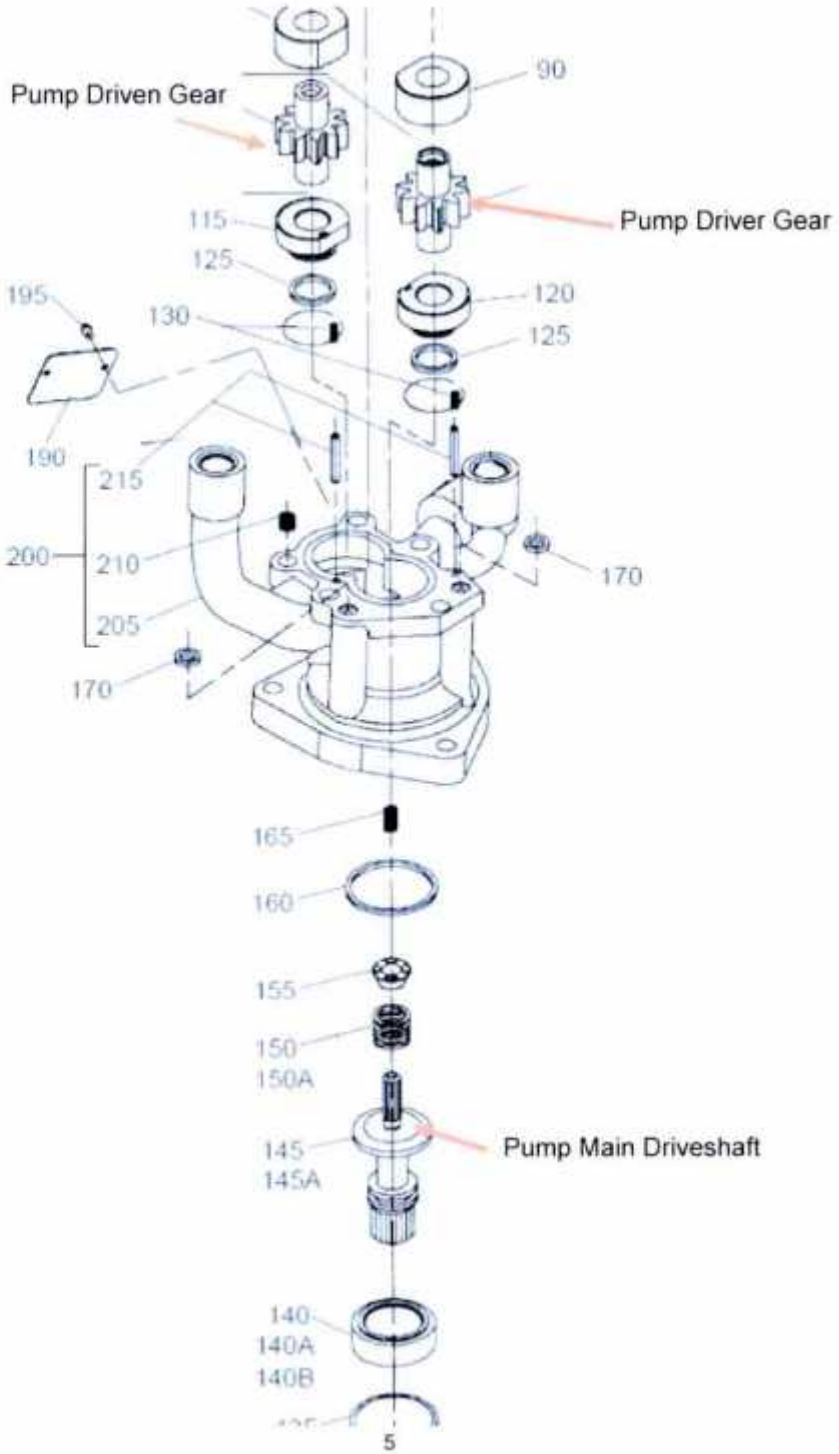
The fuel nozzle was bench tested and met two of four fuel flow test points and all spray angle requirements. The two fuel flow test point deviations were minor and not considered contributory to the event. The results of the flow test are included as Appendix B. The fuel nozzle was then disassembled and appeared normal with the exception of the corrosion resulting from immersion in salt water.

The input drive shaft to the PTG turned freely. The PTG was disassembled and no internal failures were noted to the drive and spool bearings. Salt water corrosion was noted in various orifices, which were clogged. The flyweights and spring were normal in appearance.

The FCU also displayed internal corrosion consistent with salt water intrusion. The flyweights, bearings, springs and shaft appeared normal.

The fuel pump driveshaft "ratcheted" when turned by hand. Normally, it is not possible to turn the fuel pump driveshaft due to the pump configuration. The corresponding output splines, which turn the FCU input shaft, were not coupled with the drive shaft as designed. The fuel pump driveshaft was then removed and severe spline wear was noted. The fuel pump was not further disassembled as the IIC directed the team to ship the unit whole back to the supplier (Triumph Engine Controls, Hartford, CT, USA) for further analysis.

Figure 1: Exploded View of Fuel Pump



The fuel pump was examined at Triumph Engine Control Systems in West Hartford, CT USA on 16 October 2013 under the supervision of the Nigerian AIB IIC.

The following excerpts from TECS Report # S-3444 document the exam.

TECS part number 113310-04A1
Rolls-Royce part number: 23074706
Serial Number: JG04AKW0182

Pump Background

- *The fuel pump was shipped from TECS as a new component (part number 113310-03A1) on April 30, 2004*
- *On August 5, 2008 (3478.6 hours TSN), it was returned to TECS for overhaul and upgrade to configuration 113310-04A1. Records indicate the main drive shaft and gear set were replaced during this overhaul. The new gears were made from an improved, more durable material. This change in gear material constituted the configuration change from part number 113310-03A1 to 113310-04A1.*
- *The pump shipped on September 10, 2008 for return to service (3478.6 hours TSN, 0.0 hours TSO).*

Results

- *No significant external damage to the pump was noted other than observed corrosion product, likely the result of immersion in salt water.*
- *All teeth of the male spline on the main drive shaft which mates with the female spline of the pump driver gear were completely worn away over approximately two thirds of their length. The mating spline of the pump driver gear showed little to no wear, and appeared in near pristine condition.*
- *Subsequent metallurgical evaluations of the main drive shaft and associated driver gear confirmed the chemical composition of the components to be typical of the required material as required by the component specifications.*
- *Core hardness, nitride case depth, and case hardness of the gear was found to be acceptable.*
- *No defects or abnormalities were observed in the microstructure of the components*

Conclusions/Recommendations

- *No definitive cause of the main drive shaft spline wear out suffered by pump s/n JG04AKW0182 could be identified by this investigation.*
- *The absence of corresponding wear on the pump driver gear spline is considered highly unusual, and no similar occurrences of spline wear through on a main drive shaft with virtually no wear on the mating part have been observed in TECS' experience.*

Engine Information:

An Allison M250-C30P gas turbine engine, S/N CAE 895745, powered the helicopter. Maintenance history was not provided. The below times were reported as of 26 October 2012, the day prior to the accident except for the fuel nozzle times. The fuel nozzle times are as of 21 October 2012.

Manufacturer	Allison
Engine Model	M250-C30P
Rating	650 Shaft Horsepower
Serial Number	CAE 895745
Engine Total Hours	18103.8 hrs
Last Inspection	unk hrs

Component	Serial Number	Part Number	TSO(hrs)	TSN (hrs)
Engine M250-C30P	895745	23004545		18103.8
Gearbox	95442	23053349	TSN	23358.8
Compressor	90066	23051643	1327.0	23864.2
Turbine	98388	23035128	302.4	7270.1
FCU	325935	23070613	1379.7	13343.0
PTG	HR47625	23086751	705.9	4529.0
Fuel Pump	JG04AKW0182	23074706	3176	6654.6
Fuel Nozzle	AG87720	23077067	0	10829.5
Bleed Valve	FF52497	23073353	478.3	13401.7

Summary of Findings:

The fuel pump main drive shaft external splines, which mate to the internal splines of the pump driver gear, were severely worn. The wear was significant enough to decouple the fuel pump main drive shaft from the pump driver gear, which provides fuel to the engine. The subsequent loss of pressurized fuel to the engine resulted in a flameout and loss of power during flight. The cause of the fuel pump main driveshaft wear is under investigation by TECS and Rolls-Royce engineering.

Appendix A, Engine Examination Photographs

Photo 1 Engine General

Photo 2 Compressor Inlet

Photo 3 Fourth Stage Turbine Wheel

Photo 4 Fuel Control Unit and Fuel Pump prior to removal

Photo 5 Lower Magnetic Chip Detector

Photo 6 Upper Magnetic Chip Detector

Photo 7 Fuel Nozzle

Photo 8 Fuel Control Unit interior

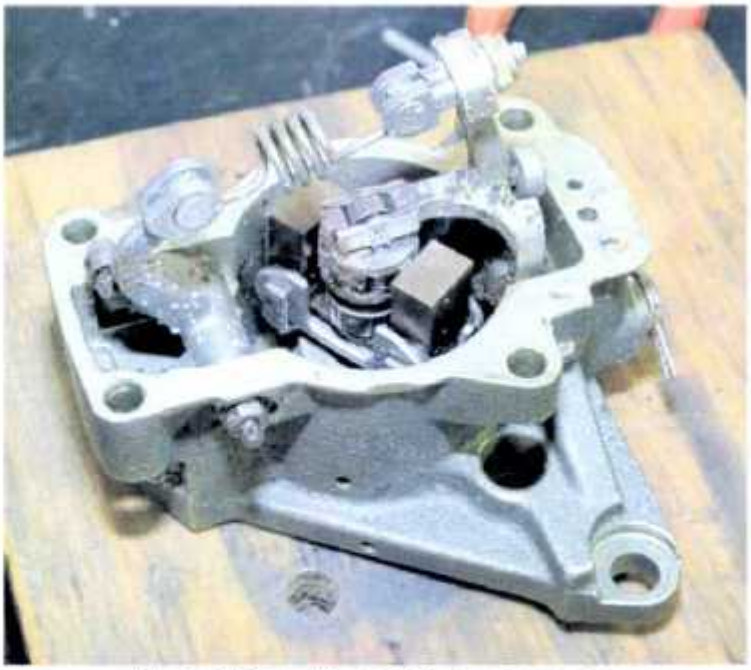


Photo 9 Power Turbine Governor interior

Photo 10 Fuel Pump Main Drive Shaft prior to removal from Fuel Pump

Photo 11 Fuel Pump Data Plate

Photo 12 Fuel Pump Main Drive Shaft upon removal

13

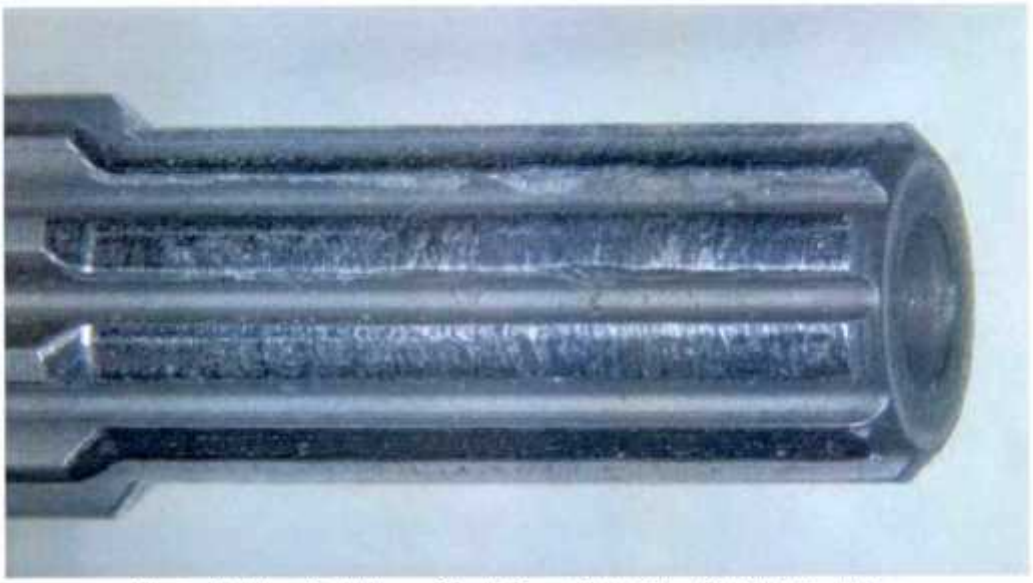


Photo 13 Magnified View of Fuel Pump Main Drive Shaft Spline Wear

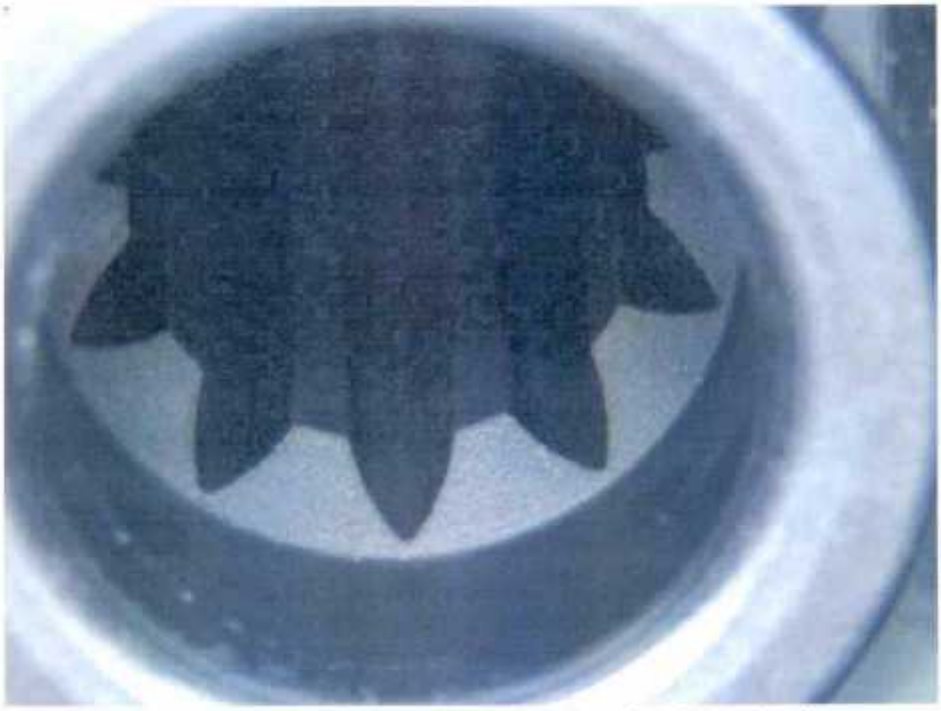


Photo 14 Magnified View of Fuel Pump Driver Gear internal splines

Appendix B, Fuel Nozzle Flow Results

time-since-o/h nozzles. Nozzles meeting service testing requirements are considered functionally serviceable with accrued service time.		
Service testing of nozzles: Testing shall be conducted using para 7., procedure and equipment, and shall meet para 8.A(2)testing limits.	250-C30 O/H Manual 73-10-03 Section 8 pg 11	
Fuel Nozzle Flow Service Limits (Table 2) Pressure Differential Across Nozzle — Fuel Flow, lb/hr(kg/hr) — Nozzle Spray Angle Psi (kPa) — Min — Max — Limits 60 (414) 23 (10.4) 30 (13.6) 25,3 70° 110° 125 (862) 58 (26.3) 80 (36.3) 56,6 60°-100° 200 (1379) 157 (71.2) 203 (92.1) 170 550 (3792) 423 (191.9) 477 (216.4) 200 75°-110°	250-C30 O/H Manual 73-10-03 Section 8 pg 11	
Instructions:	**Refer to:**	**Sign:**
For nozzles that have met service testing requirements, the following information shall be reviewed and evaluated prior to the release of a nozzle for reinstallation on an engine. • Check the physical condition of the external threads, spray tip exit orifices and the air shroud's wear coating and front face. Refer to para. 5., for inspection and repair guidelines. • Check the remaining serviceable time. • Check the evidence of internal contamination.	250-C30 O/H Manual 73-10-03 Section 8 pg 11	

Triumph Engine Control Systems

APPENDIX D

ENGINEERING DEPARTMENT

SHORT REPORT SUMMARY	Triumph Engine Control Systems REPORT NO. S-3444
REPORT TITLE: MFP-264 Investigation of Pump S/N JG04AKW0182 Main Drive Shaft Spline Wear Out Resulting in Power Loss and Autorotation to Water (Nigeria)	DATE: 2013/12/18
	DEPT. NO. 934

SCOPE OF REPORT: Inspection and evaluation of returned hardware

BACKGROUND & PURPOSE

On October 27, 2012, during take-off from an offshore oil platform near Escravos, Nigeria, a Bell model 206L4 helicopter (aircraft s/n 52273, registration number 5N-BFF) operated by Pan African Airlines experienced an engine flameout followed by a successful autorotation to water landing. The aircraft was powered by a Rolls-Royce model 250-C30P engine (s/n 895745) which incorporated Triumph Engine Control Systems' (TECS) model MFP-264-1 main fuel pump (s/n JG04AKW0182). All crew (1) and passengers (3) evacuated safely and were rescued immediately. The helicopter was secured to a rescue vessel, but turned upside-down after approximately 10 minutes in the water. The helicopter was recovered to shore later on the same day. The engine was subsequently examined at NAC and Greystones in South Africa on 28 and 29 August 2013. It was noted that when the pump main drive shaft was rotated, the control drive shaft on the opposite side of the pump body did not turn. The pump was then disassembled to examine the main drive shaft inboard spline, which was noted to be severely worn. The pump was returned to TECS and received on October 14, 2013 for evaluation.

Pump s/n JG04AKW0182 had been shipped from TECS as a new component (configuration 113310-03A1) on April 30, 2004. On August 5, 2008 (3478.6 hours TSN) it was returned to TECS for overhaul and upgrade to configuration 113310-04A1. Records indicate that as part of the overhaul, the main drive shaft and gear set were replaced. The new gears were made from an improved, more durable material (CPM-10V), and it was this change to gear material which constituted the configuration change from 113310-03A1 to 113310-04A1. The pump shipped on September 10, 2008 for return to service (3478.6 hours TSN, 0.0 hours TSO). At the time of the incident, the pump was reported to have accumulated 6654.6 hours TSN, 3176 hours TSO.

DESCRIPTION Project objectives, salient hardware features, test and analytical procedures, etc. as applicable

The investigation was conducted on October 16, 2013 at the TECS facility in West Hartford, CT. Participants in the investigation are listed in the table below:

Name	Affiliation	Title
[redacted]	Triumph Engine Control Systems	Senior Product Support Engineer
	Triumph Engine Control Systems	Customer Support Engineer
	Triumph Engine Control Systems	Manager, Hydromechanical Engineering
	Triumph Engine Control Systems	Director, Hydromechanical Engineering
	Triumph Engine Control Systems	Senior Materials Engineer
	Triumph Engine Control Systems	Senior Assembly and Test Technician
	Accident Investigation Bureau of Nigeria	Accident Investigator
	Rolls-Royce Corporation	Air Safety Investigator

The investigation was conducted in accordance with the plan outline included in appendix I.

Throughout the pump examination, photographs were taken to document all observations. These photographs are included in appendix II.

Written b[redacted]ky 12/13 | Distributio[redacted]

Approved b[redacted] | Approved by:

[redacted]

Charter Oak Boulevard • P.O. Box 150651 • West Hartford, CT 06115-0651 • Tel: 860-236-0651 • Fax: 860-232-1873 • www.triumphgroup.com

The shipping box containing the pump under investigation was retrieved from locked stores and opened in the presence of the investigation team. A visual inspection of the pump was completed, during which it was noted that the main drive shaft, shaft seal, loading spring, and spring seat had been removed from the pump prior to receipt at TECS. Material deposits, likely corrosion product, were noted on the mounting face of the pump, the main drive shaft flange inside of the seal runner surface inner diameter, at the various fluid connection ports, and around the control drive shaft output spline.

Shipping plugs were removed from all fuel ports and the pump body rotated in multiple directions over a collection vessel to capture any remaining fuel, however none could be recovered. The torque required to rotate the gears was measured using a spline adapter and a workhorse main drive shaft. The pump was then disassembled for examination of its detail parts, particularly the pumping gears.

At the conclusion of the visual examination of the pump, TECS recommended that a metallurgical evaluation of the pump main drive shaft and pumping gears be conducted to confirm composition. The Nigerian and Rolls-Royce representatives concurred, and the metallurgical evaluation was subsequently completed by TECS materials engineering on October 28, 2013.

RESULTS Significant accomplishments or effects

No significant external damage to the pump was noted other than the observed corrosion product, likely the result of immersion in salt water. The torque measured to rotate the pumping gears (14 in-lbs breakaway, 10 in-lbs running) was unremarkable and within specified limits (30 in-lbs maximum) for this pump.

All teeth of the male spline on the main drive shaft which mates with the female spline of the pump driver gear were completely worn away over approximately two thirds of their length. Surprisingly, the mating spline of the pump driver gear showed little to no wear, and appeared in near pristine condition. A measurement under wires of this spline yielded a value of 0.1902 in., only slightly below the new part print limit of 0.1926 in.

Subsequent metallurgical evaluations of the main drive shaft and associated driver gear confirmed the chemical composition of the drive shaft to be typical of the required H-11 tool steel per AMS 6487 and the gear to be typical of the required CPM-10V per TECS specification CEPS 534. Core hardness, nitride case depth, and case hardness of the gear was found to be acceptable. No defects or abnormalities were observed in the microstructure of the parts which appeared typical of the required CPM-10V and H11.

CONCLUSIONS / RECOMMENDATIONS

No definitive cause of the main drive shaft spline wear out suffered by pump s/n JG04AKW0182 could be identified by this investigation. The absence of corresponding wear on the pump driver gear spline is considered highly unusual, and no similar occurrences of spline wear through on a main drive shaft with virtually no wear on the mating part have been observed in TECS' experience.

Examination and measurement of main drive shaft and driver gear spline wear from a broader sample of pumps is recommended, and TECS is in the process of building this database. Additionally, TECS recommends that the component record card and any other available maintenance information for pump s/n JGAKW0182 be thoroughly reviewed to determine if any maintenance on this component was performed outside of TECS' approved facilities. Further examination of the mating gearbox for potential anomalies, particularly lack of spline to pilot concentricity and squareness, is also recommended.

Appendix I
Investigation Plan

This document is subject to the controls on the first page

MFP-264 Main Fuel Pump s/n JG04AKW0182 Investigation

History
4/30/2004 – OE shipment - P/L 113310-03A1; TSN = 0.0 hrs

8/5/2008 – pump rec'd for overhaul from Bristow Nigeria, update to P/L 113310-04A1 (SB 73-3); TSN 3478.6 hrs. Main drive shaft and gears replaced.
9/10/2008 – pump shipped – P/L 113310-04A1; TSN = 3478.6 hrs; TSO = 0.0 hrs
10/27/2012 – B206L4 s/n 52273 auto-rotation into water. TSN = 6654.6 hrs; TSO 3176 hrs

Investigation plan:

1) Retrieve boxed unit from locked stores.

2) Photograph unopened package.

3) Open package in presence of investigation witnesses.

4) Perform visual inspection of pump. Photograph from all 6 sides, with additional details as appropriate (drive shaft external spline, control spline, etc.)

5) Perform formal as received inspection of pump, documenting all findings.

6) If present, remove shipping plugs from ports, collecting residual fuel in clean glass container.

7) Visually inspect ports for presence of contamination, photograph as appropriate. Collect any contaminant observed.

8) Measure drive shaft torque (breakaway = _____ in-lbs; running = _____ in-lbs).

9) Disassemble to remove main drive shaft and gears. Photograph hardware as appropriate.

10) Submit components for material / metallurgical evaluation.

Figure AI-1:Shipping container

Figure AI-2: Packing materials

Figure AI-3: Packing materials

Figure AI-4: Packing materials

Figure AI-5: Packing materials

Figure AI-6: Packing materials

Figure AI-7: Packing materials

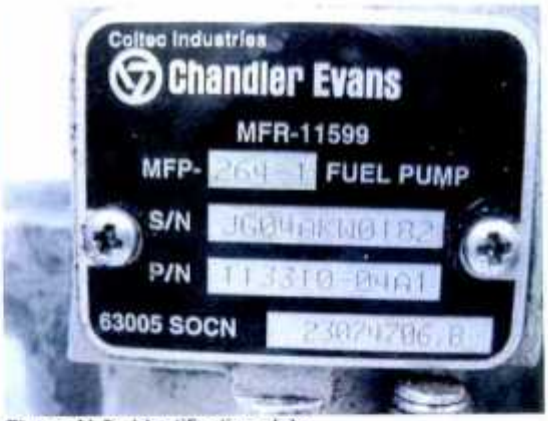


Figure AI-8: Identification plate

Figure AI-9: Pump body

Figure AI-10: Pump body

Figure AI-11: Pump body

Figure AI-12: Pump body

Figure AI-13: Pump mounting face (corrosion product)

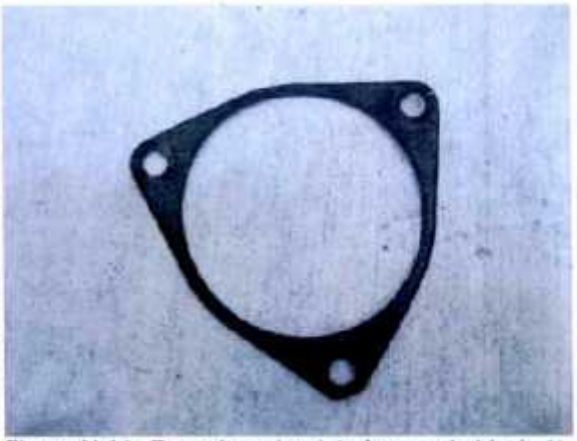


Figure AI-14: Pump / gearbox interface gasket (side 1)

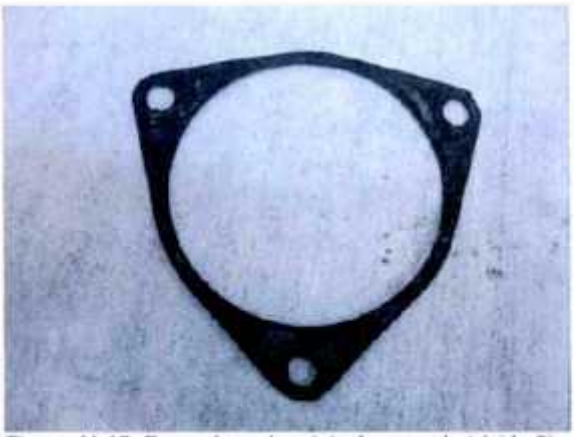


Figure AI-15: Pump / gearbox interface gasket (side 2)

Figure AI-16: Pump / control interface gasket (side 1)

Figure AI-17: Pump / control interface gasket (side 2)

Figure AI-18: Gear inlet port

Figure AI-19: Bypass return port

Figure AI-20: Pump discharge port

Figure AI-21: Overboard drain port

Figure AI-22: Main drive shaft

Figure AI-23: Main drive shaft outboard spline

Figure AI-24: Main drive shaft seal

Figure AI-25: Main drive shaft (corrosion product)

Figure AI-26: Main pump / control drive housing interface

Figure AI-27: Main drive shaft loading spring and seat

Figure AI-28: Control drive shaft output spline

Figure AI-29: Control drive shaft seal

Figure AI-30: Control drive shaft (removed)

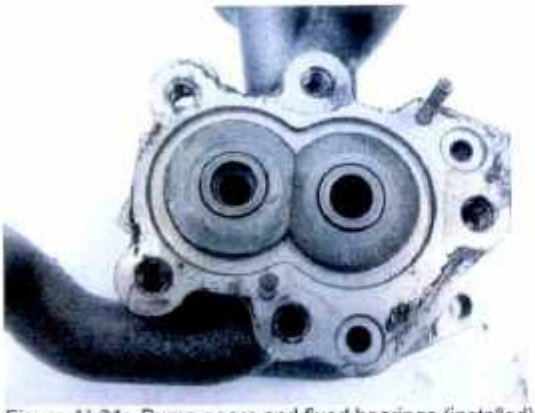


Figure AI-31: Pump gears and fixed bearings (installed)

Figure AI-32: Pump driver gear and fixed bearing (installed)

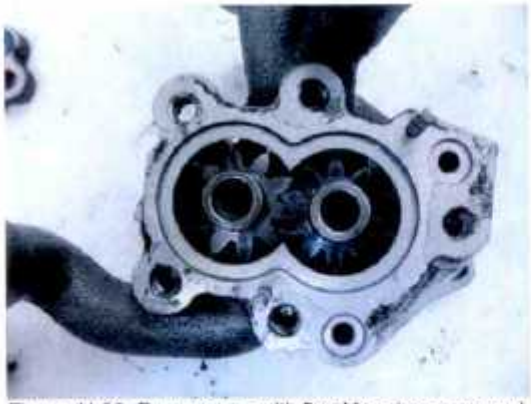


Figure AI-33: Pump gears with fixed bearings removed

Figure AI-34: Fixed bearings

Figure AI-35: Pump floating bearings (installed)

Figure AI-36: Pump floating bearings (removed)

Figure AI-37: Pump driver gear spline (main drive shaft end)

Figure AI-38: Pump driver gear spline (main drive shaft end, 10X)

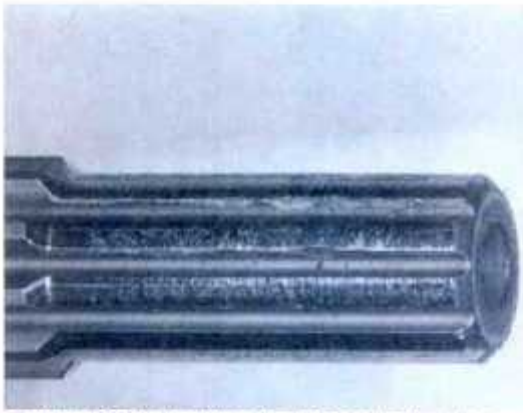


Figure AI-39: Main drive shaft inboard end – worn Splines, 7X

Figure AI-40: Main drive shaft inboard end – worn splines, 20X

APPENDIX E

ALERT

Allison

COMMERCIAL ENGINE BULLETIN

ENGINE, FUEL AND CONTROL – CECO ENGINE DRIVEN FUEL PUMP – INTERNAL SPLINE INSPECTION

1. PLANNING INFORMATION:

A. Effectivity:

All Allison Model 250–C18, –C20, –C28, –C30 (except 250–C30R/3), –C20R, –B15, –B17 and –B17F engines with Chandler Evans (CECO) fuel pumps are affected by this Bulletin. Following are the CECO Fuel Pumps affected:

250 ENGINE MODEL	CECO MODEL	CECO P/N	ALLISON P/N
Series I & II	MFP 263 (Std. Gear Pump)	113300–01A1 113300–02A1	23057339 23065132
Series II (250–C20R/2(SP) Only)	MFP 262 (Jet Eductor Pump)	112160–A1 112160–A2	23051980 23057337
Series III/IV	MFP 264–1 (Std. Gear Pump)	113310–01A1 113310–02A1	23057339 23065133
Series IV	MFP 264–2 (Jet Eductor Pump)	113320–01A1 113320–02A2	23057340 23065134

B. Reason:

A number of Chandler Evans (CECO) fuel pumps have been found with badly worn internal drive shaft splines at relatively low hours.

C. Description:

The CECO fuel pump is removed and the internal spline backlash is checked.

D. Approval:

Technical aspects are FAA approved.

E. Compliance:

Compliance Code 2: To be complied with within 25 hours following receipt of this bulletin and every 100 hours thereafter until further notice.

August 21, 1997

250–C18 Series — CEB A–295
250–C20 Series — CEB A–1352
250–C28 Series — CEB A–73–2066
250–C30 Series (except 250–C30 R/3) — CEB A–73–3091
250–C20R Series — CEB A–73–4040
250–B15G — TP CEB A–169
250–B17 Series — TP CEB A–1305

1. PLANNING INFORMATION (Continued)

F. Interchangeability:

Not affected.

G. Material Availability:

Not applicable.

H. Tooling:

Not applicable.

I. Weight and Balance:

Not affected.

J. Electrical Load Data:

Not affected.

K. References:

(1) 5W2 Operation and Maintenance Manual, Turboshaft Models 250–C18A, –C18B, –C18C.

(2) 5W4 Parts Catalog, Turboshaft Models 250–C18A, –C18B, –C18C.

(3) 10W2 Operation and Maintenance Manual, Turboshaft Models 250–C20, –C20B, –C20F, –C20J.

(4) 10W2S Operation and Maintenance Manual, Turboshaft Model 250–C20S.

(5) 10W4 Parts Catalog, Turboshaft Models 250–C20, –C20B, –C20F, –C20J.

(6) 10W4S Parts Catalog, Turboshaft Model 250–C20S.

(7) 16W2 Operation and Maintenance Manual, Turboshaft Models 250–C28B, –C28C.

(8) 16W3 Overhaul Manual, Turboshaft Models 250–C28B, –C28C.

(9) 16W4 Illustrated Parts Catalog, Turboshaft Models 250–C28B, –C28C.

(10) 14W2 Operation and Maintenance Manual, Turboshaft Model 250–C30, –C30S, –C30G, –C30G/2, –C30P, –C30M.

(11) 14W2L, R, U Operation and Maintenance Manual, Turboshaft Models 250–C30L, –C30R, –C30U.

(12) 14W4 Illustrated Parts Catalog, Turboshaft Models 250–C30, C30P, C30M, –C30S, –C30G, –C30G/2.

(13) 14W4R,U Illustrated Parts Catalog, Turboshaft Models 250–C30R, –C30U.

1. PLANNING INFORMATION (Continued)

K. Reference: (Continued)

(14) GTP 5232–2 Operation and Maintenance Manual, Turboshaft Models 250–C20R, –C20R/1, –C20R/2, –C20R/4.

(15) GTP 5232–4 Illustrated Parts Catalog, Turboshaft Models 250–C20R, –C20R/1, –C20R/2, –C20R/4.

(16) 6W2 Operation and Maintenance Manual, Turboprop Model 250–B15G.

(17) 6W4 Parts Catalog, Turboprop Model 250–B15G.

(18) 11W2 Operation and Maintenance Manual, Turboprop Models 250–B17, –B17B, –B17C, –B17D, –B17E.

(19) 11W4 Parts Catalog, Turboprop Models 250–B17, –B17B, –B17C, –B17D, –B17E.

(20) GTP 5243–2 Operation and Maintenance Manual, Turboprop Models 250–B17F, –B17F/1, –B17F/2.

(21) GTP 5143–4 Illustrated Parts Catalog, Turboprop Models 250–B17F, –B17F/1, –B17F/2.

L. Other Publications Affected

None.

M. Prerequisites

None.

2. ACCOMPLISHMENT INSTRUCTIONS.

A. Check the CECO fuel pump for internal spline backlash as follows:

(1) Remove CECO fuel pump from the engine per the applicable 250 Operation and Maintenance Manual.

(2) Cut out a template. For pumps with less than 200 hours operating time, mark the template with a 4° angle. For pumps with greater than 200 hours operating time, mark the template with a 5° angle. (See Figure 1.) Paste the template on 5 x 8 inch index card, cardboard, or thin aluminum. Cut out a circle as follows:

(a) For fuel pump Models MFP 262 and 263 the circle should be 1.5 inch diameter.

(b) For fuel pump Models MFP 264–1 and 264–2 the circle should be 2.7 inch diameter.

(3) Place the template around the fuel pump pilot as shown in Figure 2.

(4) Bend a paper clip or piece of lockwire to fit between the splines on the drive shaft to serve as a pointer. (See Figure 3.) Install paper clip on shaft.

CAUTION: IN ORDER TO OBTAIN AN ACCURATE ANGULAR CHECK, WHEN PERFORMING THE FOLLOWING STEPS TAKE CARE NOT TO PUSH THE PUMP SHAFT SIDE TO SIDE.

(5) While pulling on the drive shaft to pull it against its aft stop, (it will have less than 0.050" movement and may have no movement) turn the drive shaft against the left stop. Align the template centerline with the pointer (See Figure 4).

2. ACCOMPLISHMENT INSTRUCTIONS: (Continued)

(6) While maintaining sufficient pressure to keep the shaft pulled outward against its aft stop, rotate the drive shaft back and forth to check drive shaft backlash.

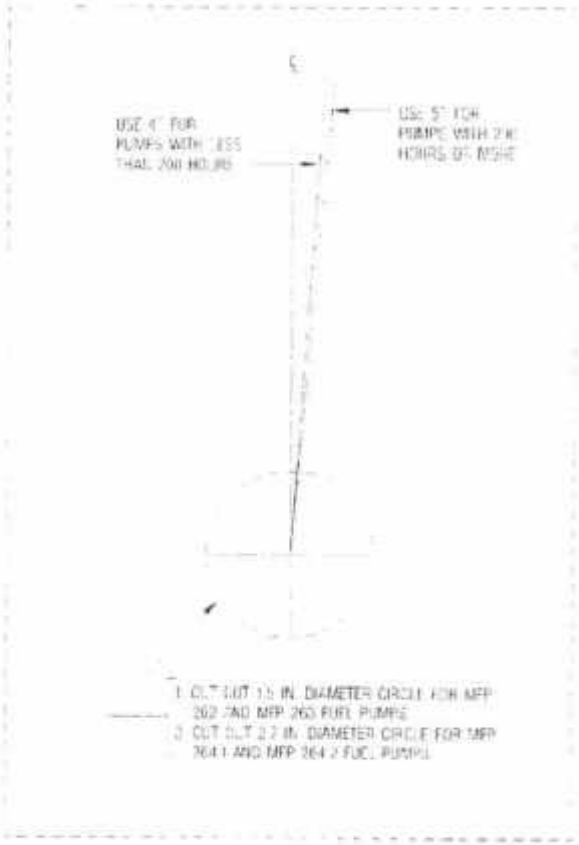
(a) If the pointer is within the 4° range, or 5° for pumps with 200 hours or more, (see Figure 5), reinstall the fuel pump, run the engine and check for leaks. (Refer to the applicable 250 Operation and Maintenance Manual)

(b) If the pointer is not within 4° range, or 5° for pumps with 200 hours or more, send to a CECO approved overhaul center. Reinstall a different pump which is new, newly overhauled, or that meets backlash check.

B. Record compliance in the Engine Log Book, Engine Assembly (white pages), Part III, Modification Record as applicable with the following:

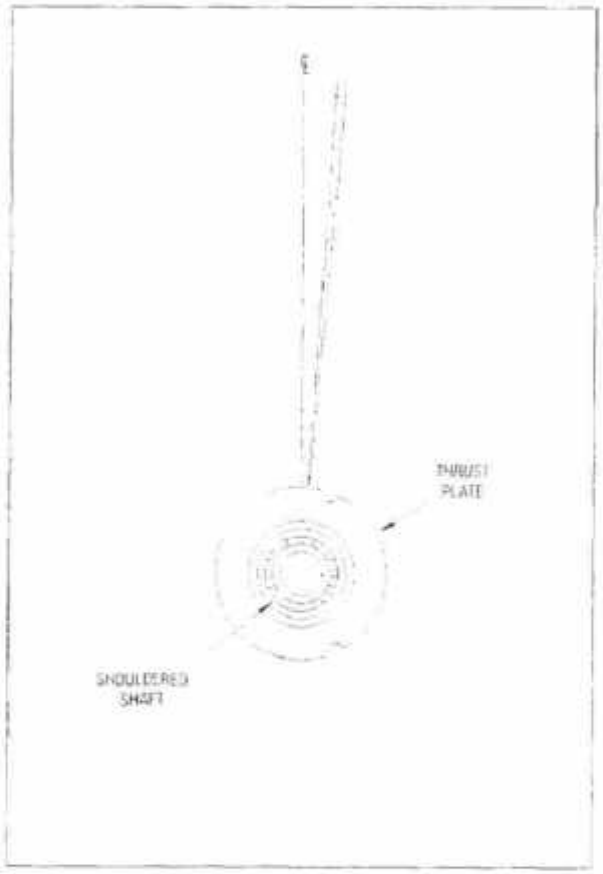
250–C18 Series		CEB A–295
250–C20 Series		CEB A–1352
250–C28 Series		CEB A–73–2066
250–C30 Series (except C30R/3)		CEB A–73–3091
250–C20R Series		CEB A–73–4040
250–B15G	TP	CEB A–169
250–B17	TP	CEB A–1305
250–B17F	TP	CEB A–73–2024

2. ACCOMPLISHMENT INSTRUCTIONS (Continued)



Drive Shaft Backlash Check Template
Figure 1

2. ACCOMPLISHMENT INSTRUCTIONS: (Continued)

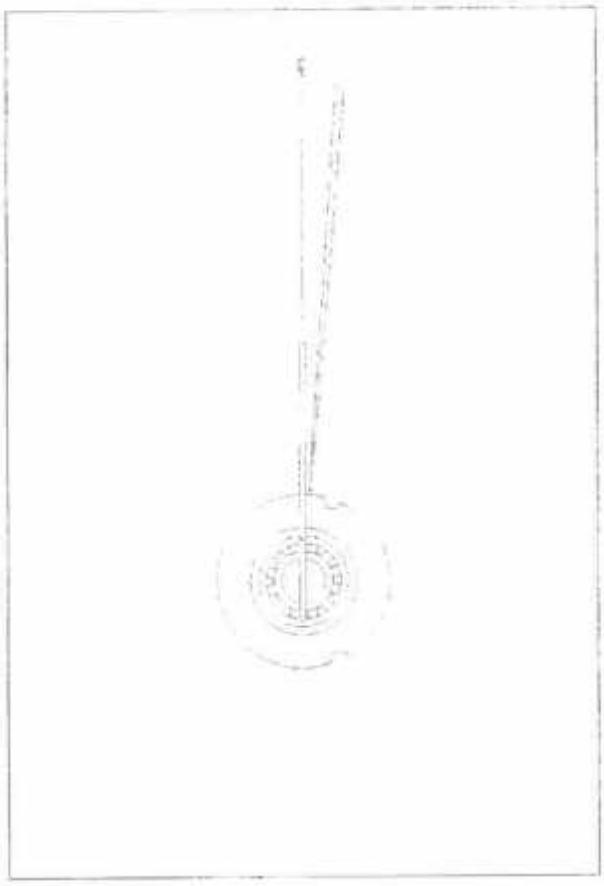


Backlash Template Installed on Fuel Pump
Figure 2

2. ACCOMPLISHMENT INSTRUCTIONS: (Continued)

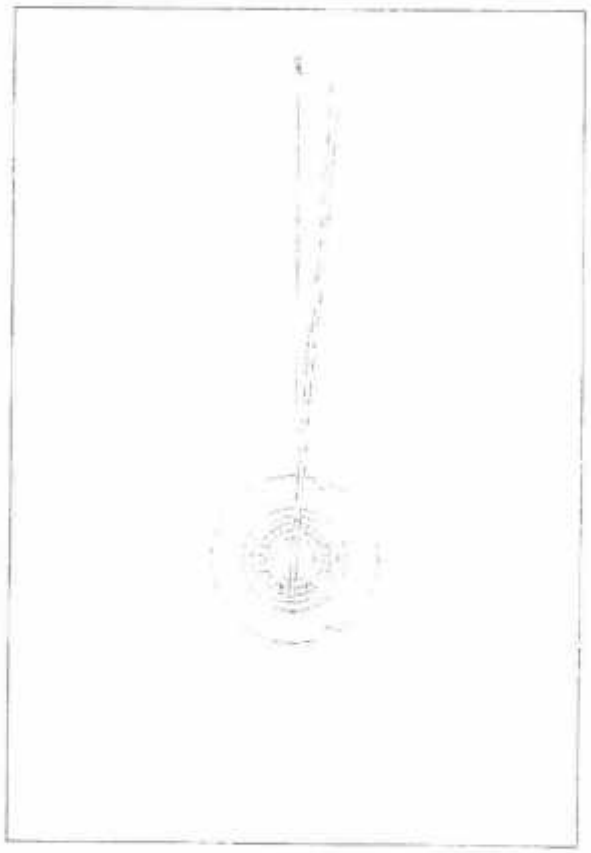
Backlash Pointer Installed on Shouldered Shaft
Figure 3

2. ACCOMPLISHMENT INSTRUCTIONS: (Continued)



Template Centerline Aligned with Pointer
Figure 4

2. ACCOMPLISHMENT INSTRUCTIONS: (Continued)



Checking Backlash
Figure 5

3. MATERIAL INFORMATION

Not Applicable

CUSTOMER SUPPORT
ALLISON ENGINE COMPANY

APPENDIX F

EXPORT CONTROLLED

COMMERCIAL ENGINE BULLETIN

Rolls-Royce

ENGINE, FUEL AND CONTROL - GOODRICH ENGINE DRIVEN FUEL PUMP IMPROVED DRIVE SHAFT DURABILITY

1. PLANNING INFORMATION

A. Effectivity

(1) Engines

All Rolls-Royce Model 250-C20, -C28, -C30, -C20R, -B17 and -B17F series engines with Goodrich (CECO) fuel pumps are affected by this bulletin.

(2) Spares - Not affected

B. Reason

New fuel pumps are released that incorporate various product improvements.

These improvements eliminate the need for repetitive spline inspections.

C. Description

This commercial engine bulletin gives you the procedure for replacing current fuel pumps with the new fuel pumps released by this bulletin.

D. Approval

Technical aspects are FAA approved.

E. Compliance

Compliance Code 7. To be complied with per customer option.

F. Interchangeability

(1) 23076729 is to be used on the -C20R/2(SP) engine model (suction pump configuration).

(2) 23074705 is to be used on all series II turboshaft and turboprop engine models except the -C20R/2 (SP).

(3) 23074706 is to be used on all -C28 and -C30P engine models.

(4) 23074707 is to be used on all -C30 engine models except the -C30P.

April 7, 2004
Revision 1
March 31, 2008

250-C20 Series
250-C28 Series
250-C30 Series
250-C20R Series

CEB-1393
CEB-73-2074
CEB-73-3117
CEB-73-4044

G. Material Availability

NEW P/N	NAME	QTY/ENG
23076729	Fuel Pump MFP 262	1
23074705	Fuel Pump MFP 263	1
23074706	Fuel Pump MFP 264-1	1
23074707	Fuel Pump MFP 264-2	1

H. Tooling – Not applicable

I. Weight and Balance – Not affected

J. Electrical Load Data – Not affected

K. References

(1) Advance Engineering Memorandum (AEM), CW112817.

NOTE: The document above is referenced for the internal use of Rolls-Royce only.

(2) 10W2 Operation and Maintenance Manual, Turboshaft Models 250-C20, -C20B, -C20F, -C20J, -C20S, -C20W (OMM).

(3) 10W4 Illustrated Parts Catalog, Turboshaft Models 250-C20, -C20B, -C20C, -C20F, -C20J, -C20S, -C20W (IPC).

(4) 16W2 Operation and Maintenance Manual, Turboshaft Models 250-C28B, -C28C (OMM).

(5) 16W4 Illustrated Parts Catalog, Turboshaft Models 250-C28B, -C28C (IPC).

(6) 14W2 Operation and Maintenance Manual, Turboshaft Models 250-C30, -C30S, -C30G, -C30G/2, -C30P, -C30M (OMM).

(7) 14W4 Illustrated Parts Catalog, Turboshaft Models 250-C30, -C30P, -C30M, -C30S, -C30G, -C30G/2 (IPC).

(8) CSP21007 Operation and Maintenance Manual, Turboshaft Models 250-C20R, -C20R/1, -C20R/2, -C20R/4 (OMM).

(9) CSP23007 Illustrated Parts Catalog, Turboshaft Models 250-C20R, -C20R/1, -C20R/2, -C20R/4 (IPC).

(10) 11W2 Operation and Maintenance Manual, Turboprop Models 250-B17, -B17B, -B17C, -B17D, -B17E (OMM).

(11) 11W4 Illustrated Parts Catalog, Turboprop Models 250-B17, -B17B, -B17C, -B17D, -B17E (IPC).

(12) CSP21008 Operation and Maintenance Manual, Turboprop Models 250-B17F, -B17F/1, -B17F/2 (OMM).

(13) CSP23008 Illustrated Parts Catalog, Turboprop Models 250-B17F, -B17F/1, -B17F/2 (IPC).

L. Other Publications Affected

(1) CSP24009 Component Maintenance Manual (CMM).

M. Prerequisites – None

2. ACCOMPLISHMENT INSTRUCTIONS

A. Replace the Fuel Pump Assembly (Ref. OMM).

(1) Remove the fuel supply line.

(2) Remove the fuel pump from the engine.

(3) Remove the fuel control (Series III and IV engine) or high pressure filter (C20R/2(SP)) from old pump.

(4) Install the fuel control or high pressure filter to new pump.

(a) For the 250-C20R/2(SP) engine, reidentify the main fuel pump and filter assembly (23070620).

(b) For the 250-C30G engine, reidentify the main fuel pump and filter assembly (23074707).

(5) Install the fuel pump to the engine.

(6) Install fuel supply line.

(7) Ground run the engine to perform functional and leak check.

B. Record compliance with this commercial engine bulletin in the applicable section of the engine logbook, engine assembly (white pages), Part III, Modification Record as applicable with the following:

250-C20 Series	CEB-1393
250-C28 Series	CEB-73-2074
250-C30 Series	CEB-73-3117
250-C20R Series	CEB-73-4055
250-B17 Series	TP CEB-1335
250-B17F Series	TP CEB-73-2031

C. Basis for quantities is per engine assembly.

250-C20 Series CEB-1393
250-C28 Series CEB-73-2074
250-C30 Series CEB-73-3117
250-C20R Series CEB-73-4055
250-B17 Series TP CEB-1335
250-B17F Series TP CEB-73-2031

3. MATERIAL INFORMATION

A. Configuration Chart

NEW P/N	QTY/ ENG	NAME	OLD P/N	QTY/ ENG	INSTRUCTIONS/ DISPOSITION
23070620	1	Pump Assembly, Fuel	23074704 23057337	1	1,3
23076729	1	Pump Assembly, Fuel	23051981	1	1,2
23074705	1	Pump Assembly, Fuel	23070459	1	1,2
23074706	1	Pump Assembly, Fuel	23070460	1	1,2
23074707	1	Pump Assembly, Fuel	23070461 23074704	1	1,2

INSTRUCTIONS/DISPOSITION NOTES

1. New/exchange item.
2. Rework at Goodrich authorized repair facility.
3. Reidentify

CUSTOMER SUPPORT
ROLLS-ROYCE

APPENDIX G

GOODRICH

Pump & Engine Control Systems, Inc.

SERVICE BULLETIN

MFP-263/264
73-3

Goodrich Pump & Engine Control Systems, Inc. Model MFP-263/MFP-264
Used on Rolls-Royce Model 250 Series II and III and IV Engines
Introduction of New Configuration Pumps to Increase the Pump Service Life

1. Planning Information:

   A. Effectivity:

   Modification is applicable to Goodrich Pump & Engine Control Systems, Inc. (GPECS) Model MFP-263 Main Fuel Pump Part Number 113300-03A1 (Rolls Royce Part Number 23070459) and Model MFP-264 Main Fuel Pump Part Numbers 113310-03A1 (RR Part Number 23070460) and 113320-03A1 (RR Part Number 23070461). Modification of earlier configuration main fuel pumps should be completed in accordance with previously approved and published service bulletins.

   B. Reason:
   To introduce a new configuration fuel pump incorporating a new material pump gear assembly. This change is being introduced to increase the pump service life, especially in harsher operating environments.

   C. Description:
   The work required by this bulletin consists of incorporating a new pump gear assembly.

   D. Compliance:
   Compliance shall be accomplished when returned for depot level maintenance.

   E. Approval:
   Technical aspects are FAA approved.

   F. Manpower:
   All pump modification work is to be performed by an authorized GPECS maintenance facility.

April 8, 2004
Rev. 1 January 5, 2006

250-C20 Series
250-C20R Series
250-C28 Series
250-C30 Series
250-B17 Series
250-B17F Series

PMI I0022

G. Material - Price and Availability:

Pump Model	Part Number	Quantity	Nomenclature	Current Unit Price List	Availability
MFP-263	114669-1	One	Gear Assembly, MFP-263	*	*
MFP-264	114670-1	One	Gear Assembly, MFP-264	*	*
ALL	113268-1	1	Plate, Identification	*	*
ALL	MS51861-1C	2	Screw, Thread Forming	*	*

* Contact a GPECS account manager for price and availability.

H. Tooling:
Refer to MFP-263 and MFP-264-1/-2 Component Maintenance Manual 73-10-08, latest revision, for any special tooling required to complete this bulletin.

I. Weight and Balance:
None.

J. Electrical Load Data:
Not changed.

K. Software Accomplishment Summary:
Not applicable.

L. References:
GPECS Model MFP-263 and MFP-264-1/-2 Component Maintenance Manual 73-10-08, latest revision.

M. Other Publications Affected:
Not applicable.

GOODRICH

Pump & Engine Control Systems, Inc.

SERVICE BULLETIN

MFP-263/264
73-3

2. Accomplishment Instructions:

CAUTION: FOLLOW ALL CAUTIONS AND WARNINGS IDENTIFIED IN CMM 73-10-08, LATEST REVISION, TO MAXIMIZE SAFETY AND HEALTH.

A. During disassembly in accordance with CMM 73-10-08 instructions, remove and discard the applicable gear set shown in Figure 1 or Figure 2. Discarded parts are to be replaced with the new corresponding part numbers shown in Figure 1 or Figure 2. Record identification plate information as some information will be transferred to the new identification plate. This includes any inspection identifiers.

B. Inspect and process remaining parts of the pump in accordance with Component Maintenance Manual 73-10-08, latest revision.

C. Reassemble with the new parts listed in paragraph 3, Material Information and Figure 1 or Figure 2, and test the pump, in accordance with the Assembly and Test Sections of Component Maintenance Manual 73-10-08, latest revision.

D. Replace the existing Identification Plate with a new one reidentifying the pump with the corresponding Rolls-Royce part number and GPECS part number from the table below. The discarded identification plate should be physically marred or destroyed to prevent inadvertant re-use.

Model	GPECS Part Number	Rolls-Royce Part Number
MFP-263	113300-04A1	23074705
MFP-264-1	113310-04A1	23074706
MFP-264-2	113320-04A1	23074707

3. Material Information:

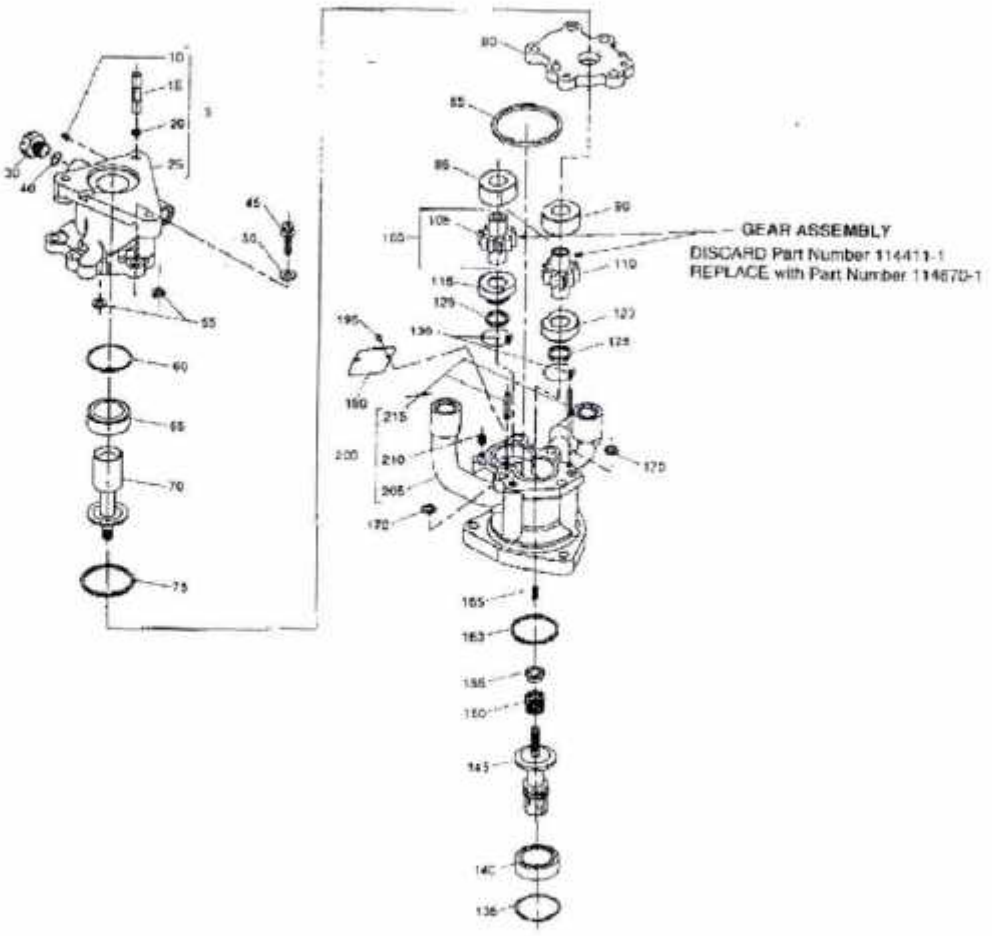
The basis for the following is per the Main Fuel Pump Assembly.

Model	New Part Number	Quantity	Nomenclature	Old Part Number	Disposition
MFP-263	113300-04A1	One	Pump, Main Level	113300-03A1	Re-identify
	114669-1	One	Gear Assembly	114247-1	Replace
MFP-264	113310-04A1	One	Pump, Main Fuel	113310-03A1	Re-identify
	113320-04A1			113320-03A1	
	114670-1	One	Gear Assembly	114411-1	Replace
All	113268-1	1	Plate, Identification	113268-1	Re-identify and Replace
All	MS51861-1C	2	Screw, Thread Forming	MS51861-1C	Replace

GOODRICH
Pump & Engine Control Systems, Inc.

SERVICE BULLETIN

MFP-263/264
73-3



MFP-264-1 Pump Assembly
Figure 2

April 8, 2004
Rev. 1 January 5, 2006

250-C20 Series
250-C20R Series
250-C28 Series
250-C30 Series
250-B17 Series
250-B17F Series

PMI I0022

3. Material Information:

The basis for the following is per the Main Fuel Pump Assembly.

Model	New Part Number	Quantity	Nomenclature	Old Part Number	Disposition
MFP-263	113300-04A1	One	Pump, Main Level	113300-03A1	Re-identify
	114669-1	One	Gear Assembly	114247-1	Replace
MFP-264	113310-04A1	One	Pump, Main Fuel	113310-03A1	Re-identify
	113320-04A1			113320-03A1	
	114670-1	One	Gear Assembly	114411-1	Replace
All	113268-1	1	Plate, Identification	113268-1	Re-identify and Replace
All	MS51861-1C	2	Screw, Thread Forming	MS51861-1C	Replace

GOODRICH

Pump & Engine Control Systems, Inc.

SERVICE BULLETIN

MFP-263/264
73-3

LIMITED DISTRIBUTION TO AUTHORIZED PERSONS ONLY

APPENDIX H

RC 951188

Precision Relief Limited.
1st Avenue, 5 Close, house 10a, Festac town, Lagos Nigeria.
Tel : +234 (0)8029827422, 01-4086344
Email: precisionrelief@gmail.com

PRECISION RELIEF LIMITED

Client: ACCIDENT INVESTIGATION BUREAU
Vessel: N/A
Cargo: JET A1
Port: N/A
Date sampled: N/A

INVOICE #: PRL/09/0009/LA12

CERTIFICATE OF QUALITY

Sample Source: BROUGHT BY CLIENT (LABELLED AS AFTER ACCIDENT BFF 28 - 29 OCT 2012)
Product: JET A1
Laboratory ID: PRL/IQ/0011/LA13
Seal Number: N/A
Container Volume: 151 LITRES

TEST PERFORMED

Embodying the most stringent requirements in the following specifications for the grade shown: AFQRJOS Issue 28-Check list (4TH May 2012)
(a) British MoD DEF STAN 91-91Issue 7, Amendment 2, (Implementation date-01 March 2013) for Turbine fuel, Aviation Kerosene Type, Jet A-1.
(b) ASTM Standard specification D 1655 – 11 for Aviation Turbine Fuels "Jet A-1"

PROPERTY	UNIT	TEST METHOD	UNIT	LIMITS	RESULT	UNCERTAINTY +/- (P=k)	ACCEPT SPEC
1 APPEARANCE							
1.1 Visual		Visual/ASTM D4176		clear,bright and visually free from solid matter and undissolved water at ambient temperature	C&B		
1.2 Colour		ASTM D156		Report	+18		-
1.4 Particulate, at point of manufacture, cumulative channel particle counts	iso code	IP 564 or 577	mg/l	Report	17/15/11		-
≥ 4µm (c)				Report	642.3		
≥ 6µm (c)				Report	192.2		
≥ 14µm (c)				Report	10.3		
≥ 21µm (c)				Report	1.3		
≥ 25µm (c)				Report	0.9		
≥ 30µm (c)				Report	0.3		
2 COMPOSITION							
2.1 Total Acidity	mgKOH/g	ASTM D3242	mgKOH/g	Max 0.015	0.0031		
2.2.1 Aromatics	%vol	ASTM D1319 / IP156	mg/100ml	Max 25.0	18.3		
2.3 Sulphur, Total	% mass	ASTM 3436e-03		Max 0.3	0.199		-
2.4 Sulphur, Mercaptans	% mass	ASTM D3227		Max 0.003	0.0044		
2.5 Doctor test		ASTM D4952		Negative	Positive		Spec limit
3 VOLATILITY							
3.1 Distillation	°C	ASTM D86	°C				
3.1.1 -Initial Boiling Point				Report	163.0		0
3.1.2 -10% Recovery				Max 205	190.9		0
3.1.3 -50% Recovery				Report	207.0		0
3.1.4 -90% Recovery				Report	244.0		0
3.1.5 -End Point				Max 300	299.0		0
3.1.6 -Residue	%vol		%vol	Max 1.5	1.5		-
3.1.7 -Loss	%vol		%vol	Max 1.5	0.5		-
3.2 Flash point	°C	IP 170-07	°C	Min 38	50.6		3
3.3 Density@15°C	kg/m3	ASTM D4052	g/ml	Min 775.0-Max 840.0	0.8147		0.003
4 FLUIDITY							
4.1 Freezing Point	°C	ASTM D2386	°C	Max minus 47.0	- 52.0		3
5 COMBUSTION							
5.1 Smoke point	mm	ASTM D1322	mm	Min 19.0	21.0		
5.3 Net Specific energy	MJ/Kg	ASTM D4529	MJ/Kg	Min 42.80	44.366		-
6 CORROSION							
6.1 Copper Strip(class)2hrs@100°C		ASTM D130		Max 1	1a		Spec limit
7 THERMAL STABILITY (JFTOT)							
7.1 Test Temperature	°C	ASTM D3241		Min 260	260		Spec Limit
7.3 Tube Rating Visual				Less than 3, Not Peacock (P) or Abnormal (A)	1		Spec Limit
7.3 Pressure Differential	mm Hg			Max 25	5		Spec Limit
8 CONTAMINANTS							
8.1 Existent Gum	mg/100ml	ASTM D381	mg/100ml	Max 7	0.5		3.0
9 WATER REACTION CHARACTERISTICS							
9.1 Microseparometer without SDA	rating	ASTM D3948	rating	Min 85			Spec limit
9.1.2 Microseparometer with SDA	rating		rating	Min 70	93		Spec limit
10 CONDUCTIVITY							
10.1 Electrical conductivity@25.4°C	Pu/m	ASTM D2624	Pu/m	Min 50 - Max 450	143		Spec limit
11 LUBRICITY							
Wear Scar Diameter	mm	ASTM D5001		Max 0.85	0.58		Spec limit

Note: The Doctor test is positive and the Mercaptans sulfur content exceeds the spefification limit of 0.003 %mass.

* was obtained refinery Certificate of Quality
All testing carried out in third party Laboratory facility

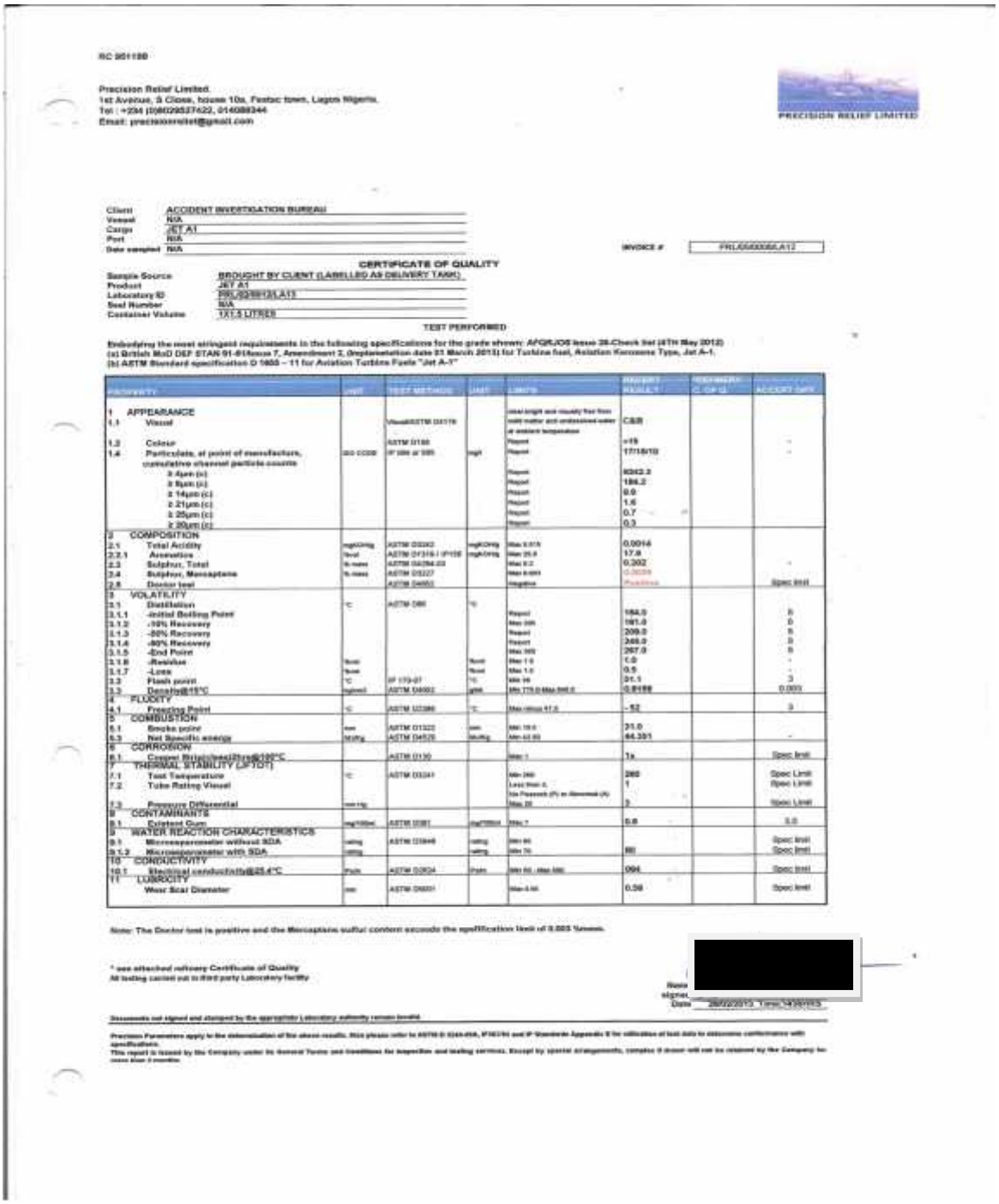
[redacted]

Name signed
Date 28/12/2013 Time 1540HRS

Documents not signed and stamped by the appropriate Laboratory authority remain invalid.

Precision Parameters apply in the determination of the above results. Also please refer to ASTM D 3244-05e, IP 367/93 and IP Standards Appendix E for utilization of test data to determine conformance with specifications.
This report is issued by the Company under its General Terms and Conditions for Inspection and testing services. Except by special arrangements, samples if drawn will not be retained by the Company for more than 3 months.

APPENDIX I



RC 901180

Precision Relief Limited.
1st Avenue, 3 Close, house 10a, Festac town, Lagos Nigeria.
Tel : +234 (0)8029537422, 0140888344
Email: precisionrelief@gmail.com

PRECISION RELIEF LIMITED

Client: ACCIDENT INVESTIGATION BUREAU
Vessel: N/A
Cargo: JET A1
Port: N/A
Date sampled: N/A

INVOICE #: PRL/[illegible]/LA12

CERTIFICATE OF QUALITY

Sample Source: BROUGHT BY CLIENT (LABELLED AS DELIVERY TANK)
Product: JET A1
Laboratory ID: PRL/0289/13/LA13
Seal Number: N/A
Container Volume: 1X1.5 LITRES

TEST PERFORMED

Embodying the most stringent requirements in the following specifications for the grade shown: AFQRJOS Issue 28-Check list (4TH May 2012)
(a) British MoD DEF STAN 91-91/Issue 7, Amendment 2, (Implementation date 01 March 2013) for Turbine fuel, Aviation Kerosene Type, Jet A-1.
(b) ASTM Standard specification D 1655 – 11 for Aviation Turbine Fuels "Jet A-1"

PROPERTY	UNIT	TEST METHOD	UNIT	LIMITS	RESULT	TECHNICIAN'S C. OF O.	ACCEPT OR?
1 APPEARANCE							
1.1 Visual		Visual/ASTM D4176		clear bright and visually free from water matter and undissolved water at ambient temperature	C&B		
1.2 Colour		ASTM D156		Report	+19		-
1.4 Particulate, at point of manufacture, cumulative channel particle counts	(ml) CCDB	IP 564 or 565	mg/l	Report	17/15/10		-
≥ 4µm (c)				Report	8063.2		
≥ 6µm (c)				Report	186.2		
≥ 14µm (c)				Report	0.0		
≥ 21µm (c)				Report	1.6		
≥ 25µm (c)				Report	0.7		
≥ 30µm (c)				Report	0.3		
2 COMPOSITION							
2.1 Total Acidity	mgKOH/g	ASTM D3242	mgKOH/g	Max 0.015	0.0014		
2.2.1 Aromatics	Vol	ASTM D1319 / IP156	mgKOH/g	Max 25.0	17.8		
2.3 Sulphur, Total	% mass	ASTM D4294-03		Max 0.3	0.302		-
2.4 Sulphur, Mercaptans	% mass	ASTM D3227		Max 0.003	0.0039		-
2.8 Doctor test		ASTM D4952		negative	Positive		Spec limit
3 VOLATILITY							
3.1 Distillation	°C	ASTM D86	°C				
3.1.1 -Initial Boiling Point				Report	164.0		0
3.1.2 -10% Recovery				Max 205	181.0		0
3.1.3 -50% Recovery				Report	209.0		0
3.1.4 -90% Recovery				Report	248.0		0
3.1.5 -End Point				Max 300	267.0		0
3.1.6 -Residue	%vol		%vol	Max 1.5	1.0		-
3.1.7 -Loss	%vol		%vol	Max 1.5	0.5		-
3.3 Flash point	°C	IP 170-07	°C	Min 38	51.1		3
3.3 Density@15°C	kg/m3	ASTM D4052	g/ml	Min 775.0 Max 840.0	0.8188		0.003
4 FLUCITY							
4.1 Freezing Point	°C	ASTM D2386	°C	Max minus 47.0	- 52		3
5 COMBUSTION							
5.1 Smoke point	mm	ASTM D1322	mm	Min 19.0	31.0		
5.3 Net Specific energy	MJ/Kg	ASTM D4529	MJ/Kg	Min 42.80	44.391		-
6 CORROSION							
6.1 Copper Strip(Class)/hrs@100°C		ASTM D130		Max 1	1a		Spec limit
7 THERMAL STABILITY (JFTOT)							
7.1 Test Temperature	°C	ASTM D3241		Min 260	260		Spec Limit
7.2 Tube Rating Visual				Less than 3, No Peacock (P) or Abnormal (A)	1		Spec Limit
7.3 Pressure Differential	mm Hg			Max 25	3		Spec Limit
8 CONTAMINANTS							
8.1 Existent Gum	mg/100ml	ASTM D381	mg/100ml	Max 7	0.8		0.0
9 WATER REACTION CHARACTERISTICS							
9.1 Microseparometer without SDA	rating	ASTM D3948	rating	Min 85			Spec limit
9.1.2 Microseparometer with SDA	rating		rating	Min 70	80		Spec limit
10 CONDUCTIVITY							
10.1 Electrical conductivity@25.4°C	Pu/m	ASTM D2624	Pu/m	Min 50 - Max 600	094		Spec limit
11 LUBRICITY							
Wear Scar Diameter	mm	ASTM D6001		Max 0.85	0.58		Spec limit

Note: The Doctor test is positive and the Mercaptans sulfur content exceeds the spefification limit of 0.003 %mass.

* see attached refinery Certificate of Quality
All testing carried out in third party Laboratory facility

[redacted]
Name
signed
Date 28/02/2013 Time[illegible]

Documents not signed and stamped by the appropriate Laboratory authority remain invalid.

Precision Parameters apply to the determination of the above results. Also please refer to ASTM D 3244-05e1, IP 367/91 and IP Standards Appendix E for utilization of test data to determine conformance with specification.
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