AIRCRAFT ACCIDENT REPORT

NPF/2012/03/14/F

Accident Investigation Bureau

Report on the accident involving Bell 427 Helicopter belonging to the Nigeria Police Force, registration 5N-POL which occurred at Kabong, Jos South L.G.A Plateau State on the 14th of March, 2012

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

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

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of Aircraft Accident/Serious Incident Investigations to apportion blame or liability.

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As the Bureau believes that safety information is of great value if it is passed on for 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 Authority of the State (NCAA). It is for this authority to ensure enforcement.

Printed in Nigeria for the Accident Investigation Bureau (AIB)

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GLOSSARY OF ABBREVIATION USED IN THIS REPORT

AD	Airworthiness Directive
AIB	Accident Investigation Bureau
AFQRJOS	Aviation Fuel Quality Requirement for Jointly Operated Systems
AMO	Approved Maintenance Organization
AOC	Air Operator's Certificate
AOP	Airline Operators Permit
ASB	Alert Service Bulletin
ATC	Air Traffic Control
ATL	Air Transport Licence
ATOL	Air Travel Operators Licence
CFR	Code of Federal Regulations
CPL	Commmercial Pilot Licence
DIG	Deputy Inspector General of Police
DPR	Directorate of Petroleum Resources
EECU	Electronic Engine Control Unit
FAA	Federal Aviation Authority
JUHI	Joint Users Hydrant Installation
MOE	Maintenance Organization Exposition
NCAA	Nigerian Civil Aviation Authority
NNPC	Nigerian National Petroleum Corporation
NPF	Nigerian Police Force

PNCF	Permit for Non Commercial Flight
SOP	Standard Operating Procedure

Aircraft Accident Report No.:	NPF/2012/03/14/F
Registered Owner and Operator:	Nigeria Police Force (NPF)
Aircraft Type and Model:	Bell 427 Helicopter
Manufacturer:	Bell Helicopter Textron, Canada
Date of Manufacture:	August 2002
Registration Number:	5N–POL
Serial No.:	56035
Location:	Landir Village in Kabong Jos North L.G.A, Plateau State, at coordinates N09°55.229, E008°51.853
Date and Time:	14th March, 2012 @ 1155hrs *All times in this report are local times (equivalent to UTC+1) unless otherwise stated*

SYNOPSIS:

Accident Investigation Bureau (AIB) was notified by the Nigerian Civil Aviation Authority (NCAA) at about 1400hrs on 14th March 2012, of an accident involving a Nigeria Police Force (NPF) Bell 427 helicopter with registration number 5N-POL at Landir Village in Kabong, Jos. Investigators were dispatched to the crash site the same day.

The helicopter 5N-POL was operated by the NPF and was registered under the private category with the NCAA. All relevant stakeholders were notified.

On Tuesday 13th March, 2012, the flight originated from Abuja airport to Jos Prison Service football field as a ferry flight. The purpose of the flight was to convey the

Deputy Inspector General of Police (DIG) Operations from Jos to Abuja. The aircraft had initial contact with Jos Control Tower at 1350hrs en-route and reported ETA to be 1400hrs.

The following day, 14th March 2012 at 0930hrs, a police fuel bowser that had arrived Jos from Abuja the previous day, fuelled the aircraft which had been parked overnight at the Jos Prison football field.

At 0958hrs, two-way communication was established between the helicopter and ATC. The pilot reported endurance of two hours, five persons on board, maintaining an altitude of 4000ft, and that it was a patrol flight around Jos city. The pilot also reported that he would be landing at the Police Headquarters, Jos and would call the Control Tower when re-joining for another patrol. The helicopter landed at the Nigeria Prisons Service football field, Jos (customarily used as a landing site for the Police Headquarters, Jos) at 1058hrs.

At about 1150hrs, the helicopter lifted up with four persons on board including the DIG. The Control Tower was notified at about 1155hrs of the helicopter's crash at Landir village, Kabong area near Jos metropolis and that all four persons on board were fatally injured.

The accident occurred in daylight at a coordinate of N09°55.229, E008°51.853.

The investigation identified the following probable causal factors:

Probable Causal Factors:

The cause of the accident cannot be conclusively decided but the investigation discovered series of discrepancies and non-compliance with Nig.CARs which includes:

a. Pilot:

i. The pilot's medical had expired as at the time of accident,

ii. Simulator recurrency had expired as at the time of accident.

b. Co-pilot:

i. The co-pilot was not type rated on the helicopter (Bell 427).

c. Engineer:

i. The engineer that released the aircraft prior to the flight had no type training and type rating on the aircraft type.

Three Safety Recommendations were made.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

The helicopter 5N-POL was operated by the Nigeria Police Force and was registered under the private category with the Nigerian Civil Aviation Authority.

On Tuesday 13th March, 2012, the helicopter lifted up from Abuja airport to Jos Prison football field as a ferry flight. The purpose of the flight was to convey the Deputy Inspector General of Police (DIG) Operations from Jos to Abuja. The aircraft had initial contact with Jos Control Tower at 1350hrs en-route and reported ETA to be 1400hrs. Thereafter, the pilot received current weather information from the ATC. The pilot further requested landing clearance on a football field, at the Nigerian Prison Service. The helicopter landed at 1406hrs.

At 1537hrs, the Jos Control Tower established another 2-way contact with the aircraft. The pilot reported that he was proceeding on aerial surveillance patrol over Jos metropolis at 4000ft with five souls on board. The patrol lasted about an hour and a half, after which the aircraft was parked overnight at the prison field with security personnel detailed to provide security around the aircraft.

At 0930hrs on 14th March, 2012, a police fuel bowser that arrived Jos from Abuja the previous day fuelled the aircraft.

At 0958hrs, two-way communication was established between the helicopter and ATC. The pilot reported endurance of two hours, five persons on board, maintaining an altitude of 4000ft, and that it was a patrol flight around Jos city. The pilot also reported that he would be landing at the Police Headquarters, Jos and would call the Control Tower when re-joining for another patrol.

At 1058hrs, the helicopter landed at the Nigeria Prisons Service football field, Jos (customarily used as a landing site for the Police Headquarters, Jos). The helicopter was again refuelled from the same police fuel bowser in readiness to convey the DIG. Both refuelling exercises were carried out by the crew.

At about 1150hrs, the helicopter lifted up with four persons on board including the DIG. There was no communication between the helicopter and ATC after lift up due to electrical power fluctuation at the Jos Control Tower from 1104hrs to 1228hrs.

At 1155hrs, Jos ATC was notified on phone by an eyewitness from the crash site that a helicopter had crashed with four fatalities at Landir Kabong, Jos North Local Government Area, Plateau State.

The crash site coordinates and elevation are N09°55.229, E008°51.853 and 3,959ft respectively.

1.2 Injuries to Persons

INJURIES	CREW	PASSENGERS	OTHERS
Fatal	2	2	Nil
Serious	Nil	Nil	Nil
Minor/None	Nil	Nil	Nil

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces and post impact fire.

Figure 1: Picture showing the wreckage of the helicopter engine at final impact point

1.4 Other Damage

Three residential houses, domestic animals and household properties were destroyed. See pictures below:

Figure 2: Picture showing the destroyed buildings

Figure 3: Picture showing the front view of the destroyed buildings

1.5 Personnel Information

1.5.1 Pilot:

Nationality:	Nigerian
Age:	55 years
Licence No:	CPL 3786(H)
Licence Validity:	11th October, 2014
Aircraft Ratings:	Bell 427, Bell 206
Medical Validity:	11th January, 2012
Simulator Validity:	6th March, 2011
Total Flying Experience:	3662hrs
On Type:	619hrs
Last 90 days:	Not available
Last 30 days:	10hrs 20mins
Last 24 hours:	Not available

1.5.2 Co-Pilot:

Nationality:	Nigerian
Age:	47 years
Licence No.:	CPL 4875(H)
Licence Validity:	7th December, 2016
Aircraft Ratings:	Bell 47G
Medical Validity:	20th April, 2012
Simulator Validity:	Nil

Total Flying Experience:	554hrs
On Type:	Not available
Last 90 days:	Not available
Last 30 days:	Not available
Last 24 hours:	Not available

He had no record of training and rating on Bell 427 helicopter.

1.5.3 Engineer who released the aircraft for flight on 13th March, 2012

Nationality:	Nigerian
Age:	52 years
Licence No.:	2205
Licence Validity:	14th October, 2012
Aircraft Ratings:	C172, AS355

He carries out maintenance duties including clearing of snags, scheduled and unscheduled inspections without appropriate type rating on the helicopter.

The above engineer carried out the pre-flight inspection of the aircraft and subsequently released the aircraft for flight from Abuja to Jos on 13th March, 2012.

The engineer has no rating on Bell 427, neither has he any authorization on his licence nor any record of training on Bell 427.

1.6 Aircraft Information

Figure 4: Picture showing a similar Bell 427 helicopter

1.6.1 General Information

Type:	Bell 427
Serial No.:	56035
Operator:	Nigeria Police Force
Manufacturer:	Bell Helicopter Textron, Canada
Year of Manufacture:	2002
Airframe Time:	477:55hrs
Total landings/cycles:	709/604 as at 2nd March, 2012
Certificate of Insurance:	6th May, 2012
Certificate of Airworthiness:	5th June, 2012

1.6.1.1 Emergency AD for Bell Model 407, 427 Helicopters issued by FAA

Airworthiness Directive (AD) No. CF-2011-17 is on improper lock washer installation, which could lead to malfunction of a servo in flight control system. See Appendix 1.

1.6.1.2 Approved Maintenance Organization (AMO)

The last AMO approval with Ref. AMO5N/NPA granted to NPF Air-Wing expired on 13th September, 2007. However, the NCAA granted the extension of the above AMO from 31st January, 2008 to March 2008 after a series of Audit Inspections by the Authority. It is pertinent to note that the operator had no valid AMO in force before the accident on 14th March, 2012. According to the Operator, the aircraft was preserved between 2008 and 2011 before being returned to service.

1.6.2 Power Plant

No. 1

Manufacturer:	Pratt & Whitney
Year of Manufacture:	October 2000
Hours:	477:55 as at 2nd March, 2012
Engine Model:	PW 207D
Cycles:	604
Serial No.:	PCE BF 0081
Last Check:	50hrs/3 months on 14th February, 2012

No. 2

Manufacturer:	Pratt & Whitney
Year of Manufacture:	October 2000
Hours:	477:55@ 2nd March, 2012
Engine Model:	PW 207D
Cycles:	604
Serial No.:	PCE BF 0082
Last Check:	50hrs/3 months on 14th February, 2012

The following pictures show the Bell 427 Helicopter Engines at the facility of Pratt & Whitney, Canada ready for teardown investigations:

Figure 5: The engines in the crate before the teardown

Figure 6: Engine on the stand before the teardown

Type of fuel used was JET A1. See the NPF fuel bowser used for refuelling below:

Figure 7: Picture showing NPF fuel bowser

1.7 Meteorological Information

Time:	**0900 UTC**
Wind:	120/12Kts
Visibility:	9km
Weather:	Nil
Cloud:	NSC
Temp/Dew:	26°C/M05°C
QNH:	1018hPa

Time:	**1000 UTC**
Wind:	090/12Kts
Visibility:	9km
Weather:	Nil
Cloud:	NSC
Temp/Dew:	28°C/M02°C
QNH:	1018hPa

Time:	**1100 UTC**
Wind:	060/10Kts
Visibility:	9km
Weather:	Nil
Cloud:	NSC

Temp/Dew: 29°C/M01°C

QNH: 1017hPa

1.8 Aids to Navigation

Available navigational aid (VOR) was serviceable but not available at the time of the occurrence due to electrical power fluctuation at the airport.

1.9 Communications

There was two-way communication between ATC and the helicopter during the first patrol flight within the Jos metropolis on the day of the accident.

Between 1104hrs and 1228hrs, ATC could not record communication with the helicopter due to electrical power fluctuation at the airport.

At 1155hrs, Jos ATC was notified of the accident through a phone call from an eyewitness at the accident site.

1.10 Aerodrome Information

Not Applicable. The accident occurred outside Jos Aerodrome.

Accident site coordinates and elevation are N09°55.229, E008°51.853 and 3,959ft respectively.

1.11 Flight Recorders

The aircraft was not equipped with a Flight Data Recorder or Cockpit Voice Recorder. Neither of these recorders was required by NCAA regulations.

1.12 Wreckage and Impact Information

The wreckage was largely in one piece but was totally destroyed by impact forces and fire. One of the tail rotor blades of the aircraft separated from its attachment point when it impacted on a building ten meters away from where the aircraft finally came to rest at the back of another building. The port engine and its exhaust appeared severely burnt while the starboard engine and its exhaust did not appear to suffer severe damage.

However, three residential buildings were destroyed as a result of the crash. Some domestic animals were also killed.

1.13 Medical and Pathological Information

The fatally injured persons were taken by the police authority to Bingham Hospital, Jos. Several efforts were made to collect pathological report but Nigeria Police Force (NPF) did not oblige the Bureau.

1.14 Fire

The aircraft wreckage showed heavy impact and fire damage. Examination of the wreckage area and vicinity revealed no evidence of a pre-impact fire or in-flight

separation of components. Attempts made by the villagers to extinguish the fire at the crash site were successful. See Figure 8 below:

Figure 8: Picture showing villagers trying to extinguish the fire at the crash site

1.15 Survival Aspect

The accident was not survivable due to impact forces and post crash fire. However, Plateau State Fire Service arrived the crash site within 15 minutes. The fire was extinguished by the combined efforts of the villagers and the State Fire Service.

Before the arrival of the emergency services, fire had already engulfed the whole aircraft and the four occupants. The Airport Fire Service did not participate in the rescue operation.

Figure 9: Picture showing rescue operation by the Nigeria Police

1.16 Test and Research

1.16.1 Engine Tear Down

The two engines of the aircraft were taken to the facility of Pratt & Whitney Canada (P&WC) at St-Hubert, Quebec, Canada; for teardown.

The engine components and accessories reviewed did not show anomalies that could have prevented normal operations prior to the event. Therefore, based on observations, the engines were still producing power at the time of the impact.

However, it was not possible to establish the power level at the time of impact. See Appendix 5 (*Engine Teardown Report from Pratt & Whitney, Canada)*

1.16.2 Engine Indicating Systems

The engine performance is monitored by engine indicating systems which consist of various sensors, probes and thermocouples mounted on the engine. Their signals are

received by the cockpit instruments either directly through wiring harness or indirectly through the Engine Control Unit (ECU). It is pertinent to note that this unit was severely burnt and as such no information was retrieved.

1.16.3 Fuel Sample Analysis

Three fuel samples were collected and analyzed in a laboratory in Lagos. The samples collected were from the police fuel bowser, Conoil bowser, and the aircraft wreckage. However, there were significant disparities in the results of the fuel samples. See Appendix 2 (*Fuel Sample Analysis Results)*

1.17 Organisational and Management Information

1.17.1 NPF Air-Wing

The Nigeria Police Air-Wing has fourteen (14) helicopters in its fleet as at December 2012. There is however, only one engineer who is rated on the Bell 427 helicopter. Although the NPF has a Standard Operating Procedure, there is no structure on ground to ensure that it is being enforced.

The training of the entire Police Air-Wing personnel is dependent on the NPF budgetary provisions.

During the course of this investigation, the Bureau discovered that both the funding of the Air-Wing as well as salaries of pilots and engineers are in accordance with Police Service Commission (PSC) and NPF Conditions of Service.

1.17.2 Nigerian Civil Aviation Authority (NCAA)

Civil Aviation is one of the most regulated industries in the world. Every single technical personnel, equipment and airport must be certified and monitored by competent

regulatory agencies known as civil aviation authorities. These are in turn assessed by the International Civil Aviation Organization (ICAO) and other international bodies. The operating principles, guidelines and standards applied in Civil Aviation are based on Standard And Recommended Practices (SARPs) of ICAO and stipulated national laws and regulations.

In Nigeria the NCAA is the regulatory body overseeing the activities of all airlines/operators, crew, engineers, navigational aids, all service providers including airport authorities and air traffic service providers.

Nig.CARs 1.2.1.1 states,

a) Pilot Licence.

1. To act as a Pilot of a Civil Aircraft of Nigerian registry, a pilot shall have in his/her physical possession or readily accessible in the aircraft a valid pilot licence or special purpose authorization issued under these Regulations;

2. To act as a pilot of a civil aircraft of foreign registry within Nigeria, a pilot shall be the holder of a valid pilot licence, and have the pilot licence in his or her physical possession or readily accessible in the aircraft.

b) Flight instructor licence: A person who holds a flight instructor licence shall have that licence, or other documentation acceptable to the Authority, in that person's physical possession or readily accessible in the aircraft when exercising the privileges of that licence.

c) Other airman licence: A person required by any part of these Regulations to have an airman's licence shall have it in their physical possession or readily accessible in the aircraft or at the work site when exercising the privileges of that licence.

d) A medical certificate: A person required by any part of these regulation to have a current medical certificate shall have it in their physical possession or readily accessible in the aircraft or at the work site when exercising the previlages of that certificate.

GENERAL

2.11.1.1(a) This section prescribes the requirements and procedures for issuing, reissuing of Class 1, Class 2 and Class 3 medical certificates.

The applicants for the flight crew licence, cabin crew and air traffic controller licence shall hold a medical certificate issued in accordance with this part.

(b) A flight crew member or air traffic controller and cabin crew member shall not exercise the privileges of his/her licence unless he/she holds a medical certificate appropriate to the licence.

Nig.CARs 5.5.1.3 sub section (c) states that "*No person may operate an aircraft, aeronautical product, or accessory to which an Airworthiness Directive applies, issued either by the State of Design, or State of Manufacture and adopted for Nigerian-registered aircraft by the Authority, or by the State of Registry for aircraft operated within Nigeria, except in accordance with the requirements of that Airworthiness Directive.*"

Nig.CARs 5.6.1.3 states that

a) No person may perform any task defined as maintenance on an aircraft or aeronautical products, except as provided in the following -

1. A pilot licensed by the Authority may perform preventive maintenance on any aircraft owned or operated by that pilot as long as the aircraft is not listed for use by an AOC holder.

2. A person working under the supervision of an aircraft maintenance engineer, may perform the maintenance, preventive maintenance, and alteration that the supervisory aircraft maintenance engineer is authorized to perform –

i. If the supervisor personally observes the work being done to the extent necessary to ensure that it is being done properly and

ii. If the supervisor is readily available, in person, for consultation,

A licensed aircraft maintenance engineer may perform or supervise the maintenance or alteration of an aircraft or aeronautical product for which he or she is rated subject to the limitation of Part 2 of these regulations.

Records available to the Bureau from both NCAA and the NPF, indicated that, the Captain's Medical, Simulator and proficiency had all expired. In addition, the aircraft was released for flight to Jos on the 13th March, 2012 by an aircraft maintenance engineer that was not type rated on Bell 427 Helicopter and therefore, not qualified to release the aircraft to service.

1.18 Additional Information

1.18.1 NCAA and Aviation Fuel Regulations in Nigeria

See Appendix 4.

1.18.2 Nigeria Police Air-Wing Safety Management

Management of an aviation organization, large or small requires the coordination of many processes and allocation of resources including funding, budgeting, communication, training, maintenance, and others. In recent years, managing safety has been added to the list of these processes. Safety is an essential part of running air transport operations.

1.18.3 Permit for Non-Commercial Flight (PNCF) granted to NPF

A Permit for Non-Commercial Flight was granted to the NPF on the 19th of November, 2010 by the Nigerian Civil Aviation Authority. However, certain conditions were stated before the approval of the permit via Ref. NCAA/ATR66/NCF37. See APPENDIX 4.

1.18.4 Human Factor Elements in the Operation of NPF Air-Wing

The James Reason Model was used in the analysis of the human factor elements identified in this investigation.

1.19 Useful or Effective Investigation Techniques

Not Applicable.

2.0 ANALYSIS

2.1 Nigeria Police Air-Wing Safety Management

The responsibility for safety management, accident mitigation and/or prevention in any organization depends on its organizational safety culture. Safety is everyone's responsibility; hence everybody should be aware of the consequences of their mistakes and strive to avoid them.

Unfortunately, not everyone realizes this even though most people want to do a good job and to do it safely. Therefore, management is responsible for fostering this basic motivation so that each employee develops high level of commitment to safety. In order to achieve this objective, management must provide the proper funding, conducive working environment, proper training, and adequate supervision, standard and approved facilities/equipment.

Management's involvement and the resources it allocates have a reflective effect on the quality of the organisation's safety programme. Sometimes, due to financial constraints, management is reluctant to release funds for enhancement of safety. However, it can usually be shown that accident prevention activities are not only cost effective but that they also tend to improve the performance of people, reduce waste and increase the overall efficiency and effectiveness of the entire organization.

Management's responsibilities for safety go well beyond financial provisions. Encouragement and active support of accident prevention programmes must be clearly visible to all staff if such programmes are to be effective. For example, in addition to determining who was responsible for an accident or incident, internal investigation should also delve into the underlying factors that induced the human effort.

The investigation revealed the following:

i. Lack of commitment by the NPF management to adhere to relevant regulation as prescribed by Nig.CARs.
ii. Weak enforcement of regulatory requirements by the concerned Authority.
iii. The Air-Wing is inadequately funded from the yearly budgetary provision of the NPF. This affects the operational capabilities of the Air-Wing which raised safety concerns in the organization including the following:
    - Low morale of the entire technical staff as a result of poor remuneration,
    - Inadequate training for the entire technical staff.

2.2 NPF Air-Wing Fuel Truck and Fuel Sample Analysis Results

At 0930hrs on 14th March, 2012, the aircraft was fuelled from a police fuel bowser that arrived Jos from Abuja the previous day. The bowser had been parked overnight at the Nigerian Prison Service football field. After refuelling, the crew requested for take-off clearance at 0958hrs with five persons on board for an aerial patrol within Jos metropolis. The helicopter landed at the same football field after the exercise.

At 1058hrs, the helicopter was refuelled from the same fuel bowser by the crew in readiness to convey the DIG. The investigation revealed that the NPF had used the fuel bowser for many years without any evidence to show that microbial growth inspection had been carried out.

Fuel Analysis Results

Three fuel samples were collected for laboratory analysis. These samples were collected from the police bowser, the Conoil bowser that supplied the police bowser, and from the accident helicopter tank.

After the laboratory analysis of the samples, the results indicated different high concentration of sulphur mercaptan contents as follows:

- CONOIL BOWSER - 0.0055%
- POLICE BOWSER - 0.0077%
- HELICOPTER TANK - 0.0055%

The total sulphur content and sulphur mercaptan is off the Aviation Fuel Quality Requirement for Jointly Operated Systems (AFQRJOS) specification for Jet A1, which is below the standard fuel quality required for Jet Fuel.

The Laboratory Test was positive and sulphur mercaptan content exceeds the maximum limit specification requirement of 0.003%. Significant and use "Mercaptan sulphur has an objectionable odour and adverse effect on aircraft fuel system elastomers and it is corrosive to the fuel system components."

However, the Bureau could not establish that the fuel quality and fuelling procedures were contributory to this accident.

2.3 NCAA Oversight of NPF Air-Wing

Civil aviation is one of the most highly regulated industries in the world. Every single technical personnel, equipment and airport must be certified and monitored by competent regulatory agencies known as Civil Aviation Authorities (CAAs). Even the CAAs themselves are in turn assessed by the International Civil Aviation Organization (ICAO) and other international bodies. The operating principles, guidelines, and standards applied in civil aviation are based on the Standards and Recommended Practices (SARPs) of ICAO and relevant National laws and regulations.

In Nigeria, the Nigerian Civil Aviation Authority (NCAA) is the regulatory body, overseeing the activities of all the airlines and aircraft operators, their pilots, engineers, cabin staff, aerodromes, and all other service providers.

NCAA therefore regulates the industry through series of well-coordinated procedures. The authority sets safety standards, issues licenses, and operating certificates to personnel and service providers. It also monitors their compliance through a range of surveillance activities. Where safety rules are breached, the NCAA takes corrective action to enforce compliance which may include sanctions such as:

- Fines
- Suspension
- Revocation
- Action by the Attorney General of the Federation

One of the key instruments of NCAA regulation is the issuance and renewal of operating licences such as Air Operator's Certificate (AOC), Air Transport Licence (ATL), Airline Operating Permit (AOP), the Permit for Non Commercial Flight (PNCF), and Air Travel Operators Licence (ATOL). NCAA's Aviation Safety Inspectors conduct unscheduled on-the-spot inspections of the operations of airlines and other service providers to ensure continuous compliance with the regulations guiding their operations.

From the records available to the Bureau during the course of this investigation, issues of weak enforcement of regulatory requirements were observed.

As at the time of the accident, NPF Air-Wing had no valid AMO in place.

2.4 NPF Compliance to AD No. CF-2011-17 dated June 29th 2011, for Bell Models 407, 427 helicopters

From the documents available to the Bureau, there was no evidence of logbook entries to establish that the NPF implemented this mandatory AD issued on 12th July 2011. However, there was a worksheet entry including other helicopters with action taken which states "*Inspected nut, the shaft and clevis assembly (225, 215 and 205) and found ok"* dated 20th October, 2011. Ref. Nig.CARs 6.5.1.8. The only remark on a paper about this AD reads "parts inspected".

In accordance with Nig.CARs 5.5.1.3 sub section (c), compliance with the Airworthiness Directive is mandatory. However, the evidence of compliance provided by the NPF to AIB was unsatisfactory.

2.5 Release Authorization of helicopter with registration 5N-POL

The aircraft maintenance engineer who carried out the pre-flight inspection of the helicopter and subsequently released it for flight from Abuja to Jos on 13th March, 2012, had previously released the helicopter for flight on 2nd, 27th February, and 2nd March, 2012 respectively.

The aircraft maintenance engineer joined the services of the NPF Air-Wing in 1984 and ever since, had carried out scheduled and unscheduled maintenance inspection checks including clearing of reported snags/defects on Bell 427 helicopters. It is pertinent to note that he has neither undergone any type training nor rated on the Bell 427 helicopter.

2.6 Human Factors associated with this accident

During the course of this investigation, the Bureau discovered various human errors ranging from the lack of valid medical certifications, simulator recurrency training/checks and proper type rating of the co-pilot. Also identified was lack of training and type rating of the engineer that signed off the aircraft as well as poor maintenance record keeping of the organization.

2.7 Engine Tear Down at the Facility of Pratt & Whitney Canada

The Engine teardown investigation was performed at Pratt & Whitney Canada P&WC Service investigation facilities at St-Hubert, Quebec, Canada.

Engine components and accessories examined did not show anomalies that would have prevented engine normal operations prior to the event. Therefore, based on these observations, the engines were still producing power at the time of impact. However, it was not possible to establish the power level at the time of impact.

2.8 Crew Training

The Bureau has no evidence to show that the NPF Air-wing has a Safety Officer to ensure the functioning of the safety system within the flight operations department. However, the approved Operations Manual of NPF Air-Wing outlines the functions, duties and responsibilities of the Safety Officer as follows:

- To determine all flight operations, standards and practices, and to ensure their compliance with all relevant national and international

regulations and with the provisions of Permit to Fly granted by the appropriate authority;

- To organize inspection of flights to check the professional standard of the NPF flight crew, and to establish improvement in standards, procedures and training.

- The nominated post holder of the crew training department should have thorough knowledge of the crew training concept for the flight crew. The person normally appointed to this position should be an active pilot. He should be responsible for all flight crew type courses and simulator training. His functions, duties and responsibilities are:

    - To coordinate all questions and matters relating to flight operational standards, regulations/provisions and training;

    - To establish training syllabus and check form for all required training and checks, in cooperation with the flight operations officer.

Due to the absence of a Safety Officer, the above mentioned responsibilities could not be addressed as required.

3.0 CONCLUSION

3.1 Findings

(1) The captain's proficiency, simulator recurrency and medical checks had expired before the accident.

(2) The co-pilot had no Bell 427 type rating on his licence.

(3) The helicopter was released by an aircraft maintenance engineer that had neither type training nor type rating on Bell 427.

(4) The helicopter crashed about 3-5 minutes after lift up.

(5) The Bureau did not receive the autopsy and pathological report of fatally injured occupants.

(6) The Plateau State Fire Service responded about 15 minutes after the crash.

(7) The Approved Maintenance Organization (AMO) certificate of the Air-Wing expired on the 12th September, 2007 and was extended to 29th January, 2008. The unit had no valid AMO certificate from Nigerian Civil Aviation Authority (NCAA) at the time of the accident.

(8) There was no two-way radio communication between the aircraft and the Jos Control Tower before the crash because of electrical power fluctuation at the Control Tower.

(9) Air Traffic Control was notified of the crash by an eyewitness through a telephone call from the crash site.

(10) Three residential buildings were destroyed and some domestic animals were killed as a result of the crash.

(11) The sulphur mercaptans content of the fuel samples exceeded the maximum limit of 0.003% required.

(12) There was no log book entry to indicate that the AD No. CF-2011-17 dated June 2011, was implemented. However, the action taken was recorded on Bell 427 Alert Service Bulletin Action sheet.

3.2 Probable Causal Factors

The cause of the accident cannot be conclusively decided but the investigation discovered series of discrepancies and non-compliance with Nig.CARs which includes:

Pilot:

i. The Pilot's medical had expired as at the time of the accident,

ii. Simulator recurrency had expired as at the time of the accident.

Co-pilot:

i. The co-pilot was not type rated on the helicopter (Bell 427).

Engineer:

i. The aircraft maintenance engineer that released the aircraft prior to the flight had no type training and type rating on the aircraft type.

4.0 SAFETY RECOMMENDATIONS

4.1 Safety Recommendation 2017-001

NPF Air-Wing should provide the proper funding, conducive working environment, develop and implement a robust training programme for its technical/operational personnel, with adequate supervision and approved equipment to enhance safety.

4.2 Safety Recommendation 2017-002

NCAA should ensure that NPF Air-Wing complies with its AMO requirements.

4.3 Safety Recommendation 2017-003

NCAA and Department of Petroleum Resources (DPR) should launch an independent inquiry into Aviation fuel quality in Nigeria. The resulting report should focus on the vulnerability and risk of each step in the distribution process. This should yield firmer regulatory oversight mechanism that ensures international quality of aviation fuels used in Nigeria.

RESPONSES TO SAFETY RECOMMENDATIONS

NPF Responses on AIB Safety Recommendations

The Police Air-Wing accepts Safety Recommendation 4.1 (2017-001)

Training:

"The Police pilots and engineers have been type-rated on the police fleet despite the inadequate funding from the government appropriation while many are still on the waiting list to be type-rated."

The Police Air-Wing accepts Safety Recommendation 4.2 (2017-002)

Approved Maintenance Organization (AMO):

"The Police Air-Wing had been able to obtain from the NCAA a valid AMO in compliance with the regulation."

NCAA Response on AIB Safety Recommendations

NCAA accepts Safety Recommendation 4.2 (2017-002)

"a. The Nigerian Civil Aviation Authority (NCAA) recertified the Nigerian Police Air-Wing in accordance with the Part 6 of the Nigerian Civil Aviation Regulations (Nig. CARs) in 2014 as an Approved Maintenance Organization (AMO), certificate number AMO/5N/NPF. This certificate was subsequently renewed in July, 2016 and is presently valid till the 26th of May, 2018..."

"b. The NCAA also accomplishes its surveillance on the certified entity to ensure their continuous compliance with the regulatory requirements."

APPENDICES

Appendix 1: Emergency AD for Bell 407, 427 helicopters

Tue, Jul 12, 2011

FAA Issues Emergency AD For Bell Model 407,427 Helicopters

Improper Lock-Washer Installation Could Lead To Servo Malfunction

The FAA has issued an Emergency Airworthiness Directive (AD) prompted by a report that a quality escape by a supplier has occurred and certain hydraulic servo actuators (servo) may have a loose nut, shaft, and clevis assembly due to improper lock-washer installation. An investigation after an accident revealed the clevis nut on the servo was loose. This condition, if not detected, could lead to a malfunction of a servo in the flight control system and subsequent loss of control of the helicopter.

The FAA has reviewed Bell Alert Service Bulletin (ASB) 407-11-96 and 427-11-35, both dated June 29, 2011, which specify the part numbers and serial numbers of the affected servos and refer to ASB 407-05-70, Revision A, dated November 10, 2005; ASB 427-05-12, Revision A, dated November 14, 2005; with HR Textron Service Bulletin (SB) 41011300-67-01, Revision 2, dated November 9, 2005; HR Textron SB 41011400-67-01, Revision 2, dated November 9, 2005; and HR Textron SB 41011700-67-01, Revision 2, dated November 9, 2005. The ASBs also specify reidentifying the servos with a "67-01" on the modification plate indicating the inspection procedures were followed.

Transport Canada, the airworthiness authority for Canada, notified the FAA that an unsafe condition may exist on these helicopter models. Transport Canada advises that a quality escape by a supplier has occurred, and a number of servos may have a loose nut, shaft, and clevis assembly. Transport Canada states in its AD that the loose connection is due to improper lock washer installation, which is not traceable or identifiable except by inspection. The authority also states a disconnect of the affected parts may lead to loss of control of the helicopter. Transport Canada classified the ASBs as mandatory and issued AD No. CF-2011-17, dated June 30, 2011, to ensure the continued airworthiness of these helicopters.

These helicopters have been approved by the aviation authority of Canada and are approved for operation in the United States. Pursuant to a bilateral agreement, Canada has notified the FAA of the unsafe condition described in the AD. The FAA is issuing this AD because it evaluated all information provided by Canada and determined the unsafe condition exists and is likely to exist or develop on other helicopters of these same type designs. Therefore, this AD requires before

further flight for certain affected servos and within 25 hours time-in-service for certain other affected servos, identified by a serial number, retracting the boot and inspecting the servo as follows:

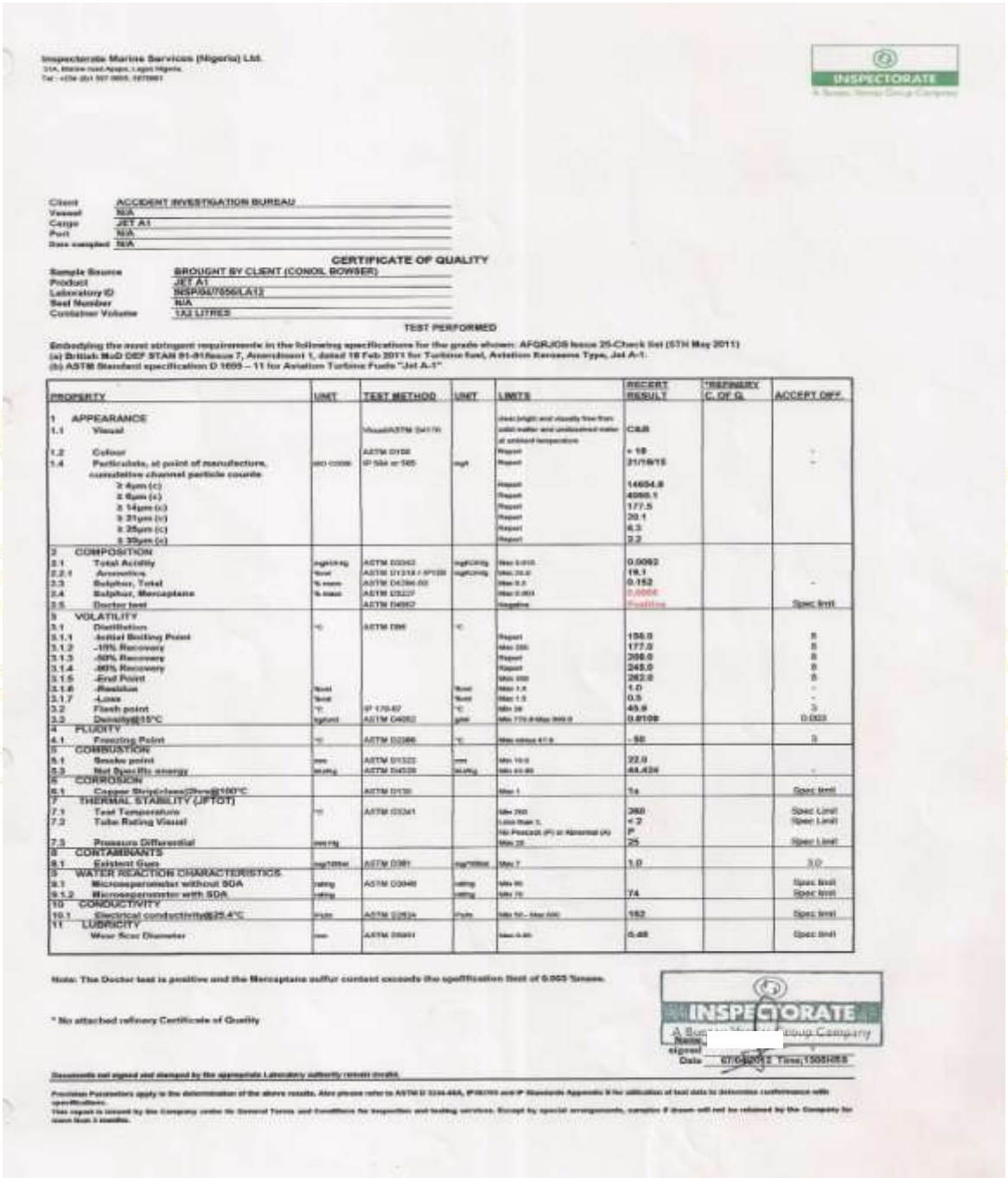
- Applying only hand pressure, determining whether the nut, shaft, or clevis assembly turns independently. If the shaft turns independently of the nut or the clevis assembly, before further flight, replacing the servo with an airworthy servo.
- If the shaft does not turn independently, inspecting to determine whether at least one tab of a lock washer is bent flush against a flat surface of the nut and at least one tab of the lock washer is bent flush against a flat surface of the clevis assembly.
- If at least one lock washer tab is not aligned and bent flush with a flat surface of the nut and at least one lock washer tab is not aligned and bent flush with a flat surface of the clevis assembly, before further flight, replacing the servo with an airworthy servo.
- If any tab of the lock washer is not bent flush against either a flat surface of the nut or clevis assembly, bending the tab flush against a flat surface.
- Reidentifying the servo by metal-impression stamping or by vibro etching "67.01" onto the modification plate.
- Before installing a servo with a P/N and S/N identified in this AD, not identified by "67-01" on the modification plate, inspecting it by following the requirements of this AD.

The actions must be done by following specified portions of the alert service bulletins described previously.

This AD differs from Transport Canada AD in that the FAA does not require that the servo be returned to the manufacturer. Also, the FAA does not limit the applicability to specific serial-numbered helicopters. The FAA has specified the inspection requirements rather than referring to the applicable service bulletins. The AD requires that the servo be replaced before further flight, and the Transport Canada AD refers to the ASB, which requires that the servo be replaced within 300 hours time-in-service.

FMI: www.faa.gov

Appendix 2: Fuel Sample Analysis Results



Inspectorate Marine Services (Nigeria) Ltd.

INSPECTORATE

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

CERTIFICATE OF QUALITY

Sample Source: BROUGHT BY CLIENT (CONOIL BOWSER)
Product: JET A1
Laboratory ID: INSP/047/056/LA12
Seal Number: N/A
Container Volume: 1X2 LITRES

TEST PERFORMED

Embodying the most stringent requirements in the following specifications for the grade shown: AFQRJOS Issue 25-Check Slot (5TH May 2011)
(a) British MoD DEF STAN 91-91/Issue 7, Amendment 1, dated 18 Feb 2011 for Turbine fuel, Aviation Kerosene Type, Jet A-1.
(b) ASTM Standard specification D 1655 – 11 for Aviation Turbine Fuels "Jet A-1"

PROPERTY	UNIT	TEST METHOD	UNIT	LIMITS	RECERT RESULT	*REFINERY C. OF Q.	ACCEPT DIFF.
1 APPEARANCE							
1.1 Visual		Visual/ASTM D4176		Clear,bright and visually free from solid matter and undissolved water at ambient temperature	C&B		
1.2 Colour		ASTM D156		Report	+ 18		-
1.4 Particulate, at point of manufacture, cumulative channel particle counts	(ISO CODE	IP 564 or 565	mg/l	Report	21/19/15		-
≥ 4µm (c)				Report	14654.8		
≥ 6µm (c)				Report	4099.1		
≥ 14µm (c)				Report	177.5		
≥ 21µm (c)				Report	20.1		
≥ 25µm (c)				Report	6.3		
≥ 39µm (c)				Report	2.2		
2 COMPOSITION							
2.1 Total Acidity	mgKOH/g	ASTM D3242	mgKOH/g	Max 0.015	0.0092		
2.2.1 Aromatics	%vol	ASTM D1319 / IP156	%vol	Max 26.5	19.1		
2.3 Sulphur, Total	% mass	ASTM D4294-03		Max 0.3	0.152		-
2.4 Sulphur, Mercaptans	% mass	ASTM D3227		Max 0.003	0.0058		
2.5 Doctor test		ASTM D4952		Negative	Positive		Spec limit
3 VOLATILITY							
3.1 Distillation	°C	ASTM D86	°C				
3.1.1 Initial Boiling Point				Report	156.0		5
3.1.2 -10% Recovery				Min 205	177.0		5
3.1.3 -50% Recovery				Report	208.0		5
3.1.4 -90% Recovery				Report	245.0		5
3.1.5 -End Point				Max 300	262.0		5
3.1.6 -Residue	%vol		%vol	Max 1.5	1.0		-
3.1.7 -Loss	%vol		%vol	Max 1.5	0.5		-
3.2 Flash point	°C	IP 170-97	°C	Min 38	45.9		3
3.3 Density@15°C	kg/cm3	ASTM D4052	g/ml	Min 775.0-Max 840.0	0.8108		0.003
4 FLUIDITY							
4.1 Freezing Point	°C	ASTM D2386	°C	Max minus 47.0	- 50		3
5 COMBUSTION							
5.1 Smoke point	mm	ASTM D1322	mm	Min 19.0	22.0		
5.2 Net Specific energy	MJ/kg	ASTM D4529	MJ/kg	Min 42.80	44.424		-
6 CORROSION							
6.1 Copper Strip classification@2hrs@100°C		ASTM D130		Max 1	1a		Spec limit
7 THERMAL STABILITY (JFTOT)							
7.1 Test Temperature	°C	ASTM D3241		Min 260	260		Spec Limit
7.2 Tube Rating Visual				Less than 3, No Peacock (P) or Abnormal (A)	< 2 P		Spec Limit
7.3 Pressure Differential	mm Hg			Max 25	25		Spec Limit
8 CONTAMINANTS							
8.1 Existent Gum	mg/100ml	ASTM D381	mg/100ml	Max 7	1.0		3.0
9 WATER REACTION CHARACTERISTICS							
9.1 Microseparometer without SDA	rating	ASTM D3948	rating	Min 85			Spec limit
9.1.2 Microseparometer with SDA	rating		rating	Min 70	74		Spec limit
10 CONDUCTIVITY							
10.1 Electrical conductivity@25.4°C	PS/m	ASTM D2624	PS/m	Min 50 - Max 600	152		Spec limit
11 LUBRICITY							
Wear Scar Diameter	mm	ASTM D5001		Max 0.85	0.48		Spec limit

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

* No attached refinery Certificate of Quality

INSPECTORATE
A Bureau Veritas Group Company

Name: [redacted]
signed
Date: 07/04/2012 Time: 1308HRS

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

Provision Parameters apply to the determination of the above results. Also please refer to ASTM D 3244-86A, IP/BS100 and IP Standards Appendix B for utilization of test data to determine conformance with specifications.
This report is issued by the Company under its General Terms and Conditions for inspection and testing services. Except by special arrangements, samples if drawn will not be retained by the Company for more than 3 months.

Inspectorate Marine Services (Nigeria) Ltd.

INSPECTORATE
A Bureau Veritas Group Company

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

CERTIFICATE OF QUALITY

Sample Source	BROUGHT BY CLIENT (POLICE TRUCK)
Product	JET A1
Laboratory ID	INSP/04/7057/LA12
Seal Number	N/A
Container Volume	1X2 LITRES

TEST PERFORMED

Embodying the most stringent requirements in the following specifications for the grade shown: AFQRJOS Issue 25-Check list (5TH May 2011)
(a) British MoD DEF STAN 91-91/Issue 7, Amendment 1, dated 18 Feb 2011 for Turbine fuel, Aviation Kerosene Type, Jet A-1.
(b) ASTM Standard specification D 1655 – 11 for Aviation Turbine Fuels "Jet A-1"

PROPERTY	UNIT	TEST METHOD	UNIT	LIMITS	RECERT RESULT	*REFINERY C. OF Q.	ACCEPT DIFF.
1 APPEARANCE							
1.1 Visual		Visual/ASTM D4176		clear, bright and visually free from solid matter and undissolved water at ambient temperature	C&B		
1.2 Colour		ASTM D156		Report	+ 16		-
1.4 Particulate, at point of manufacture, cumulative channel particle counts	ISO CODE	IP 564 or 565	mg/l	Report	17/15/12		-
≥ 4µm (c)				Report	902.1		
≥ 6µm (c)				Report	248.1		
≥ 14µm (c)				Report	20.5		
≥ 21µm (c)				Report	3.4		
≥ 25µm (c)				Report	1.6		
≥ 30µm (c)				Report	0.9		
2 COMPOSITION							
2.1 Total Acidity	mgKOH/g	ASTM D3242	mgKOH/g	Max 0.015	0.0073		
2.2.1 Aromatics	%vol	ASTM D1319 / IP156	mgKOH/g	Max 25.0	17.9		
2.3 Sulphur, Total	% mass	ASTM D4294-03		Max 0.3	0.053		-
2.4 Sulphur, Mercaptans	% mass	ASTM D3227		Max 0.003	0.0076		
2.5 Doctor test		ASTM D4952		Negative	Positive		Spec limit
3 VOLATILITY							
3.1 Distillation	°C	ASTM D86	°C				
3.1.1 -Initial Boiling Point				Report	156.0		8
3.1.2 -10% Recovery				Max 205	171.0		8
3.1.3 -50% Recovery				Report	198.0		8
3.1.4 -90% Recovery				Report	237.0		8
3.1.5 -End Point				Max 300	257.0		8
3.1.6 -Residue	%vol		%vol	Max 1.5	1.0		-
3.1.7 -Loss	%vol		%vol	Max 1.5	0.5		-
3.2 Flash point	°C	IP 170-87	°C	Min 38	43.9		3
3.3 Density@15°C	kg/m3	ASTM D4052	g/ml	Min 775.0 Max 840.0	0.7996		0.003
4 FLUIDITY							
4.1 Freezing Point	°C	ASTM D2386	°C	Max minus 47.0	- 53		3
5 COMBUSTION							
5.1 Smoke point	mm	ASTM D1322	mm	Min 19.0	22.0		
5.3 Net Specific energy	MJ/Kg	ASTM D4529	MJ/Kg	Min 42.80	44.584		-
6 CORROSION							
6.1 Copper Strip(class)2hrs@100°C		ASTM D130		Max 1	1a		Spec limit
7 THERMAL STABILITY (JFTOT)							
7.1 Test Temperature	°C	ASTM D3241		Min 260	260		Spec Limit
7.2 Tube Rating Visual				Less than 3,	2		Spec Limit
				No Peacock (P) or Abnormal (A)	P		
7.3 Pressure Differential	mm Hg			Max 25	25		Spec Limit
8 CONTAMINANTS							
8.1 Existent Gum	mg/100ml	ASTM D381	mg/100ml	Max 7	1.0		3.0
9 WATER REACTION CHARACTERISTICS							
9.1 Microseparometer without SDA	rating	ASTM D3948	rating	Min 85			Spec limit
9.1.2 Microseparometer with SDA	rating		rating	Min 70	96		Spec limit
10 CONDUCTIVITY							
10.1 Electrical conductivity@25.4°C	Ps/m	ASTM D2624	Ps/m	Min 50 - Max 600	133		Spec limit
11 LUBRICITY							
Wear Scar Diameter	mm	ASTM D5001		Max 0.85	0.65		Spec limit

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

* No attached refinery Certificate of Quality

INSPECTORATE
A Bureau Veritas Group Company
Name
Signed
Date [illegible]

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

Precision Parameters apply in the determination of the above results. Also please refer to ASTM D 3244-[illegible] for utilisation of test data to determine conformance with specifications.
This report is issued by the Company under its General Terms and Conditions for inspection and testing services. Except by special arrangements, samples if drawn will not be retained by the Company for more than 3 months.

Inspectorate Marine Services (Nigeria) Ltd.
[redacted]

INSPECTORATE
A Bureau Veritas Group Company

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

CERTIFICATE OF QUALITY

Sample Source: BROUGHT BY CLIENT (LABELLED AS AIRCRAFT WREAKAGE)
Product: JET A1
Laboratory ID: INSP/04/7055/LA12
Seal Number: N/A
Container Volume: 182 LITRES

TEST PERFORMED

Embodying the most stringent requirements in the following specifications for the grade shown: AFQRJOS Issue 25-Check Sat (5TH May 2011)
(a) British MoD DEF STAN 91-91/Issue 7, Amendment 1, dated 18 Feb 2011 for Turbine fuel, Aviation Kerosene Type, Jet A-1.
(b) ASTM Standard specification D 1655 – 11 for Aviation Turbine Fuels "Jet A-1"

PROPERTY	UNIT	TEST METHOD	UNIT	LIMITS	RECERT RESULT	*REFINERY C. OF Q.	ACCEPT DIFF.
1 APPEARANCE							
1.1 Visual		Visual/ASTM D4176		clear,bright and visually free from solid matter and undissolved water at ambient temperature	C&B		
1.2 Colour		ASTM D156		Report	+ 12		-
1.4 Particulate, at point of manufacture, cumulative channel particle counts	ISO CODE	IP 564 or 565	mgt	Report	21/18/14		-
≥ 4µm (c)				Report	10850.4		
≥ 6µm (c)				Report	3800.8		
≥ 14µm (c)				Report	138.2		
≥ 21µm (c)				Report	19.9		
≥ 25µm (c)				Report	7		
≥ 30µm (c)				Report	2.2		
2 COMPOSITION							
2.1 Total Acidity	mgKOH/g	ASTM D3242	mgKOH/g	Max 0.015	0.0064		
2.2.1 Aromatics	%vol	ASTM D1319 / IP156	mg/KOH/g	Max 25.0	18.8		
2.3 Sulphur, Total	%-mass	ASTM D4294-03		Max 0.3	0.187		-
2.4 Sulphur, Mercaptans	%-mass	ASTM D3227		Max 0.003	0.0058		
2.5 Doctor test		ASTM D4952		Negative	Positive		Spec limit
3 VOLATILITY							
3.1 Distillation	°C	ASTM D86	°C				
3.1.1 -Initial Boiling Point				Report	154.0		8
3.1.2 -10% Recovery				Max 205	174.0		8
3.1.3 -50% Recovery				Report	203.0		8
3.1.4 -90% Recovery				Report	241.0		8
3.1.5 -End Point				Max 300	261.0		8
3.1.6 -Residue	%vol		%vol	Max 1.5	1.0		-
3.1.7 -Loss	%vol		%vol	Max 1.5	0.5		-
3.2 Flash point	°C	IP 170-07	°C	Min 38	46.1		3
3.3 Density@15°C	kg/cm3	ASTM D4052	g/ml	Min 775.0-Max 840.0	0.8072		0.003
4 FLUIDITY							
4.1 Freezing Point	°C	ASTM D2386	°C	Max minus 47.0	- 51		3
5 COMBUSTION							
5.1 Smoke point	mm	ASTM D1322	mm	Min 19.0	22.0		
5.3 Net Specific energy	MJ/Kg	ASTM D4529	MJ/Kg	Min 42.80	44.459		-
6 CORROSION							
6.1 Copper Strip(class)2hrs@100°C		ASTM D130		Max 1	1a		Spec limit
7 THERMAL STABILITY (JFTOT)							
7.1 Test Temperature	°C	ASTM D3241		Min 260	260		Spec Limit
7.2 Tube Rating Visual				Less than 3, No Peacock (P) or Abnormal (A)	< 2 P		Spec Limit
7.3 Pressure Differential	mm Hg			Max 25	25		Spec Limit
8 CONTAMINANTS							
8.1 Existent Gum	mg/100ml	ASTM D381	mg/100ml	Max 7	1.0		3.0
9 WATER REACTION CHARACTERISTICS							
9.1 Microseparometer without SDA	rating	ASTM D3948	rating	Min 85			Spec limit
9.1.2 Microseparometer with SDA	rating		rating	Min 70	78		Spec limit
10 CONDUCTIVITY							
10.1 Electrical conductivity@25.4°C	Ps/m	ASTM D3624	Ps/m	Min 50 - Max 600	591		Spec limit
11 LUBRICITY							
Wear Scar Diameter	mm	ASTM D6091		Max 0.85	0.47		Spec limit

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

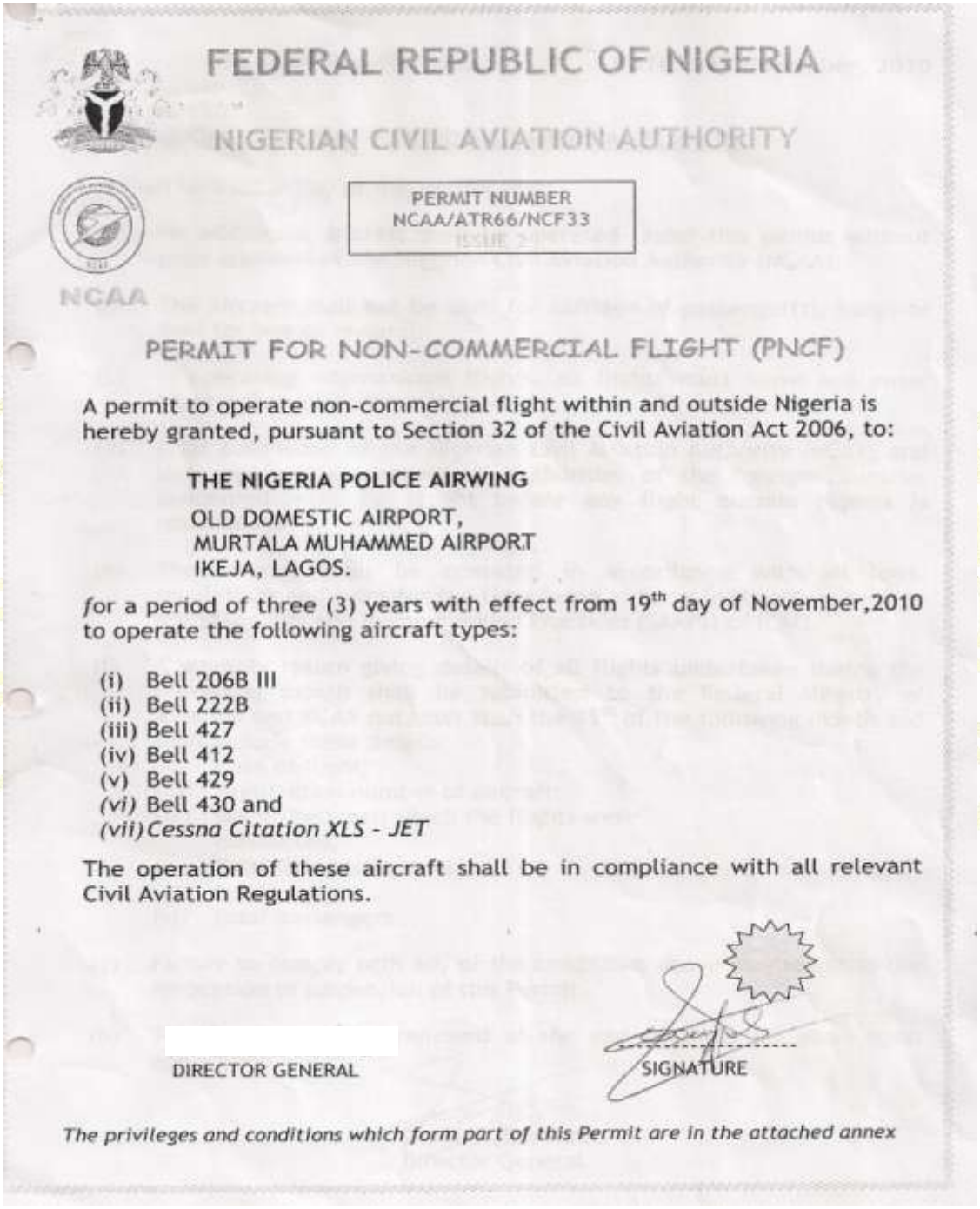
* No attached refinery Certificate of Quality

INSPECTORATE
A Bureau Veritas Group Company
Name: [redacted]
Date: 07/04/2012 Time: 1305HRS

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

Precision Parameters apply in the determination of the above results. Also please refer to ASTM D 3244-86A, IP/26/93 and IP Standards Appendix E for utilization of test data to determine conformance with specifications.
This report is issued by the Company under its General Terms and Conditions for inspection and testing services. Except by special arrangements, samples if drawn will not be retained by the Company for more than 3 months.

Appendix 3: PNCF granted to the NPF Air-Wing



FEDERAL REPUBLIC OF NIGERIA

NIGERIAN CIVIL AVIATION AUTHORITY

PERMIT NUMBER
NCAA/ATR66/NCF33

NCAA

PERMIT FOR NON-COMMERCIAL FLIGHT (PNCF)

A permit to operate non-commercial flight within and outside Nigeria is hereby granted, pursuant to Section 32 of the Civil Aviation Act 2006, to:

THE NIGERIA POLICE AIRWING

OLD DOMESTIC AIRPORT,
MURTALA MUHAMMED AIRPORT
IKEJA, LAGOS.

for a period of three (3) years with effect from 19th day of November,2010 to operate the following aircraft types:

(i) Bell 206B III
(ii) Bell 222B
(iii) Bell 427
(iv) Bell 412
(v) Bell 429
(vi) Bell 430 and
(vii) Cessna Citation XLS - JET

The operation of these aircraft shall be in compliance with all relevant Civil Aviation Regulations.

DIRECTOR GENERAL

SIGNATURE

The privileges and conditions which form part of this Permit are in the attached annex

NCAA/ATR66/NCF37 DATE: 19th November, 2010

CONDITIONS OF PERMIT FOR NON-COMMERCIAL FLIGHTS:

It shall be a condition of this Permit that:

(a) No additional aircraft shall be operated under this permit without prior approval of the Nigerian Civil Aviation Authority (NCAA);

(b) The aircraft shall not be used for carriage of passenger(s), cargo or mail for hire or reward;

(c) In operating international flights, all flights must leave and enter Nigeria through Customs Airport;

(d) Prior permission of the Nigerian Civil Aviation Authority (NCAA) and the appropriate aeronautical authorities of the foreign countries concerned must be sought before any flight outside Nigeria is undertaken.

(e) The aircraft shall be operated in accordance with all laws, regulations and rules for the time being in force in Nigeria as well as the Standards and Recommended Practices (SARPs) of ICAO.

(f) A monthly return giving details of all flights undertaken during the preceding month shall be submitted to the Federal Ministry of Aviation and NCAA not later than the 15th of the following month and shall include these details:
  (i) date of flight;
  (ii) registration number of aircraft;
  (iii) points between which the flights were conducted;
  (iv) total flying time involved;
  (v) total cargo;
  (vi) total passengers.

(g) Failure to comply with any of the conditions above may result to the revocation or suspension of this Permit.

(h) This Permit may be renewed at the end of three (3) years upon application.

Appendix 4: NCAA and Aviation Fuel Regulations in Nigeria

AVIATION FUEL QUALITY IN NIGERIA

Aviation fuel, specifically Jet fuel (most commonly defined as Jet A-1) is a specialized type of petroleum based fuel used in aircraft turbine engines. Jet A-1 is closely related to kerosene-based products, the usage in jet engines requires high quality production and maintenance of high purity during transport and storage. In addition, Jet A-1 requires the continuous application and monitoring of specialized additives, which prevent biodegradation (build-up of micro-organisms) which could clog fuel systems or the build-up of water particles which potentially leads to ice problems.

The risk of fuel contamination in aviation is well understood around the world. To address the issue, regulators have defined strict standards and procedures for the production, handling, storage, and distribution of aviation fuels. Globally, these standards have ensured safe operations, and only a few recent incidents are known. Nevertheless, fuel contamination is considered a serious threat to aviation safety, as it can easily lead to multiple or all engines of an aircraft stalling.

AVIATION FUEL DISTRIBUTION AND QUALITY CONTROLS IN NIGERIA

The regulation and supervision of aviation fuel distribution and quality controls in Nigeria fall primarily under two governmental entities: the Department of Petroleum Resources (DPR) and the Nigerian Civil Aviation Authority (NCAA).

The distribution starts with the importation of Jet A-1 fuel by DPR from foreign refiners. Interesting to note is the fact that only Jet A-1 is imported of which, a certain part is later distributed for domestic kerosene. When the product leaves the refinery it comes with a quality inspection certificate. Upon arrival of the product at the port of importation in Nigeria, DPR verifies this certificate and ensures the quality meets international standards. According to international practice, Jet A-1 fuel that does not

meet the strict standards for aviation can be sold to the domestic market as kerosene. In addition, DPR can allocate a certain amount of certified Jet A-1 for the domestic kerosene market, for example if the demand for Jet A-1 is low and kerosene demand is higher.

Thereafter the product is distributed to various marketers into their own storage facilities. From there the marketers, using their dedicated trucks that have been specially coated to transport Jet A-1, ship their fuel from the seaport to their storage facility at the airport by passing through Joint Users Hydrant Installation (JUHI) at Murtala Muhammed International Airport, Ikeja. However, if any marketer receives Jet A-1 as domestic kerosene they may at this point haul the fuel as simple kerosene for local distribution, most probably without any further verification and quality control.

The next, most important verification and tests are done at the JUHI before the Jet A-1 fuel is accepted for storage and prior to dispensing into the hydrant. These tests focus primarily on the compliance with ASTM specification or DEF STAN 91-91 for Jet A-1 fuel. The tests include: (a) specific gravity, (b) flash point, (c) conductivity, and (d) melting point. The results obtained are compared with the quality certificates from the refinery and the certificates issued by DPR. Thereafter the fuel goes through various filtrations, visual and water checks before being accepted into the receiving tanks at the JUHI. This conformity tests aim at ensuring that the product accepted into JUHI tanks is of the same quality and standard as that of the refinery. Finally, the fuel then moves through hydrants or fuel trucks to the aircraft, where last step water checks are carried out.

Supervision of the above described procedure lies with these two entities, the DPR and NCAA. DPR is primarily responsible to assure testing is done at the importing port, and supervises distribution to marketers. NCAA is responsible for airport operations, which includes the storage and distribution of fuels at the airport. However, it is unclear if this

includes operations at JUHI, which by nature of its operations should be supervised by DPR.

THE CHALLENGES OF AVIATION FUEL QUALITY IN NIGERIA

The challenge of poor aviation fuel quality has been a significant concern in Nigeria for quite some time. Poorly maintained equipment used for the storage and transportation of jet fuel as well as inappropriate handling practices are cited as major factors. In tropical environments, the presence of hydrocarbon utilizing micro-organisms is a particular problem since they thrive at the interface between water droplets present in the jet fuel.

If Jet A-1 fuel is not stored properly and verified regularly, micro-organisms, which included bacteria and fungi, may grow quickly and contaminate the fuel. That this is in fact an ongoing problem is confirmed by operators in Nigeria reporting that they need to change aircraft fuel filters at between four and ten times the normal frequency because of the microbial contamination alone.

Another, far more serious, quality issue of Jet A-1 fuel quality are recent allegations that certain fuel marketers have sold the domestic product of the so called dual purpose kerosene to airlines as Jet A-1. While domestic kerosene in Nigeria is in fact imported as Jet A-1, but distributed as much cheaper kerosene, the rigid quality requirements for Jet A-1 are not assured. In addition, it is not clear if the kerosene had in fact been supplied via JUHI or directly pumped into aircraft by the operator or supplier. In any case, the usage of domestic kerosene for aviation represents a serious quality infringement, which could lead to engine stalling and accidents.

Both issues, poor storage and maintenance of aviation fuel, as well as the alleged tampering of Jet A-1 with domestic kerosene point at a lack of regulatory supervision of the distribution and supply of Jet A-1 fuel. The fact that two entities of different

ministries are in charge of assuring regulation and supervision of aviation fuel import, storage, and distribution, renders the issue even more challenging.

Appendix 5: Engine Teardown Report from Pratt & Whitney, Canada

Engine Teardown Report

Service Investigation

Pratt & Whitney Canada
A United Technologies Company

Accident / Incident Report

P&WC 8114 (11-98)

Report No.:12-015

Nigerian Police Air Wing

Bell 427 & Registration 5N-POL

Jos, Plateau, Nigeria

March 14, 2012

PW207D

S/N BF0081 / BF0082

Written By:

Service Investigation Department

Approved By:

Manager, Service Investigation Department

Date of Issue: August 26, 2014

Distribution :

File 12-015

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Service Investigation

Pratt & Whitney Canada
A United Technologies Company

Accident/Incident Report P&WC 8114 (11-98)

Report No.: 12-015

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I ANALYSIS

1.0 ACCIDENT SYNOPSIS

On 14 March 2012 at 10h58 following a morning flight over Jos metropolis, the helicopter landed at the Jos prison football field for refuelling from the Police fuel bowser. At about 11h25, the helicopter departed from the Jos prison football field with 2 crew's members & 2 passengers. At 11h25 the Jos Control Tower was notified through a phone call that 5N-POL had crashed with 4 fatalities. The aircraft hit two houses before contacting the ground and finished its journey against a third one. The helicopter suffered substantial damage resulting from impact and post impact fire. The Nigerian Accident Investigation Bureau (AIB) decided to send the engine at P&WC for further investigation.

2.0 SUMMARY OF FINDINGS

The engines were received at P&WC Saint-Hubert Service Centre packed together in a wooden box (Photos No.1 & 2). Engine s/n BF0081 was upside down in the box.

Photo No.1

Photo No.2

The starboard engine s/n BF0082 was torn down on April 1st and 2nd, engine BF0081 (Port side) teardown was initiated on April 2nd and completed on 3rd. Both engines compressor (Ng) and power turbine (Npt) rotor were free to rotate; external overall condition shows evidence of impact damages and post impact fire damages. Inlet, compressor and diffuser areas revealed the presence of dust and dirt ingested following impact. Ingestion level was higher on engine BF0082 possibly due to the fact that the helicopter hit a earth brick built house on its starboard side. Combustion liners were in good condition. Compressor turbine (CT) vane ring displayed burning with melted and splattered material at airfoil and outer rim and the turbine support cases displayed burning and melted material, theses damages were located at 5 o'clock on engine BF0082 and at 8 o'clock on engine BF0081. C.T. blades and C.T. shroud segments were severely damaged, it is suspected to be from exposure to residual accumulated fuel burning and torching inside engine core while engine Ng was spooling down post impact. Power turbine (PT) vane ring displayed burning and melted material that was in line with CT vane ring damages. The PT blades displayed splattered material. PT disks were unremarkable.

Both engines internal P3 air passage from gas generator case to Fuel Management Module were verified and found free of contaminant.

Both reduction gearbox were in unremarkable condition.

Testing of engines accessories did not reveal any anomalies which would have prevented normal operation of engine prior to the event.

Residual fuel analysis collected from engine BF0082 filter bowl did not reveal any anomalies that would have prevented normal operation prior to the event.

3.0 DISCUSSION

Based on engine dust and dirt ingestion, cold section and liners unremarkable condition (making abstraction of dirt), the high velocity impact on CT shroud segments resulting from the CT blades fractures, the cleanliness of the CT blades tip fracture versus the airfoil; it is believed that both engines were still producing power at moments of impact. This suggests that the damage observed to hot section components were secondary to the event and occurred after the aircraft impact. It is believed this damage occurred from exposure to residual fuel burning and torching inside the engine core. Based on pictures from the crash site, engines BF0081 and BF0082 hot section non-matching burning angle location is believed to have resulted from the fact that the helicopter hit the house on its starboard side. Due to a high level of dirt ingestion, engine s/n BF0082 (starboard) combustion efficiency was reduced and this hot section burnt before the aircraft tilted on its port side, while engine s/n BF0081 (port) was still burning residual fuel inside its core.

4.0 CONCLUSION

Engine components and accessories review did not show any anomalies that would have prevented the engines' normal operations prior to the event. Therefore, based on observations, the engines were still producing power at the moment of the impact. However, it is not possible to establish the power level at the moment of impact.

II FACTUAL INFORMATION

1.0 INVESTIGATION PARTICIPANTS

The investigation on the Engines was performed on 1-3 April 2014 at the Pratt & Whitney Canada (P&WC) Service Investigation Facilities at Saint-Hubert, Quebec, Canada. The following individuals participated in the investigation as representatives of their respective organisations:

Air Safety Investigator

Accident Investigation Bureau, Nigeria

Investigator

Accident Investigation Bureau, Nigeria

Accessories Investigator

Pratt & Whitney Canada

Service Investigation

Pratt & Whitney Canada

Service Investigation

Pratt & Whitney Canada

2.0 LEFT HAND ENGINE HISTORY

PW207D S/N BF0081

Hours Since New: 388.4 hrs.

Cycles Since New: Unknown

Hours Since Overhaul: Not applicable

Cycles Since Overhaul: Not applicable

The engine logbook was not available for review.

3.0 LEFT HAND ENGINE EXAMINATION

All positional references are in relation to view from aft looking forward. Upstream and downstream references are in relation to gas path flow from the compressor inlet to exhaust.

3.1 External Condition

The engine was removed from the wooden box and installed on a disassembly stand for detailed inspection. The data plate confirmed the engine serial number (Photos No.3 & 4). Airframe related components were still installed on engine;

starter generator, front engine mounting rod, oil pressure and temperature sensors (Photo No.5), rear airframe fire seal, P3 bleed tube (Photo No.6) and rear airframe mounting rod (Photo No.7).

Photo No.3

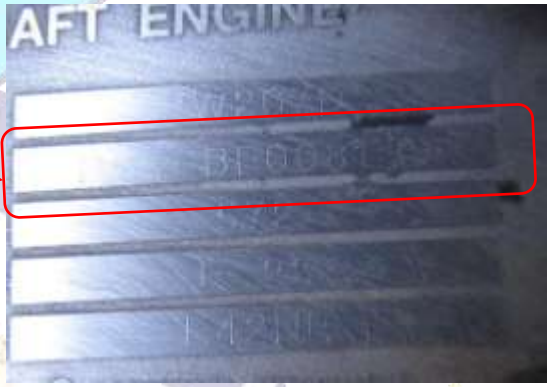

Photo No.4

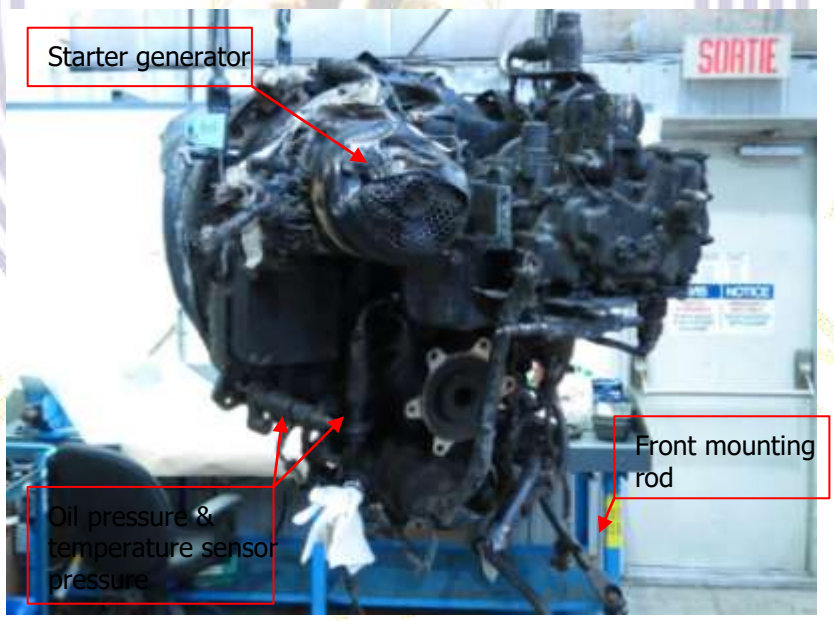

Photo No.5

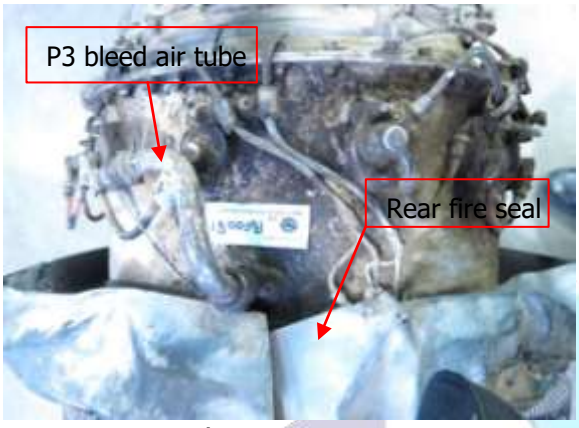

Photo No.6

Photo No.7

The engine was entirely exposed to post impact fire, the external components displayed soot stain. The fuel manifold, the fuel pump inlet and outlet tubes silicon cuff was completely melted (Photos No.8 & 9). The Fuel Management Module (FMM) vapour box was disintegrated (Photo No. 10). The inlet screen, the front and rear engine fire seals displayed impact and post impact crash fire damage (Photo No.11). The engine harness and connectors displayed fire damage (Dotted arrow Photo No.12). The engine harness connectors were still engaged to their terminals (Photos No. 12 & 13).

Photo No.8

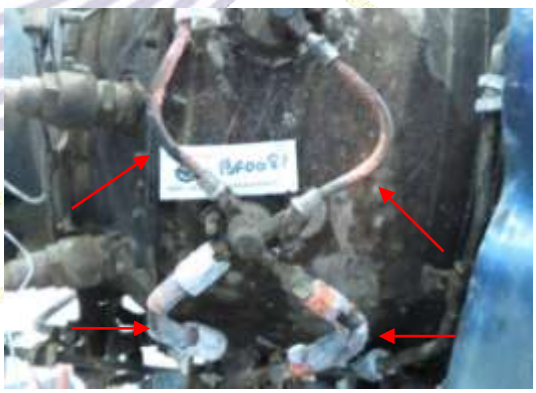

Photo No.9

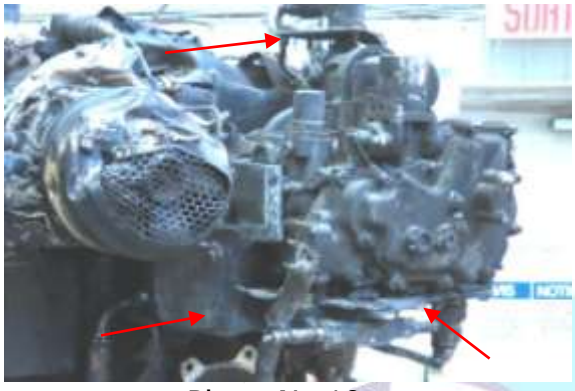

Photo No.10

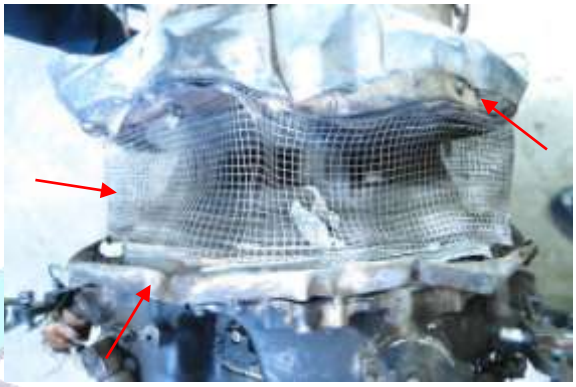

Photo No.11

Photo No.12

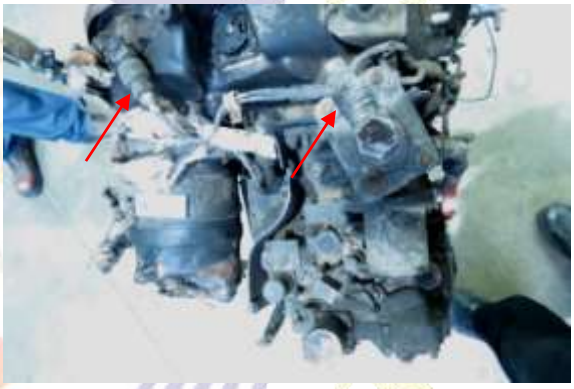

Photo No.13

3.1.1 **External Cases**

Turbine Exhaust Case: The turbine exhaust case displayed environmental dust and soot stain, otherwise it was unremarkable.

Turbine Support Case: The turbine support case external surface displayed environmental dust and soot stain (Photo No.14).

Photo No.14

Gas Generator Case: The gas generator case displayed dust, soot stain and deformation due to impact damage at the 10 o'clock position (Photo No.15).

Photo No.15

Diffuser case: The diffuser case displayed soot on external surface (Photo No.16).

Photo No.16

Inlet case: The inlet case displayed soot and dust stain on the external surface (Photo No.17), showing apparent damage to the external surface.

Reduction gearbox front housing: The front reduction gearbox housing displayed soot stain.

3.1.2 **Pneumatic Lines**

Compressor Discharge Air (P3): The FMM P3 feed line, was still properly installed and lock wired to the #8 bearing carbon seal cover (Photo No.18) but it was partially released at the FMM connector due to post impact fire damage (Photo No.19).

Photo No.18

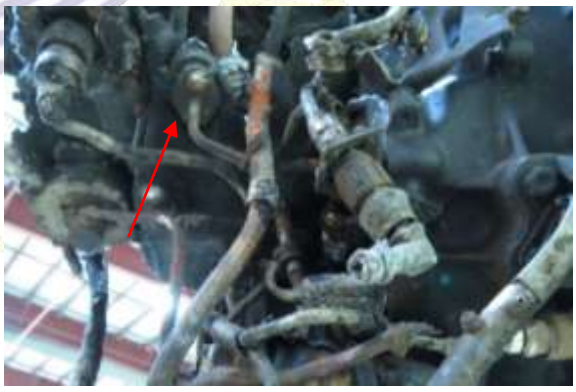

Photo No.19

3.1.3 **Chip Detector and Filter**

Reduction Gearbox Chip Detector: Was seized into the RGB front housing. (Photo No.20)

Oil Filter: Clean (Photo No.21)

Photo No.20

Photo No.21

3.2 **Disassembly Observations** (Internal components)

3.2.1 **Compressor Section**

Inlet Screen: The compressor inlet screen displayed deformation at wire mesh and melted outer rubber sealing bands (Photo No.22).

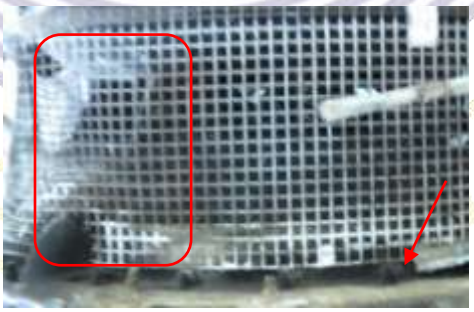

Photo No.22

Inlet Case: The inlet case displayed heavy dust stain at inlet area (Photo No.23).

Photo No.23

Centrifugal Impeller: The centrifugal impeller displayed foreign object damage and dirt deposit at inlet vane (Photo No.24), otherwise it was unremarkable. The impeller back face was unremarkable (Photo No.25). There was no pre or post impact rubbing indication.

Photo No.24

Photo No.25

Centrifugal Impeller Shroud: The impeller shroud displayed dirt deposit at abraidable surface and at damper pocket (Photo No.26).

Photo No.26

No. 3 Bearing Air seal: The seal was in good condition.

No. 3 Bearing and flex housing: The #3 ball bearing and adjacent hardware were unremarkable (Photo No.27).

Photo No.27

Diffuser Case: The diffuser case displayed light foreign object damage at apex area and combustion soot at P3 area (Photo No.28).

Photo No.28

Gas Generator Case: The gas generator case displayed dirt deposit and post impact fire soot stains (Photo No.29).

Photo No.29

3.2.2 **Combustion Section**

Combustion Chamber Liners: The inner and outer liners displayed soot on external surface due to post impact internal fire into the gas generator core area (Photos No.30 & 31).

Photo No.30

Photo No.31

3.2.3 **Turbine Section**

Compressor Turbine (CT) Disk & Blades: The CT blades displayed burning, flaked surface coating at airfoil tips (Photos No.32 & 33), impact damage and dirt deposit at airfoil surface. The C.T. disk was unremarkable (Photo No.34).

Photo No32

Photo No.33

Photo No.34

Compressor Turbine Vane Ring: The CT vane ring displayed burning with splattered and melted material at airfoil and outer rim at 8 o'clock position (Photos No.35 to 38).

Photo No.35
Trailing edge side

Photo No.36
Trailing edge and outer rim

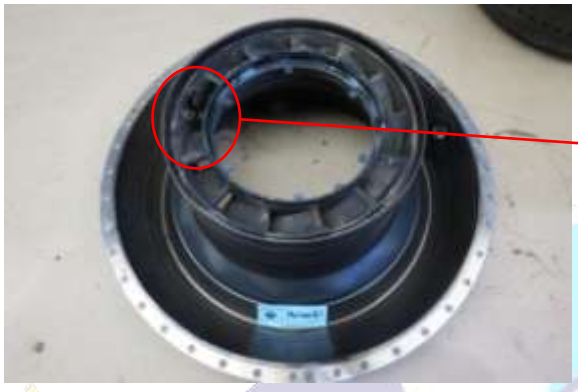

Photo No.37
Leading edge side

Photo no.38
Leading edge side

Compressor Turbine Shroud Segments: The CT shrouds segments displayed burning associated with splattered material and impact damage at 8 o'clock position (Photos No. 39 & 40).

Photo No.39

Photo No.40

Turbine Support Case: The turbine support case displayed burning and melted material at CT shroud segments retaining lip area and CT vane seal ring sealing diameter 8 o'clock position (Photo No.41).

Photo No.41

Power Turbine (PT) Vane Ring: The power turbine vane ring displayed burning, splattered and melted material at airfoil and outer rim leading edge side at 8 o'clock (Photos No. 42 & 43). The PT vane ring honey comb seal displayed rubbing indication.

Photo No.42

Photo No.43

Power Turbine Disk and Blades: The PT blades displayed impact and splattered material at blades airfoil (Photos No.44 & 45). The PT blades shroud knife edge displayed light rubbing indication.

Photo No.44

Photo No.45

Power Turbine Shaft: The PT shaft was unremarkable.

Turbine Exhaust Case: The turbine exhaust case displayed cooked oil deposit at #5 bearing area (Photo No.46) and soot at gas path (Photo No.47).

Photo No.46

Photo No.47

3.2.4 Reduction Gearbox (RGB)

Rear Housing: The rear RGB housing and installed hardware were visually unremarkable (Photos No.48 & 49).

Photo No.48

Photo No.49

Front Housing: The front RGB housing, the reduction gear train, the no. 1, 2 & 6 to 16 bearings and the accessory gearbox hardware were visually unremarkable (Photo No.50).

Photo No.50

Oil Pump Assembly: The oil pump pack was unremarkable (Photo No.51).

Photo No.51

3.3 **Controls and Accessories Evaluation**

Note: The sub-paragraph only contains visual observation of the accessories. The accessories in the sub-paragraphs were tested using their appropriate components maintenance manual test procedure. The finding did not reveal anomalies that would have prevented normal operation of the accessories prior to the event (refer. Accessories Accident Report, RFA14AH00002A).

3.3.1 Ignition **System**

Exciter Box: The exciter box was not received with the engine.

Ignition Leads: The ignition leads were consumed due to post impact fire, the igniters' terminal ferrule displayed soot-stain and surface corrosion (Photo No.52).

Photo No.52

Igniters: The igniters displayed soot-stains**.** Electrode erosion was normal for engine total accumulated time.

3.3.2 **Fuel System**

Fuel Management Module (FMM): The exterior of the fuel management module (FMM) was blackened, ash and soot was attached to the exterior, impact damages were observed, and the fireshield had been partially consumed by the post impact fire (Photo No.53). FMM by-pass switch/indicator and power lever potentiometer were loose and could be moved by hand. There was no fuel remaining in the filter bowl and the filter element had been damaged by the post impact fire, but there was no debris visible in the pleats. Lockwire was present at all locations.

Photo No.53

The FMM was installed with a slave fuel filter on the test stand; it was observed that fuel was leaking from the cover and the overboard drain. The cover was removed and the packing gasket was found to be heat-damaged (Photo No.54). A new gasket was installed and the prior test repeated and further leaks were observed, indicating that it would not be possible to conduct the test sequence. The electrical tests were completed. The FMM was disassembled, no major discrepancies were observed.

Photo No.54

Chemical analysis was conducted on the contents of the original fuel filter, and slave fuel filter elements. Carbon was present on the original filter due to heat-exposure during the post impact fire. The slave filter-element contained metallic particles made up of iron based alloy similar to stainless steel and carbon-steel, molybdenum and traces of calcium and silicon. This was suggestive of normal component wear. There were no anomalies evident that would have prevented normal operation of the FMM prior to the event.

Flow Divider Valves (FDV): The exterior of the flow divider valve (FDV) and the heat-shield were discoloured due to heat exposure (Photo No.55). Burned residue was present in the fuel ports. Chemical analysis of the residue indicated that it was composed of carbon with fluorine, suggesting that it was burned packing. Lockwire was present at the inlet adapter mounting. It was not possible to conduct a complete test as the FDV was leaking. However, the limited testing that was possible indicated that the flow divider functioned to transfer fuel pressure between primary, secondary and dump. The FDV was disassembled, the internal components were blackened and the packing had been damaged by the post impact fire (Photo No.56). There were no scratches observed on the interior or exterior surfaces of the valves or in the bores of the housing that would have prevented normal operation of the FDV prior to the event.

Photo No.55

Photo No.56

Fuel Nozzles: Carbon deposits were present on the nozzle tips. The stains were heavier at the No. 3, 6, 9, 10 nozzles (Photo No.57). Since combustion liner did not show indication of abnormal burning into gas path, that carbon deposit is believed to be due to post impact fuel residue burning. Burned residue was present in the inlet strainer of the No. 2, 4, 6 and 11 nozzles (Photo No.58). Chemical analysis of debris collected on strainers nozzles was mainly composed of carbon with fluorine (suggestive of burned packing material). The nozzles were bench tested, the deviation observed were secondary to post impact fire. .

Photo No.57
Nozzle No. 6 tip

Photo No. 58
Nozzle No. 6 strainer

Fuel Heater (FOHE): The exterior was soot-stained. There was burned residue and fibres adhering to the exterior. There were no blockages visible in the core.

3.3.3 **Indicating System**

Inlet temperature (T1) thermocouple: The exterior of the engine inlet (T1) thermocouple was soot-stained. The inside of the electrical connector was heat-damaged (Photo No.59). The T1 thermocouple was bench tested, deviation observed were secondary to post impact fire.

Photo No.59

Gas Generator (Ng) speed sensor: The exterior of the Ng speed sensor was soot-stained. Burned debris was present inside the electrical connector and the rubber seal was heat-damaged. There was melted residue adhering to the exterior of the electrical connector shell. The cover at the sensor housing was missing (Arrow Photo No.60). The Ng sensor was bench tested, deviations observed were secondary to post impact fire.

Photo No.60

Power turbine (Npt) speed sensor: The exterior of the Npt speed sensor was soot-stained. Burned, damp debris was present inside the electrical connector and the rubber seal was heat damaged (Photo No.61). The Npt speed sensor was bench tested, deviation observed were secondary to post impact fire.

Photo No.61

Engine Torque (Tq) sensor: The exterior of the Tq sensor was soot-stained. Dry debris including melted seal material was present inside the electrical connector. The rubber seal in the electrical connector had been damaged by the post impact fire (Photo

No.62). The Tq sensor was bench tested, deviation observed were secondary to post impact fire.

Photo No.62

ITT Probes and T6 Harness: The T6 left and right harnesses were exposed to external engine fire and were soot-stained.

Engine Harness: The exterior of the wiring harness was damaged by the post impact fire. The harness had been cut. The rubber and plastic components had been damaged by the post impact fire. There were no legible markings on the rubber sleeves. Fluid was seeping from the insulation (the engine had been placed upside down in the transit box permitting oil to escape from the gearbox which impregnated the harness).

4.0 RIGHT HAND ENGINE HISTORY

PW207D S/N BF0082

Hours Since New: 388.4 hrs.

Cycles Since New: Unknown

Hours Since Overhaul: Not applicable

Cycles Since Overhaul: Not applicable

The engine logbook was not available for review.

5.0 RIGHT HAND ENGINE EXAMINATION

All positional references are in relation to view from aft looking forward. Upstream and downstream references are in relation to gas path flow from the compressor inlet to exhaust.

5.1 External Condition

The engine was removed from the wooden box and installed on a disassembly stand for detail inspection. The data plate confirmed the engine serial number (Photos No.63 & 64). Airframe related components were still installed on engine; starter generator, oil pressure and temperature sensors (Photo No.65), the rear airframe fire sealand the P3 bleed tube (Photo No.66).

Photo No.63

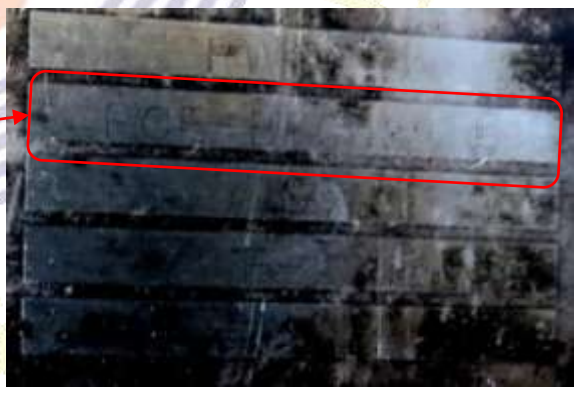

Photo No.64

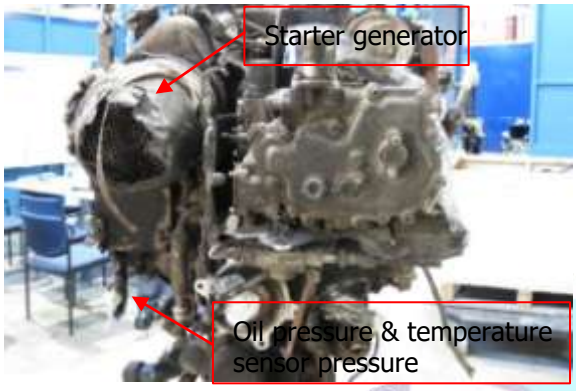

Photo No.65

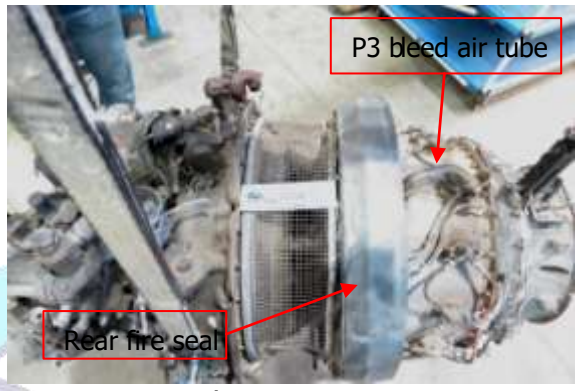

Photo No.66

The engine was entirely exposed to post impact fire, external components displayed soot stains. The fuel manifold silicon cuff was completely melted (Photo No.67). As received, the fuel pump inlet and outlet tubes were disconnected (Arrows Photo No.68) and the fuel filter cover locking pin was removed (Dotted arrow Photos No.68), the Fuel Management Module (FMM) vapour box was disintegrated (Photo No.69). The inlet screen and the engine front and rear fire seals displayed impact and fire damage (Photo No.70). The engine harness and connectors displayed fire damage (Arrow Photos No.71 & 72). The engine harness connectors were still engaged to their terminals (Dotted arrow Photo No. 72).

Photo No.67

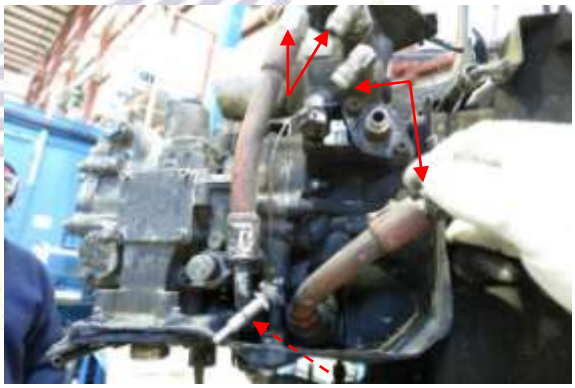

Photo No.68

Photo No.69

Photo No.70

Photo No.71

Photo No.72

5.1.1 **External Cases**

Turbine Exhaust Case: The turbine exhaust case displayed environmental dust stain and impact damage at the 3 o'clock position (Photos No.73 & 74).

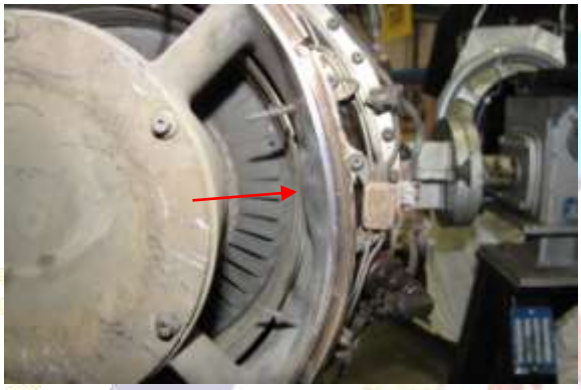

Photo No.73

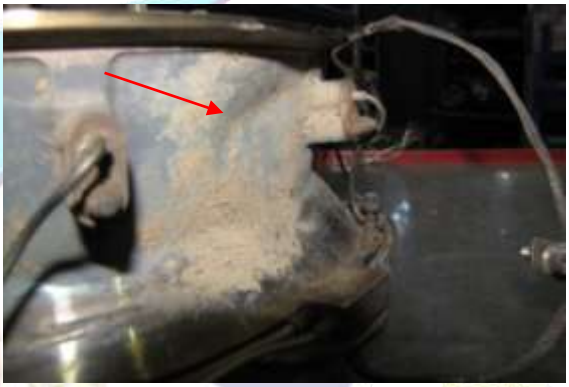

Photo No.74

Turbine Support Case: The turbine support case external surface displayed environmental dust and soot stain.

Gas Generator Case: The gas generator case displayed dust and soot stain (Photo No.75).

Photo No.75

Diffuser case: The diffuser case displayed dust and soot stain on external surface.

Inlet case: The inlet case displayed heavy dust deposit at inlet area (Photo No.76).

Photo No.76

Reduction gearbox rear housing: The rear reduction gearbox housing showed no apparent damage to the external surface.

Reduction gearbox front housing: The front reduction gearbox housing displayed soot stains.

5.1.2 **Pneumatic Lines**

Compressor Discharge Air (P3): The FMM P3 feed line from the #8 bearing carbon seal cover nipple to the FMM, was still properly installed and lock wired (Photo No.77). It was, however, partially released at the FMM connector due to post impact fire damage (Photo No.78).

Photo No.77

Photo No.78

5.1.3 **Chip Detectors and Filter**

Reduction Gearbox Chip Detector: The reduction gearbox chip detector was melted due to post impact fire (Photo No.79).

Photo No.79

Oil Filter: Clean (Photo No.80).

Photo No.80

5.2 Disassembly Observations

5.2.1 Compressor Section

Inlet screen: The compressor inlet screen displayed deformation at the wire mesh and melted outer rubber sealing bands.

Centrifugal Impeller: The centrifugal impeller inducer side displayed foreign object damage and heavy dirt deposit (Photo No.81), otherwise it was unremarkable. The impeller back face was unremarkable. There was no pre or post impact rubbing indication.

Photo No.81

Centrifugal Impeller Shroud: The impeller shroud displayed dirt on the abraidable surface (Photo No.82). The damping cavities also displayed dirt deposits (Photo No.83).

Photo No.82

Photo No.83

No. 3 Bearing Air seal: The seal was in good condition.

No. 3 Bearing and flex housing: The #3 ball bearing and adjacent hardware were unremarkable (Photo No.84).

Photo No.84

Diffuser Case: The diffuser case displayed foreign object damage and dirt deposit at the apex and P3 area (Photos No.85 & 86).

Photo No.85

Photo No.86

Gas Generator Case: The gas generator case displayed dirt deposit on the inner wall (Photo No.87).

Photo No.87

5.2.2 **Combustion Section**

Combustion Chamber Outer Liner: The outer liner displayed coating loss (Arrow Photo No.88) and carbon build-up (Dotted arrow Photo No.88); otherwise was unremarkable (Photo No.89).

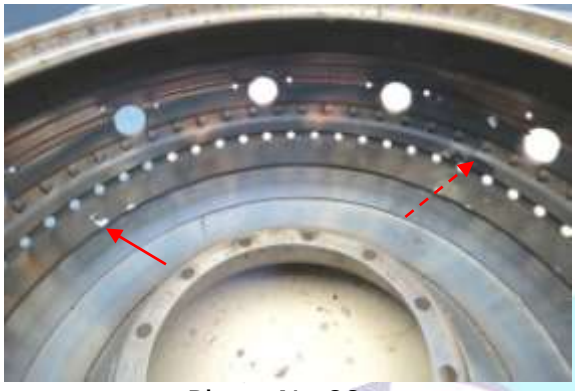

Photo No.88

Photo No.89

Combustion Chamber Inner Liner: The inner liner displayed coating loss (Arrow Photo No.90) and carbon build-up (Dotted arrows Photo No.90); otherwise it was unremarkable.

Photo No.90

5.2.3 **Turbine Section**

Compressor Turbine (CT) Disk & Blades: The CT blades displayed fractured tips (Photo No.91 & 92), flaked surface coating (Arrow Photo No.92), and heavy dirt deposit at airfoil surface (Photo No.93). The absence of dirt deposit on the CT blade tips indicates that the fractures occurred later following the aircraft ground impact and dirt ingestion. The CT disk was unremarkable (Photo No.94).

Photo No.91

Photo No.92

Photo No.93

Photo No.94

Compressor Turbine Vane Ring: The CT vane ring displayed burning with melted and splattered material at the airfoil and outer rim at 5 O'clock (Photos No.95 to 97).

Photo No.95

Photo No.96

Photo No.97

Compressor Turbine Shroud: The CT shrouds segments displayed burning associated with splattered material and impact damage at the 5 o'clock position (Photos No. 98 & 99).

Photo No.98

Photo No.99

Turbine Support Case: The turbine support case displayed dirt deposit (Photo No.100), post impact fire burning, and soot at 5 O'clock (Photo No.101).

Photo No.100

Photo No.101

Power Turbine (PT) Guide Vane Ring: The power turbine vane ring displayed burnt, splattered and melted material at airfoil and outer rim at 5 o'clock (Photos No.102 & 103). The PT vane ring honey comb seal displayed rubbing and burning indication (Photo No.104).

Photo No.102

Photo No.103

Photo No.104

Power Turbine Disk and Blades: The PT blades displayed impact and splattered material at airfoil (Photo No.105). The PT blades shroud knife edge displayed rubbing indication (Photo No.106).

Photo No.105

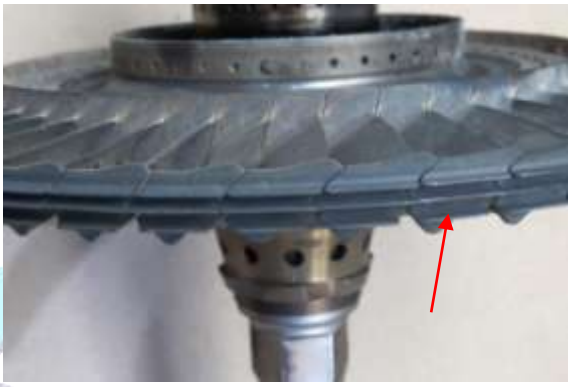
Photo No.106

Power Turbine Shaft: The PT shaft was unremarkable.

5.2.4 Reduction Gearbox (RGB)

Rear Housing: The rear RGB housing and installed hardware was visually unremarkable (Photos No.107 & 108).


Photo No.107


Photo No.108

Front Housing: The front RGB housing, the reduction gear train, the no. 1, 2 & 6 to 16 bearings and the accessory gearbox hardware were visually unremarkable (Photo No.109).

Photo No.109

Oil Pump Assembly: The oil pump pack was unremarkable (Photo No.110).

Photo No.110

5.3 **Controls and Accessories Evaluation**

Note: The sub-paragraph only contains visual observation of the accessories. The accessories in the sub-paragraph were tested using their appropriate components maintenance manual test procedure. The finding did not show defect evident that would have prevented normal operation of the accessories prior to the event (refer. Accessories Accident Report, RFA14AH00002A).

5.3.1 Ignition System

Exciter Box: The exciter box was not received with the engine.

Ignition Leads: Only one ignition lead was received, it was consumed due to post impact fire.

Ignition Plugs: Only one igniter was received and showed soot-stained. Electrode erosion was normal for the engine total accumulated time.

5.3.2 Fuel System

Fuel Management Module (FMM): The exterior of the fuel management module (FMM) was blackened, and the fire-shield had been partially consumed by the post impact fire (Photo No.111). The locknuts at the airframe power lever cable/cam-box were loose and the fittings could be turned by hand. The bypass switch/indicator and the power lever potentiometer were loose and could be moved by hand. The filter dowel retaining pin was not in the drain-port. On removal of the fuel filter, a small amount of fuel that was present was collected. There was soot present in the fuel, but no evidence of water. The filter element was darkened, but there was no debris visible in the pleats. Lockwire was missing from the power lever cam-box locknut. Lockwire was present at all other locations. A slave filter was installed and the FMM was tested.

Photo No.111

Chemical analysis of the contents of the original fuel filter element confirmed the presence of iron based particles with silicon and traces of aluminium. Chemical analysis of the contents of the slave fuel filter element confirmed the presence of aluminium with traces of sodium. There were no anomalies evident that would have prevented normal operation of the FMM prior to the event.

Flow Divider Valves (FDV): The exterior of the flow divider valve (FDV) and the heat-shield were discoloured due to heat exposure (Photo No.112). Burned residue was present in the fuel ports. Chemical analysis of the residue indicated that it was composed of carbon with fluorine, suggesting that it was burned packings. Lockwire was present at the inlet adapter mounting.

It was not possible to conduct a complete test as the FDV was leaking. The limited testing that was possible indicated that the flow divider did not transfer fuel pressure between primary, secondary, and dump.

The FDV was disassembled (Photo No.113) to determine the cause of the observations recorded during testing. The internal components were blackened and the packing's had been damaged by the post impact fire. There were no scratches observed on the interior or exterior surfaces of the valves or in the

bores of the housing. The transfer valve movement was restricted due to the burned packings. There were no defects evident that would have prevented normal operation of the FDV prior to the event

Photo No.112

Photo No.113

Fuel Nozzles: Brick debris was present between many of the nozzle sheaths and stems (Photo No.114). Carbon deposit was present on the nozzle tips (Photo No.115). Since the combustion liner did not show indication of abnormal burning into the gas path, that carbon deposit is believed to be due to post impact fuel residue burning. Burned residue was present in the inlet strainer of the No. 3 and 5 nozzles (Photo No.116). Chemical analysis of debris from the strainers was composed of carbon with various levels of silicon, aluminium, fluorine, iron, calcium, and potassium. The nozzles were bench tested, the deviations observed were secondary to post impact fire.

Photo No.114

Photo No.115

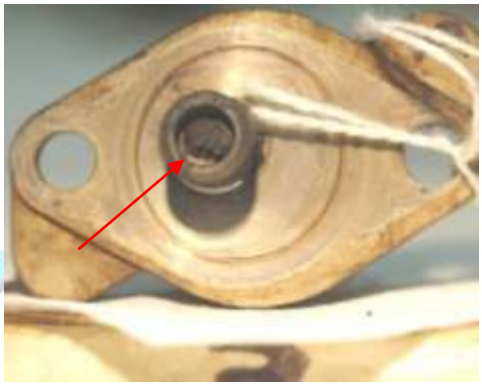

Photo No.116

Fuel Heater: The exterior was soot-stained. There were no blockages visible in the core.

5.3.3 **Indicating System**

Inlet Temperature (T1) thermocouple: The exterior of the engine inlet-temperature (T1) thermocouple was soot-stained. The inside of the electrical connector was heat-damaged and the seal was melted and cracked. The T1 thermocouple was bench tested, deviations observed were secondary to post impact fire.

Gas Generator (Ng) speed sensor: The exterior of the gas-generator (Ng) speed sensor was soot stained, burned, damp debris was present inside the electrical connector, and the rubber seal was heat-damaged (Photo No.117). The Ng speed sensor was bench tested, deviations observed were secondary to post impact fire.

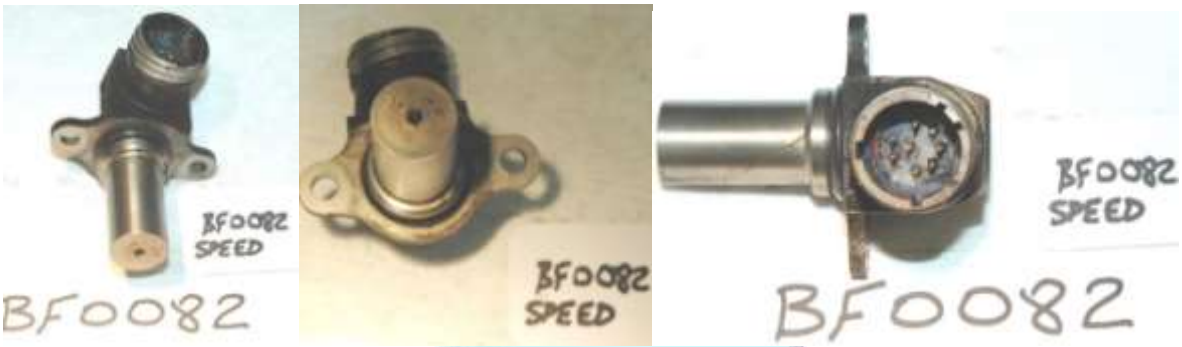

Photo No.117

Power Turbine (Npt) speed sensor: The exterior of the power-turbine (Npt) speed sensor was soot-stained, burned, damp debris was present inside the electrical connector and the rubber seal was heat-damaged. All connector pins were dirty (Photo No.118). The Npt speed sensor was bench tested, deviations observed were secondary to post impact fire.

Photo No.118

Engine Torque (Tq) sensor: The exterior was soot-stained. Dry debris and burned sealing material was present inside the electrical connector (Photo

No.119). The torque sensor was bench tested, deviations observed were secondary to post impact fire.

Photo No.119

ITT Probes and T6 Harness: The T6 left harness displayed one bent T6 probe (Photo No.120) otherwise both harnesses were visually unremarkable.

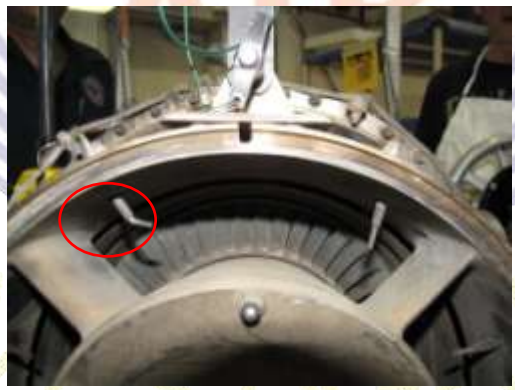

Photo No120

Engine Harness: The exterior of the wiring harness was damaged by the post impact fire. The harness was found cut. The rubber and plastic

components were damaged by the post impact fire. There were no legible markings on the rubber sleeves.


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