AIRCRAFT ACCIDENT REPORT
PAAN/2010/04/16/F

Accident Investigation Bureau

Report on the Serious Incident involving Pan African Airlines Nigeria Limited Bell 412-EP Helicopter Registration 5N-BFU at NNPC Housing Complex, Warri, Delta state, Nigeria On 16th April, 2010.

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 Organisation, 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.

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

ADs	Airworthiness Directives
AFCS	Automatic Fuel Control System
AFCU	Automatic Fuel Control Unit
AIB	Accident Investigation Bureau

ATPL	Airline Transport Pilot Licence
A&P	Airframe and Power Plant
C of A	Certificate of Airworthiness
CAVOK	Ceiling and Visibility OK
C-BOX	Combining Gear Box
C of A	Certificate of Airworthiness
CPL	Commercial Pilot Licence
CVR	Cockpit Voice Recorder
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
HUMS	Health and Usage Monitoring System
ICAO	International Civil Aviation Organisation
ITT	Inter Turbine Temperature
MDS	Main Drive Shaft
MFCU	Manual Fuel Control Unit
MM	Maintenance Manual
NavAids	Navigational Aids
NCAA	Nigerian Civil Aviation Authority
NCARs	Nigeria Civil Aviation Regulations
NNPC	Nigerian National Petroleum Corporation

N/A	Not Applicable
OPs	Operations
PAAN	Pan African Airlines Nigeria Limited
PIC	Pilot in command
PF	Pilot Flying
RPM	Revolutions Per Minute
S/N	Serial Number
TSN/CSN	Time Since New/Cycles Since New
TSO/CSO	Time Since Overhaul/Cycles Since Overhaul
T-Card	Task Card
USA	United State of America
WT	Warri Terminal

Aircraft Accident Report No.	**PAAN/2010/04/16/F**
Registered Owner and Operator:	Pan African Airlines Limited
Aircraft Type and Model:	Bell 412-EP Helicopter
Nationality:	Nigerian
Registration:	5N-BFU
Location:	NNPC Housing Complex, Warri
Date and Time:	16th April, 2010. 1355hrs *(All the times in this report are local time, equivalent to UTC+1 unless otherwise stated)*

SYNOPSIS

The Accident Investigation Bureau was notified of the serious incident on the 16th of April 2010 by the Nigerian Civil Aviation Authority (NCAA). Other relevant authorities and stake holders were also notified. An Investigator was dispatched to the site of the incident on 17th of April 2010.

On 16th April, 2010 at 0748hrs, a Bell 412-EP Helicopter, with registration 5N-BFU, operated by Bristow/PAAN was on a charter flight from Warri Terminal (WT) to Funiwa with eight passengers on board. The Captain was the Pilot Flying.

On a second flight from Warri at 0946hrs, 5 to 10 minutes into the flight to Abiteye, the crew noticed an abnormal torque split indication and oscillation on engine #2 torque needles.

Two tests were carried out to confirm the torque split indication but the indication was not replicated.

During the second test flight there was a loud noise and severe vibration; the pilot noticed engine power loss indication and entered autorotation. The Captain selected a landing area in view while the co-pilot declared MAYDAY. The aircraft landed safely at the NNPC Housing Complex field. There were no injuries to persons on board the aircraft as the autorotation was successfully accomplished.

The investigation identified the following:

Causal Factor:

Improper assembly of the Main Drive Shaft coupling and inappropriate duplicate inspection that followed the assembly.

Contributory Factor:

i. None adherence to Bell 412 Maintenance Manual procedures.

ii. Inadequate oversight functions of Bristow/PAAN quality assurance and safety department.

Two safety recommendations were made.

1.0 Factual Information

1.1 History of the Flight:

On the 16th of April 2010 at 0748hrs, Bristow/PAAN Helicopter with registration 5N-BFU departed Warri Terminal (WT) for Funiwa on a revenue flight, with eight passengers, and at 0847hrs picked up twelve passengers on the return leg to WT.

At 0946hrs, 5N-BFU departed WT for second flight of the day with twelve passengers. Few miles enroute Abiteye, the crew noticed an abnormal torque split on engine #2 with associated oscillation on engine #2 torque needle indicating 10%. This necessitated an air return. The crew returned to WT base for a snag assessment. On landing at WT, passengers disembarked and cargo was off-loaded. While the rotors were still running, Maintenance Engineer II boarded the aircraft for a test flight to assess the torque split and parameter indications. After the test flight, 5N-BFU returned to base at 1034hrs.

Maintenance actions were carried out in the WT hangar; this necessitated a second test flight.

At 1340hrs, 5N-BFU departed WT on a second test flight with same flight crew and the Maintenance Engineer II on board to ascertain if the torque split on engine #2 had cleared. After an unsuccessful flight to determine the cause of the torque split, the aircraft was returning to WT when at 400ft on base leg, the #2 engine chip light illuminated, followed by vibrating noise from the engine.
The # 1 engine chip light also illuminated with further vibration and grinding noise with subsequent loss of power to the main rotor. The PIC entered autorotation, and selected an area in sight for

emergency landing. The co-pilot declared Mayday and the aircraft landed at the Nigerian National Petroleum Corporation (NNPC) housing complex field at 1355hrs.

The incident occurred in day light.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	2	1	Nil

1.3 Damage to Aircraft

The aircraft was substantially damaged around the engine tunnel and bulkhead. See fig 1.3 below.

Fig 1.3 showing damage to tunnel area housing the Main Drive Shaft (MDS)

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Captain

Nationality	:	American
Age	:	62 years
Gender	:	Male
Licence/Number	:	ATPL/2025268
Valid to	:	30th September, 2010
Medical Validity	:	31st October, 2010
Ratings	:	Bell 205,214 and 412
Total flying time	:	15,000hrs
Total on type	:	9,000hrs
Last 90 Days	:	74hrs
Last 28 Days	:	18:36hrs
Last 24 hours	:	2:45hrs

1.5.2 The First Officer

Nationality	:	Nigerian
Age	:	31years
Gender	:	Male
Licence/Number	:	CPL/5109 (H)
Licence Validity	:	6th December, 2010
Medical Validity	:	31st Dec, 2011
Rating	:	Bell 412
Total flying time	:	990hrs

Total on type	:	785hrs
Last 90 Days	:	122hrs
Last 28 Days	:	17hrs
Last 24 hours	:	2:45hrs

1.5.3 Maintenance Engineer I

Nationality	:	Austrian
Age	:	68 Years
Gender	:	Male
Licence No.	:	1008 (A&C)
Validity	:	08 August, 2010
Aircraft Ratings	:	B206, B407, B412, CESSNA 208, PT6

He has his Aircraft Maintenance Engineer's Licence validated by the Nigerian Civil Aviation Authority (NCAA). The licence was valid at the time of the incident and he is rated on the aircraft Bell 412.
His training record showed that he attended a Bell 206 Field Maintenance Training course at Bell Helicopter Company Service Training School in April 1972, a Bell 412 Field Maintenance Training course at Bell Helicopter Textron Training center in April 1984, Bell 407 Field Maintenance training course by Air Logistics, L.L.C in Lagos in April 2003, Bell 206 recurrent course by Air Logistics, L.L.C in Lagos in October 2004 and Bell 412 recurrent training by Air Logistics, L.L.C Lagos in October,2008.

He is the base engineer at the Warri Terminal of the company. He certified the first inspection column on the work sheet of the Main Drive Shaft change and released the aircraft for the first flight of the day that morning. He also authorised the Maintenance Engineer II to carry out the test flight.

1.5.4 Maintenance Engineer II

Nationality	:	American
Age	:	53 Years
Gender	:	Male
Licence No.	:	003498903 (FAA)

He is one of the two engineers that carried out the Main Drive Shaft change and he also carried out the test flights. He holds an American Federal Aviation Administration (FAA) A and P (Airframe and Power Plant) Mechanic certificate but he was not rated on the aircraft and he did not hold any validation as at the time of the incident. His licence was later validated after the incident on 12th March, 2012. Correspondence with the FAA indicated that he holds a Private Pilots certificate.

He worked with Petroleum Helicopters for 19 years and had an authorisation from the company to carry out helicopter ground runs on Bell 412 issued on the 17th of February 1989. He also worked with American West Airlines for 3 years and Bristow group for 10 years.
His training records showed that he holds a Bell 212, 412 recurrent training certificates (14th July 2005) from Air Logistics, Mexico, Bell 412 recurrent training certificate (10th October, 2008) from Air Logistics, Lagos.

1.5.5 Maintenance Engineer III

Nationality	:	American
Gender	:	Male

Licence No. : 003498917 (FAA)

He was one of the two engineers that carried out the Main Drive Shaft change. He had no validation from NCAA at the time of the incident but his licence was later validated after the incident on 25th October, 2011.

His training records showed that he attended a basic helicopter training course at the Naval Air Training Center, Memphis Tennessee in August 1985, Bell 412 Airframe field maintenance Training course at Fort Worth, Texas in 1997 and Bell 412 A.F.C.S Training course also at Fort Worth, Texas in 1998.

1.5.6 Maintenance Engineer IV

Nationality : South African

Gender : Male

Licence No. : 2495 (NCAA)

He is the Chief Engineer at the Warri Terminal base. He is licensed and rated on the aircraft type and he carried out the second inspection of the Main Drive Shaft change after Engineer II had applied the torque seal.

His training records showed that he attended Bell 412 Field Maintenance Training Course by Bell Helicopter Training Academy in December 1992, a course on Aircraft Vibration and Control by Chadwick and Helmuth in January 1994, Bell 206 recurrent training by Air Logistics, L.L.C Lagos in October 2004, Bell 412 recurrent training by Air Logistics, L.L.C Lagos in October 2008.

1.5.7 Maintenance Engineer V

Nationality	:	Nigerian
Gender	:	Male
Licence No.	:	981

He is rated on the aircraft type (Bell 412) and he was called by Engineer I to sign the duplicate inspection column on the work sheet though he did not perform the duplicate inspection.

His training records showed that he attended a course on Bell 212 Helicopter with Pratt and Whitney PT6T-3B Engines, Airframe, Engine and Electrical Systems Field Maintenance by Bristow Helicopters Engineering Training School, Surrey in September 1988, Bell 412 Maintenance Course by Air Logistics, L.L.C Lagos in October 2003, Bell 407 Field Maintenance Course by Air Logistics, L.L.C Lagos in April 2003, Bell 206 recurrent training by Air Logistics L.L.C Lagos in October 2004, and Bell 412 recurrent training by Air Logistics, L.L.C Lagos in October 2008.

1.6 Aircraft Information

1.6.1 General Information

Type	**:**	BELL 412-EP
Serial No.	:	36318
Manufacturer	:	Bell Helicopters
Date of Manufacture	:	2003
Airframe time	:	6848hrs

C of A Validity : 9th October, 2010

1.6.2 Power Plant No.1

Manufacturer	: Pratt & Whitney, Canada
Model	: PT6-3D
Serial Number	: TH 0852
Total Cycles	: 3142
Total Time since New (TSN)	: 2739.5hrs
Total Time since Overhaul (TSO)	: 2739.5hrs

1.6.3 Power Plant No.2

Manufacturer	**: Pratt & Whitney Canada**
Model	: PT6-3D
Serial Number	: TH 0444
Total Cycles	: 8285
Total Time since New (TSN)	: 6573.40hrs
Total Time since Overhaul (TSO)	: 2739.50hrs

Prior to the incident flight, the aircraft's Main Drive Shaft was scheduled for change on the 12th of April, 2010 but the change was carried out on the 5th of April, 2010 at 6805.3 airframe hours at Warri Terminal Base.

MAIN ROTOR:

	SERIAL NUMBERS	TIME SINCE NEW	TSO
M/Rotor Hub	: A-1987	: 3791.8hrs	: 1570.5hrs
M/Rotor Blade	: A-3095	: 2784.9hrs	: N/A
M/Rotor Blade	: A-1709	: 5141.3hrs	: N/A
M/Rotor Blade	: A-3195	: 4089.6hrs	: N/A
M/Rotor Blade	: A-3089	: 2772.1hrs	: N/A

TAIL ROTOR:

	SERIAL NUMBERS	TIME SINCE NEW	TSO
T/Rotor Hub	: HB-635	: 617.3hrs	: N/A
T/Rotor Blade	: A-16396	: 826.9hrs	: N/A
T/Rotor Blade	: A-14221	: 3380.9hrs	: N/A

There were no outstanding Airworthiness Directives (ADs) in force as it relates to the Main Drive Shaft or the combining gear box at the time of the incidence.

The aircraft's combining gear box (C-Box) was replaced on the 8th of October, 2009 after 640hrs in service.

The aircraft Main Drive Shaft was due for 600hrs change on the 12th of April, 2010 but the change was carried out on the 5th of April, 2010 at 6805.3 airframe hours at Warri Terminal Base.

The six bolts and nuts/lock washers on the transmission end of the drive shaft coupling were found intact. However, on the C-box end of the drive shaft coupling, four bolts were found missing while the remaining two bolts were found broken and detached from the attachment point.

Type of fuel used is Jet A1.

1.7 Meteorological Information

The actual weather information from Osubi tower on the day of the incident was as follows:

Wind	:	240/05
Visibility	:	≥10Km
Cloud	:	Nil
Weather	:	CAVOK
QNH	:	1012hPa
Temp.	:	30˚C

1.8 Aids to Navigation

N/A.

1.9 Communications

There was good communication between the crew and WT base. The crew declared May Day and WT transmitted the information to

Chevron Fire and Rescue Service; they responded to the emergency call and were at the site of the incident five minutes later.

1.10 Aerodrome Information

The incident occurred at NNPC Housing complex field, one nautical mile away from Warri Terminal, which was the intended aerodrome and two hundred meters (200m) from NNPC gas plant located at the complex area.

1.11 Flight Recorders

The aircraft was fitted with a solid-state Cockpit Voice Recorder (CVR) manufactured by L3 Communications and a Fairchild solid-state Flight Data Recorder (FDR).

The aircraft data recorders were found and retrieved in good condition.

1.11.1 Flight Data Recorders (FDR)

Part Number	:	S800-2000-00
S/N	:	01553
Model	:	F1000
Manufacturer	:	Fairchild

See Fig.1.11.1 below.

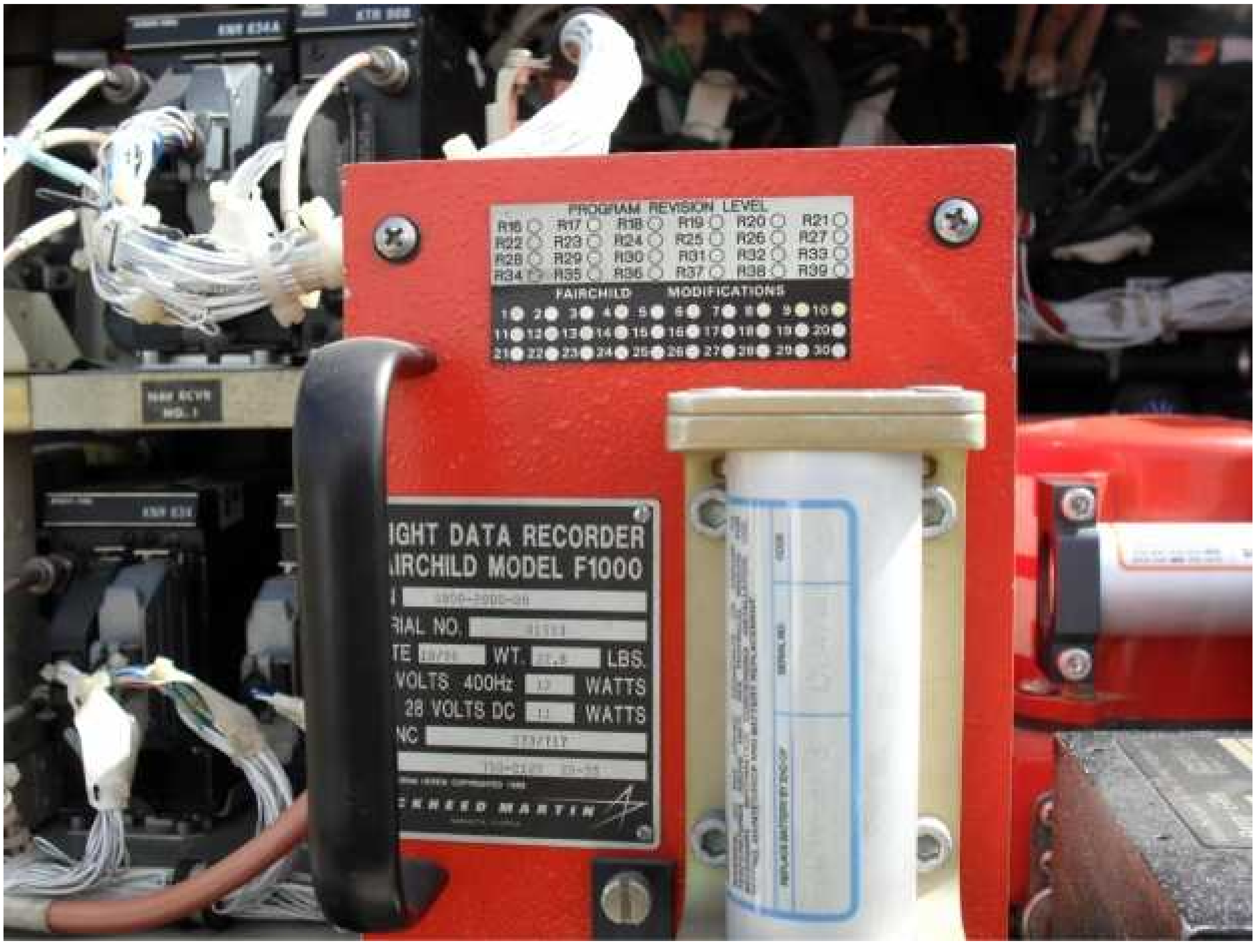

Fig.1.11.1

1.11.2 Cockpit Voice Recorder (CVR)

Part Number	:	2100-1010-00
S/N	:	000229961
Model	:	FA2100
Manufacturer	:	L3 Communications

See Fig.1.11.2 below.

Fig.1.11.2

1.12 Wreckage and Impact Information

The aircraft came to rest at the NNPC housing complex and was found intact. The Main Drive Shaft coupling sheared off from its attachment point at the combining gear box end. The tunnel area housing the Main Drive Shaft and the combining gear box was also damaged.

The six bolts and nuts/lock washers on the transmission end of the drive shaft coupling were found intact. However, on the C-box end of the drive shaft coupling, four bolts were found missing while the remaining two bolts were found broken and detached from the attachment point. See. Fig.1.12 b, c, d, e and f.

The four (4) missing bolts work loosed over time, shedding the load bearing capability of the assembly by 67% and transferring the load to the two bolts that were found. Fig 1.12a below shows the indentation marks made by the fractured bolts. The lock washers on the C-box end were not found.

Fig1.12a Indentation marks

Fig 1.12b: Picture showing aircraft in its final rest position

Fig 1.12c: Picture showing the damaged part of a coupling joint of the drive shaft

Fig 1.12d showing damage to tunnel area housing the Main Drive Shaft (MDS)

Fig1.12e showing two bolts found on the C-box end inside the aircraft.

Fig. 1.12f showing bolts intact at the transmission end.

1.13 Medical and Pathological Information

Toxicological investigations were carried out on the crew to determine the presence of, or use of drugs, alcohol or any other substance of abuse. The test results were negative. See fig 1.13a and b below.

Instant Technologies Inc.

Initial Drug Screen Result Form

Specimen ID Number 6068560

Collection Test Date 17-04-2010

Company/Employer Information (information about the company doing the testing)

Company PAN AFRICAN AIRLINES

Address Suite

City State Postal Code

Collector's Name [redacted] Phone [redacted]

Specimen Temperature: (90-100 F) In Range ☒ Other Fax

Donor Information (information about the person being tested)

Donor's Name [redacted]

ID # or SSN

Identification

Expiration

Notes

Certification (Donor and Collector)

I hereby certify that the specimen provided is my own ... been substituted or adulterated. I further agree and grant permission for the testing of my specimen for drug metabolites and/or alcohol.

[redacted] 17/04/2010

Donor's Signature Date

I hereby certify that I collected the specimen provided by the aforementioned Donor and that it was not substituted or adulterated to the best of my knowledge. The specimen temperature and color were acceptable.

[redacted] 17-04-2010

Collector's Signature Date

Initial Drug Test Results (Confirm ... non-negative results must be ...)

Drug Name	Device Code	Negative	Confirm	Not Tested
Cocaine	COC	☒	☐	☐
Marijuana	THC	☒	☐	☐
Opiates/Morphine	OPI/MOR	☒	☐	☐
Amphetamines	AMP	☒	☐	☐
Methamphetamine	mAMP	☒	☐	☐
Phencyclidine	PCP	☐	☐	☒
Benzodiazepine	BZO	☐	☐	☒
Barbiturates	BAR	☐	☐	☒
Methadone	MTD	☐	☐	☒
Tricyclic Antidepressants	TCA	☐	☐	☒
Oxycodone	OXY	☐	☐	☒
Propoxyphene	PPX	☐	☐	☒
Methylenedioxymethamphetamine	MDMA	☐	☐	☒
ALCOHOL SCREEN	ALC	☒		Level 0.000 mg/dL

Adulteration Panel Results

OX — Oxidant ☐ In Range Other

S.G. — Specific Gravity In Range ☐ Other

pH — pH In Range ☐ Other

Instant Technologies Inc.

Initial Drug Screen Result Form

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Specimen ID Number 6068557

Collection Test Date 17-04-2010

Company Information (Information about the company doing the testing)

Company Bristow
Address Lagos Suite N/A
City Lagos State N/A Postal Code N/A
Collector's Name [redacted] Phone
Specimen Temperature: (90-100 F.) In Range ☒ Other Fax

OFFICE

Donor Information (Information about the person being tested)

Donor's
ID # or [redacted]
Identifi Expiration Aug 2-11
tes

Donor and Collector

I hereby certify that ... has not been substituted or adulterated. I further agree and grant permission for the testing of my specimen for drug metabolites and/or alcohol.

[redacted]

Donor's Signature Date 17 April 2010

I hereby certify that I collected the specimen provided by the aforementioned Donor and that it was not substituted or adulterated to the best of my knowledge. The specimen temperature and color were acceptable.

[redacted]

Collector's Signature Date 17-04-2010

Last Name [redacted]

Initial Screen Results (All Screens ... non negative results must be confirmed ...)

Drug Name	Device Code	Negative	Confirm	Not Tested
Cocaine	COC	☒	☐	☐
Marijuana	THC	☒	☐	☐
Opiates/Morphine	OPI/MOR	☒	☐	☐
Amphetamines	AMP	☒	☐	☐
Methamphetamine	mAMP	☒	☐	☐
Phencyclidine	PCP	☐	☐	☒
Benzodiazepine	BZO	☐	☐	☒
Barbiturates	BAR	☐	☐	☒
Methadone	MTD	☐	☐	☒
Tricyclic Antidepressants	TCA	☐	☐	☒
Oxycodone	OXY	☐	☐	☒
Propoxyphene	PPX	☐	☐	☒
Methylenedioxymethamphetamine	MDMA	☐	☐	☒
ALCOHOL SCREEN	ALC	☒		Level 0-000 mg/dL

Adulteration Panel Results

OX — Oxidant ☐ In Range Other

S.G. — Specific Gravity In Range ☐ Other

pH — pH In Range ☐ Other

1.14 Fire

There was no fire outbreak.

1.15 Survival Aspect

The aircraft came to rest and was found intact. The Captain, First officer and the Maintenance Engineer II on board the aircraft all disembarked without assistance and no injury.

The emergency response procedure was initiated by Chevron Fire Fighting and Rescue Service. The incident was survivable since there was no damage to the aircraft cockpit and cabin areas. There was livable volume available after the incident. The damage to the aircraft was confined within the engine compartment area.

Fig 1.15 Showing aircraft intact

1.16 Test and Research

The engines and combining gear box of the aircraft 5N-BFU were sent to Pratt and Whitney, Canada, the manufacturer of the engine, for a tear down. The result indicated that both engines and combining gear box were in a serviceable state at the time of the occurrence and there were no evidence of sudden stoppage of the engines and combining gear box, neither were there evidence of seizure. See Appendix 1

Samples of the aircraft fuel, Jet A1, were taken from the aircraft fuel tanks for analysis. The results of the analysis did not show any contamination. See below.

RESULTS OF THE ENGINE OIL, GEAR BOX AND AVIATION FUEL SAMPLES LABORATORY ANALYSIS

GEAR BOX OIL SAMPLES

CONTAMINATION CHECK:

METAL DEBRIS	NON PRESENT
WATER	NON PRESENT
FUEL IN OIL	NON PRESENT
HYDRAULIC FLUID IN OIL	NON PRESENT
ANY OTHER CONTAMINANT	NON PRESENT
GENERAL CONDITION OF THE ENGINE OIL	SATISFACTORY

ENGINE OIL SAMPLE

ENGINE NUMBER 1

CONTAMINATION CHECK:

METAL DEBRIS	NON PRESENT
WATER	NON PRESENT

FUEL IN OIL	NON PRESENT
HYDRAULIC FLUID IN OIL	NON PRESENT
ANY OTHER CONTAMINANT	NON PRESENT
GENERAL CONDITION OF THE ENGINE OIL	WITHIN SATISFACTORY

ENGINE NUMBER 2

CONTAMINATION CHECK:

METAL DEBRIS	NON PRESENT
WATER	NON PRESENT
FUEL IN OIL	NON PRESENT
HYDRAULIC FLUID IN OIL	NON PRESENT
ANY OTHER CONTAMINANT	NON PRESENT
VISCOSITY	WITHIN SPECICIFICATION
GENERAL CONDITION OF THE ENGINE OIL	SATISFACTORY

AVIATION FUEL SAMPLE

APPEARANCE	COLOURLESS
MICROBIAL GROWTH	NON PRESENT
FLASH POINT	WITHIN SPECIFICATION
VOLATILITY	WITHIN SPECIFICATION

CONTAMINATION CHECK

WATER	NON PRESENT
OIL IN FUEL	NON PRESENT
DENSITY/SPECIFIC GRAVITY	WITHIN LIMIT
IMPURITIES	NON PRESENT

The results of the analysis do not indicate any contaminations of the sample or any indication of any associated adverse conditions.

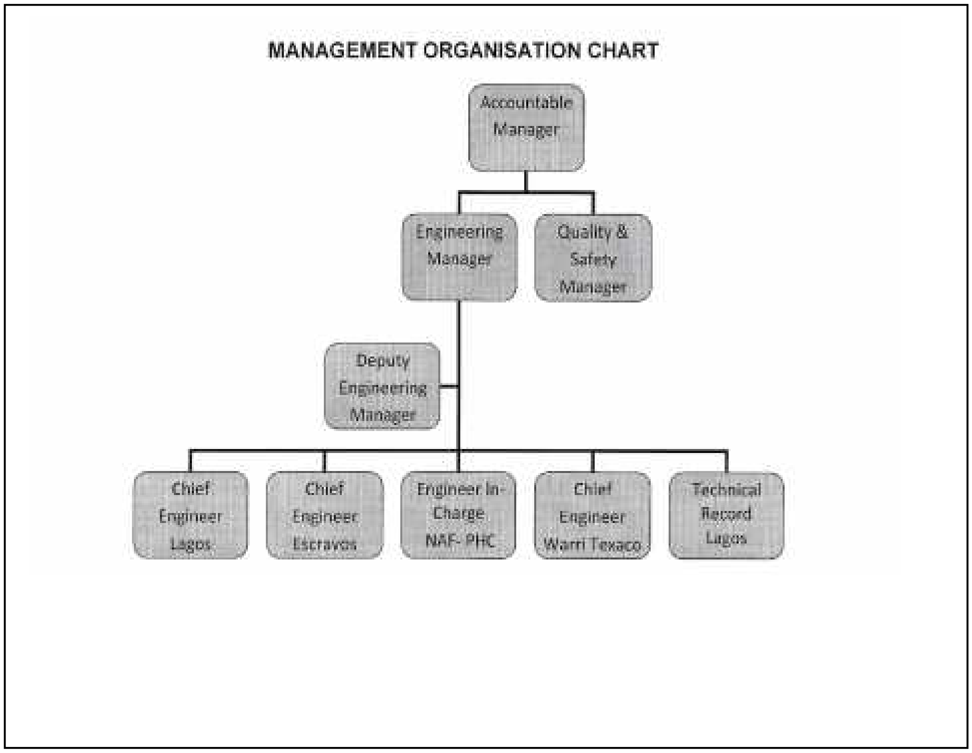
The analysis also indicated that the samples were within the manufacturer's specification.

1.17 Organization and Management Information

1.17.1 PAN AFRICAN AIRLINES NIGERIA LIMITED

1.17.1.1 ENGINEERING MANAGEMENT STRUCTURE

MANAGEMENT ORGANISATION CHART



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 QUALITY MANUAL PART 7 - QUALITY SYSTEMS PROCEDURES (MAINTENANCE – 2)*

Eligibility

To be eligible for the issue of a Company authorisation, personnel must be:

a. 18 years of age or above.

b. Able to read, write and communicate to an understandable level in the English language;

c. Capable of carrying out their responsibilities with an acceptable level of integrity.

d. Have the knowledge, regulatory requirements, company procedures, experience and competency requirements prescribed for the category sought.

e. Sufficient understanding of human factors and human performance limitations

Qualification – General

The following basic requirements must be met for Certifying Staff to be issued with a Company authorisation:

a. To be considered for authority to issue Certificates of Release to Service for an aircraft on the Nigerian Register, an applicant must, *as a minimum, hold a valid Nigerian Licence or validation in one of the following categories; Airframe, Power plant, Avionics, Components or other ratings as determined by the Authority.*

b. Have satisfactorily completed appropriate training on the tasks for which authorisation is sought ***and:***

c. Be assessed by the Quality & Safety Department, for an adequate understanding of Company procedures and legislative requirements ***and:***

d. Have satisfactorily completed aircraft type or component course in an approved training organisation and if required, appropriate training for a different model/configuration even though the type rating is held.

e Sufficient understanding of human factors and human performance limitations.

It is the duty of the Quality Assurance Manager to ensure that all technical personnel are appropriately qualified and certified to carry out functions in line with the Company Quality Systems Manual as approved by the Regulatory Authority.

During the course of this investigation, the Bureau discovered that there were deviations from the requirements of the Quality Systems Manual.

1.17.1.3 AIR TESTS (OPs MANUAL SECTION 8.7.2)

Occasions for Test Flights: A test flight is any flight which requires a pilot to examine any aspect of the behavior or performance of an aircraft or of any of its systems or components in order to assess their serviceability or to assist in the diagnosis of any defect which may be known to exist.

Where a helicopter is required to fly for purpose of testing any equipment installed or carried in the aircraft as a result of modification, this must be carried out under 'B' condition.

Any flight under 'B' conditions must be carried out by the company Flight Test Department in accordance with the approved procedure (F1 Approval). Refer to the Company Maintenance Organisation Exposition part 1 volume 3(chapter 4) for full details.

Test flights are required on the following occasions:

a) For C of A Renewal
b) To assist engineering in diagnosing a defect.
c) Following a major component change or after rectification or adjustment of a flying control, engine or avionics system or component.

No test flight of any seriousness should be given to an inexperienced pilot. Before carrying out an air test at night or in IMC, the commander must be satisfied that such a flight can be safely performed.

With the exception of Power assurance checks and Navaids /Radio tests, flight testing must not be done when passengers are being carried. If further diagnosis of an in-flight system failure is required, then passengers must be disembarked before the test flight is made. The same provision applies to post rectification testing, which should be completed before embarking the passengers.

Checks to be carried out before any test flight or ground run the pilot should ascertain that:

a) The nature of the maintenance which has been performed.
b) All necessary ground checks have been accomplished.
c) The purpose of the test flight and the particular component/systems required to be tested. Determine which maneuvers need to be carried out to establish the integrity of the system and in which order they should be accomplished to give the greatest margin of safety.

The Bureau discovered the following deviations from the Ops manual:

1) All necessary ground checks were not accomplished before the test flight.
2) The flight test was carried out by the Pilot and the maintenance engineer; this test should have been carried out by the flight test department. This was not the case here.

1.17.1.4 BELL 412 MAINTENANCE AND COMPANY POLICY ON RECTIFICATION OF REPORTED SNAGS

The company policy on rectification of reported snag is, after a pilot encounters a defect while flying the aircraft, he will record the nature of such defect in the records of defects column in the aircraft Tech log.

The engineer will carry out the necessary rectification for the defect and clear the defect in the action taken column.

He also will raise a log entry sheet (T-Card) to record the action taken to rectify the defect; the T-Card will then be filed with the aircraft documents.

According to Bristow/PAAN operations manual, Part A, Section 8.7, before any test flight or ground run, the pilot should ascertain that;

a) The nature of the maintenance, which has been performed.

b) All necessary ground checks have been accomplished.

c) The purpose of the test flight and the particular component/systems required to be tested. Determine what maneuvers need to be carried out to establish the integrity of the system and in which order they should be accomplished to give the greatest margin of safety.

There was deviation from the company policy on rectification of reported snag by the Captain and the maintenance engineer. They did not carry out the required procedure as contained in the Company Policy.

According to BELL 412 MM-9, the procedures to be followed when there is torque split mismatch indications are as follows:

Engine torque difference between engine 1 and 2 shall not exceed 4% during power application throughout this maintenance procedure. However, during normal operation, torque split may exceed 4%. +2/-2 switch may be used to trim engines for either torque matching or ITT matching.

At 100% rotor rpm, gradually increase collective to 60% transition torque or mast torque (as applicable) and match engines torques using +2/-2 switch. Gradually increase collective to flat pitch and note the torque split. Gradually increase collective to full power(either transition torque or mast torque(as applicable),ITT, or N1 LIMIT)and note the torque split throughout the power range, torque matching should remain constant within 4%.And note, If torque does not remain constant throughout the power range, adjust as follows:

a. *If Engine 1 torque reading is greater than Engine 2 by more than 4%, move tube (7) rod end forward decrease on lever (25).*
b. *If Engine 1 torque reading is less than Engine 2 by more than 4%, move tube (7) rod end Aft and increase on lever (25).*

Place collective stick full down, rotate both engine throttles to full Increase. Use rpm incr/decr switch to obtain 100%rotor rpm and match engine torques using +2 /-2 switches. Increase collective pitch slowly in a series of equal steps from flat pitch to full power(either transition torque or mast torque(as *applicable),ITT or N1 limit). Rotor rpm should remain at 100 plus or minus throughout power sweep.*

If rotor rpm drops (decay below tolerance) or over speed (increase above tolerance) during power applications, make a cam rate adjustment. Make adjustments in small increments of approximately 0.125 in. (3.18mm) measured on cam slot.

a. *For increased cam compensation to correct droop, adjust cam (20) counter clockwise relative to bell crank (23).*
b. *For reduced cam compensation to correct over speed, adjust cam (20) clockwise relative to bell crank (23).*
c. *After each cam adjustment, move the collective to "full down" and then "full up" positions to ensure there is no fouling between slider housing (22) and cambox slot. Verify that a minimum of 0.010 in. (0.25mm) cam slot shows below and above slider housing (22). If required adjust (13) for proper clearance.*

Actuate rpm incr/decr switch to full decrease with collective in full down position. Rotate both engine throttle to full incr and record rotor rpm. The recorded rotor rpm should be 97%.If not adjust actuator (8) rod end. But do not exceed 104% rpm.

Actuate rpm incr/decr switch to full incr and verify rotor rpm is 101.5% or 103.5%.The required range for twin engine beep is 97 to 101.5% or 97 to 103% rotor rpm.
With collective stick full up, hold rpm incr/decr switch to increase until actuator (8) is fully retracted. Hold +2/-2 switch to +2 until ITT actuator (3) is fully retracted. Verify minimum clearance of 0.010 in. (0.25mm) between stop screw (19) on both governors (1 and 5).

Then, check complete system for security of all parts and ensure no interference exists. Apply corrosion preventive compound to all exposed threads.

The above procedures as contained in the aircraft maintenance manual were not adhered to by the team of maintenance engineers troubleshooting the abnormal torque split indication prior to the flight test.

1.17.1.5 TORQUE WRENCH CALIBRATION PROCEDURE

According to the company procedure, torque wrenches are calibrated once a year. Before usage of the torque wrench, the engineer checks the calibration date, and ensures that the correct torque value was set on the torque wrench before use.

1.17.1.6 MUTUAL ASSISTANCE AND COOPERATION AGREEMENT BETWEEN BRISTOW HELICOPTERS LTD AND PAN AFRICAN AIRLINES NIGERIA LTD.

This mutual Assistance and Cooperation Agreement (the "Agreement") is made this 1st day of July,2006 between Bristow Helicopters Limited of General Aviation Area, Murtala Muhammed Airport, Ikeja ("Bristow"), and Pan African Airlines Nigeria Limited of Old Domestic Wing, Murtala Muhammed Airport, Ikeja ("Pan African").

Bristow and Pan African are referred to herein individually as a "Party" and collectively as "Parties".

RECITALS

A. *The Parties are individually engaged in the business of helicopter transportation, maintenance, search and rescue and related services in the offshore oil and gas industry as well as other business sectors.*

B. In furtherance of their respective business interests, the parties wish to mutually assist, engage and co-operate with each other in the areas of commercial, operational and technical support services as set out in schedule 1 of this Agreement.

C. The parties are desirous of documenting the terms and conditions under which the mutual assistance and cooperation shall provide.

NOW THEREFORE, in consideration of the mutual promises herein made, the parties hereby agree as follows:

1. DEFINITIONS

In this agreement, unless the content otherwise admits:

"Effective date" means the date of execution of this agreement

"Personnel/Employee" means the staff being seconded to the Requesting party

"Requesting Party" means the party for whom services are to be performed

"The Service" means the services to be performed under this Agreement

"Year" means 1st July to 30th June of every year

2. DURATION

This agreement shall commence on the effective date and shall terminate on 30th June, 2011

3. DESCIPTION OF THE SERVICES

The Parties agree to provide to each other whenever required, any of the Services stated in Schedule 1 annexed hereto as may reasonably be required and requested by the other party.

4. PERFORMANCE OF THE SERVICES

The Parties agree that each may provide any of the services through any of its employees, affiliates., professional advisers or other representative and shall whenever necessary second to the Requesting Party any of its employees, affiliates, professional advisers or other representatives for that purpose.

SCHEDULE 1

SCOPE OF SERVICES

1. *Logistics*
2. *Financial Services*
3. *Human Resources*
4. *Quality, Security and Safety*
5. *Sharing of Facilities (Hanger and Ramp Services)*
6. *Provision of accommodation*
7. *Travel Coordination*
8. *Operational/Technical support services*
9. *All forms of training, including training of Pilots, Engineers, Supply chain management, Dangerous Goods Course, CRM, Technical Records e.t.c*

10. *Provision of Crew for Aircrafts*

11. *Supply of work Parties for maintenance checks on Aircrafts, Information Systems Review, Repair and overhaul.*

12. Supply of specialists and experts in aircraft Avionics and engineering

13. Any other services requested.

AIB discovered that PAAN did not take advantage of the mutual agreement existing with Bristow in terms of personnel requirements when the need arose.

1.17.2 NIGERIAN CIVIL AVIATION AUTHORITY (NCAA)

Nigerian Civil Aviation Authority is the regulatory body for aviation in Nigeria. It became autonomous with the passing into law of the Civil Aviation Act 2006 by the National Assembly and assent of the President of the Federal Republic of Nigeria. The Act not only empowers the Authority to regulate Aviation Safety without political interference, but also to carry out oversight functions of Airports, Airspace, Meteorological Services, etc as well as economic regulations of the industry.

1.17.2.1 AUTHORISED PERSONNEL TO APPROVE FOR RETURN TO SERVICE (Nig.CARs 5.6.1.4)

a) No person or entity, other than the authority may approve an aircraft, airframe, aircraft engine, propeller, appliance, or component part for return to service after it has undergone maintenance, preventive maintenance, rebuilding or alteration, except as provided in the following:

1) A pilot licensed by the authority may return his or her aircraft to service after performing authorized preventive maintenance.

2) A licenced aircraft engineer may approve aircraft and aeronautical products for return to service after he or she has performed, supervised, or inspected its maintenance subject to the limitation of section 2.4.4 of this part.

1.17.2.2 VALIDATION OF AIRCRAFT MAINTENANCE ENGINEER LICENCES (Nig.CARs 2.2.4.7)

1) A person, who holds a current and valid AME licence issued by another contracting state in accordance with ICAO Annex 1, may apply for a validation of such licence for use on aircraft registered in Nigeria.

2) The applicant for the validation certificate shall present to the authority the foreign licence and evidence of the experience required by presenting the personal record.

3) The applicant for the validation certificate shall demonstrate to the authority evidence of language proficiency in English.

4) The authority will verify the authenticity of the licence, rating authorizations with the state of licence issue prior to issuing the validation.

5) The authority will only validate ratings or authorization on the foreign licence together with the validation of a licence.

6) The authority may issue a validation certificate which will be valid for one year, provided the foreign licence, ratings or authorization remains valid.

1.17.2.3 REPORTING MECHANICAL IRREGULARITIES (Nig.CARs 8.5.1.19)

A PIC shall ensure that all mechanical irregularities occurring during flight time are

(1) for general aviation operations, entered in the aircraft logbook and disposed of in accordance with the MEL or other approved or prescribed procedure and

(2) for commercial air transport operations and aerial work

operations, entered in the aircraft maintenance records section of the technical log for the aircraft at the appropriate points before, during and at the end of that flight time.

During the course of this investigation, AIB discovered that the requirements of the Nig.CARs were not adhered to by PAAN.

1.18 Additional information.

HEALTH AND USAGE MONITORING SYSTEMS (HUMS)

This system was developed for large twin engine helicopters operating in support of the offshore oil industry. HUMS are now widely used on helicopters to monitor component health and usage. This system is intended as a post-flight diagnostic tool. HUMS data is collected and recorded from sensors and accelerometers for routine analysis, which can help in the detection of early signs of component failure, particularly within rotor gearboxes. These early signs will enable maintenance engineers embark on maintenance procedure when the need arises.

Health and Usage Monitoring Systems (HUMS) are integrated with aircraft management computers to enable maintenance engineers detect early warnings of parts that will need attention or replacement.

1.19 Useful or effective investigation techniques.

Nil.

2.0 ANALYSIS

2.1 MAIN DRIVE SHAFT CHANGE

The Aircraft's (5N-BFU) Main Drive Shaft was scheduled for change on 12th of April, 2010 but the change was carried out on the 5th April, 2010 and the incident occurred on the 16th April, 2010.

According to Engineer I, two line Engineers (Engineer II and Engineer III) carried out the Main Drive Shaft (MDS) installation, while he (Engineer I) did the first inspection of MDS installation and the Chief engineer in Warri (Engineer IV), did the second inspection of the installation. Engineer I stated that Engineer III installed the MDS following the Bell Maintenance Manual procedure and same Engineer III tightened the forward and aft bolts attaching the shaft to the forward (transmission) and Aft(C-box flanges) adapter flanges using a torque wrench.

Engineer I further stated that he checked the torque setting of the torque wrench to certify that the correct value was set. Engineer III continued with balancing of the MDS at the ground run, he was assisted by Engineer II who was observing the RADS, selected the balance weights required and handed over to engineer III who installed them on the drive shaft.

Engineer I stated that after the second and final ground run for balancing the shaft, the obtained balance figures from the RADS equipment were satisfactory, the readings were 0.08psi on the rear (C-box end) and 0.28psi on the transmission (forward end) of the shaft. He went further to check the tightening of all nuts of the forward and aft couplings to confirm that the nuts were tightened to the correct torque value. Engineer III then went on to apply the torque seal.

In the course of AIB investigation, it was discovered that the installation and inspection procedures as carried out by the maintenance engineers were not appropriate. There was no evidence that the torque values were validated by the use of acratork torque calibration analyzer at the time of inspection. The normal procedure requires that an engineer appropriately rated on the aircraft carry out inspections on the installed bolts to confirm that they were properly torque loaded. Thereafter, a second engineer is also required to carry out similar inspection and crosscheck the torque values before applying the torque seal.

Physical inspection of the damage, showed that the MDS coupling sheared off from its attachment point at the C-box end; damaging the tunnel area. The MDS is held in place at this end by six retention bolts, two of the retention bolts were found though damaged.

Most materials and structures have fatigue endurance limits, and if the stress is below the endurance limit, failure will not occur even with many load cycles. In this instance, because two bolts held the MDS in place, the fatigue endurance limit was exceeded hence the failure. The two bolts found had snapped at about 40 degrees slant as shown in the Fig 2.1a below. This is consistent with a single point overload failure with no evidence of slow crack propagation. This is an indication of high tensile load on the bolts and subsequent tensile fracture. It is consistent with the failure of the bolts as shown in the Fig 2.1a below. In this case, the four bolts not found work-loosed over time, transferring the load to the two bolts that were found broken. However, AIB does not have any evidence to show that the lock washers were either installed or not, as none was found. Six bolts and nuts/washers on the transmission end of the drive shaft were inspected and found intact.

Fig 2.1a showing two bolts found on the C-box end inside

"FAILURE FROM LACK OF LOCKING MECHANISM:"

"In order to prevent bolts from loosening over time, various locking mechanisms are employed, they include lock washers. If this locking mechanism is not applied during installation or replacement, a catastrophic event may result. They are required when vibration or joint movement will cause loss of clamp load and joint failure"– (*Charles C. Roberts, Jr.*). This was the case in this event.

Lock Washers are metal discs used in the assembly of items with screws or bolts; they are designed to keep the parts from coming loose. Lock washers prevent movement by providing tension between the surfaces that they contact. This provides additional friction that keeps the parts from loosening. They can be used in combination with other washers to adjust the spacing required but in order to perform their locking friction; they need to contact the work surface.

Shown below in Figures 2.1b and 2.1c is the illustrative diagram of assembly as provided by the manufacturer.

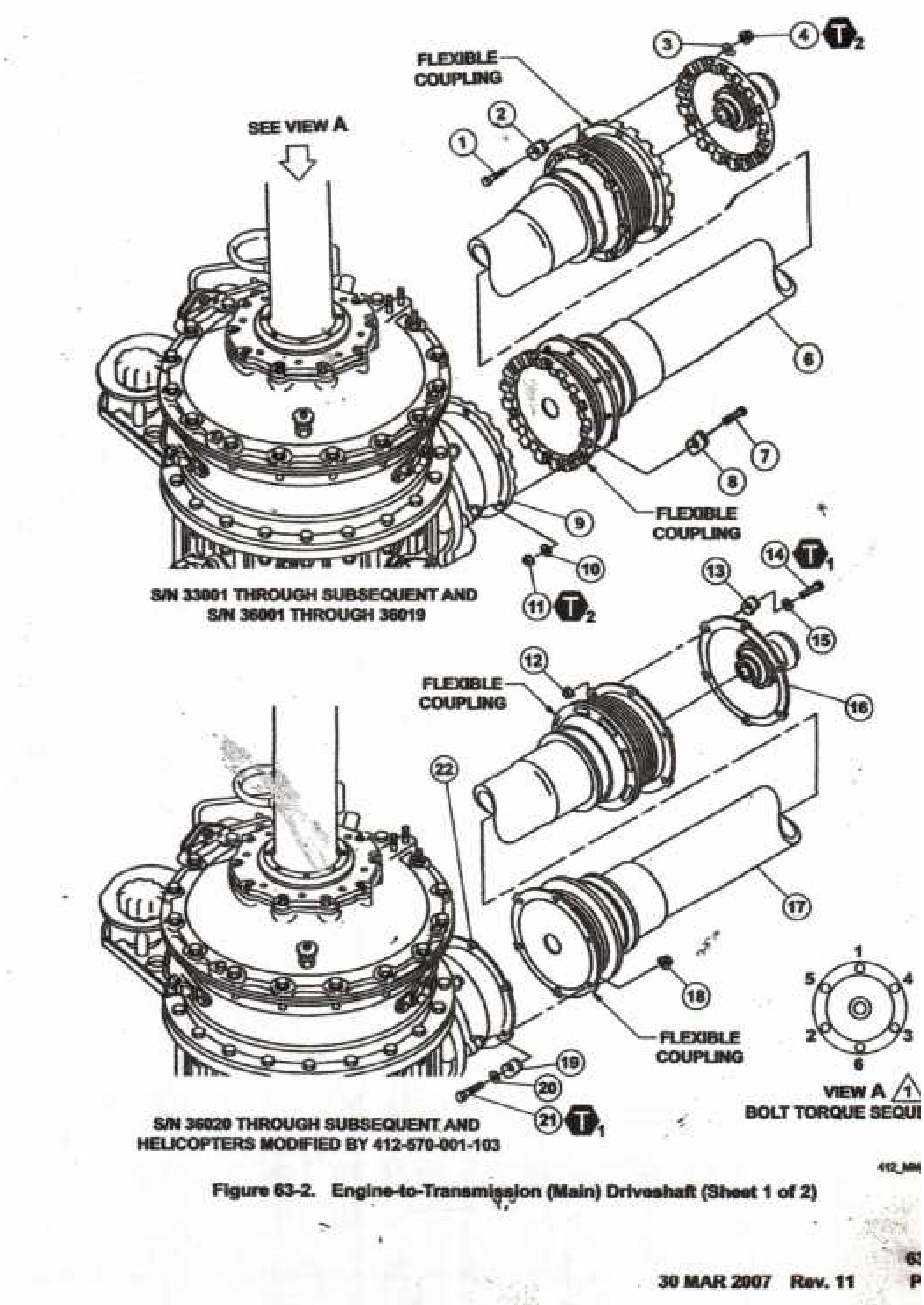


Fig. 2.1b

*-412-MM-6 **Bell Helicopter** A Textron Company

1. Bolt
2. Balancing weight
3. Washer
4. Nut
5. Engine-to-driveshaft curvic coupling adapter
6. Driveshaft
7. Bolt
8. Balancing weight
9. Main input quill curvic coupling adapter
10. Washer
11. Nut
12. Nut
13. Balancing weight
14. Bolt
15. Washer
16. Engine-to-driveshaft curvic coupling adapter
17. Driveshaft
18. Nut
19. Balancing weight
20. Washer
21. Bolt
22. Main input quill curvic coupling adapter

T1 70 TO 90 IN-LBS (7.91 TO 10.16 Nm)

T2 100 TO 140 IN-LBS (11.30 TO 15.81 Nm)

NOTE

1 Torque bolts in three steps; 1/3 full torque, 2/3 full torque, and full torque respectively. Tighten bolts in sequence as shown in Detail A. Repeat sequence at each torque step.

Figure 63-2. Engine-to-Transmission (Main) Driveshaft (Sheet 2 of 2)

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Fig. 2.1c

The consequence of under torqueing is that the joints will flex and fail under fatigue: the retention bolts will gradually work loose one after the other over time with the vibration of the rotating assembly; this is evident from the physical inspection of the Main Drive Shaft assembly.

According to PAAN African Airlines OPS MANUAL SECTION 8.7.2: *A test flight is any flight which requires a pilot to examine any aspect of the behavior or performance of an aircraft or of any of its systems or components in order to assess their serviceability or to assist in the diagnosis of any defect which may be known to exist.*

Test flights are required on the following occasions: for C of A Renewal, to assist engineering in diagnosing a defect and following a major component change or after rectification or adjustment of a flying control, engine or avionics system or component.

Maintenance Engineer I stated that an emergency float bag was removed from 5N-BFU to service another aircraft. The aircraft was then parked in the hangar for three days before it was returned to service.

There was no evidence to show that the required test flight was conducted after the Main Drive Shaft change; which is a major component change.

2.1.1 MAINTENANCE ENGINEER I

He is an Austrian, and has his Aircraft Maintenance Engineer's License validated by the Nigerian Civil Aviation Authority (NCAA), his license was valid at the time of the incident and he is rated on the aircraft; Bell 412.

He is the base engineer at the Warri Terminal of the company and he released the aircraft for the first flight of the day.

He stated that after the installation of the Main Drive Shaft, he checked the tightening of all the nuts of the forward and aft couplings to confirm the nuts were tight, which was the first inspection. Engineer III applied the torque seal and Engineer I called the chief engineer (Engineer IV) for the second inspection of the Main Drive Shaft installation. Engineer I being satisfied that the job was properly done, signed on the work sheet. He also stated that when he required a duplicate inspection signed on the T-card entry, Engineer IV who did the duplicate inspection was not available, so he requested another licensed Engineer V who was not involved in the job from the beginning, though type rated on the aircraft to sign the duplicate inspection, which he did.

For the installation of MDS, duplicate inspection procedure requires that an appropriately licensed engineer carry out the first inspection and a second appropriately licensed engineer repeats the same inspection to confirm proper torque loading and safety before the application of torque seal and completion of documentation.

The duplicate inspection procedure carried out by the PAAN engineers was inappropriate.

2.1.2 MAINTENANCE ENGINEER II

He is an American and holds Federal Aviation Authority A and P (Airframe and Power Plant) Mechanic certificate but his training records did not show any evidence of initial training or ratings on the aircraft, Bell 412.

During the course of the investigation, AIB discovered that he holds a Private Pilots certificate. He worked with Petroleum Helicopters for 19 years, American West Airlines for 3 years and Bristow group for 10 years.

He participated in the Main Drive Shaft change and was on board during the test flights to diagnose the “torque split” indication.

Evidence from the Nigerian Civil Aviation Authority revealed that his A and P certificate was not validated at the time of the incident.

According to the Nigerian Civil Aviation Regulations (Nig.CARs 2.2.4.7);
A person, who holds a current and valid AME licence issued by another contracting state in accordance with ICAO Annex 1, may apply for a validation of such licence for use on aircraft registered in Nigeria;

The applicant for the validation certificate shall present to the authority the foreign licence and evidence of the experience required by presenting the personal record.

The applicant for the validation certificate shall demonstrate to the Authority evidence of language proficiency in English.

The Authority will verify the authenticity of the licence, rating authorizations with the state of licence issue prior to issuing the validation.

The Authority will only validate ratings or authorization on the foreign licence together with the validation of a licence.

The Authority may issue a validation certificate which will be valid for one year, provided the foreign licence, ratings or authorization remains valid.

PAAN African Airlines Quality and Safety Procedure also states that the following basic requirements must be met for Certifying Staff to be issued with a Company authorization. To be considered for authority to issue Certificates of Release to Service for an aircraft on the Nigerian Register, an applicant must, as a minimum, hold a valid Nigerian Licence or validation in one of the following categories: Airframe, Power plant, Avionics, Components or other ratings as determined by the Authority.

In line with the Nig.CARs and the company Quality and Safety Procedure, the maintenance engineer II does not hold a Nigerian licence or validation and should not have carried out any certifying maintenance task, inspection or test flights on any Nigerian registered aircraft.

The Regulatory Authority confirmed that he had not been issued with any Aircraft Maintenance Engineers Licence and neither was he issued with validation for any foreign licence at the time of the incident. The Authority went further to say that they could not provide any record on the engineer.

2.1.3 MAINTENANCE ENGINEER III

He is an American and participated in the Main Drive Shaft change. He had no validation from NCAA at the time of the incident.

The provisions of the Nig.CARs and the company Quality and Safety Procedure as stated above were not adhered to, therefore in line with these provisions, the maintenance engineer III should not have carried out any certifying maintenance task or inspection on any Nigerian registered aircraft.

2.2 THE FLIGHT

The crew were qualified to conduct both the revenue and the test flights. The evidence available to AIB shows that the Captain had a total flying time of 9000hrs on type as at the time of the incident. The first officer had a total flying time of 785hrs on type as at the time of the incident. Both are rated on Bell 412.

The Crew Resource Management (CRM) was good. The pilot flying carried out a successful autorotation and landed the aircraft at NNPC housing estate field while the co-pilot declared May-day, May-day.

2.2.1 THE TEST FLIGHT

After the air return, passengers were disembarked while the engines were still running. Engineer II boarded the aircraft without carrying out the proper procedures on what should be done on ground before the test flight to assess the torque split and parameter indication.

The procedures outlined in the operations manual were not followed by the captain and Maintenance Engineer II. The captain did not make a tech log entry indicating the snag he encountered in flight in accordance with the Nigeria Civil Aviation Regulations Nig.CARs 8.5.1.19. See chapter 1.17.2.3 above.

The maintenance engineer did not follow the procedure as contained in the Bell 412 maintenance manual before embarking on the test flight. When there is excessive torque split mismatch indication on Bell 412 as reported by the captain, it is an indication of a problem, which requires corrective actions. These procedures outlined in the aircraft maintenance manual as it relates to the vibration were also not followed by the maintenance engineer. See chapter 1.17.1.4 above.

The captain did not carry out the procedure outlined in the company's operations manual as it relates to flight tests; the snag was not entered in the tech log. However, the test flight was carried out contrary to the requirements of the Nigeria Civil Aviation Regulations as it applies to reporting of snags. The Maintenance Engineer II also did not follow the provisions of the Nigeria Civil Aviation Regulations and the company maintenance procedure as it applies to reporting of snags and taking corrective actions. Bell 412 Maintenance Manual (MM) recommended maintenance actions were not adhered to; instead Maintenance Engineer II boarded the aircraft for a test flight while the engines were still running. After the first test flight, 5N-BFU returned to Base at 1034hrs.

In the course of AIB investigation, there was no documented evidence to show that proper maintenance action was taken before the second test flight was embarked upon.

2.3 QUALITY AND SAFETY DEPARTMENT/MANAGER:

According to Bristow/PAAN Management Organisation 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.

The Quality and Safety Department maintains a list of all company authorizations including details of the scope of the authorisation granted the certifying staff. This information is available to the Engineering Managers and Chief Engineers.

According to PAAN Quality Manual Part 7 - Quality Systems Procedures (Maintenance-2) See 1.17.1.2 :- *It is the duty of the Quality and Safety Manager to ensure that all foreign technical personnel's licences are properly validated in line with the* *requirements of the Nigeria Civil Aviation Regulations and the company policy*.

This was not done, yet the engineer was among the certifying staff authorised by the company without the knowledge of NCAA.

2.4 ENGINE TEAR DOWN

The aircraft engines were shipped to Pratt and Whitney, Canada, the manufacturer of the engine for investigation of reported power loss and torque split indications. The engine consists of reduction gear box, left hand power section and right hand power section. The main drive shaft coupling is an airframe component and was therefore not subject to Pratt and Whitney examination.

The reduction gearbox did not show any evidence to explain the shearing off of the Main Drive Shaft coupling retaining bolts. Both right and left hand clutch assembly were operating normally and did not show any evidence of damage from skidding or non engagement.

Analysis of the debris found in the oil filter elements identified as low alloy steel that is usually associated with gear material. The debris found on the chip detectors that caused the reported chip lights to come on was consistent with the material composition of the No. 3 bearing air seal.

The accessories were bench tested and disassembled; they revealed no defect or discrepancies that could cause the shearing of the Main Drive Shaft coupling. However, the automatic fuel control setting, wear in the R/H No. 2 AFCU Pressure regulator and stiffening of the bypass valve diaphragm could have contributed to a torque split.

Investigation of the Automatic Fuel Control Unit (AFCU), Manual Fuel Control Unit (MFCU), fuel pump and power turbine governors from each engine, and the torque limiter revealed nothing that would have resulted in a power loss.

Observations from testing of the No.1 engine control pack suggest that the AFCU had been adjusted in the field. Wear was also evident on the bypass valve. Observations recorded during testing of the power turbine governors and torque limiter suggests in-service adjustment and normal wear. There were no defects or damage evident that would have prevented normal operation prior to the event/incident.

Engine disassembly and testing of the accessories did not reveal any damages or defects that would have caused or contributed to the shearing off of the Main Drive Shaft coupling retaining bolts.

Both engine power sections and reduction gearbox displayed no indication of any pre-impact anomalies or distress that would have precluded normal engine operation prior to the event. The reported dual power loss as perceived by the flight crew was due to the de-coupling of the main output drive shaft.

See full details in Appendix 1.

It is evident that there was no seizure of the combining gear box that could have resulted to loss of power to the main drive shaft as was revealed during the engine tear down.

2.5 NIGERIAN CIVIL AVIATION AUTHORITY (NCAA)

Nigerian Civil Aviation Authority is empowered by law to regulate and carry out oversight functions in the aviation sector in the country. These functions, among others, include authority to carry out Inspection/maintenance task on a Nigerian registered aircraft, authorize personnel to approve aircraft return to service and validation of Aircraft Maintenance Engineers Licenses.

NCAA approves operating documents such as Operations Manual, Maintenance Procedures, Quality and Safety procedure Manual etc for airline operators.

Nig.CARs 5.6.1.4 and 2.2.4.7 require that for a licensed Aircraft Maintenance engineer to carry out maintenance task, Inspection or to release for service, his or her foreign license must be validated by the Regulatory Authority.

There was no evidence that the Maintenance Engineer's License was validated in line with the NCARs 2.2.4.7 as at the time of the serious incident.

2.6 THE AIRCRAFT

The aircraft was certified airworthy at the time of the incident. There were no deferred defects or any known discrepancies in the aircraft technical logbook at the time of the incident. The aircraft was not fitted with a Health and Usage Monitoring System (HUMS).

The Health and Usage Monitoring System (HUMS) was developed for large twin engine helicopters operating in support of the offshore oil industry. HUMS are now widely used on helicopters to monitor component health and usage. This system is intended as a post-flight diagnostic tool. HUMS data is collected and recorded from sensors and accelerometers for routine analysis which can help detection of early signs of component failure, particularly within rotor gearboxes. This early signs will enable maintenance engineers embark on maintenance action when the need arises.

These systems are integrated with aircraft management computers to alert maintenance personnel with early warnings of parts that will need attention or replacement.

If this equipment was installed on the aircraft (5N-BFU), it could have detected imminent failure of the main rotor gearbox system or any other moving parts and necessary maintenance actions carried out. This could have forestalled the incident at inception.

3.0 CONCLUSIONS

3.1 FINDINGS

3.1.1 The Captain did not make a tech log entry of the observed torque split.

3.1.2 The pilot entered autorotation, while the co-pilot broadcast May day May day.

3.1.3 The Captain did not shut down the engines before embarking on the first test flight.

3.1.4 The crew and the engineer embarked on an assessment flight for troubleshooting purposes contrary to the company's Standard Operating Procedures (S.O.Ps).

3.1.5 The Engineer that conducted the test flight did not have his licence validated by the Nigerian Civil Aviation Authority (NCAA).

3.1.6 The maintenance engineer did not make any entry in the work sheet or tech log of the job he did to rectify the torque split snag.

3.1.7 There was a Mutual Assistance and Cooperation Agreement between Bristow and PAAN Africa to facilitate personnel and equipment exchange at the time of the incident.

3.1.8 AIB does not have evidence of corrective action taken by maintenance to rectify the torque split before the second test flight.

3.1.9 There was torque split indication and mismatch on both engines up to 10 %.

3.1.10 No. 1 engine chip detector light came on with a loud noise with subsequent power loss to the rotor system.

3.1.11 The incident occurred on the return leg to Warri Terminal after the second test flight.

3.1.12 The coupling of the drive shaft sheared from its attachment point at the C-box end.

3.1.13 The main rotor stopped as a result of the detachment of the drive shaft from the main rotor and the aircraft could no longer produce motive force.

3.1.14 The aircraft was found intact after the incident.

3.1.15 There was no fire outbreak.

3.1.16 The aircraft was fitted with a CVR and FDR.

3.1.17 There were no nuts or lock washers found on the combining gear box end of the drive shaft.

3.1.18 All the six bolts and nuts/ lock washers on the transmission end of the drive shaft were inspected and found satisfactory.

3.1.19 5N-BFU was not fitted with Health Usage Monitoring Systems (HUMS).

3.1.20 There were two impact marks on the tunnel as a result of the shearing of the main drive shaft.

3.1.21 The bulkhead/fire wall was also damaged.

3.1.22 The drive shaft was replaced during 600hrs/12 Months scheduled inspection.

3.1.23 The main drive shaft was replaced on the 5th of April, 2010.

3.1.24 The complete combining gear box was replaced on the 8th of October, 2009.

3.2 Causal Factor:

Improper assembly of the Main Drive Shaft coupling and inappropriate duplicate inspection that followed the assembly.

3.3 Contributory Factors:

i. None adherence to Bell 412 Maintenance Manual procedures.

ii. Inadequate oversight functions of Bristow/PAAN quality assurance and safety department.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendation 2015-008

i) The Regulatory Authority should ensure strict compliance by operators to regulatory requirements as it relates approval requirements by certifying personnel.

ii) The Regulatory Authority should ensure that all helicopters operating within the country and especially the off-shore operations should be fitted with a Health and Usage Monitoring Systems (HUMS).

4.2 Safety Recommendation 2015-009

Bristow/PAAN Quality and Safety Department should ensure compliance with standard procedures and the use of manufacturers' manuals in the maintenance activities by all approved certifying personnel.

COMPANY SAFETY ACTIONS

Bristow/Pan African airlines have taken the following safety actions during the course of this investigation:

1) The Maintenance Engineers I and II Licences have been appropriately validated by the Nigerian Civil Aviation Authority.

2) A new procedure is now in place, which incorporates fixed Torque wrench calibration units in the workshop. This ensures that the torque values are validated by the use of acratork torque calibration analyser at any time.

3) After the MDS failure, the company fleet support unit has issued a directive changing the procedure of carrying out MDS changes, introducing a final torque check with a separate duplicate inspection after replacing MDSs.

APPENDIX 1: ENGINE TEARDOWN REPORT

Pratt & Whitney Canada
Une société de United Technologies / A United Technologies Company

Service Investigation
Engine / Component Investigation Report
P&WC 1076 (03-04)

Report No.: 10TS00004
S/O: 165422

Customer: Bristow Helicopters Group Ltd

Model: PT6T-3D

Date Investigated: August 2010

Serial No.: 11035 RGB
TH0852 PS (1)
TH0444 PS (2)

Time Since Last O/H: RGB: 613.9
(1) PS: N/A
(2) PS: 2739.5

Total Time: RGB: 9044.8
(1) PS: 2739.5
(2) PS: 6573.4

Starts Since Last O/H: RGB: N/A
(1) PS: N/A
(2) PS 4137:

Total Starts: RGB: N/A
(1) PS: 3142
(2) PS: 8285

Flights Since Last O/H: RGB: N/A
(1) PS: N/A
(2) PS: 13062

Total Flights: RGB: N/A
(1) PS: 9070
(2) PS: 24994

Previous O/H by: RGB: P&WC St-Hubert Service Centre, Sept 2009
(1) PS: N/A
(2) PS: P&WC St Hubert Service Centre, August 2007

Reason for Previous Shop Visit: RGB: Overhaul
(1) PS: N/A
(2) PS: Overhaul

Date Engine Manufactured: RGB: August 1994
(1) PS: April 2007
(2) PS: February 2001

Reason for Engine Removal: Reported Dual Engine Power Loss

Major Part(s) Affected

Part No./Serial No.	Description	Condition	Time
3121029-01 / A000N38H	Exhaust Case	Cracked	6573.4

1.0 Synopsis

1.1 The subject engine consisting of reduction gearbox S/N 11035, left hand (L/H) (1) power section S/N TH0852 and right hand (R/H) (2) power section S/N TH0444, was received at Pratt & Whitney Canada (P&WC) for investigation of reported power loss

1.2 It was reported that during a test flight on the 16 April, 2010 of a Bristow Helicopter Bell 412 EP, registration number 5N-BFU to investigate a torque split problem an engine chip warning light illuminated on the right hand power section followed by a grinding noise in the rear of the aircraft. Shortly thereafter, the left hand power section chip light illuminated and a loud noise was heard and the crew reported a total loss of power. An autorotation was performed and the helicopter landed in a field without any further incident. It was also reported that the main input drive shaft bolts sheared at the RGB output coupling and both engines were still running after landing and were shutdown by the pilot.

1.3 The engine modules were separated in the field and were sent back to P&WC St Hubert Service Centre in three individual shipping containers. The main drive shaft coupling (Photo No. 1) is an airframe component and was not subject to a P&WC evaluation.

Photo No. 1 (Photo Taken in the field)

2.0 Investigation Participants

2.1 The following individuals participated in the investigation as representatives of their respective organisations :

[redacted]	Accident Investigator	Nigeria Accident Investigation Bureau
	Accident Investigator	Nigeria Accident Investigation Bureau
	Technical Inspector Continuing Airworthiness	Transport Canada
	Investigator	Pratt & Whitney Canada
	Accessory investigator	Pratt & Whitney Canada

3.0 Investigation of Reduction Gearbox S/N 11035

3.1 Visual examination of the reduction gearbox (RGB) external did not show any apparent damage (Photo No. 2).

Photo No. 2

3.2 The RGB chip detectors and oil filter elements were received separately. There were a few metallic particles on the chip detectors (Photo No. 3 and 4). An oil sample from the RGB center oil system was also received. The oil filter elements, chip detectors and oil sample were submitted to P&WC Chemical analysis laboratory for analysis. Refer to section 7.0 of this report for the results.

Photo No. 3 (L/H Side)

Photo No. 4 (R/H Side)

3.3 Examination of the RGB output gearshaft area did not show apparent damage except for the output shaft drain cover (Photo No. 5) that was rubbed on the inner diameter mainly at the 6 o'clock position (Photo No. 6). The RGB rotated freely and both clutch assemblies were showing normal engagement.

Photo No. 5

Photo No. 6

3.4 The RGB right and left hand cover were removed and no damage was observed. The torque meter pistons and cylinder were inspected and no damage was observed (Photos No. 7 and 8).

Photo No. 7 (L/H Side)

Photo No. 8 (R/H Side)

3.5 The RGB input housing was removed and examination did not show any apparent damage (Photo No. 9). The R/N and L/H idler gears were removed and examination of the No. 8 ball bearings did not show any damage (Photo No. 10 and 11).

Photo No. 9


Photo No. 10 (L/H side)


Photo No.11 (R/H Side)

3.6 The diaphragm area did not show any apparent damage (Photo No. 12).


Photo No. 12

3.7 The clutch assemblies were removed. The L/H clutch assembly was engaging normaly (Photo No. 13). Disassembly of the L/H clutch assembly revealed normal engaging witness marks on the clutch gear inner diameter and on the clutch shaft with no evidence of discoloration or slippage (Photos No. 14 and 15). There was evidence of some false-brinelling on the No. 12 ball bearing (Photo No. 16) which is normal operational wear.


Photo No. 13


Photo No. 14

Photo No. 15

Photo No. 16

3.8 Disassembly of the R/H hand clutch assembly revealed normal engaging witness marks (Photo No. 17) on the clutch gear inner diameter and on the clutch shaft with no evidence of discoloration or slippage (Photos No. 18 and 19). There was evidence of some false-brinelling on the No. 12 ball bearing (Photo No. 20) which is normal operational wear.

Photo No. 17

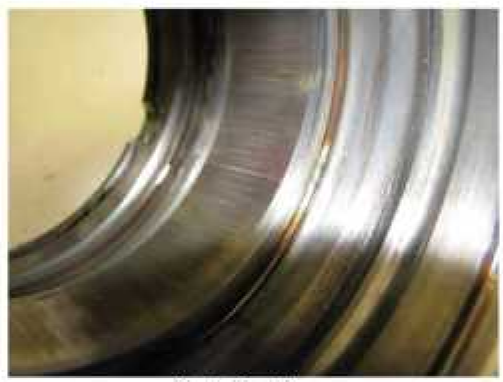

Photo No. 18

Photo No. 19

Photo No 20

3.9 Both L/H and R/H input gearshafts were removed and examination of the No. 5 duplex ball bearings did not show any damage (Photo No. 21 and 22).


Photo No. 21 (L/H Side)


Photo No. 22 (R/H Side)

3.10 The output gearshaft area was examined and no apparent damage was observed (Photo No. 23). The output gearshaft was removed and examination of the No. 15, 16 and 17 bearings did not show any damage (Photo No. 24).


Photo No. 23


Photo No. 24

4.0 Investigation Power section TH0444

4.1 Examination of the R/H (No. 2) power section (Photo No. 25) showed no external damage except for a crack on the left hand side of the exhaust case (Circle Photo No. 26).

Photo No. 25

Photo No. 26

4.2 The crack on the exhaust case wall ran radially for approximately 1.750 inch from the exhaust port weld, and 0.630 inch through the weld and exhaust port, then branched axially 1.225 and 1.075 inch. into the exhaust port (Photo No. 27).

Photo No. 27

4.3 The power section was separated at the "C" flange and the examination of the hot section area did not show any damage (Photo No. 28). The compressor turbine (CT) blade tip clearance measured 0.019 inch to 0.024 inch with evidence of rubbing on one shroud segment at the 10 o'clock position (Photo No. 29). This is considered normal operation condition.

Photo No. 28

Photo No. 29

4.4 The power turbine disc was removed (Photo No. 30) and there was evidence of rubbing on the shrouded tips (Photo No. 31). The PT stator showed rubbing between the 10 to 2 o' clock position and 5 to 6 o'clock position (Photo No. 32 and 33).

Photo No. 30

Photo No. 31

Photo No. 32 (3 o'clock position)

Photo No. 33 (6 o'clock position)

4.5 The No. 3 bearing air seal rotor showed rubbing over the complete circumference (Photo No. 34) from contact with air seal stator (Photo No. 35).

Photo No. 34

Photo No. 35

5.0 Investigation Power Section TH0852

5.1 Examination of the left hand (No. 1) power section (Photos No. 36).

Photo No. 36

5.2 The power section was separated at the "C" flange and examination of the hot section area did not show any damage (Photo No. 37). The compressor turbine (CT) blade tip clearance measured 0.018" to 0.022" with evidence of rubbing on the shroud segments (Photo No. 38). One shroud segment showed axial crack initiating from the upstream edge (Photo No. 39). The blade tip clearance is considered normal, however, the cracking found on one of the shroud is not but did not influence the engine performance.

Photo No. 37

Photo No. 38

Photo No. 39

5.3 The power turbine disc was removed (Photo No. 40) and there was evidence of rubbing on the shrouded tips (Photo No. 41). The PT stator showed rubbing between the 10 to 1 o' clock position and 5 to 7 o'clock position (Photo No. 42 and 43).

Photo No. 40

Photo No. 41

Photo No. 42 (3 o'clock position)

Photo No. 43 (6 o'clock position)

5.4 The No. 3 bearing air seal rotor showed rubbing over the complete circumference (Photo No. 44) from contact with air seal stator (Photo No. 45).


Photo No. 44

Photo No. 45

6.0 Metallurgical Analysis

6.1 The exhaust case of the R/H power section was submitted to P&WC Material Investigation Laboratory for analysis of the cracking.

6.2 The cracked area was cut from the case in the laboratory to examine the fracture surfaces. The crack was extending on both sides of the resistance weld (red oval and Photo No. 46). The outer surface of the case showed a branching crack associated with buckling of the base material (green arrows). The inner surface at the cracked area showed no evidence of impact or others damages (Photo No. 47).

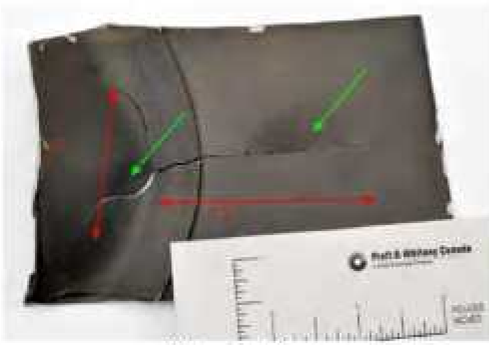

Photo No. 46

Photo No. 47

6.3 The cracks were opened in the laboratory to evaluate the fracture surfaces "A" and "B" (Photo No.48). The green doted oval indicates the location of the main origin. The crack extended parallel to the resistance weld and at a distance of approximately 3/16 inches from the edge of the weld. The white arrows show the direction of the secondary cracks propagation.

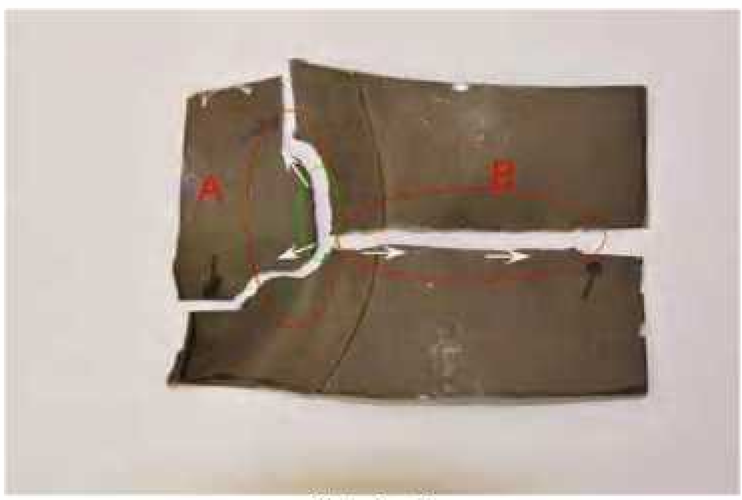

Photo No. 48

6.4 The surface of fracture "A" exhibited a granular dull gray coloration suggesting that the fracture was older. The fracture occurred as the result of fatigue initiating from multiple origins along the outer surface of the case (Photo No. 49). Close-up views of the fracture surface (Photo No. 50) showed faint river lines emanating from the outer surface.

Photo No. 49

Photo No. 50

6.5 The fracture surface "B" in the area of the resistance weld (red doted oval Photo No. 51) exhibited a granular and dull gray coloration suggesting that the fracture surface was older. The left hand side of the fracture occurred by shear overload and exhibited a yellowish fracture surface. The green arrow indicates the crack propagation direction (Photo No. 52).

Photo No. 51

Photo No. 52

7.0 Chemical Analysis

7.1 The oil filter element, the chip detectors and oil sample were submitted to P&WC Chemical Laboratory for analysis.

7.2 The parts were cleaned ultrasonically with acetone to collect any solid contaminants. The acetone was then filtered through a 1.2 µm Milipore filter. The patches obtained this way were analysed with ASPEX instrument for detailed analysis. All particles over 0.001 mm (1 micron) were analysed.

7.3 The result of the analysis is presented in the table below. The quantity of contaminant found is not considered abnormally high.

Samples	Normalized number of particles	Nature of the contaminants
Sample 1 Filter LH 3034508	582 113	Few aluminum alloy present as fine dust (maximum size is 33µm with average at 5µm) Few silicon oxide up to 25µm Traces of chromium SST similar to AMS 5613 up to 300µm Traces of silver particles associated with silicon (Si) and chlorine (Cl), up to 40µm. Traces of 18-8SST present as fine dust up to 30µm. Traces of copper particles associated with silicon (Si) up to 15µm.
Sample 2 Filter Center 3059256-01	5 698 536	Mainly low alloy steel similar to AMS 6260 / 6265 up to 165µm (see attached pictures). Traces of silver particles associated with iron up to 250µm.
Sample 3 Filter RH 3029315	1 266 438	Some chromium SST similar to AMS 5613 up to 230µm; particles were associated with silicon (Si). Some low alloy steel similar to AMS 6260 / 6265 up to 225µm. Traces of silicon oxide up to 180µm (see attached pictures). Traces of silver particles associated with iron up to 150µm. Traces of aluminum alloy similar to AMS 4260 up to 140µm
Sample 4 Oil sample	3711	Some high nickel SST similar to AMS 5732, up to 180µm Few silver particles up to 110µm Few low alloy steel similar to AMS 6260/ 6265 up to 30µm.
Sample 5 Chip Detector LH	324 769	Mainly chromium SST similar to AMS 5613 up to 110µm Traces of low alloy steel similar to AMS 6260 / 6265 up to 120µm.
Sample 6 Chip Detector RH	411 866	Some chromium SST similar to AMS 5613 up to 100µm Some low alloy steel similar to AMS 6260 / 6265 up to 100µm.
Sample 7 Chip Detector M	1 778 054	Mainly low alloy steel similar to AMS 6260 / 6265 up to 250µm. Traces of chromium SST similar to AMS 5613 up to 100µm.

Definitions:

Mainly: Over 50% of the particles in the sample
Some: Between 25 and 50% of the particles in the sample
Few: Between 10 and 25% of the particles in the sample
Traces: Between 5 and 10% of the particles in the sample

8.0 Accessories investigation

8.1 The engine accessories were bench tested to gain further insight on the reported engine torque split.

8.2 Bench testing revealed there were no defects or damage evident that would have prevented normal operation prior to the event. The torque split may have been due to the automatic fuel control setting, wear in the R/H AFCU Pr regulator and stiffening of the R/H AFCU bypass valve diaphragm. For complete analysis of the accessories please refer to the accessories incident report 10TS00004B located in Appendix "A".

9.0 Discussion

9.1 The reduction gearbox did not show any evidence to explain the shearing of the main drive shaft coupling retaining bolts. Both right and left hand clutch assembly were operating normally and did not show any damage from skidding or non engagement.

9.2 The cracking of the external wall of the exhaust case occurred as a result of fatigue originating from a crack extending parallel to the resistance weld. The distance between the crack and the edge of the resistance weld was approximately 3/16 inches. The fracture surface of crack "A" was granular and exhibited a dull gray coloration suggesting that the crack was older.

9.3 The crack identified "B" propagated in fatigue perpendicularly from crack "A" on approximately 1/2 inches, across the resistance weld. The first half inches of the fracture surface exhibited a granular and dull gray coloration similar to the fracture surface "A". The remaining surface of the fracture was by shear overload and exhibited a light yellowish coloration suggesting a more recent event.

9.4 Analysis of the debris found in the oil filter elements showed a small quantity of debris that was mainly identified as low alloy steel that is usually associated to gear material. The debris found on the chip detectors that caused the reported chip lights was consisted with the material composition of the No. 3 bearing air seal.

9.5 The accessories were bench tested and disassembly revealed no defect or discrepancies that could cause the shearing of the main drive shaft coupling. However, the automatic fuel control setting wear in the R/H No. 2 AFCU Pr regulator and stiffening of the bypass valve diaphragm could have contributed to a torque split.

10.0 Conclusions

10.1 Engine disassembly and testing of the accessories did not reveal any damages or defects that would have caused or contributed to the shearing of the main drive shaft coupling retaining bolts.

10.2 Both engine power sections and reduction gearbox displayed no indication of any pre-impact anomalies or distress that would have precluded normal engine operation prior to the event.

10.3 The reported dual power loss as perceived by the flight crew was likely due to the de-coupling of the main output shaft.

NL:RB 01 November 2010

[redacted]
for
[redacted]
Investigator

[redacted]
[redacted] Eng.
Service Investigation Manager

Distribution:

[redacted]
File: 10-039

[redacted]
Authorities

Appendix "A"

P&WC Acessories Incident Report 10TS00004B

Pratt & Whitney Canada Corp.
1000 Marie-Victorin,
Longueuil, Quebec,
Canada J4G 1A1

RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch
List of Accessories:

Accessory	P&WC P/N	Manufacturer	Supplier P/N	S/N	P&WC CS Order Number
Engine S/N: TH0852 Position: No. 1 left					
Accessory	**P&WC P/N**	**Manufacturer**	**Supplier P/N**	**S/N**	**P&WC CS Order Number**
Fuel pressure regulating valve	3020373	Honeywell	3244708-1	U/K	6104130965
Fuel pump	3045802-01	Hamilton Sundstrand	025277-300-08	PE10522	6104130965
Automatic fuel control unit (AFCU)	None	Honeywell	3244883-12	D43286	6104130965
Manual fuel control unit (MFCU)	3118099-03	Honeywell	3244884-3	C44693	6104130965
Engine S/N: TH0444 Position: No. 2 right					
Accessory	**P&WC P/N**	**Manufacturer**	**Supplier P/N**	**S/N**	**P&WC CS Order Number**
Fuel pressure regulating valve	3020373	Honeywell	3244708-1	U/K	6104130965
Fuel pump	3045802-01	Hamilton Sundstrand	025277-300-08	PE10693	6104130965
Automatic fuel control unit (AFCU)	None	Honeywell	3244883-12	C43632	6104130965
Manual fuel control unit (MFCU)	3118099-03	Honeywell	3244884-3	C44531	6104130965
Engine S/N: 11035 Position: RGB					
Accessory	**P&WC P/N**	**Manufacturer**	**Supplier P/N**	**S/N**	**P&WC CS Order Number**
Universal torque control (TCU)	None	Honeywell	3244881-2	C42519	6104130965
Power turbine governor (PTG)	None	Honeywell	3244885-2	C45089	6104130965
Power turbine governor (PTG)	None	Honeywell	3244885-2	D45421	6104130965

Pratt & Whitney Canada Corp.
1000 Marie-Victorin,
Longueuil, Quebec,
Canada J4G 1A1

RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch
Accessory: TH0852 No. 1 engine fuel pump, automatic fuel control unit (AFCU) and manual fuel control unit (MFCU) pack
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The AFCU, manual fuel control unit and the fuel pump were removed as a pack. The exterior was soiled. The throttle moved freely over the full range. The part-power trim stop was in the stowed (flight) position. The index mark on the Sg dome was aligned with the datum line on the bypass valve collar. Lockwire was present at all locations. The lockwire seals were marked P&WC. Prior to testing the air adapter was removed to inspect the governor lever orifice. There was no obstruction visible in the orifice. The fuel pump outlet filter was removed and inspected. It was observed that the packing on the filter bowl/filter element interface was broken but complete, and there was no debris visible in the pleats of the filter element. It was concluded that the packing broke during removal of the filter element from the bowl. Fluid residue from the filter bowl was collected and forwarded to the Chemical Laboratory for analysis. Analysis confirmed that the fluid was jet fuel with no water present, and trace evidence of metallic debris that is typical from the operation of the fuel pump. The throttle lever maximum Ng stop screw protrusion was measured at 0.395in (the factory setting is 0.555in), indicating that it had been adjusted prior to receipt. With the unit mounted on the test stand the air system was pressurized and checked for leaks. No leaks were evident. The unit was run at 6800RPM, with the throttle at maximum and P3 air at 125psia and the nozzle flow was monitored for ten minutes for a decrease (as would be anticipated if there was a leak in the acceleration bellows was leaking). No fuel flow decrease was observed during the monitoring period. The AFCU/MFCU pack was tested in accordance with test record sheet TR 1640 Rev. 11 (Honeywell CMM 73-20-71 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):

Test point 1.01, 1.02, 1.03, 1.04, 1.06, 1.09, 1.12 Metering valve and bypass valve differential pressure setting: the nozzle flow was above, or slightly above the CMM maximum limit.
Test point 2.03 Enrichment spring setting: the nozzle flow was slightly above the CMM maximum limit.
Test point 3.01 Governor spring setting: nozzle flow was above the CMM maximum limit.
Test point 4.01 idle speed stop setting and pickup angle: the nozzle flow was below the CMM minimum limit.

The AFCU was disassembled in order to determine the cause of the observations recorded during testing. The fuel inlet screen was clean. The tip of the governor lever was soot stained and corrosion was present on the lever fulcrum pins. The flyweights did not fall freely when the driveshaft was tipped. Soot was present in the bleeds. The Pr regulator rod was dirty. The tip of the bypass valve was burnished.

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RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch

Figure 1
TH0852 fuel control and pump pack as received

Figure 2
TH0852 AFCU bypass valve and bleeds

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1000 Marie-Victorin,
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Canada J4G 1A1

RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch

Accessory: TH0852 No. 1 engine manual fuel control unit (MFCU)
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The MFCU was removed as part of a pack with the automatic fuel control unit and the fuel pump. The exterior was soiled. The throttle moved freely over the full range. Lockwire was present at all locations. The lockwire seals were marked P&WC. The MFCU was tested as a pack with the AFCU and fuel pump in accordance with test record sheet TR1680 Rev. 02 (Honeywell CMM 73-20-72 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):
Test point 5 & 7: the nozzle flow was slightly above the CMM maximum limit.

Accessory: TH0444 No. 2 engine fuel pump, automatic fuel control unit (AFCU) and manual fuel control unit (MFCU) pack
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The AFCU was removed as part of a pack with the manual fuel control unit and the fuel pump. The exterior was soiled. The throttle moved freely over the full range. The part-power trim stop was in the stowed (flight) position. The index mark on the Sg dome was aligned with the datum line on the bypass valve collar. Lockwire was missing from the Pg port elbow (it was removed when the pack was removed from the engine), but the elbow could not be moved by hand. Lockwire was present at all other locations. The lockwire seals were marked P&WC. Prior to testing the air adapter was removed to inspect the governor lever orifice. There was no obstruction visible in the orifice. The fuel pump outlet filter was removed and inspected. There was no debris visible in the pleats of the filter element and no significant fluid residue was present. The throttle lever maximum Ng stop screw protrusion was measured at 0.535in (the factory setting is 0.555in), indicating that it may have been adjusted prior to receipt. With the unit mounted on the test stand the air system was pressurized and checked for leaks. No leaks were evident. The unit was run at 6800RPM, with the throttle at maximum and P3 air at 125psia and the nozzle flow was monitored for ten minutes for a decrease (as would be anticipated if there was a leak in the acceleration bellows was leaking). No fuel flow decrease was observed during the monitoring period. The AFCU/MFCU pack was tested in accordance with test record sheet TR 1640 Rev. 11 (Honeywell CMM 73-20-71 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):

Test point 1.01 Metering valve and bypass valve differential pressure setting: nozzle flow was below the CMM minimum limit.
Test point 1.02 & 1.04 Metering valve and bypass valve differential pressure setting: the nozzle flow was slightly above the CMM maximum limit.
Test point 1.06, 1.09, 1.12 Metering valve and bypass valve differential pressure setting: the nozzle flow was below the CMM minimum limit.
Test point 2.03 Enrichment spring setting: the nozzle flow was below the CMM minimum limit.
Test point 3.01 Governor spring setting: the nozzle flow was above the CMM maximum limit.
Test point 4.01 Idle speed stop setting and pickup angle: the nozzle flow was below the CMM minimum limit.
Test point 5.02 Low end acceleration and throttle movement effect: the nozzle flow was below the CMM minimum limit.

The bypass valve retaining screws were tightened to the CMM toque-limit and the test repeated. This restored the readings in test point 1 to within CMM limits.

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To: Nelson Lynch

Partial disassembly of the AFCU revealed the bypass valve diaphragm was stiffening. The bypass valve and sleeve were worn. There were lateral grooves worn into the Pr regulator sleeve.

Figure 3
TH0444 fuel control and pump pack as received

Accessory: TH0444 No.2 engine manual fuel control unit (MFCU)
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The MFCU was removed as part of a pack with the automatic fuel control unit and the fuel pump. The exterior was soiled. The throttle moved freely over the full range. Lockwire was present at all locations. The lockwire seals were marked P&WC. The MFCU was tested as a pack with the AFCU and fuel pump in accordance with test record sheet TR1680 Rev. 02 (Honeywell CMM 73-20-72 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):
Test point 5, 7, 9: nozzle flow was above or slightly above the CMM maximum limits.

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RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch
Accessory: TH0852 No. 1 engine Power turbine governor (PTG)
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The exterior was lightly soiled. The driveshaft turned freely. The control lever moved freely over the full range and returned under the influence of its spring. There was a P&WC Accessories Business service label on the drive-body. Lockwire was present at all locations. The lockwire seals were marked P&WC. The power turbine governor (PTG) was tested in accordance with test record sheet TR5621 Rev. 05 (Honeywell CMM 73-20-69 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):
Test point 3 & 6: the Pr-Pg pressure was above the CMM maximum limit.

Figure 4
TH0852 (No. 1) power turbine governor as received

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1000 Marie-Victorin,
Longueuil, Quebec,
Canada J4G 1A1

RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch
Accessory: TH0444 No. 2 engine Power turbine governor (PTG)
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The exterior was lightly soiled. The driveshaft turned freely. The control lever moved freely over the full range and returned under the influence of its spring. Lockwire was present at all locations. The lockwire seals were marked P&WC. The power turbine governor (PTG) was tested in accordance with test record sheet TR5621 Rev. 05 (Honeywell CMM 73-20-69 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):

Test point 3 & 6: the Pr-Pg pressure was above the CMM maximum limit.

Figure 5
TH0444 (No. 2) power turbine governor as received

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Longueuil, Quebec,
Canada J4G 1A1

RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch
Accessory: 11035 Universal torque limiter unit (TLU)
Note: This unit was not on the engine at initial engine delivery
Investigation Results:
The exterior surfaces were lightly soiled and wet with oil. The torque setting adjustment was set at 5. Lockwire was present at all locations. The seals were marked P&WC. The unit was tested in accordance with test record sheet TR6613 Rev. 01 (Honeywell CMM 73-20-68 original issue). The following observations were recorded (refer to the appendix for a summary of the test observations):

Test point 2.01 Nominal torque limiter setting at position 5: the No. 1 Pr-Pg was above the CMM maximum limit
Test point 3.02 Fine limiter adjustment check: the pressure in the No. 1 & 2 bellows that was required to achieve a Pr-Pg of 8.6in.Hg was above the CMM maximum limit.

Figure 6
Universal torque limiter unit as received

5.0 Closing Statement

This report collected at the time of the review may be altered or corrected on the basis of further information.

Pratt & Whitney Canada Corp.
1000 Marie-Victorin,
Longueuil, Quebec,
Canada J4G 1A1

RFA No: 10TS00004B
SI File No:10039

ACCESSORIES INCIDENT REPORT

Date issued: 2010-09-24
To: Nelson Lynch

[redacted]
Engine Controls & Accessories Technical Services
Mail Stop: 05AQ1

Appendix
Summary of test observations

The reference values quoted for each test point represent values for these parameters extracted from the appropriate component maintenance manual test procedures. The component maintenance manual ranges of values are those used to re-certify an accessory and are provided here for reference purposes only.

No. 1 AFCU test observations

Test point 1.01 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPMN, the throttle at maximum, and P3 air at 40psia the nozzle flow was 293pph. This was slightly above the CMM maximum limit of 285pph.

Test point 1.02 Metering valve and bypass valve differential pressure setting: with the drive-speed at 2900RPM, the throttle at 31 degrees nominal, and P3 air at 40psia the nozzle flow was 80pph. This was slightly above the CMM maximum limit of 79pph.

Test point 1.03 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPM, the throttle at maximum, and P3 air at 90psia the nozzle flow was 657pph. This was slightly above the CMM maximum limit of 642pph.

Test point 1.04 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPM, the throttle at maximum, and P3 air at 125psia the nozzle flow was 764pph. This was above the CMM maximum limit of 728pph.

Test point 1.06 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPM, the throttle at maximum, and P3 air at 40psia the nozzle flow was 290pph. This was slightly above the CMM maximum limit of 285pph.

Test point 1.09 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPM, the throttle at maximum, and P3 air at 40psia the nozzle flow was 290pph. This was slightly above the CMM maximum limit of 285pph.

Test point 1.12 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPM, the throttle at maximum, and P3 air at 40psia the nozzle flow was 290pph. This was slightly above the CMM maximum limit of 285pph.

Test point 2.03 Enrichment spring setting: with the drive-speed at 5800RPM, the throttle at maximum and P3 air at 70psia the nozzle flow was 482pph. This was slightly above the CMM maximum limit of 458pph.

Test point 3.01 Governor spring setting: with the drive-speed at 7047RPM, the throttle at 90 degrees nominal, and P3 air at 100psia the nozzle flow was 719pph. This was above the CMM maximum limit of 655pph.

Test point 4.01 idle speed stop setting and pickup angle: with the drive-speed at 3300RPM, the throttle at 29degrees nominal, P3 air at 30psia the nozzle flow was 98pph. This was below the CMM minimum limit of 110pph.

TH0852 MFCU test observations

Test point 5: with the solenoid energized at 24vdc, the fuel supply at 720pph, the throttle at 25degrees, and bypass pressure set at 65psig the nozzle flow was 92pph. This was slightly above the CMM maximum limit of 90pph.

Test point 7: with the solenoid energized at 24vdc, the fuel supply at 720pph, the throttle at 40degrees, and bypass pressure set at 65psig the nozzle flow was 97pph. This was slightly above the CMM maximum limit of 95pph.

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TH0444 AFCU test observations

Test point 1.01 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPMN, the throttle at maximum, and P3 air at 40psia the nozzle flow was 241pph. This was below the CMM minimum limit of 275pph.
Test point 1.02 Metering valve and bypass valve differential pressure setting: with the drive-speed at 2900RPMN, the throttle at 31 degrees nominal, and P3 air at 40psia the nozzle flow was 82pph. This was slightly above the CMM maximum limit of 79pph.
Test point 1.04 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPMN, the throttle at maximum, and P3 air at 125psia the nozzle flow was 744pph. This was slightly above the CMM maximum limit of 728pph.
Test point 1.06 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPMN, the throttle at maximum, and P3 air at 40psia the nozzle flow was 242pph. This was below the CMM minimum limit of 275pph.
Test point 1.09 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPMN, the throttle at maximum, and P3 air at 40psia the nozzle flow was 243pph. This was below the CMM minimum limit of 275pph.
Test point 1.12 Metering valve and bypass valve differential pressure setting: with the drive-speed at 6800RPMN, the throttle at maximum, and P3 air at 40psia the nozzle flow was 242pph. This was below the CMM minimum limit of 275pph.
Test point 2.03 Enrichment spring setting: with the drive-speed at 5800RPM, the throttle at maximum and P3 air at 70psia the nozzle flow was 437pph. This was below the CMM minimum limit of 441pph.
Test point 3.01 Governor spring setting: with the drive-speed at 7047RPM, the throttle at 90 degrees, P3 air at 100psia the nozzle flow was 696pph. This was above the CMM maximum limit of 655pph.
Test point 4.01 Idle speed stop setting and pickup angle: with the speed at 3300RPM, the throttle at 29 degrees nominal, and P3 air at 30psia the nozzle flow was 85pph. This was below the CMM minimum limit of 110pph.
Test point 5.02 Low end acceleration and throttle movement effect: with the drive-speed at 2100RPM, the throttle at 40 degrees, and P3 air at 25psia the nozzle flow was 130pph. This was below the CMM minimum limit of 145pph.

TH0444 MFCU test observations

Test point 5: with the solenoid energized at 24vdc, the fuel supply at 720pph, the throttle at 25degrees, and bypass pressure set at 65psig the nozzle flow was 91pph. This was slightly above the CMM maximum limit of 90pph.
Test point 7: with the solenoid energized at 24vdc, the fuel supply at 720pph, the throttle at 40degrees, and bypass pressure set at 65psig the nozzle flow was 96pph. This was slightly above the CMM maximum limit of 95pph.
Test point 9: with the solenoid energized at 24vdc, the fuel supply at 1350pph, the throttle at 90degrees, and bypass pressure set at 115psig the nozzle flow was 620pph. This was above the CMM maximum limit of 602pph.

TH0852 Power turbine governor test observations

Test point 3: with the drive-speed at 4300RPM, the Pr-Pa pressure at 34.3in.Hg, and the lever at 75degrees the Pr-Pg pressure was 8.8in.Hg. This was above the CMM maximum limit of 7.8in.Hg.
Test point 6: with the drive-speed at 4050RPM, the Pr-Pa pressure at 34.3in.Hg, and the lever at 65degrees the Pr-Pg pressure was 8.3in.Hg. This was above the CMM maximum limit of 7.5in.Hg.

TH0444 Power turbine governor test observations

Test point 3: with the drive-speed at 4300RPM, the Pr-Pa pressure at 34.3in.Hg, and the lever at 75degrees the Pr-Pg pressure was 9.8in.Hg. This was above the CMM maximum limit of 7.8in.Hg.
Test point 6: with the drive-speed at 4050RPM, the Pr-Pa pressure at 34.3in.Hg, and the lever at 65degrees the Pr-Pg pressure was 8.7in.Hg. This was above the CMM maximum limit of 7.5in.Hg.

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11035 TLU test observations

Test point 2.01 Nominal torque limiter setting at position 5: with the pressure in the No. 1& No. 2 bellows set at 51.1psig the No. 1 Pr-Pg was 8.6in.Hg. This was above the CMM maximum limit of 7.8in.Hg.
Test point 3.02 Fine limiter adjustment check: the pressure in the No. 1 & 2 bellows that was required to achieve a Pr-Pg of 8.6in.Hg was 65.4psig. This was above the CMM maximum limit of 64psig.