



AIRCRAFT ACCIDENT REPORT

DANA/2012/06/03/F

Accident Investigation Bureau

**Report on the Accident to
DANA AIRLINES NIGERIA LIMITED
Boeing MD-83 aircraft with registration 5N-RAM
which occurred at Iju-Ishaga Area of Lagos State,
Nigeria
On 3rd June 2012**



This Report is produced by the Accident Investigation Bureau (AIB), 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.

It is not the purpose of aircraft accident/serious incident investigations to apportion blame or liability.

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

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

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

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

ABV	Abuja
AFM	Aircraft Flight Manual
AGL	Above ground level
AIB	Accident Investigation Bureau
ATB	Air Turn Back
ATC	Air Traffic Controller
ATPL	Air Transport Pilot Licence
C of A	Certificate of Airworthiness
CB	Circuit Breaker
CRM	Crew Resource Management
CSD	Constant Speed Drive
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
DNA	Deoxyribonucleic Acid
ERAMI	Waypoint
ESN	Engine Serial Number
FAA	Federal Aviation Administration
FAAN	Federal Airport Authority of Nigeria
FDR	Flight Data Recorder
FEGV	Fan Exit Guide Vane
FH	Flight Hour



FO	First Officer
FRSC	Federal Road Safety Corps
FSC	Fuel System Components
GSM	Global System for Mobile
IFR	Instrument Flight Rules
IFSD	In Flight Shut Down
IGVs	Inlet Guide Vanes
ILS	Instrument landing System
LDP	Landing Decision Point
LOS	Lagos
MEL	Minimum Equipment List
MRO	Maintenance Repair Overhaul
NAMA	Nigeria Airspace Management Agency
NCAA	Nigerian Civil Aviation Authority
NEMA	National Emergency Management Agency
NDB	Non Directional Beacon
NTSB	National Transportation Safety Board
OCC	Operations Control Centre
PAIFA	PANAM Aviation International Flight Academy
PHCN	Power Holdings Company of Nigeria
PF	Pilot Flying
PIC	Pilot in Command



PM	Pilot Monitoring
QNH	Airfield Pressure corrected for sea level
QRC	Quick Reference Checklist
QRH	Quick Reference handbook
RT	Radio Telephony
SB	Service Bulletin
SMS	Safety Management System
SOP	Standard Operating Procedure
TSN/CSN	Time Since New/Cycles Since New
TSO/CSO	Time Since Overhaul/Cycles Since Overhaul
UER	Unscheduled Engine Removal
VHF	Very High Frequency
VMC	Visual Meteorological Condition
VOR	Very High Omni-directional Range
VSI	Vertical Speed Indicator
WX	Weather



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Aircraft Accident Report No: DANA/2012/06/03/F

Registered Owner and Operator: Dana Airlines (Nig.) Ltd.

Manufacturer: Boeing Company, USA

Model: MD-83

Nationality: Nigerian

Registration: 5N-RAM

Place of Accident: Iju-Ishaga Area Of
Lagos State

Date And Time: 3rd June 2012 at about
1545:00hrs.
*All times in this report are
local times (equivalent to
UTC+1) unless otherwise
stated*

Location: N 06° 40.310' E 003° 18.837'
Elevation 177ft

SYNOPSIS:

Accident Investigation Bureau (AIB) was notified by the Federal Airport Authority of Nigeria (FAAN) Fire Service section at about 1605:00hrs on 3rd June 2012, of an accident involving a Dana Airlines Boeing MD-83 aircraft with registration 5N-RAM at Iju-Ishaga area of Lagos.

Air Safety Investigators were dispatched to the scene of the accident and investigation commenced immediately. All appropriate stakeholders were notified accordingly.

In accordance with International Civil Aviation Organization (ICAO) Annex 13, the National Transportation Safety Board (NTSB) of the United States of America (USA),



representing the State of Design and Manufacture of the aircraft, appointed an Accredited Representative along with a team of experts from Federal Aviation Administration (FAA), the Boeing Company and Pratt & Whitney USA.

The operator co-operated with the investigation and provided assistance as required. The Nigerian Civil Aviation Authority (NCAA) was kept informed of developments.

On 3rd June 2012 at about 1545:00hrs, 5N-RAM, a Boeing MD-83, a domestic scheduled commercial flight, operated by Dana Airlines Nigeria Limited as flight 0992 (DANACO 0992), crashed into a densely populated area. Engine number 1 lost power seventeen minutes into the flight with a further loss of power on number 2 engine on final approach to runway 18R at Murtala Muhammed Airport, Lagos, Nigeria. Visual Meteorological Conditions (VMC) prevailed at the time and the airplane was on an Instrument Flight Rules (IFR). All 153 persons onboard the airplane, including six crew were fatally injured. There were also six confirmed ground fatalities. The airplane was destroyed. There was post impact fire. The flight originated from Abuja (ABV) and the destination was Lagos (LOS).

AIB published a preliminary report on 5th September, 2012 and four interim statements have been published.

Four Interim Safety Recommendations were made and have been implemented by the Operator and the Regulatory Authority.

The investigation identified the following:

Probable Causal Factors:

1. Engine number 1 lost power seventeen minutes into the flight, and thereafter on final approach, Engine number 2 lost power and failed to respond to throttle movement on demand for increased power to sustain the aircraft in its flight configuration.



2. The inappropriate omission of the use of the Checklist, and the crew's inability to appreciate the severity of the power-related problem, and their subsequent failure to land at the nearest suitable airfield.

3. Lack of situation awareness, inappropriate decision making, and poor airmanship.

Eight Safety Recommendations were made.



1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 3rd June, 2012 at about 1545:00hrs, 5N-RAM, a Boeing MD-83, a domestic scheduled commercial flight, operated by Dana Airlines (Nig.) Limited as flight 0992 (DANACO 0992), crashed into a densely populated area of Iju-Ishaga, a suburb of Lagos, following engine number 1 loss of power seventeen minutes into the flight and engine number 2 loss of power while on final approach to Murtala Muhammed Airport Lagos, Nigeria. Visual Meteorological Conditions prevailed at the time and the airplane was on an instrument flight plan. All 153 persons onboard the airplane, including the six crew were fatally injured. There were also six confirmed ground fatalities. The airplane was destroyed. There was post impact fire. The flight originated at Abuja (ABV) and the destination was Lagos (LOS).

The airplane was on the fourth flight segment of the day, consisting of two round-trips between Lagos and Abuja. The accident occurred during the return leg of the second trip. DANACO 0992 was on final approach to runway 18R at LOS when the crew declared a Mayday call "Dual Engine Failure – negative response from the throttles." According to records, the flight arrived ABV as Dana Air flight 0993 at about 1350:00hrs and routine turn-around activities were carried out.

DANACO 0992 initiated engine start up at 1436:00hrs. Abuja Control Tower cleared the aircraft to taxi to the holding point of runway 04. En-route ATC clearance was passed on to DANACO 0992 on approaching holding point of runway 04. According to the ATC ground recorder transcript, the aircraft was cleared to line-up on runway 04 and wait, but the crew requested for some time before lining-up.



DANACO 0992 was airborne at 1458:00hrs after reporting a fuel endurance of 3 hours 30 minutes. The aircraft made contact with Lagos Area Control Centre at 1518:00hrs and reported 1545:00hrs as the estimated time of arrival at LOS at cruising altitude of 26,000 ft.

The Cockpit Voice Recorder (CVR) retained about 30 minutes 53 seconds of the flight and started recording at 1513:44hrs by which time the Captain and First Officer (F/O) were in a discussion of a non-normal condition regarding the correlation between the engine throttle setting and an engine power indication. However, they did not voice concerns then that the condition would affect the continuation of the flight. The flight crew continued to monitor the condition and became increasingly concerned as the flight transitioned through the initial descent from cruise altitude at 1522:00hrs and the subsequent approach phase.

DANACO 0992 reported passing 18,100ft and 7,700ft, at 1530:00hrs and 1540:00hrs respectively. After receiving radar vectors in heading and altitude from the Controller, the aircraft was issued the final heading to intercept the final approach course for runway 18R.

According to CVR transcript, at 1527:30hrs the F/O advised the Captain to use runway 18R for landing and the request was made at 1531:49hrs and subsequently approved by the Radar Controller. The crew accordingly changed the decision height to correspond with runway 18R. At 1531:12hrs, the crew confirmed that there was no throttle response on the left engine and subsequently the Captain took over control as Pilot Flying (PF) at 1531:27hrs. The flight was however continued towards Lagos with no declaration of any distress message. With the confirmation of throttle response on the right engine, the engine anti-ice, ignition and bleed-air were all switched off. At 1532:05hrs, the crew observed the loss of thrust in No.1 Engine of the aircraft.



During the period between 1537:00hrs and 1541:00hrs, the flight crew engaged in pre-landing tasks including deployment of the slats, and extension of the flaps and landing gears. At 1541:46hrs the First Officer inquired, "both engines coming up?" and the Captain replied "negative" at 1541:48hrs. The flight crew subsequently discussed and agreed to declare an emergency. At 1542:10hrs, DANACO 0992 radioed an emergency distress call indicating "dual engine failure . . . negative response from throttle."

At 1542:35hrs, the flight crew lowered the flaps further and continued with the approach and discussed landing alternatively on runway 18L. At 1542:45hrs, the Captain reported the runway in sight and instructed the F/O to retract the flaps and four seconds later to retract the landing gears.

At 1543:27hrs, the Captain informed the F/O, "we just lost everything, we lost an engine. I lost both engines". During the next 25 seconds until the end of the CVR recording, the flight crew attempted to recover engine power without reference to any Checklist.

The airplane crashed into a densely populated residential area about 5.8 miles north of LOS. The airplane wreckage was approximately on the extended centreline of runway 18R, with the main wreckage concentrated at N 06° 40.310' E 003° 18.837' coordinates, with elevation of 177ft.

During the impact sequence, the airplane struck an uncompleted building, two trees and three other buildings. The wreckage was confined in a small area, with the separated tail section and engines located at the beginning of the debris trail.

The airplane was mostly consumed by post crash fire. The tail section, both engines and portions of both wings representing only about 15% of the airplane, were recovered from the accident site for further examination.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	6	147	6
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to Aircraft

The Aircraft was destroyed. See Figures 1, 2 and 3.



FIGURE 1: TAIL PLANE OF THE AIRCRAFT AT THE CRASH SITE



FIGURE 2: LEFT HAND ENGINES AND WHAT WAS LEFT OF PRINTING PRESS AT THE CRASH SITE



FIGURE 3: THE TAIL PLANE BEING REMOVED FROM THE CRASH SITE

1.4 Other Damage

A storey building, one 2-storey building, Power Holding Company of Nigeria (PHCN) electric poles/cables and a warehouse/printing press were completely burnt and destroyed. See Figures 4 and 5.



FIGURE 4: THE 2-STOREY BUILDING THE AIRCRAFT CRASHED INTO



FIGURE 5: THE DAMAGED 2-STOREY BUILDING

1.5 Personnel Information

1.5.1 Captain

Nationality:	American
Age:	55 years
Gender:	Male
License No:	ATPL 3138436
Aircraft rating:	A320, DC-9, FK28, SF340
Instrument Rating Currency:	Valid till 7th February, 2013
Medical:	Valid till 1st October, 2012



Total flying Experience:	18116:06 hrs
On type:	7,466:06 hrs
Last 90 days:	116:06 hrs
Last 28 days:	78:49 hrs
Last 24 hrs:	N/A

However, DC-9 and MD-83 are considered common type ratings.



CONDITIONS AND LIMITATIONS

1. This Certificate of Validation authorises the holder to fly as **Pilot-in-Command** MD-80/83 (Simulator) Valid Till 06 Aug 2012 
 2. This Certificate of Validation may be cancelled, suspended or varied as if it were a licence granted under the provisions of the CIVIL AVIATION ACT for the time being in force.
 3. Subject to any cancellation or suspension thereof this Certificate of Validation will have effect from **25 Apr 2012** to **01 Oct 2012**. 
 4. The holder is/ not authorised to act as an instructor on a NIGERIA registered aircraft.
 5. This Certificate of Validation is only valid when Accompanied by a current **1 Class Medical** and simulator.
- Whilst under contract to: **DANA AIR**. 

Provided that the said agreement remains in force and that the holder of the licence to which the certificate of Validation relates remains employed on flights operated by the Company and provided that the licence to which by this validation refers remains current throughout the period specified in paragraph 3.

FEDERAL REPUBLIC OF NIGERIA



**NIGERIAN CIVIL AVIATION AUTHORITY
CERTIFICATE OF VALIDATION**

This **Airline Transport Pilot Licence**
Number **3138436**
Issued on **08 Jan 2011**

To: 

by **USA FEDERAL AVIATION ADMINISTRATION**.

Is/are hereby rendered valid for the purpose of the CIVIL AVIATION ACT, for the time being in force. The holder is authorised under the ACT to exercise the privileges of this/these licence(s) in NIGERIA registered aircraft subject to the conditions and within limitations specified overleaf.

Signature of Issuing Officer



Date and Stamp

Issued in accordance with the provisions of the Civil Aviation Act and Air Navigation Regulations for the time being in force.
BY AUTHORITY FOR THE DIRECTOR-GENERAL, NCAA

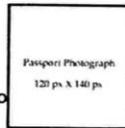
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Certificate Processed By: Adayi, Sunnie
ID Code: 250412-0607-0036-7387 page 1 of 4



**NIGERIAN CIVIL AVIATION AUTHORITY
MEDICAL CERTIFICATE**

- i. Name of holder: 
- ii. Sex: **MALE**
- v. Date of Birth: **02 FEB 1957**
- iv. Place of Birth: **REHOVOT, UNITED STATES OF AMERICA**
- iii. Nationality: **AMERICAN**
- vi. Address: **2454 OKEECHOBEE LN FLORIDA 33312, UNITED STATES OF AMERICA**
- vii. Signature of Authority:



**Nigerian Civil Aviation Authority
Aeromedical Standards**

19 APR 2012



MEDICAL CERTIFICATE CLASS: CLASS 1

- viii. Licence Number: **3138436**
(UNITED STATES OF AMERICA)
 - ix. Height: **181 CM**
 - x. Weight: **83 KG**
 - xi. Colour of Hair: **BROWN**
 - xii. Colour of Eyes: **BROWN**
 - xiii. Date of Examination: **02 APR 2012**
 - xiv. Signature of Holder:
 - xv. Aeromedical Assessment: **FIT FOR A.T.P.L.**
 - xvi. Limitations/Restrictions: **A) SHALL WEAR CORRECTIVE LENS AND CARRY A SPARE SET OF SPECTACLES**
 - xvii. Date of Issue: **01 APR 2012**
 - xviii. Certificate Valid Till: **01 OCT 2012**
 - xix. Name of A.A.M.E.: **DR. O. O. APANTAKU**
 - xx. Date of
- | | <u>Last</u> | <u>Next</u> |
|--------------------------|-------------|-------------|
| Comprehensive Med. Exam. | 01 APR 2012 | 01 APR 21 |
| Med. (General) Exam. | 01 APR 2012 | 01 OCT 21 |
| Electrocardiogram (ECG) | 01 APR 2012 | 01 APR 21 |
| Audiogram | 01 APR 2012 | 01 APR 21 |

Certificate Issued By: Dr. Haggai, Wilfred Tuhunmang
Date of Issue: 01 Apr 2012
ID Code: 030412-20601-0031-7387

Certificate Issued By: Dr. Haggai, Wilfred Tuhunmang
Date of Issue: 01 Apr 2012
ID Code: 030412-20601-0031-7387

000512

FIGURE 6: THE STAMPED BUT UNSIGNED LICENCE OF THE CAPTAIN



The captain was employed on 14th March, 2012. He began flying line training operations under the supervision of a training captain on 26th April, 2012 after completing ground school and simulator training.

The background checks were said to have been done with nothing found to disqualify the pilot.

The pilot was suspended in 2009 by the United States Federal Aviation Administration (FAA) for some misdemeanours related to a heavy landing and fixing of panels that were neither entered in the aircraft logbook nor reported.

The revalidated licence issued to him by NCAA was stamped but not signed by any NCAA official. See Figure 6 above.

Most of the recommendation letters submitted by the captain were also not signed. The line trainings that preceded the captain's checkout had a lot of adverse remarks made by the training captain. They are as follows:

1. "Callout and operating procedures needs to improve, Abuja Company Procedures to be adhered to, PM RT procedures and callout"
26th April, 2012.
2. "Expanded checklist and cockpit flow time management" "RT procedures and reporting needs to be standardized to ICAO format"
27th April, 2012.
3. "Standardized Operating procedures, RT to be standardized ICAO positioning" " SOP RT procedures" "SOP positioning" "SOP Positioning reporting" 28th April, 2012.



4. "SOP Airport departures ABV to be adhered to" "RT Procedure Positioning reporting" "SOP" "SOP RT Reporting to be improved, Standard call out" "RT Procedures & Positioning needs to [be] improved" 29th April, 2012.
5. "RT procedures to be improved" 30th April, 2012.
6. "PM LOC approach Runway 18L" "Released for final line check. 01st May, 2012"
7. "GOOD AIRMANSHIP WAS SHOWN ON THESE 2 SECTORS PLEASE OBSERVE TRANSITION ALTITUDES/ LEVELS ARE DIFFERENTLY AS THE USA, MONITOR ATC TRANSMISSIONS CONSTANTLY AS ATC ACCENT IS ALSO DIFFERENT HERE IN NIGERIA". 01st May, 2012

He started flying as checked out captain on 2nd May, 2012 and had accrued over 120 hours of flight time before the accident.

There was no documented evidence that the crew performed the mandatory CRM training.

1.5.2 First Officer

Nationality:	Indian
Age:	34 years
Gender:	Male
Licence No:	CPL 5999
Aircraft Rating:	DC-9
Instrument Rating Currency:	Valid till 04th March, 2013



Proficiency Check:	Valid till 04th September, 2012
Medical:	Valid till 05th September, 2012
Total flying Experience:	1,143:40 hrs
On type:	808:32 hrs
Last 90 days:	154:21 hrs
Last 28 days:	42:43 hrs
Last 24 hrs:	03:23 hrs

However, DC-9 and MD-83 are considered common type ratings. He was previously employed at Dana Air as the Director of Cabin Service before he was hired as a pilot in January 2011.

1.6 Aircraft Information:

Aircraft Type:	MD-83
Year of Manufacture:	1990
Serial Number:	53019
Registration:	5N-RAM
Total Airframe time:	60850:47hrs
Certificate of Airworthiness:	Issued 16th September, 2011
Category:	Transport (Passenger)
Certificate of Registration:	Issued 3rd February, 2009
Operator:	Dana Airlines Ltd



FIGURE 7: THE AIRCRAFT BEFORE THE ACCIDENT

Engine Type:	JT8D-217C
Manufacturer:	Pratt & Whitney
Engine No 1:	
Total Time since new:	54318:29hrs
Cycles:	30928
Serial No:	P718142
Engine No 2:	
Total Time since new:	26021:46hrs
Cycles:	12461
Serial No:	P728113D



A review of the aircraft technical logs did not reveal any anomaly that would have had serious effect on the airworthiness of the aircraft. The airplane had last undergone maintenance on 1st June 2012, and after a return to service flight on 2nd June 2012, it operated four revenue flights (two round trips between LOS and ABV) and another four flights on 3rd June 2012.

Fuelling records indicated that the aircraft uplifted 8000lbs of fuel before departure from ABV. The flight crew reported to ATC that they had a total of 26,000lbs of fuel.

Preliminary analysis of fuel samples from the refuelling truck and the supply tank at ABV were negative for contamination.

Detailed engines examination was carried out in the USA. History, operational and performance information of the accident aircraft engines were looked into.

The two engines were found at the crash site on both sides of the burnt-out fuselage with the left engine facing the opposite direction. Physical inspection carried out showed that there was little or no damage to the engine fan blade which was consistent with low thrust engine. This also corroborated the fact that the engines were not fully powered.

Check A-03 was carried out on 31st May, 2012. The Left Aileron Bus Cable was replaced and adjusted with duplicate inspection carried out on 1st June, 2012. Work was carried out on the APU Fuel Shut-Off Valve Electrical Plug on 2nd June, 2012. The aircraft was serviceable and airworthy at the time of the accident.

Dana Airlines MD-83 5N-RAM A-03 check accomplished on 01/06/2012 included the following:

- A-03 check consists of a 1A plus 4A-1 plus 450 FH items.



- No. 35 OAMP 71-2401 General visual inspection – CSD 1 charge and scavenge filter differential pressure indicators Interval 1A WC TC-801A-010.
- No. 36 OAMP 72-2401 General visual inspection – CSD 2 charge and scavenge filter differential pressure indicators Interval 1A WC TC-801A-010.
- No. 47 OAMP 71-7901 Restoration – clean or replace No. 1 engine oil pressure filter and check for contamination Interval 1A WC TC-801A-020 TC-801A-021.
- No. 48 OAMP 72-7901 Restoration – clean or replace No. 2 engine oil pressure filter and check for contamination Interval 1A WC TC-801A-020 TC-801A-021.
- No. 49 OAMP 71-7203 Detailed inspection – visible parts of No. 1 engine compressor fan blades Interval 1A WC TC-801A-022.
- No. 50 OAMP 72-7203 Detailed inspection – visible parts of No. 2 engine compressor fan blades Interval 1A WC TC-801A-022.
- No. 68 OAMP 71-0501 Zonal inspection – No. 1 engine (demountable power plant) Interval 1A WC TC-801A-508.
- No. 69 OAMP 72-0501 Zonal inspection – No. 2 engine (demountable power plant) Interval 1A WC TC-801A-508.
- No. 70 OAMP 77-0501 Zonal inspection – No. 1 engine upper and lower nacelle doors Interval 1A WC TC-801A-508.
- No. 71 OAMP 78-0501 Zonal inspection – No. 2 engine upper and lower nacelle doors Interval 1A WC TC-801A-508.
- No. 72 OAMP 70-0501 Zonal inspection – External surfaces of power plants, cowl doors, inlet areas, and nose cowls from ground level Interval 1A WC TC-801A-509.
- No. 73 OAMP 80-501 Zonal inspection – External surfaces of the pylons from ground level Interval 1A Work card TC-801A-509.

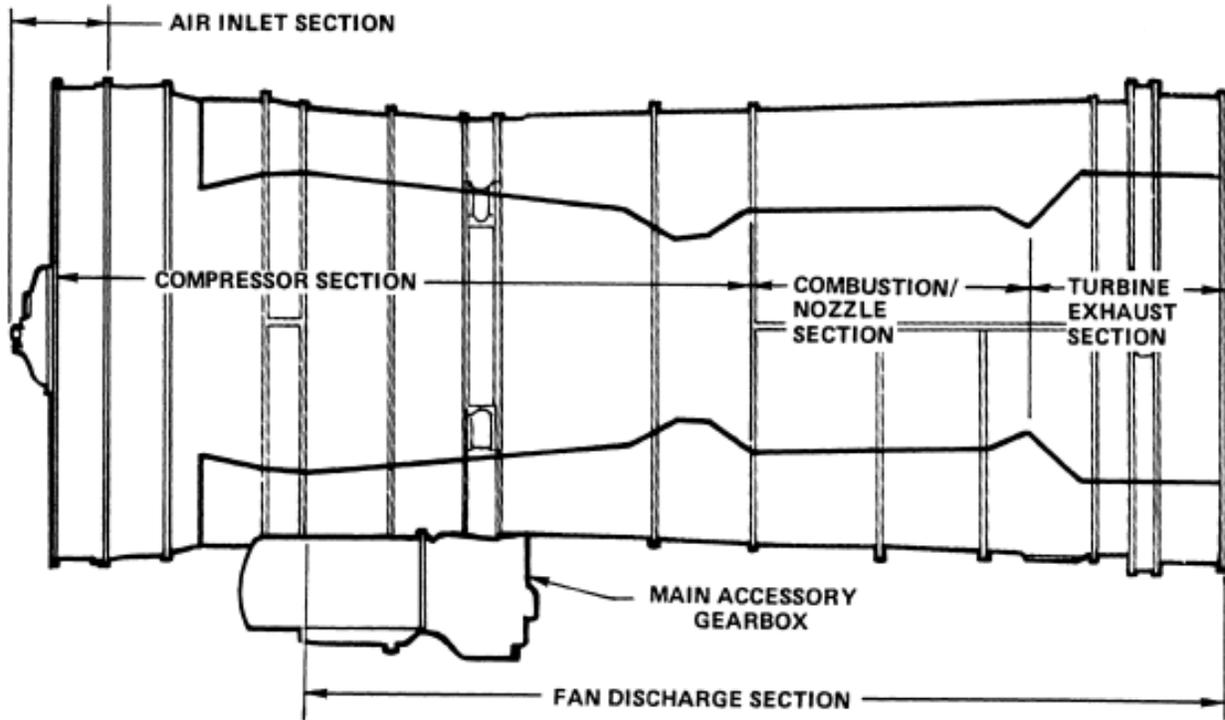
The engines were overhauled at Millenium Engine Associates Inc. in Miami Florida. Manufacturer's Service Bulletin (SB) 6452 on the JT8D engines with a Category 6 compliance was issued in October 2003.



The type of fuel used was JET-A1.

1.6.1 Engine Description

The JT8D-217C series engine is an axial-flow front turbofan engine having a fourteen stage split compressor, a nine can (can-annular) combustion chamber, and a split four stage reaction impulse turbine. The engine has six general sections, the air inlet section, the compressor section, the combustion section, the turbine and exhaust section, the accessory drives, and the fan discharge section (**FIGURE 8**) and seven main shaft bearings shown in **FIGURE 9** (listed in Appendix A **TABLE 1**). The engine is equipped with a full length annular fan discharge duct. The low pressure system is made up of the front compressor rotor and the stages 2, 3, and 4 turbine rotors and is mechanically independent of the high pressure system which consists of the rear compressor rotor and the stage 1 turbine rotor (**FIGURE 9**).



L-60496 (0000)

FIGURE 8: SECTION IDENTIFICATION

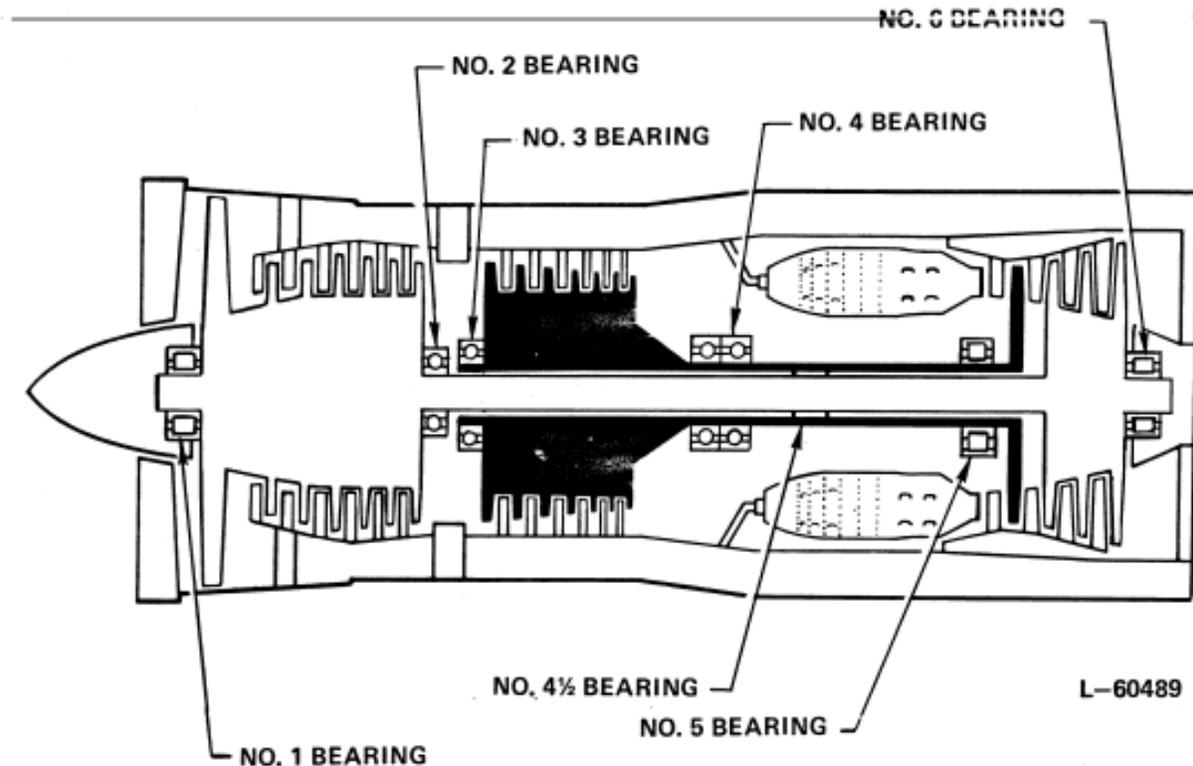


FIGURE 9: ENGINE BEARING AND INTERNAL DIAGRAM

The engine is mounted from two points. The front mount is located at the fan discharge intermediate case. The engine rear mount is located at the turbine exhaust section outer duct. According to the FAA Type Certificate Data Sheet E9NE, Revision 12, dated December 13, 2010, the sea level static thrust takeoff rating of the JT8D-217C engine is 20,850 pounds and the sea level static thrust maximum continuous rating is 18,000 pounds, both are flat rated to 77°F (25°C).

1.6.2 LEFT ENGINE (NO. 1) – SERIAL NUMBER (SN) 718142

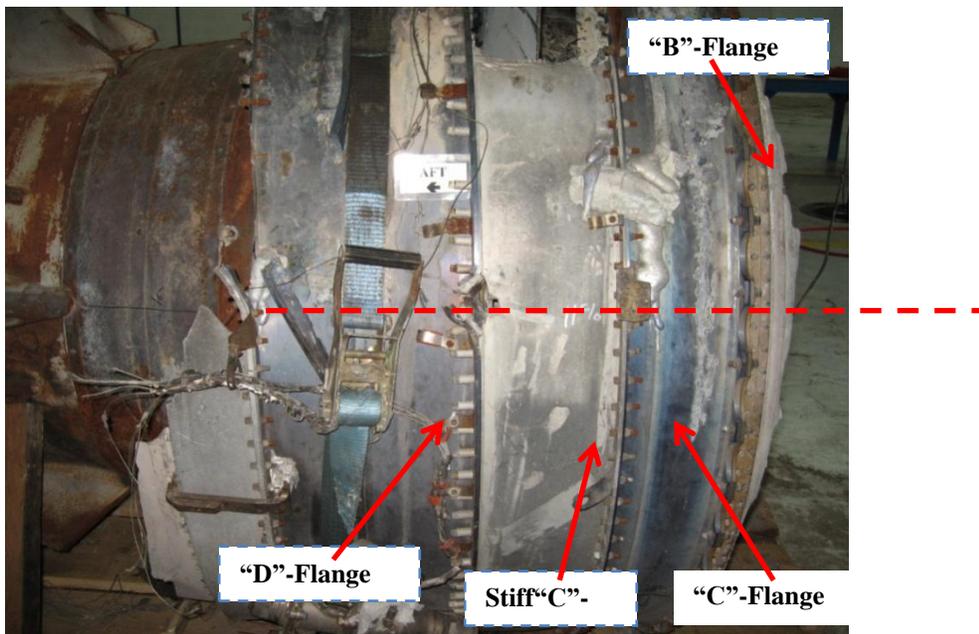
The engine was un-crated and placed on pallets for examination and disassembly (**FIGURE 10**). The inlet case, and the front and rear fan cases were attached as a unit, but were no longer attached to the rest of the engine. This unit was clogged approximately 120° clockwise direction relative to the core of the engine. The fan and

exhaust ducting was missing from the "D"-flange (aft flange of the rear fan case) aft except for a section of the front compressor fan duct that was still attached to the D-flange and ranged from 9 to 13-inches axially and approximately 100° circumferentially.



FIGURE 10: TOP VIEW OF THE NO. 1 ENGINE S/N 718142

The inlet case, and the rear fan case were intact but the front fan case was missing material from the 5:00 to 10:00 o'clock position. The part of the front fan case that remained exhibited signs of thermal distress and melted material. The inlet case and the front fan case did not exhibit any significant distortion; however, the rear fan case exhibited inward distortion/deformation at the 7:30 o'clock position and also at the 11:00 o'clock position with part of the "D"-flange (approximately 5 bolt holes in length) missing. The "C"-flange (front flange of the rear fan case) was fractured at approximately the 11:00 o'clock position, which was in-line axially with the rear fan case stiffening rib and "D"-flange fractures. All the flange fractures were deformed in the aft direction (**FIGURE 11**).



**FIGURE 11: DAMAGED TO THE FRONT AND REAR FAN CASES
AT THE 11:00 O’CLOCK POSITION**

The nose bullet and the front accessory drive cover were both missing, exposing the No. 1 bearing and N1 tachometer (tacho) drive gear. Molten material was observed in the area of the front accessory drive attachment flange. All the No. 1 bearing rollers were present and appeared cylindrical but were covered in rust.¹ The cage was shiny and appeared to be intact (**FIGURE 12**). The N1 tacho drive was intact and undamaged but also covered in rust. The inlet guide vanes (IGVs) were all fractured at their inner diameter (centre body location) with three of the IGVs missing. The IGVs that remained were bent in the direction of rotation (clockwise) at their ID relative to their OD, many were buckled at their outer diameter attachment point, and none exhibited any significant impact damage (**FIGURE 13**). Based on the location of the 6:00 strut, where the No. 1 bearing oil tubes are located, the outer ring of the inlet case with the IGVs still attached was rotated approximately 120° clockwise from the matching centre body strut location.

¹ After the accident, both engines were removed from the accident site, stored outdoors and were exposed to the environment prior to being shipped to the US for the detailed engine exam and disassembly.

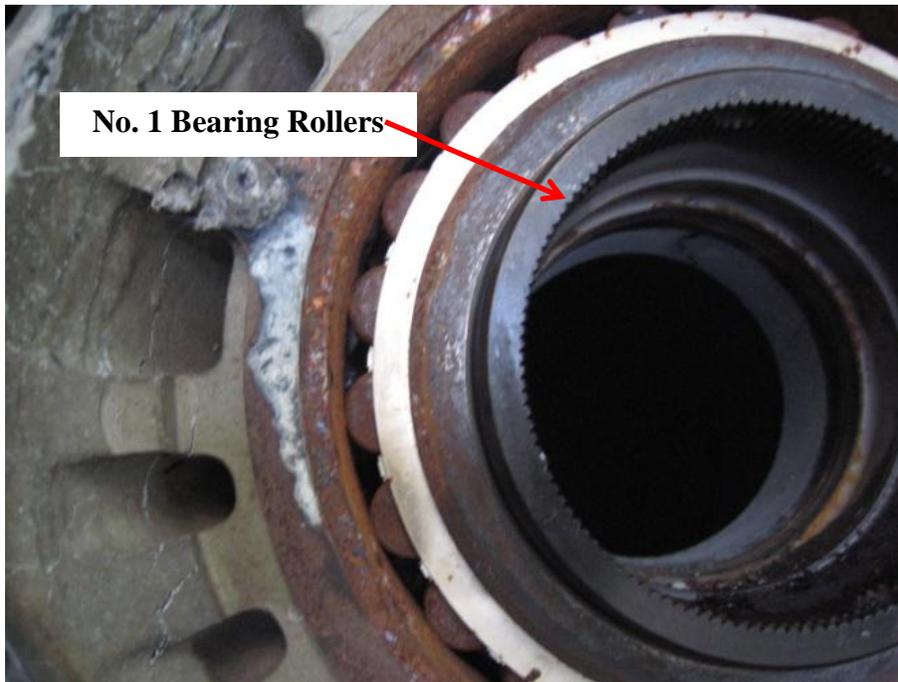


FIGURE 12: NO. 1 ROLLER BEARING INTACT AND COVERED IN RUST

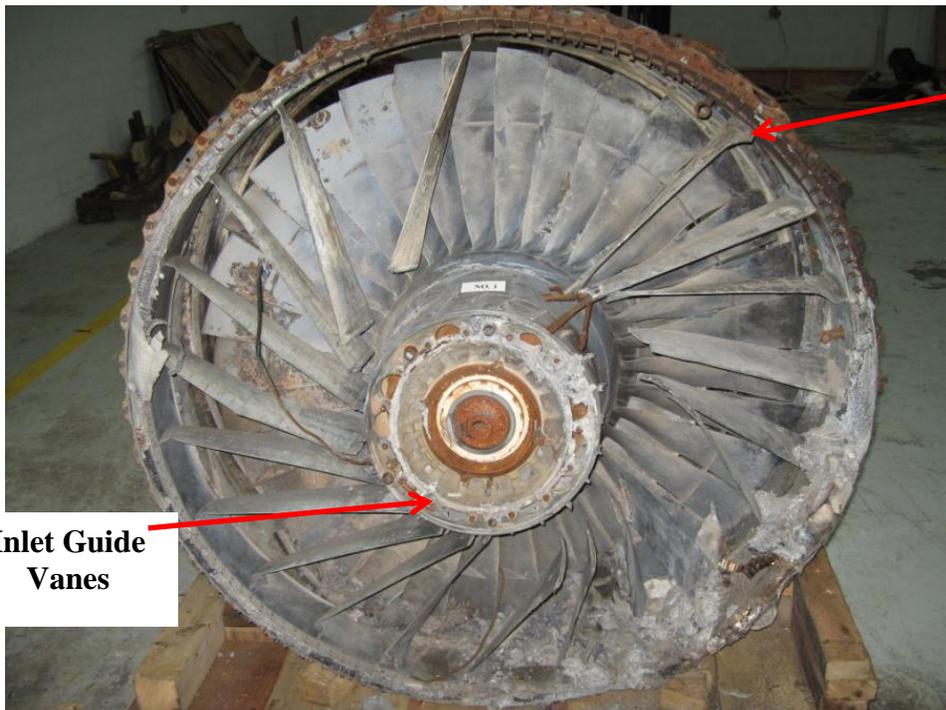


FIGURE 13: INLET CASE WITH FRACTURED AND DAMAGED INLET GUIDE VANES



All the fan blades were present and secured in the fan hub. Numerous blades exhibited small leading edge nicks, tears, and dents with some exhibiting leading edge round bottom impact marks with material transfer. The material deformation associated with this damage was in the direction of rotation and/or aft. A single fan blade was fractured at the leading edge corner tip. Three randomly blade tips were curled/bent in the direction opposite rotation and five random blades (of which two were adjacent to each other) were bent in the direction of rotation. One fan blade exhibited appreciable forward blade tip corner bending while a different blade exhibited appreciable aft bending. Four adjacent blades exhibited blade spanwise buckling. Several sets of blades exhibited mid-span shroud shingling.

Seven of the tangential fan exhaust duct strut rods that connect the turbine exhaust case to the exhaust duct were still secured to the turbine exhaust case at their inner ends. Five were fractured at their inner end (turbine exhaust case mount rail location), two were almost entirely intact (one at the 2:00 o'clock and one at the 10:00 o'clock position) and fractured at their outer end; the eighth rod was missing. The exhaust mixer remained attached to the turbine exhaust case. At the 6:00 o'clock position, exhaust mixer was deformed inwards with longitudinal/axial scrape marks. The majority of the remainder of the mixer was pushed/buckled inwards and forward. The turbine exhaust inner duct and tail cone were still attached to the turbine exhaust case centre body (No. 6 bearing housing). The turbine exhaust duct was dented and cracked at the 6:00 o'clock position, in-line with inward deformation of the tail cone. The deformed area of the tail cone also exhibited axial scrape marks (**FIGURE 14**). No other significant damage was noted on the exhaust duct or tail cone.



FIGURE 14: EXHAUST CASE, INNER DUCT, CONE AND MIXER DAMAGE AT THE 6:00 O'CLOCK POSITION



U.S. Department of Transportation Federal Aviation Administration		Form Approved OMB No. 2120-0020 11/30/2007	Electronic Tracking Number
MAJOR REPAIR AND ALTERATION (Airframe, Powerplant, Propeller, or Appliance)		For FAA Use Only	
INSTRUCTIONS: Print or type all entries. See Title 14 CFR §43.9, Part 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form. This report is required by law (49 U.S.C. §44701). Failure to report can result in a civil penalty for each such violation (49 U.S.C. §46301(a)).			
1. Aircraft	Nationality and Registration Mark	Serial No.	
	Make	Model	Series
2. Owner	Name (As shown on registration certificate)		Address (As shown on registration certificate)
	Address		City _____ State _____
	Zip _____		Country _____
3. For FAA Use Only			
4. Type			
Repair	Alteration	Unit	Serial No.
<input type="checkbox"/>	<input type="checkbox"/>	AIRFRAME	(As described in item 1 above)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	POWERPLANT	Pratt & Whitney JT8D-217C 718142
<input type="checkbox"/>	<input type="checkbox"/>	PROPELLER	
<input type="checkbox"/>	<input type="checkbox"/>	APPLIANCE	Type _____ Manufacturer _____
5. Unit Identification			
6. Conformity Statement			
A. Agency's Name and Address		B. Kind of Agency	
Millenium Engine Associates Inc 8555 NW 64 th Street Miami, Florida 33166		<input type="checkbox"/> U.S. Certificated Mechanic	<input type="checkbox"/> Manufacturer
		<input type="checkbox"/> Foreign Certificated Mechanic	C. Certificate No.
		<input checked="" type="checkbox"/> Certificated Repair Station	Y2MR496Y
		<input type="checkbox"/> Certificated Maintenance Organization	
D. I certify that the repair and/or alteration made to the unit(s) identified in item 5 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge.			
Extended range fuel per 14 CFR Part 43 App. B <input type="checkbox"/>	Signature/Date of Authorized Individual Chief Inspector [Redacted] August 03, 2011		
7. Approval for return to Service			
Pursuant to the authority given persons specified below, the unit identified in item 5 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is <input checked="" type="checkbox"/> Approved <input type="checkbox"/> Rejected			
BY	<input type="checkbox"/> FAA Flt. Standards Inspector	<input type="checkbox"/> Manufacturer	<input type="checkbox"/> Maintenance Organization
	<input type="checkbox"/> FAA Designee	<input checked="" type="checkbox"/> Repair Station	<input type="checkbox"/> Inspection Authorization
Certificate or Designation No. Y2MR496Y		Signature/Date of Authorized Individual Chief Ins [Redacted] August 03, 2011	

FIGURE 15: US DEPARTMENT OF TRANSPORT MAJOR REPAIR AND ALTERATION CERTIFICATE S/N 718142

No. 1 Engine was overhauled at Millenium Engine Associates Inc. (MRO), Miami, Florida, U.S.A on the 3rd August, 2011. See Figure 15 above. Records available to AIB showed that Service Bulletin 6452 was not accomplished on this engine during all the shop visits. The maintenance repair organization (MRO) is approved by both NCAA and FAA. The history of shop visits of engine serial number (ESN) 718142 as shown below;



Engine Type: - JT8D-217C

ESN: - 718142

POSITION #1

- * Engine Shop Visit done at ST Aerospace Engine dated 28 October 2000.
- * Engine Shop Visit done at Pacific GAS Turbine dated 1 November 2002.
- * Engine Shop Visit done at Dallas Aviation Field Service dated 1 June 2004.
- * Engine Shop Visit done at Pacific GAS Turbine dated 24 August 2004.
- * Engine Shop Visit done at Pacific GAS Turbine dated 3 February 2005
- * Engine Shop Visit done at Pacific GAS Turbine dated 30 August 2007.
- * Engine Shop Visit done at IBERIAI Maintenance dated 19 April 2010.
- * Engine Shop Visit done at Millenium Engine Associates, Inc. dated 3 August, 2011.

1.6.3 Right Engine (No. 2) – SN728113

The engine was un-crated and placed on pallets for examination and disassembly (**FIGURE 16**). The engine was intact from the nose bullet aft to the exhaust tail cone with all major modules in place. Engine cases appeared round and did not exhibit signs of structural deformation or case breach. Fan and exhaust ducting was missing from the "E"-flange (aft flange of the fan exit guide vane (FEGV) Outer Case) aft to the "F"-flange (forward flange intermediate case outer diameter ring) and from the "G"-flange (aft flange of the intermediate case outer diameter ring) to the "K"-flange (forward flange of the turbine case outer diameter ring). Some wiring, and pneumatic and oil system plumbing along with crash debris were removed to facilitate teardown (**FIGURE 17**).



FIGURE 16: RIGHT-HAND SIDE OF THE NO. 2 ENGINE S/N 728113

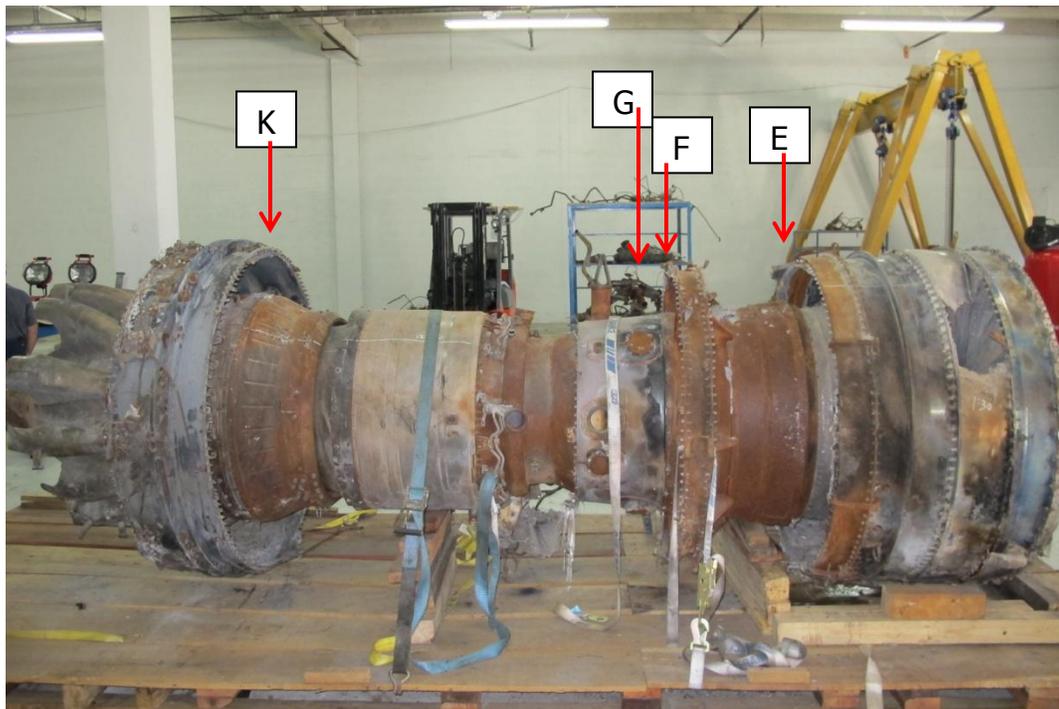


FIGURE 17: RIGHT-HAND SIDE OF NO. 2 ENGINE WITH FLANGE LOCATIONS

The inlet area was inspected and it was noted that the inlet nose bullet was partially melted exposing the front accessory drive cover. All the IGV's were in place and secure with five vanes, located between the 10:00 o'clock and 12:00 o'clock positions, buckled at the mid-span (**FIGURE 18**). No significant leading edge impact damage was noted.

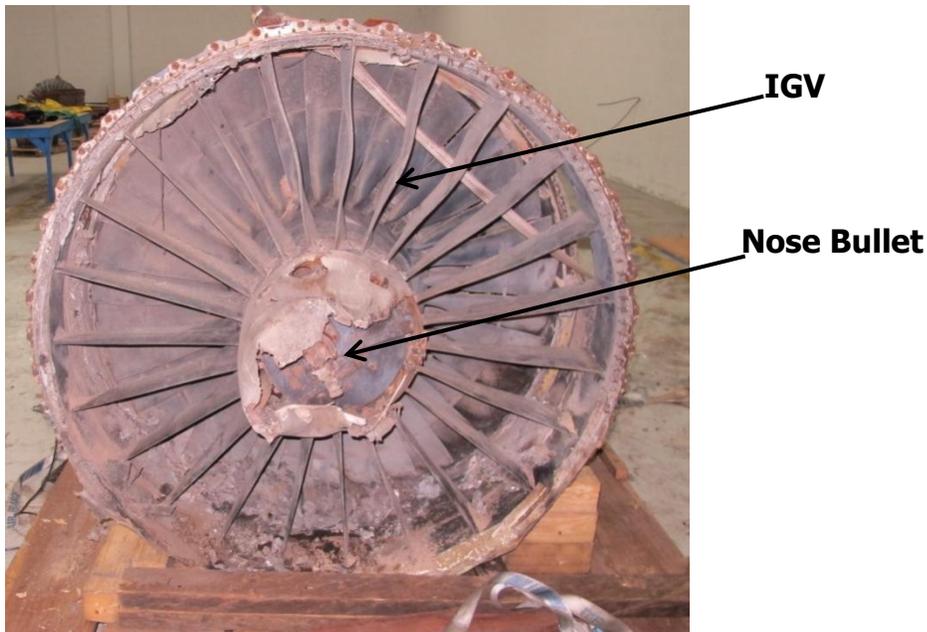


FIGURE 18: ENGINE INLET

The forward fan case exhibited damage in three locations. Case material was missing circumferentially from the 12:00 to 1:30 positions and from the 8:00 to 11:00 o'clock positions, the edges of these holes exhibited thermal distress and indications of melting. An inward puncture with associated case deformation was present at the 4:00 o'clock position, approximately 4 inches in diameter with indications of melting around the fracture surfaces (**FIGURE 19**).



FIGURE 19: FORWARD FAN CASE THERMAL AND IMPACT DAMAGE

The exhaust mixer lobes exhibited crushing damage both radially inward and forward from the 6:00 to 9:00 o'clock positions. The tail cone and inner exhaust duct were both present and undamaged (**FIGURE 14**). There was no distress noted in the exhaust duct mount rails.



U.S. Department of Transportation Federal Aviation Administration		Form Approved OMB No. 2120-0020 11/30/2007	Electronic Tracking Number
MAJOR REPAIR AND ALTERATION (Airframe, Powerplant, Propeller, or Appliance)		For FAA Use Only	
INSTRUCTIONS: Print or type all entries. See Title 14 CFR §43.9, Part 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form. This report is required by law (49 U.S.C. §44701). Failure to report can result in a civil penalty for each such violation (49 U.S.C. §46301(a)).			
1. Aircraft	Nationality and Registration Mark		Serial No.
	Make		Model Series
2. Owner	Name (As shown on registration certificate)		Address (As shown on registration certificate)
			Address _____ City _____ State _____ Zip _____ Country _____
3. For FAA Use Only			
4. Type		5. Unit Identification	
Repair	Alteration	Unit	Make Model Serial No.
<input type="checkbox"/>	<input type="checkbox"/>	AIRFRAME	(As described in item 1 above)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	POWERPLANT	Pratt & Whitney JT8D-217C 728113
<input type="checkbox"/>	<input type="checkbox"/>	PROPELLER	
<input type="checkbox"/>	<input type="checkbox"/>	APPLIANCE	Type _____ Manufacturer _____
6. Conformity Statement			
A. Agency's Name and Address		B. Kind of Agency	
Millenium Engine Associates Inc 8555 NW 64 th Street Miami, Florida 33166		<input type="checkbox"/> U.S. Certificated Mechanic	<input type="checkbox"/> Manufacturer
		<input type="checkbox"/> Foreign Certificated Mechanic	C. Certificate No.
		<input checked="" type="checkbox"/> Certificated Repair Station	Y2MR496Y
		<input type="checkbox"/> Certificated Maintenance Organization	
D. I certify that the repair and/or alteration made to the unit(s) identified in item 5 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge.			
Extended range fuel per 14 CFR Part 43 App. B <input type="checkbox"/>		Signature/Date of Authorized Individual Chief Inspector [Redacted] December 02, 2011	
7. Approval for return to Service			
Pursuant to the authority given persons specified below, the unit identified in item 5 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is <input checked="" type="checkbox"/> Approved <input type="checkbox"/> Rejected			
BY	<input type="checkbox"/> FAA Flt. Standards Inspector	<input type="checkbox"/> Manufacturer	<input type="checkbox"/> Maintenance Organization
	<input type="checkbox"/> FAA Designee	<input checked="" type="checkbox"/> Repair Station	<input type="checkbox"/> Inspection Authorization
Certificate or Designation No.		Other (Specify) _____	
		Signature/Date of Authorized Individual	

FIGURE 20: US DEPARTMENT OF TRANSPORT MAJOR REPAIR AND ALTERATION CERTIFICATE s/N 728113

No. 2 Engine was overhauled at Millenium Engine Associates Inc. (MRO), Miami, Florida, U.S.A on the 2nd December, 2011. See Figure 20 above. The maintenance repair organization (MRO) is approved by NCAA and FAA respectively. Record available to AIB showed that Service Bulletin 6452 was accomplished on this engine during one of the



shop visits in Volvo Aero Engine Maintenance facility on 27th September, 2005. The history of shop visits of engine serial number: ESN. 728113 as shown below;

Engine Type: - JT8D-217C

ESN: - 728113

POSITION #2

- * Engine Shop Visit done at Pratt & Whitney dated 21 November 2001.
- * Engine Shop Visit done at Volvo Aero dated 27 September 2005.
- * Engine Shop Visit done at IAI Bedek Aviation Group dated 2 February 2009.
- * Engine Shop Visit done at Millenium Engine Associates, Inc. dated 2 December 2011.

1.6.4 Engines Audio Spectrum Analysis

The audio spectrum analysis was performed and nothing conclusive was determined. The test was carried out by Pratt and Whitney, and observed by Boeing, FAA and NTSB as requested by AIB.

1.6.5 Auxiliary Power Unit (APU)

The auxiliary power unit (APU) supplies pneumatic and electrical power for ground starting of main engines, fuselage air-conditioning, and ground operation of the aircraft electrical system in the absence of ground power or an operating engine. The APU can also be operated in flight to provide an alternate source of electric power. The APU was sent to the USA for analysis.

1.6.6 Battery Power

Two 14-Volt Batteries are installed in the Electrical/Electronic (E/E) compartment. They are connected in series to provide 28 Volts DC to the Starter Control Relay of the APU and through an 80-ampere Circuit Breaker (CB) directly to the Battery Direct Bus.



1.6.7 Fuel System - Airframe

The fuel on the MD-83 aircraft is stored in three integral tanks; left main, centre and right main. Additional fuel is stored in fuselage tanks to be transferred to the centre wing tank when space is available. A series of flapper valves incorporated into two flow baffles near the inboard end of each main tank, creates a reservoir. The reservoir provides a head of fuel around the tank pumps during all normal manoeuvres and aircraft attitude changes. Engine fuel supply from the tanks to the engines is accomplished by tank boost pumps through lines direct to the engines. The right and left main tank-to-engine fuel feed lines are interconnected by a cross feed line and a cross feed valve.

The fuel feed system consists of six fuel boost pumps (two single pumps for each main tank and two series-mounted pumps for the centre tank), necessary check valves, a cross feed valve, two engine fuel fire shutoff valves, and an APU fuel fire shutoff valve. Fuel is supplied to the engine and the APU through shrouded lines. The shroud system has a drain valve located on the lower right side of the fuselage aft of the wheel well. A start pump is also installed in the right main tank to provide starting fuel pressure to engines and/or APU when AC power is not available.

The fuel vent system permits equalization of pressure differential in the tanks, created during refuelling/defueling or manoeuvring of the aircraft. The system is designed to prevent siphoning or spilling of fuel during normal flight or ground manoeuvres.

Fuel Suction Feed capability

The MD-80 engines suction feed certification capability was demonstrated in accordance with FAR 25.1351(d) Amdt. 25-41 "Operation without normal electrical power. It must be shown by analysis, tests, or both, that the airplane can be operated safely in VFR conditions, for a period of not less than five minutes, with the normal electric power (electric power sources excluding the battery) inoperative, with critical type fuel (from

the standpoint of flameout and restart capability), and with the airplane initially at the maximum certified altitude.”

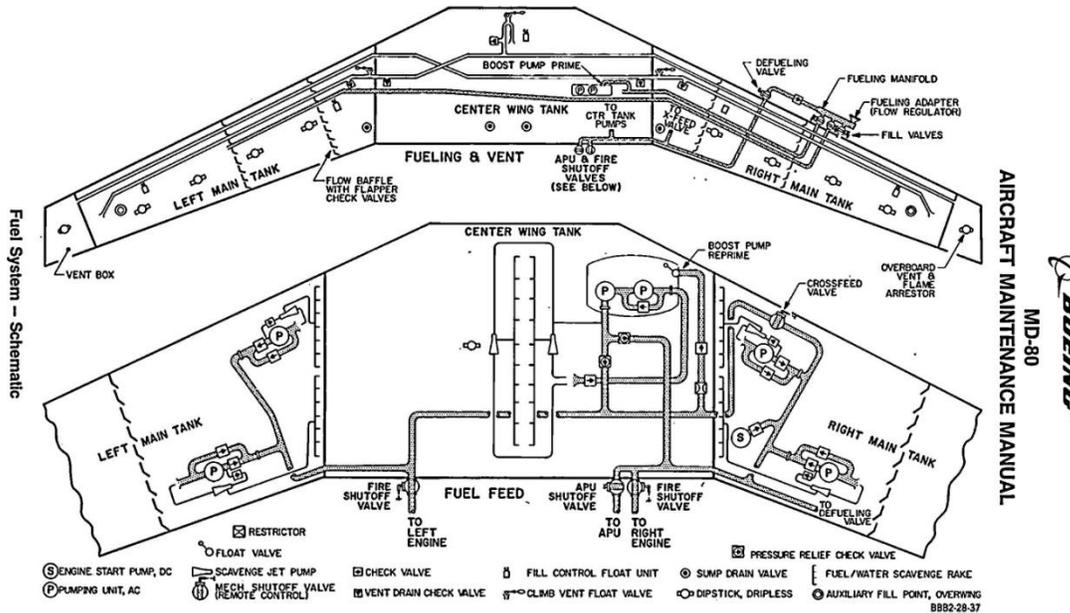


FIGURE 21: FUEL SYSTEM SCHEMATIC -- AIRFRAME

1.6.8 The Engine Fuel System

The engine fuel distribution and control system consists of subsystems and components necessary to supply filtered, pressurized and metered fuel for steady state acceleration and deceleration fuel flow to the engine combustion section.

Fuel flows through the duct at the high point of the engine, to the fuel supply bridle and centrifugal first stage of the engine-driven fuel pump then to the air/fuel heater. Any restriction to fuel flow caused by accumulation of foreign matter creates a pressure drop across the fuel filter. This causes a light on the annunciator panel in the flight compartment to come on, and the air shutoff valve is opened to allow warm 13th-stage bleed air to flow through the air/fuel heater. Fuel passes through the main fuel filter to the high-pressure gear stage of the engine-driven fuel pump and out to the fuel control where it is filtered, metered and either passed to the pressurizing and dump valve, or

bypassed back to the inlet of the fuel pump high-pressure gear stage. Before entering the main fuel filter, a portion of the fuel is diverted to provide the motive fluid stream for the eductor. Fuel discharging from the eductor nozzle evacuates the eductor chamber by entraining vapour molecules, compressing and mixing them in a constant-area mixing section, and then forcing the mixture into the inlet of the fuel pump centrifugal first stage. Fuel leaving the fuel control passes through the fuel flow meter and fuel/oil cooler to the pressurizing and dump valve. Upon leaving the pressurizing and dump valve, the fuel flow is divided and passes into primary and secondary manifolds. Fuel enters the dual inlet manifolds where it is distributed through the nine individual fuel nozzles into the combustion chambers.

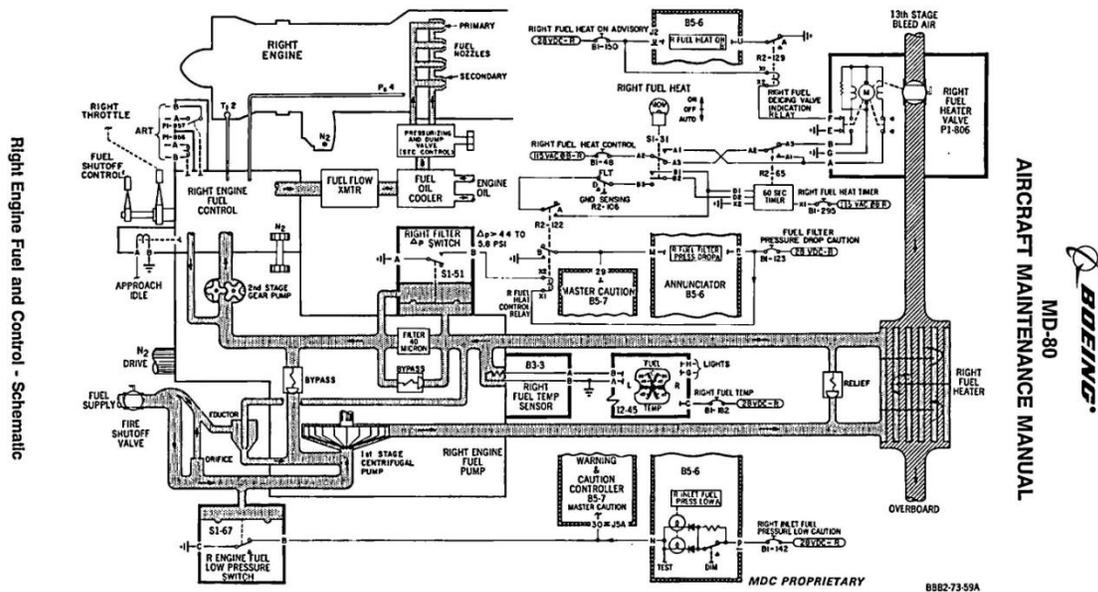


FIGURE 22: FUEL SYSTEM SCHEMATIC – ENGINE



1.6.9 Fuel System Components (F.S.C.) (Engine No. 1. ESN: 718142) Teardown Report

The only parts of the fuel system that were available for examination were the fuel nozzles, and left- and right-hand primary and secondary fuel manifolds, which are located on the diffuser case. For this engine, the fuel nozzle documentation was covered in the combustion module section. There was no residual fuel remaining in the fuel system. Both fuel manifolds were removed from the engine for evaluation.

The fuel-feeder lines that attach to the No. 5 fitting were both (primary and secondary) fractured flush with the No. 5 fitting and a piece of the fuel-feeder tubes remained within the No. 5 fittings in both manifolds (**FIGURE 23**). These fractured fuel-feeder tubes both exhibited shear lips. The left-hand manifold exhibited the following damage and observations:

- 1) heavily sooted at fuel nozzle fitting Nos. 8, 9 and 1,
- 2) the primary fuel transfer tube was pinched almost closed at the No. 8 fuel nozzle fitting (**FIGURE 24**), and
- 3) the primary fuel transfer tube diameter was reduced at the No. 7 fuel nozzle fitting. The fuel-feeder lines that attach to the No. 6 fitting were both fractured at the No. 6 fitting with an appreciable piece of the secondary feeder tube was still attached and twisted/crimped (**FIGURE 25**).



FIGURE 23: RIGHT-HAND FUEL MANIFOLD WITH FRACTURED FEEDER TUBE



FIGURE 24: PINCHED TRANSFER TUBE



FIGURE 25: FRACTURED FEEDER LINE

1.6.9.1 Fuel System Components (Engine No. 2 ESN 728113) Teardown Report

The part of the fuel system that was available for examination during the Engine Teardown process were the fuel nozzles, the fuel manifolds, the P & D valve-to-fuel manifold feeder tube, fuel oil cooler to P & D valve tube and fuel control-to fuel flow transmitter tube.

Significantly, the secondary fuel flow feeder line that connects to the right-hand manifold was collapsed and bent downstream of the junction, neither of which completely blocked flow. However, the right-hand primary and secondary manifold supply tubes were bent at the No. 5 fittings. Similar damage was noted on the left-hand



primary and secondary manifold supply tube at the No. 6 fittings. Again, neither of these bends completely obstructed flow. Furthermore, the left hand primary manifold had a circumferential crack just outboard of the fan duct pass through.

Detailed engine examination was carried out in the USA. History, operational and performance information of the accident aircraft engines were looked into. See Appendix A for details of teardown investigation.

The engine teardown was performed at Global Engine Maintenance facility (formerly Millenium Engine Associates) in the USA. The organization is also responsible for securing and ensuring that all the parts examined are returned to the engine owners with the permission of the investigating body. However, certain components such as the right fuel manifold were not available for subsequent examination.

1.6.10 Hydraulics

Main hydraulic power is provided by two, separate, closed-circuit hydraulic systems identified as the left and right systems. One engine-driven hydraulic pump on each engine, supplies power to the corresponding system. The hydraulic systems are filled with a fire-resistant hydraulic fluid and are normally pressurized by the engine-driven pumps to approximately 3000psi. Hydraulic power is required for the operation of the elevator boost, rudder, flaps, slats, flight spoilers, ground spoilers, ventral stairway, engine thrust reversers, landing gears, brakes and nose wheel steering systems. Each main hydraulic system is provided with similar components and the necessary controls and indicators for system operations. Up till the time of the crash, hydraulic related systems were all operative, e.g. the landing gears were extended and retracted before the crash.



1.7 Meteorological Information

The Weather Forecast for MMIA issued by MET Office at MMIA Ikeja at 030955Z

0312/0418 19007K 9999

SCT 013 TEMPO 0312/0318 TS

BKN 013 FEW 020 CB PROB 30

0317/0317 5000- TSRA BKN009

FEW019 CB BECMG

0320/0322 19004KT FEW 009

TEMPO 0405/0407 VRB 02KT

5000 BR FEW 008

Actual Weather LOS

Time: 1400 UTC

Wind: 200/06 kts

Visibility: 10 Km

Weather: Nil

Cloud: SCT 1400

Temperature/Dew: 31/23⁰C

Tempo Information: NOSIG

QNH: 1013 hPa

Time: 1500 UTC

Wind: 190/07 kts

Visibility: 10 km

Weather: Nil

Cloud: SCT 420m

Temp.: 30⁰C/23⁰C

QNH: 1013 hPa

The weather was available to the Crew. The light condition available to the Crew was daylight at the time of the accident. The Satellite Imagery Report in Figure 26 below shows that Lagos was clear of any bad weather.

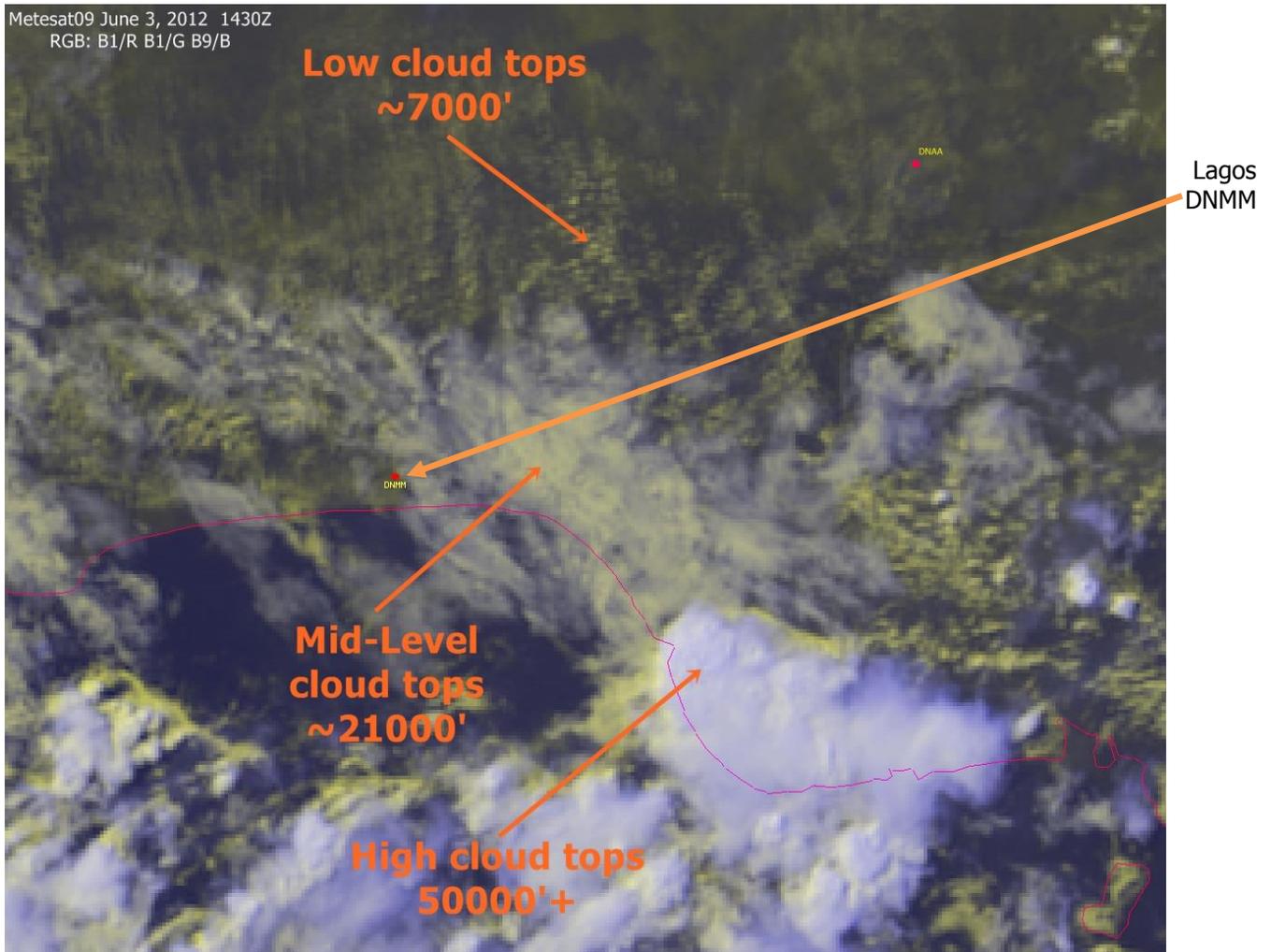


FIGURE 26: SATELLITE IMAGERY REPORT OF LAGOS ON THE DAY OF THE ACCIDENT

1.8 Aids to Navigation

The Navigation aids available at the time of the accident were ILS and VOR/DME on both runways 18L and 18R. Their effectiveness on the day of the accident were as follows:

"LAG"	VOR/DME:	Serviceable
	ILS/DME:	Serviceable



1.9 Communications

There was good communication between the aircraft and the Radar Control as evident from the Cockpit Voice Recorder (CVR) and the Control Tower tape/transcript. Communication was Strength Five. The status of the equipment on the day of the accident was as follows:

Lagos Radar VHF 124.7 Control: Serviceable

Lagos Control Tower VHF 118.1: Serviceable

1.10 Aerodrome Information

Lagos was the intended landing airfield before the crash. The aerodrome has two parallel runways 18L/36R and 18R/36L serving both the International and the Local airport with standard equipment. ATC, weather and the Fire services are readily available to the airport users.

The airport elevation is 135ft and runway length of 18L/36R is 9,006ft (2745m) while 18R/36L is 12,795ft (3,900m).

There are other suitable airports for landing between Abuja and Lagos, notably Ilorin Airport which was officially filed as the alternate. Akure and Ibadan Airports were within the reach of the crew in an emergency.

1.11 Flight Recorders

The Flight Recorders were located around the rear cargo hold. They were severely burnt and found around where the burnt-out cargo compartment was located. See Figure 27 (on page 44).

The Flight Data Recorder was recovered, washed/cleaned in fresh water and placed in the custody of AIB before being sent to National Transportation Safety Board (NTSB) for data download and analysis.



The two flight recorders, the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR) were analysed at the facilities of the (NTSB), Washington, D.C., USA. The solid-state based memory in the CVR was in good condition and retained 30 minutes 53 seconds of audio information. The digital tape-based memory in the FDR succumbed to the post-crash fire and melted, consequently no data could be recovered from it.

In accordance with regulatory requirement, the aircraft was equipped with flight recorders as follows:

Flight Data Recorder

Part Number: 980-4100-FWUS
S/N: 1340
Manufacturer: Fairchild

Cockpit Voice Recorder

The aircraft was installed with a solid state cockpit voice recorder (CVR);

Part Number: 2100-1010-00
S/N: 292937
Manufacturer: L3/Fairchild

The unit records 30 minutes of digital cockpit audio in a four-channel format; one for each flight crew audio panel, one channel for the cockpit area microphone (CAM) and one channel for the interphone, public address or additional crew member. The CVR suffered severe heat and fire damage but the memory modules were extracted from the crash survivable memory unit for repair and evaluation. The ribbon cable was replaced and the memory was downloaded normally.

The transcript began as the aircraft was in cruise heading toward Lagos. The CVR captured events from cruise, descent and accident sequence over a duration of 30 minutes and 53 seconds.



FIGURE 27: PICTURE OF THE SEVERELY BURNT FLIGHT RECORDERS

1.12 Wreckage and Impact Information

The airplane crashed in a built-up area of Iju-Ishaga, a densely populated area in Lagos State. The wreckage was confined to a small area around the crash site, with the tail section and engines located at the beginning of the debris trail. The airplane was mostly consumed by post-crash fire. The tail section, both engines and portions of both wings, representing only about 15% of the airplane were recovered from the accident site while the rest of the aircraft was destroyed by the impact forces and fire outbreak.

The airplane crashed in a residential area about 5.8 miles north of LOS. The airplane wreckage was on approximately the extended centreline of runway 18R, with the main wreckage concentrated at N 06° 40.310' E 003° 18.837' coordinates, with Elevation of 177ft. See Figure 28 below.

During the impact sequence, the airplane struck an uncompleted building, two trees and three other buildings. The wreckage was confined in a small area, with the separated tail section and engines located at the beginning of the debris trail. See Figures 28 and 29 on the following page.

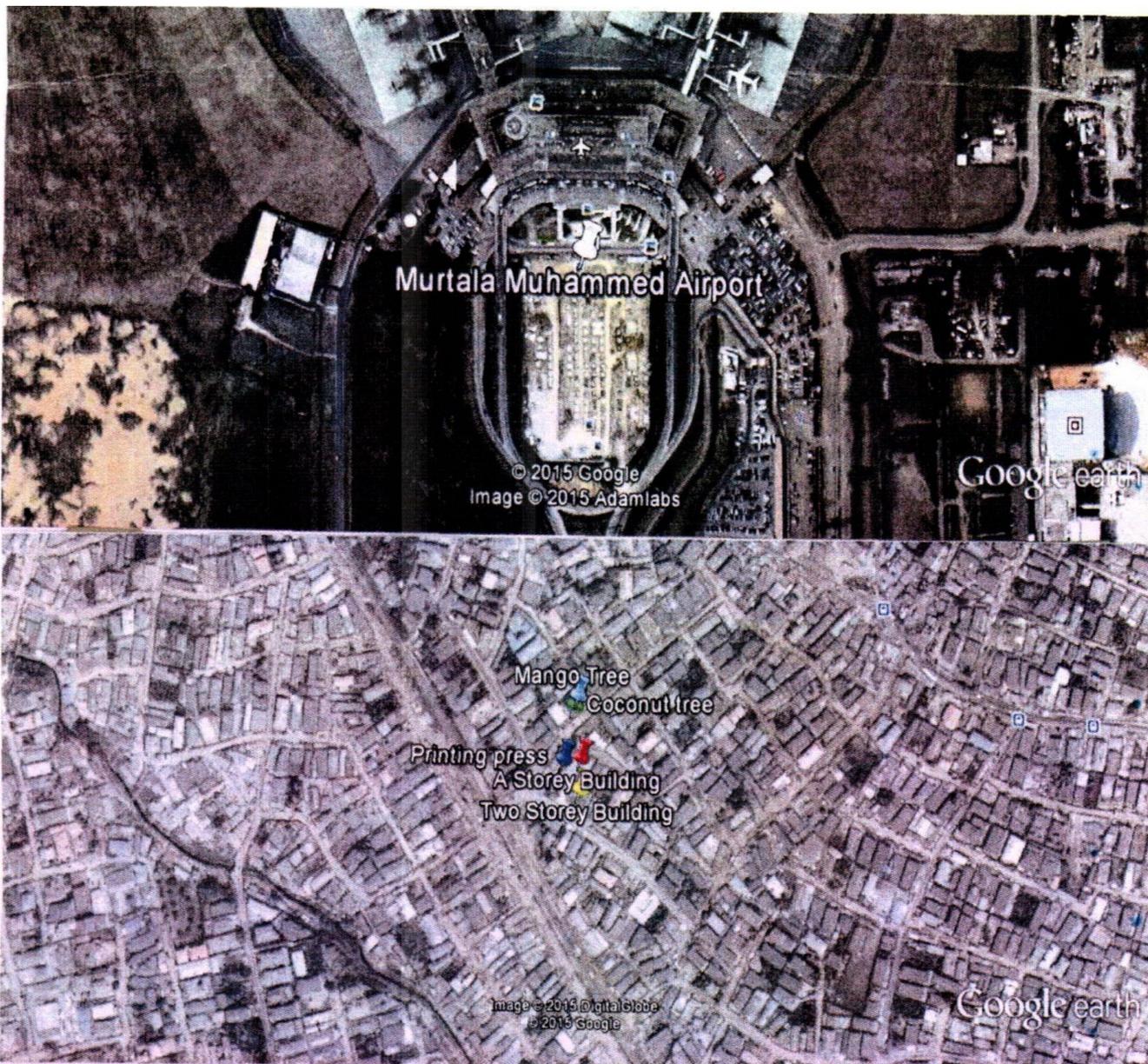


FIGURE 28: PICTORIAL REPRESENTATION OF CRASH SITE

Dana crash site coordinates; Coconut tree - N06°40.353', E003° 18.843' with elevation – 184ft (shown), **Mango tree**- N06°40.348', E003° 18.841' with elevation – 190ft (shown), **Printing Press** - N06°40.317', E003° 18.834' with elevation – 171ft, **A storey Building** pulled down by the left wing- N06°40.318', E003° 18.845' with elevation – 177ft (shown), Position of the **two storey Building**- N06°40.300', E003° 18.845' with elevation – 171ft (shown), **1st Point of Impact** of aircraft right wing with the building (No. 3 Okusanya Street) N06°40.350', E003° 18.838' with elevation – 190ft (not shown), **Position of the Left engine** - N06°40.316', E003° 18.844' with elevation – 164ft (not shown), **Position of the Right engine** -N06°40.310', E003° 18.841' with elevation – 164ft (not shown)

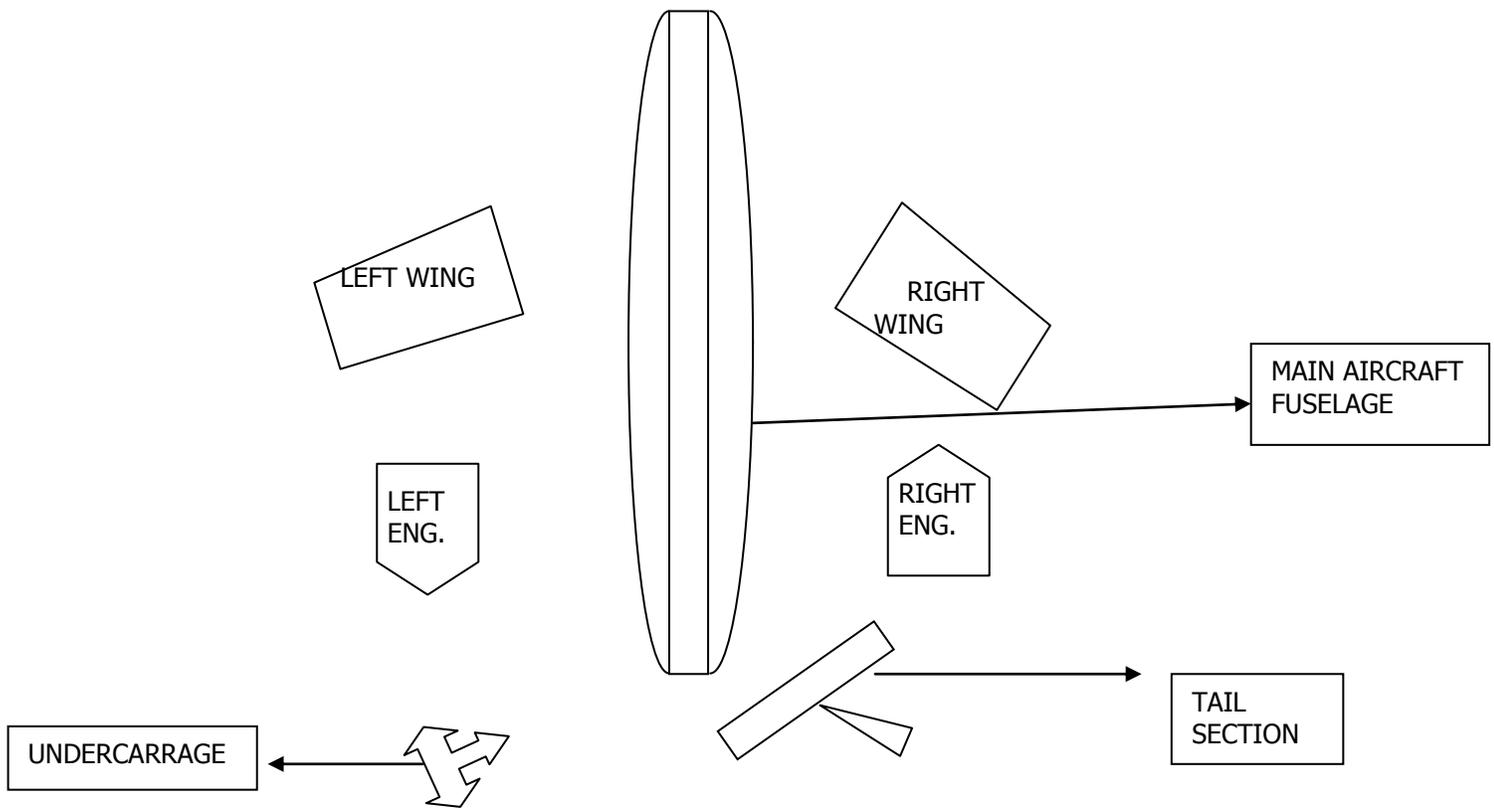


FIGURE 29: THE CRASH SITE WRECKAGE DISTRIBUTION



FIGURE 30: THE TWO ENGINES LYING SIDE BY SIDE IN THE WRECKAGE AT THE CRASH SITE

1.13 Medical and Pathological Information

The Lagos State University Teaching Hospital (LASUTH) carried out autopsy to identify the cause of death, identification of recognizable bodies and DNA test was carried out to identify unrecognizable bodies. Some of the most difficult cases were sent overseas for proper analysis and identification. The cockpit area was completely burnt and destroyed; this made it impossible to identify the crew.

However, one hundred and forty-eight (148) bodies were identified positively through DNA. There were at least three (3) suspected victims among the 148 bodies positively identified and three (3) unidentified bodies out of one hundred and fifty-two (152)



bodies recovered from the crash site. There were fifteen (15) nationals representing nine (9) countries on board the ill-fated aircraft. See Appendix E (on page 167) for the detailed pathological report.

1.14 Fire

There was outbreak of fire which consumed about 85% of the aircraft. However, there was no evidence of in-flight fire before the crash. The evidence available showed that the aircraft departed Abuja with about twenty-six thousand pounds of fuel (26,000lbs) and the expected burn-off to Lagos was 8,000lbs. This meant that the airplane crashed with about 18,000lbs of fuel on-board. One of the buildings the airplane crashed into was a printing press with a huge amount of paper and other printing materials which enhanced the fire. The Fire Services that were at the crash site came with water and foam chemical extinguishers. The crash was into a built-up area which made accessibility to the crash site almost impossible for the fire services to move their equipment to fight the fire. It was a massive fire which consumed the entire length of the airplane fuselage. It took the combined effort of all the fire services which include Federal, State, and Airport fire services to put out the huge fire. The crash site was smouldering for over four days while body recovery and evidence gathering were in progress.

1.15 Survival Aspects

The nature of the crash greatly reduced the chances of survival due to massive post-crash fire. There was no liveable volume within the forward section of the aircraft. The ground impact, with over eighteen thousand pounds (18,000lbs) of fuel onboard the aircraft, and a printing press with a warehouse of printed books and paper materials turned the whole area into a huge fire ball.



The pathology report showed that some passengers died of smoke inhalation, that is, of carbon monoxide poisoning. "This suggests that the victims were alive for some time in the fire that probably followed the crash, that is, they did not die immediately after the impact." Though the response of the search and rescue team was prompt, the operation of the fire services was hampered by inaccessibility to the crash site as a result of a bad road network. The massive crowd at the scene did not help the situation; crowd control became a big problem to the fire services and the National Emergency Management Agency (NEMA).

The recovery of bodies was intermittently delayed due to the crowd interrupting the recovery process by the massive looting that took place while the recovery was going on. The bodies of some passengers were however found in the 2-storey building into which the aircraft crashed. The cockpit area was completely destroyed, with the pathologist unable to identify any of the flight crew, either physically or by DNA testing, as a result of the impact and massive fire.

1.16 Test and Research

1.16.1 Fuel Test

Test was performed on the fuel truck, fuel bay and other aircraft belonging to Dana Airlines. See below the fuel test analysis report.

Fuel Test Analysis:

"Please note both samples provided do not show similar consistency as observed from test results carried out, implying that they are not of the same refinery batch source. Analysis - Sample brought by client and labelled MRS ABUJA has a low microseparometer rating of 57pS/m which is below the required specification of 70 pS/m for samples with SDA. (Microseparometer rating is a water separation index that rates the ability of a fuel to release entrained or emulsified water when passed through a fibreglass filter coalescer.) - Sample brought by client and Labelled BOWSER (MRS



RF2213) Truck gave a positive indication of presence of reactive Sulphur compounds, and further qualitative testing gave results of Mercaptans Sulphur of 0.0047% mass which exceeds the specification limit of 0.003% mass (Mercaptans Sulphur are free radicals present in fuel having an unpleasant odour, and attack certain elastomer materials found in fuel systems.).”

1.16.2 Simulator Programme Conducted at the PANAM Aviation Academy (PAIFA) Florida, USA (Ref, MD- 83 Air Accident Investigation)

Simulator Flight Test was carried out in Miami Florida USA. Details are shown below:

The simulator was prepared with a take-off weight of 138,000 lbs, fuel of 26,400 lbs and the airport assumed scenario of Abuja with temperature of 31⁰C, QNH 1013 hPa and wind calm, landing weight of 130,000lbs. The first engine start-up was with all booster pumps ON and the engine parameters were as follows:

	Left Engine	Right Engine
EPR	1.03	1.03
Oil Pressure	44	44
N ₁	27	27
N ₂	55	55
EGT	433	432
Hyd. Pressure	2600	2900 psi
Oil Temp.	79	82
Fuel Temp.	32	31

Engines were shut down and the second engine start-up was with all Booster pumps OFF and relevant parameters were as follows:

	Left Engine	Right Engine
EPR	1.03	1.03
Oil Pressure	44	44
N ₁	27	27
N ₂	55	55
EGT	433	432
Hyd. Pressure	2600	2900 psi
Oil Temp.	79	82
Fuel Temp.	32	31



The Simulator was then prepared for the first take-off with the centre tank booster pumps selected ON while the wing tank booster pumps were left in the OFF position. Engine parameters were as follows:

	Left Engine	Right Engine
EPR	1.03	1.03
Oil Pressure	44	44
N ₁	26	26
N ₂	53	53
EGT	396	394
Hyd. Pressure	3000	3000psi
Oil Temp.	32	32
Fuel Temp.	59	72

The simulator climbed to 5000ft and made the first landing. Second T/O was with Main tanks booster pumps selected ON and the centre tank booster pumps were selected OFF and the engine parameters were exactly the same as the previous take off.

The next take-off was with the wing tanks booster pumps ON, centre tanks booster tanks OFF and climbed to 26000ft with engine parameters recorded at every 5000ft, after take-off, fuel was observed depleting from the wing tanks while the centre tank fuel remain constant.

At 5000ft, engine parameters recorded as:

	Left Engine	Right Engine
EPR	1.21	1.24
Oil Pressure	44	44
N ₁	62	65
N ₂	79	80
EGT	374	379
Hyd. Pressure	3000	3000psi
Oil Temp.	31	32
Fuel Temp.	100	96



At 10,000ft, engine parameters recorded as:

	Left Engine	Right Engine
EPR	1.33	1.36
Oil Pressure	44	44
N ₁	70	71
N ₂	82	83
EGT	357	374
Hyd. Pressure	3000	3000
Oil Temp.	31	31
Fuel Temp.	98	98

At 15,000ft, engine parameters recorded:

	Left Engine	Right Engine
EPR	1.35	1.37
Oil Pressure	44	44
N ₁	70	71
N ₂	81	82
EGT	352	356
Hyd. Pressure	1600	1600
Oil Temp.	30	30
Fuel Temp.	98	95



At 20,000ft the engine parameters were recorded as:

	Left Engine	Right Engine
EPR	1.40	1.40
Oil Pressure	44	44
N ₁	72	72
N ₂	81	81
EGT	349	349
Hyd. Pressure	1600	1600
Oil Temp.	28	29
Fuel Temp.	94	93

At 25,000ft, the engine Parameters were recorded as:

	Left Engine	Right Engine
EPR	1.52	1.52
Oil Pressure	44	44
N ₁	75	75
N ₂	82	82
EGT	355	355
Hyd. Pressure	1600	1600
Oil Temp.	27	26
Fuel Temp.	91	90



At 26,000ft, all the six booster pumps were selected OFF and some manoeuvres like steep turns, rapid descent and slow flights were performed. The speed was increased to 290kts, then reduced to 250kts and further down to 210kts. The engine driven pumps were observed to have sustained the engines with NO engine parameter fluctuations.

Descent commenced to 5000ft, aircraft configured for landing but with only 28° of flap and at 15 miles to touch ground, both engines were shut down and the final approach commenced. The simulator touch down at the middle of the runway and over ran the runway. Second attempt was with flaps 15° and the result was the same as flap 28°.

Simulator was repositioned for final approach with gear down and flaps 15° but this time at 2200ft, then engine shut down but it was not possible to make the field. It crashed before the threshold of the runway.

Another normal take-off was carried out and climbed to 15000ft. Fuel restriction/contamination was simulated by shutting down the left engine to correspond to engine rollback, the right engine parameters were observed to be normal. The simulator was configured for landing with 28° flaps, both the hydraulic pressure and the electrical power were normal and sustained. The simulator was descended to 2,200ft followed by flaps selected up, gears selected up and the systems operation and responses remain normal as the MD-83 control surfaces are cable powered.

Thereafter, the right engine was shut down, the flaps were selected up and the landing gear also selected up but on landing it was discovered that the right landing gear was not fully retracted before touch down but the flaps were fully up. Electrical operations were from the hot battery bus (Battery Switch On).



1.16.3 Fuel Nozzle Test

The fuel nozzles from both engines were quarantined for further evaluation and testing. Work scope, testing facility, and test dates were determined and the test was carried out in the USA.

1.16.4 Metallurgical Test of Fuel Manifold Component

Fuel manifold segment test from #1 Engine was performed at the NTSB laboratory in the USA. The fuel manifold from Engine #2 was not provided by the operator who had custody of the accident engines.

The Fuel Manifold segment from Engine #1 of a Pratt & Whitney JT8D-217C revealed during examination using stereo microscope, that the fractures were consistent with overstress separations and bending load. See Appendix I for the full report.

1.17 Organizational and Management Information

Dana Airlines Nigeria Limited was incorporated as a private limited liability company in Nigeria, a member of Dana Group of companies.

Dana Airlines Nigeria Limited is an Air Operator Certificate (AOC) holder with operational base in Murtala Muhammed Airport (MMA 2), Ikeja where it maintains operational and line maintenance support facilities. The Airline operates both scheduled and non-scheduled domestic passenger services within Nigeria.

1.17.1 Description of Organizational Structure

Dana Airlines Nigeria Limited has in place a functioning management system headed by a senior corporate official who is the Accountable Manager and has the overall accountability including the authority and control of the resources necessary to finance, implement and enforce policies and procedures within the operations.

a. The Company Board of Directors appoints the Dana Airline Limited Management.



b. The Accountable Manager of Dana Airlines sees to the day to day running of the airline. He has under him a Management Team who performs assigned functions to help achieve the company corporate goals.

c. The Director of Flight Operations reporting to the Accountable Manager has the responsibility of running the Flight Operations Department in line with the applicable requirements of the Nig. CARs.

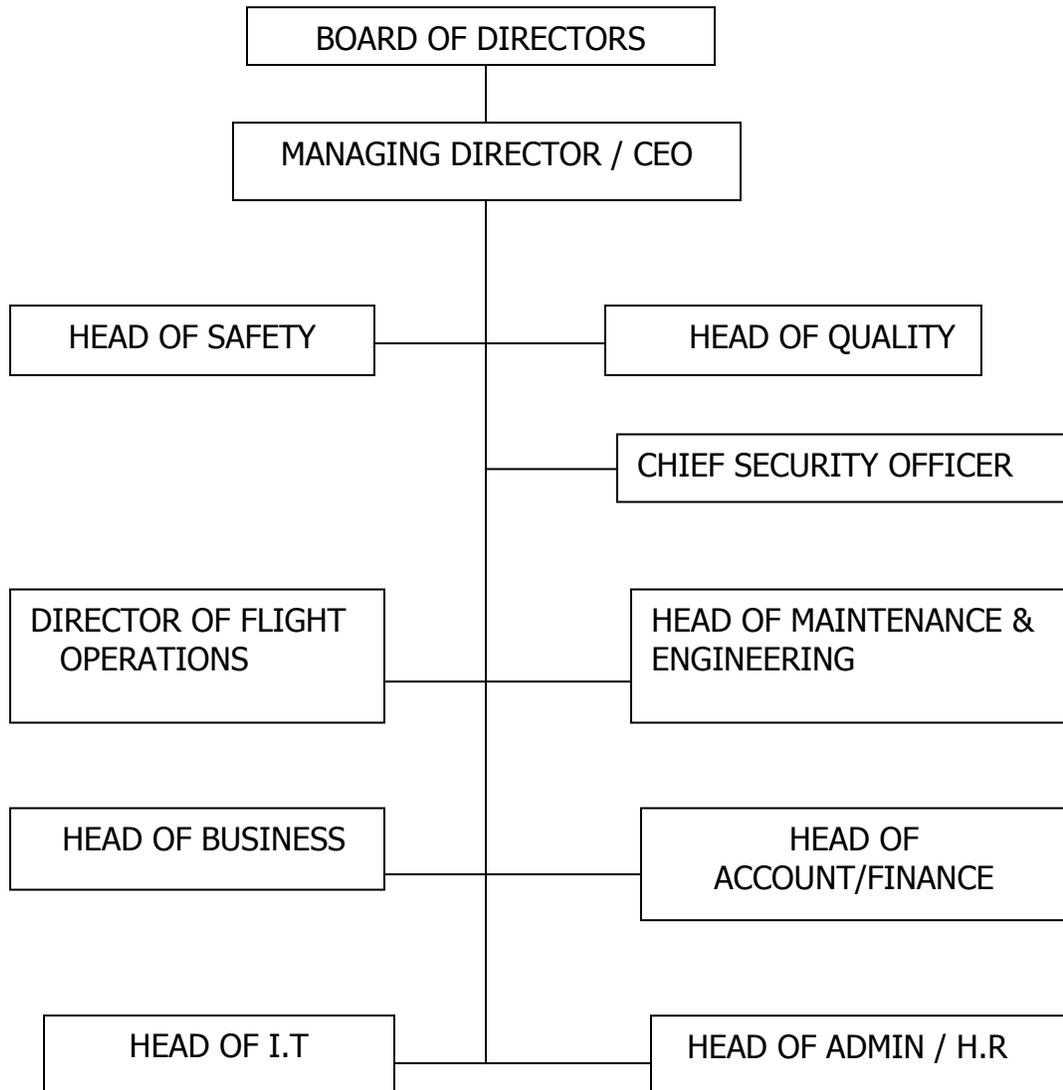
d. The Head of Maintenance & Engineering reporting to the Accountable Manager has the responsibility of running the Maintenance and Engineering Department in line with the applicable requirements of the Nig. CARs.

e. The Head of Quality reporting to the Accountable Manager monitors compliance with the approved procedures to ensure compliance with the applicable Nig. CARs requirements.

f. The Head of Safety, reporting to the Accountable Manager monitors the implementation of the airline safety management programme.

g. The Chief Security Officer reporting to the Accountable Manager ensures the safe and efficient operation of the security apparatus of the airlines within limits set by professional and mandatory criteria.

The General Company Organogram is as shown below:



1.17.1.1 Chief Pilot

Reports to : The Director of Flight Operations

Direct Subordinates : The Fleet Captains

The Chief Pilot is responsible for all crew irrespective of fleet and shall be an active line pilot (commander) rated on one or more aircraft type. The Chief Pilot is responsible to



the Director of Flight Operations for the safe and efficient operation of Dana Air Fleet of aircraft and the management of its flight crew training resources.

Responsibilities

The Chief Pilot is responsible for:

- a) Effective man management, discipline, development and motivation of flight deck crew to ensure performance to the highest standards of flight safety and passenger care;*
- b) Advising on flight training matters, recommending courses of training to maintain and improve standards as appropriate.*
- c) Recommending pilot training appointments, and ensuring training captains operate to a high standard and a full awareness of their responsibilities to both the airline and the regulatory authority;*
- d) Advising on the selection and recruitment of new entrant pilots*
- e) Advising on flight technical matters, ensuring Company procedures and techniques are consistent with the aircraft manufacturer's requirements, and the relevant technical and airworthiness authorities.*
- f) Maintenance of all records of aircrew licences and medicals.*
- g) Maintaining all records, of aircrew conversion training and periodic training and testing.*
- h) Random check of Voyage Reports complete flight documentation.*
- i) Operation of the pilot leave policy and approval of leave; Flying company routes on a regular basis, keeping the Director of Flight Operations informed of any potential.*

With reference to Dana Airline approved Ops Manual Part A, the authority of the Captain, responsibilities of the co-pilot, the use of the Quick Reference Checklist used to stabilize emergency conditions are clearly stated, situation awareness and clear decision making capability were emphasized and can be seen in Appendices 'B' and 'C'. There was no record of mandatory company procedure indoctrination in accordance with Nig. CARs 8.10.1.9a.



1.17.1.2 Recruitment of Foreign Pilots

Reference to the approved Ops Manual, Part A, Section 6, Dana Airlines outlined some qualifications and requirements for the recruitment of foreign pilots which included:

Oral interview of shortlisted candidates following the advertisement on-line, and there after other information on technical competencies and skills; aviation experience; credentials and licences; interpersonal skills; medical fitness; security background check and English language fluency, and any other information if so required upon successful implication of the above, the foreign crew license will be revalidated by NCAA in order to fly Nigeria Registered aircraft, general written test, appraisal check flight for 2hrs in the simulator, ground school at PAIFA, Miami in Florida short and long course.

The investigation revealed that the Quality Department of Dana Airlines Nigeria Limited was not involved in the recruitment process and screening of the flight crew as stated in the company's Operations Manual.

1.17.2 Nigerian Civil Aviation Authority (NCAA)

The NCAA is charged with regulation of airlines, Personnel, Equipment, and Organizations etc., in Nigeria. Below are some pertinent regulations to this investigation which the airline needed to comply with as an AOC holder.

Validation and Conversion of Foreign Licences, Ratings, Authorisation and Certificates

Nig. CARs. 2.2.4.1 General Requirements for Validation

- 1) A person who holds a current and valid pilot licence issued by another Contracting State in accordance with ICAO Annex 1, may apply for a validation of such licence for use on aircraft registered in Nigeria.*
- 2) The applicant for the validation certificate shall present to the Authority the foreign licence and evidence of the experience required by presenting the record (e.g. logbook).*



- 5) *The Authority will verify the authenticity of the licence, ratings authorizations and the medical certificate with the state of licence issue prior to issuing the validation.*

Checklist Compliance

Nig. CARs. 8.5.1.9 *The PIC shall ensure that the flight crew follows the approved checklist procedures when operating the aircraft.*

Diversion Decision – Engine Inoperative

Nig. CARs. 8.8.1.10 *(a) Except as provided in paragraph (b), the PIC shall land the aircraft at the nearest suitable aerodrome at which a safe landing can be made whenever an engine of the aircraft fails or is shut down to prevent possible damage.*

Initial Aircraft Flight Training

Nig. CARs. 8.10.1.15 *(a) No person may serve nor may any AOC holder use a person as a flight crewmember unless he or she has completed the initial flight training approved by the Authority for aircraft type.*

(b) Initial flight training shall focus on the manoeuvring and safe operation of the aircraft in accordance with AOC holders normal, abnormal and emergency procedures.

(c) An AOC holder may have separate initial flight training curricula, which recognise the experience.

1.17.3 Nigerian Airspace Management Agency (NAMA)

NAMA is charged among other functions with the responsibility of providing Air Navigation Services to airspace users in Nigeria. However, NCAA has oversight functions over NAMA. Air traffic services which include Air Traffic Control (ATC), Area Control, Radar etc., are under its administration. Air Traffic Controllers are charged with helping pilots at any time especially during emergency.

The airspace manager submitted a report on Dana Air Flight 0992. See Appendix H.



1.17.4 Millenium Engine Associates Incorporated

Millenium Engine Associates Incorporated is a Maintenance Repair Overhaul (MRO) facility approved by the United States Department of Transportation, and the Federal Aviation Administration, to perform major repairs and alterations on aircraft airframe, powerplant, propeller and appliance.

The MRO is equally approved by Nigerian Civil Aviation Authority (NCAA) to perform repairs and overhaul of engines and components on Nigerian registered aircraft.

Millenium Engine Associates Incorporated overhauled the two engines on the crashed aircraft. No. 1 Engine on 5N-RAM was overhauled on the 3rd of August 2011, while No. 2 Engine had its shop visit on 2nd of December 2011 at the Millenium facility.

Millenium Engine Associates Incorporated has since changed its name to Global Engine Maintenance, LLC with the same FAA Certificate No. Y2MR496Y. Under the new name, it overhauled the No.1 Engine ESN 725851 on a similar aircraft with registration 5N-SAI operated by Dana Airlines Nigeria Limited on 11th of April 2013, which had an air return on 6th October 2013, for engine failing to respond to throttle movement.

The engine teardown was performed at Global Engine Maintenance facility (formerly Millenium Engine Associates) in the USA. The organization is also responsible for securing and ensuring that all the parts examined are returned to the engine owners with the permission of the investigating body. However, certain components such as the right fuel manifold were not available for subsequent examination.

1.17.5 Pratt and Whitney

This is a United Technologies Company. Pratt and Whitney is an approved primary manufacturing organization, manufacturer of the JT8D-217C and JT8D-219 engine series installed on 5N-RAM amongst other axial-flow turbofan engines.



Turbojet Engine Service Bulletin No JT8D 6452

Pratt and Whitney was fully aware of the problem of reported secondary fuel manifold assembly fractures, causing fuel leaks which resulted to unscheduled engine removals, in-flight shutdowns and air returns including engine-contained fire in 2001.

The manufacturer issued a Service Bulletin JT8D 6452, in October 2003, providing secondary fuel manifold assemblies fabricated with new tube material, which have a significantly greater fatigue life than the old tube material at 0.080 inch (2,032mm) displacement.

The improved fatigue life of the new material will result in manifold configurations that are more durable, reducing the occurrence of fractures.

Following several instances of reported secondary fuel manifold assembly fractures due to thermal stresses, causing 94 UERs, 1 IFSD, 2 ATBs, and 1 contained fire, Pratt and Whitney issued an SB with compliance code '6'.

1.18 Additional Information

1.18.1 Dana Airlines Nigeria Limited Internal Investigation on 5N-RAM

Dana Airlines Nigeria Limited carried out an internal investigation on the accident aircraft 5N-RAM.

Below is an extract from the report:

Flight Operations: Record Check (6/6/2012)

In this department, we began by interviewing the Chief Pilot to intimate us with the hiring process followed by the department in the recruitment of flight staff. The following were enumerated in order:

1. Advertisement on-line through the following agencies:

- Climb –to-350 located in the US*
- PARC Aviation located in the UK*

2 . Oral interview of short listed candidates



3. General written test

4. Appraisal checks flight for 2 hours in the Simulator.

5. Background check is carried out on successful candidates.

- *By calling on previous employers*
- *By checking on people who know the candidates.*

6. Ground school at PAIFA, Miami Florida: Candidates are grouped under two categories thus:

- *Candidates who are current and qualified are taken through SHORT course of 4 days duration.*
- *Candidates who are not current but qualified are taken through a LONG course of 7 days duration.*

SHORT COURSE comprises: (System, CRM, RVSM, and Hazmat)

3 training sessions of 4 hours each and 4th session of proficiency check in the simulator.

LONG COURSE comprises:

6 training sessions on system knowledge of 4 hours each and a 7th session of proficiency check in the simulator.

7. Company Indoctrination

8. Medical Check

9. Air law for those who pass their medicals.

10. Validation by the NCAA.

11. Line Training of up to 25 hours flying.

12. Release to Line Operation.

Observation

- 1. Record of due diligence performed on accident Captain in respect of Falcon Airlines where he acquired flying hours as PIC, was not sighted in his file. Note that he flew the MD 80 for Falcon Airlines.*



2. *Record of security background check carried out was not sighted.*
3. *Recommended letters from persons attesting for the suitability of the candidate were not signed.*
4. *The following remarks were noted during accident Captain check-out Flight (Line Training)*
 - (a) *On 26/04/12: "Call-out & Operating procedures needs to improve."*
 - (b) *On 26/04/12: "Company procedures to be adhered to."*
 - (c) *On 27/04/12: "Procedures & position reporting needs to be standardized to ICAO format."*
 - (d) *On 28/04/12: "Standard Operating procedures to be standardized to ICAO position".*
 - (e) *ON 29/04/12: "RT Reporting to be improved".*
 - (f) *On 29/04/12: "RT Procedures & positioning reporting needs to improve."*
 - (g) *On 30/04/12: "RT procedures to be improved".*
5. *There was no record showing any improvement before accident captain took command.*
6. *We tried to do a due diligence on accident Captain, as part of this investigation by contacting Spirit Airlines, where he flew 6500hrs on the MD83 as PIC. We were informed that they were already working with the NTSB and that we could contact the NTSB for any information we may need on accident Captain.*
7. *There are no records of Ground school attendance in Miami.*
8. *There are no records of Indoctrination courses conducted for Pilots.*
9. *Departure and arrival call-out to OCC, which is a standard procedure, was not complied with by all the pilots. Accident Captain, the PIC of the ill-fated Flt 0992 did not call Abuja or Lagos OCC throughout the flight.*



RECOMMENDATION

It is observed that Quality Department of Dana Airlines is not involved at any stage in the recruitment process of flight crew. The Quality department should be involved at the screening phase of the recruitment exercise.

1.18.2 Related Incident – MD-83, 5N-SAI (Air return due to No.1 Engine Power Loss and Not Responding to throttle movement) ESN P725851D

On 6th October 2013, 5N-SAI MD-83 belonging to Dana Airlines Nigeria Limited, operating flight 0348 Port Harcourt to Lagos, suffered loss of power on No.1 Engine during climb out at 14,000ft. The Engine failed to respond to throttle movement and remained at idle power 1.03 EPR. The Captain noticed a dip of the left wing, loss of thrust, and auto throttle disconnected.

The crew noticed slow acceleration of the No. 1 Engine in the previous flight legs. The Captain asked the ground Engineer to ride with him in the cockpit to monitor the subject Engine. During acceleration check at the threshold, the crew observed that left engine took thirty seconds (30 sec) to accelerate from idle rpm to 58-60% N2 instead of 6 seconds as recommended by the M.M. (from ground Idle to 1.4 EPR).

The table below shows the parameters on both engines up to the moment thrust was lost on the left engine, as recorded by the Engineer riding in the cockpit.

IDLE

	LH Engine	RH Engine
N1	28%	28%
EGT	420°C	440°C
N2	54%	50%
FF	1000pph	1000pph
EPR	1.03	1.03

Take-off EPR target 1.94

CLIMB

	LH Engine	RH Engine
N1	46%	86%
EGT	350°C	480°C
N2	70%	86%
FF	1270pph	14,300pph
EPR	1.03	1.71

However, the Captain reported technical problem to ATC, declaring engine problem and that he was returning to Port Harcourt. The engine was dropped and sent for teardown in an FAA approved Repair station (FJ Turbine Power) to determine the cause of failure having been previously overhauled in Global Engine Maintenance LLC, Florida, USA (Millenium Engine Associates Inc.) on 11th April, 2013. See Figure 31 (page 69).

Upon removal of the fan discharge ducts, it was noted that the R/H fuel manifold inlet fairing was improperly installed due to lack of engagement of the front and rear sections on the inboard side. Image 1 shows assembly as installed on engine. Image 2 shows assembly as removed from engine. See Appendix F for Images 1 and 2.

The R/H fuel manifold assembly showed a fracture on the secondary fuel inlet tube, No.5 fuel nozzle at 5 o'clock position. The secondary fuel manifold inlet tube was liberated adjacent to the No. 5 fuel nozzle coupling location. Reference Service Bulletin (SB) 6452.

A Service Bulletin was issued by the Manufacturer to address a problem relating to the cause of the engine not responding to throttle movement. 5N-SAI was the latest incident in the Airline regarding engine failure to respond to throttle movement. This led



to the discovery of two fuel manifolds enclosing primary and secondary fuel supply lines in the fan air discharge section located approximately 5 o'clock position, which were found not to have conformed to standard configuration, resulting in the secondary supply line being severed. See Appendix F.

U.S. Department of Transportation Federal Aviation Administration		Form Approved OMB No. 2120-0020 11/30/2007	Electronic Tracking Number
MAJOR REPAIR AND ALTERATION (Airframe, Powerplant, Propeller, or Appliance)		For FAA Use Only	
INSTRUCTIONS: Print or type all entries. See Title 14 CFR §43.9, Part 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form. This report is required by law (49 U.S.C. §44701). Failure to report can result in a civil penalty for each such violation (49 U.S.C. §46301(a)).			
1. Aircraft	Nationality and Registration Mark	Serial No.	
	Make	Model	Series
2. Owner	Name (As shown on registration certificate)	Address (As shown on registration certificate)	
		City	State
Zip			
3. For FAA Use Only			
4. Type		5. Unit Identification	
Repair	Alteration	Unit	Make
<input type="checkbox"/>	<input type="checkbox"/>	AIRFRAME	(As described in item 1 above)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	POWERPLANT	Pratt & Whitney
<input type="checkbox"/>	<input type="checkbox"/>	PROPELLER	Model
<input type="checkbox"/>	<input type="checkbox"/>	APPLIANCE	Serial No.
		Type	
		Manufacturer	
6. Conformity Statement			
A. Agency's Name and Address		B. Kind of Agency	
Global Engine Maintenance, LLC 10300 NW 19 th Street, Suite 104 Doral, Florida 33172		<input type="checkbox"/> U.S. Certificated Mechanic	<input type="checkbox"/> Manufacturer
		<input type="checkbox"/> Foreign Certificated Mechanic	C. Certificate No.
		<input checked="" type="checkbox"/> Certificated Repair Station	Y2MR496Y
		<input type="checkbox"/> Certificated Maintenance Organization	
D. I certify that the repair and/or alteration made to the unit(s) identified in item 5 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge.			
Extended range fuel per 14 CFR Part 43 App. B	<input type="checkbox"/>	Signature/Date of Authorized Individual George W. Lopez – Chief Inspector April 11, 2013	
7. Approval for return to Service			
Pursuant to the authority given persons specified below, the unit identified in item 5 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is <input checked="" type="checkbox"/> Approved <input type="checkbox"/> Rejected			
BY	<input type="checkbox"/> FAA Flight Standards Inspector	<input type="checkbox"/> Manufacturer	<input type="checkbox"/> Maintenance Organization
	<input type="checkbox"/> FAA Designee	<input checked="" type="checkbox"/> Repair Station	<input type="checkbox"/> Inspection Authorization
Certificate of Designation No. Y2MR496Y		Signature/Date of Authorized Individual George W. Lopez – Chief Inspector April 11, 2013	

FIGURE 31: FAA MAJOR REPAIR AND ALTERATION CERTIFICATE



1.18.3 Regulatory Information

The Nigerian Civil Aviation Authority (NCAA) carried out an audit of Dana Airlines Nigeria Limited between the 9th and 12th December 2013. There were open findings that needed to be addressed by the Operator.

However, on the 18th December 2013, NCAA directed that all the Engines that had been previously overhauled by Millenium MRO should be sent to NCAA approved engine shop(s) for overhaul before they could be allowed to be re-installed on any Dana Airlines aircraft that may be allowed to commence operations. See Appendix D

Investigation revealed that NCAA documents for the background checks and MROs monitoring are not adequately structured to reveal anomalies.

1.18.4 Witness Account by Ground Personnel (Abuja)

On arrival of the aircraft in Abuja, the ground staff asserted that the Captain ordered that the rear passenger exit door should not be opened nor used for passenger disembarkation/embarkation.

Routine turnaround activities were performed, which includes the transit flight preparations and refuelling of the aircraft in which 8000lbs of fuel was uplifted in addition to what was left in the main tanks and thus summed up the total fuel on board at departure as 26000lbs.

At two separate times, the Station Manager and the Duty Ramp Officer requested permission from the Captain to board the passengers. This was refused first by the Captain and secondly by the First Officer as both stated that they were having a meeting with all the crewmembers.

The Engineer that rode on the flight from Lagos on relief duty disembarked in Abuja to take over from the ground Engineer in Abuja, who later died in the ill-fated crash.

All these were confirmed by Dana Airline personnel in Abuja.



1.18.4.1 Other Witness Accounts

Other witness's accounts were recorded, mostly from former pilots of the airline. They gave their various perceptions/opinions about Dana Airlines Nigeria Limited maintenance culture and other safety related issues e.g. the habit of not entering defects in the technical log book. Most of them left the airline either sacked or frustrated out of the company and are being owed various amounts of money.

1.19 Useful or Effective investigation Techniques

Nil.



2.0 ANALYSIS

2.1 The Conduct of Flight

On 3rd June 2012, Dana Airlines Nigeria Limited operated a Boeing MD-83 aircraft registered 5N-RAM as DANACO 0993 from Lagos to Abuja on an instrument flight rule (IFR). The flight was uneventful and was about one hour late as it arrived Abuja at about 1450:00hrs. According to Dana Airlines Nigeria Limited ground Engineer in Abuja, the Captain after parking, ordered that the rear passenger exit door should not be used for passenger disembarkation/embarkation. The reasons for this instruction were not known. Routine turnaround activities were performed which included the transit flight preparations and refuelling of the aircraft in which 8000lbs of fuel was uplifted that summed up the total fuel on board at departure as 26000lbs. The Lagos inbound flight was called DANACO 0992. At two separate times, the Station Manager and the Duty Ramp Officer requested permission from the Captain to board the passengers. This was refused first by the Captain and secondly by the First Officer as both stated that they were having a meeting with the crewmembers. Details of this meeting were not known to anyone. These were all confirmed by Dana Airlines Nigeria Limited ground personnel in Abuja.

Finally, the passengers boarded and the crew requested for engine start up and FL330 (thirty three thousand feet) to Lagos from the Control Tower. Engine start up clearance was approved, temperature of 23°C, QNH 1013 and to squawk 0412. Subsequently the aircraft was cleared to taxi to the holding point of runway 04. En-route clearance on airway UH340 was passed to DANACO 0992 to climb to FL180 (eighteen thousand feet) initially and to request level change en-route. On approaching holding point of runway 04, DANACO 0992 was cleared to line up on runway 04 and wait but DANACO 0992 requested for some time before lining-up, according to the ATC ground recorder transcript.

The aircraft was airborne Abuja for Lagos at 1458:00hrs. After airborne, DANACO 0992 contacted Kano Control Centre for traffic information and was further cleared to FL260



(Twenty six thousand feet). Thereafter, DANACO 0992 was cleared to continue with Kano Centre by Abuja ATC.

According to the CVR, as early as 17 minutes into the flight, the crew started discussing an unspecified problem with particular reference to the 'left' which AIB believed was a reference to the left engine. This coincided with the time the CVR 30-minutes limit started recording and at 1515:56hrs the Captain stated that "we just want to get # home" which AIB believed was the aircraft.

During further discussions, the First Officer asked if he can call in the Engineer who was repositioning to Lagos to help analyse the problem but the Captain refused. The Captain concluded, "well I don't need him here cause we can figure it out, he's not going to be able to help us". During the period that the flight crew were discussing and trying to manage the situation they were facing, the Captain also asked the First Officer if any Engineer had tampered with the panel by the rear exit door on ground Abuja and finally concluded that "this is the guy that had an issue with us. uh he's pissed off at us"; according to the CVR transcript. The flight however continued towards Lagos as the crew continuously discussed the problem with vague references to EPR and non-response from the throttle inputs, with the left engine operating at idle power or inoperative. The crew decided that they should start a gradual descent and accordingly established contact with Lagos ATC, passed the estimates of ERAMI at 1530:00hrs and LAG at 1543:00hrs which was followed with a request for descent clearance. Meanwhile, from the CVR transcript, there was no evidence that the crew did call for the non-normal/emergency checklist in an attempt to ascertain the sudden and unexplained non-response of the left engine to throttle movement.

During the initial descent, the Captain wanted the F/O who was then the Pilot Flying (PF) to increase the rate of descent but the F/O stated that he would prefer a gradual descent in order to have enough height over Lagos. Lagos ATC had cleared DANACO 0992 to descend initially to FL160 (Sixteen thousand feet) and to expect radar vectors for an ILS approach for runway 18L and further approved high speed approach. The



flight crew accordingly maintained a continuous monitoring watch of the situation. At 1527:30hrs the F/O advised the Captain to use runway 18R for landing and the request was made at 1531:49hrs and subsequently approved by the Radar Controller. The crew accordingly changed the decision height to correspond with runway 18R.

Earlier at 1531:12hrs, the crew confirmed that there was no throttle response on the left engine and subsequently the Captain took over control as PF at 1531:27hrs. Then flight was however continued towards Lagos with no declaration of any distress message. With the confirmation of throttle response on the right engine, the engine anti-ice, ignition and bleed-air were all switched off. At 1534:33hrs the Captain confirmed that "okay this one is good for us so far".

At 1535:19hrs, the Captain instructed the F/O to call 'it' then since they were probably not going anywhere and concluded that "we're gonna be investigated by the NCAA". The flight crew became increasingly concerned as the flight transitioned into the approach phase during which time the crew received series of heading and altitude radar vectors from the Radar Controller. At the same time, the crew also carried out some of the pre-landing tasks that included the extension of slats at 1537:07hrs and the speed-brakes were deployed at 1537:10hrs. The First Officer indicated that they were slightly high and the Captain replied that he was correcting and then requested for flaps eleven. At 1537:53hrs the Captain further requested for flaps one-five (flaps fifteen). And subsequently the problem became compounded as thrust was required to continue the final approach. Meanwhile, there was no evidence from the CVR transcript, that an engine-out descent profile was followed and flown towards Lagos.

At 1538:35hrs, both crew indicated that they were 21 miles on the localizer. At 1538:54hrs, there was EGPWS automated voice warning of "landing gear" which the Captain responded to at 1539:10hrs by requesting for the landing gear to be selected down. At 1539:56hrs, Lagos Radar Controller requested DANACO 0992 to verify passing seven thousand seven hundred feet which was confirmed by the First Officer. At



1540:42hrs, he confirmed to the Captain that they were five thousand, fifteen miles, which the Captain acknowledged with an increase in the rate of descent.

According to the CVR transcript at 1541:46hrs the First Officer inquired if “both engines come up” and the Captain replied “negative” at 1541:48hrs. The two engines finally did not respond to throttle inputs as both engines failed to produce the commanded thrust. From evidence available, there was never any call for the checklist both normal and non-normal/emergency throughout the entire flight and the use of the Quick Reference Hand Book (QRH) was never detected.

At 1541:56hrs, the F/O asked the Captain if he can declare an emergency and they subsequently discussed and agreed to declare an emergency. At 1542:10hrs, DANACO 0992 radioed an Emergency Distress Call stating “Dual Engine Failure, negative response from throttles”. The Radar Controller then requested DANACO 0992 to “say again the last transmission” and the crew repeated the Distress message before the Radar Controller directed DANACO 0992 to contact the Control Tower on 118.1 MHz for landing instructions. DANACO 0992 was however unable to contact the Tower before the crash.

According to the CVR transcript, they tried to change frequency to 118.1 MHz which was indicated by a sound similar to radio frequency knob spinning at 1542:25hrs but were unable to select the Tower frequency. At 1542:35hrs the Captain requested for flaps twenty eight which the First Officer selected. This was after the crew had declared an Emergency of dual engine failure. At 1542:50hrs the First Officer informed the Purser through the intercom to prepare for landing and that, as of then the situation appeared under control.

At 1543:30hrs there was an automated voice of “altitude” followed by the Captain’s indication of sighting the runway at 1543:45hrs. He then instructed the First Officer to select the flaps up at 1543:49hrs followed by another instruction to select the landing gears up at 1543:50hrs. At this point, the Captain stated that he would not want to stall the aircraft. The Captain then concluded that “we just lost everything, we lost an



engine, I lost both engines". And during the next twenty five seconds, the Captain requested for everything that could help recover thrust including "relight", "ignition override" "just anything" to be given to him. During the later stages of the approach, there were numerous sounds similar to stabilizer trim in motion as the Captain tried to keep the aircraft flying to avoid impacting obstacles but to no avail. From 1543:32hrs the automated voice of "altitude" continued sounding until the end of recording. Indeed, the Captain expressed concern that he would not want to stall the aircraft, as the aircraft had no power. The last event captured on the CVR was "too low gear" at 1544:29hrs.

The aircraft crashed into a densely populated residential area about 5.8 miles north of Lagos airport at 1544:33hrs in daylight and in Visual Meteorological Conditions, reference point N06° 40.318, E003° 18.845, elevation of 177ft. The aircraft wreckage was on approximately the extended centre line of runway 18R.

The aircraft was largely consumed by impacts and post crash fire with the tail section, the two burnt engines and portions of both wings representing only about 15% of the airplane which was recovered from the crash-site for further examination. The flight recorders were recovered with signs of extreme exposure to fire, which made the FDR unreadable due to the damage caused by the fire. However, the CVR was downloaded successfully.

2.2 Dana Airlines Policy/Procedures

Dana Airlines has an NCAA approved Operations Manual to guide their operations and enhance safety. However, a good policy and procedure is one thing, understanding the need for adherence to these policies and procedures is another. As evident in the CVR transcript, the crew did not follow the dictates of the Operations Manual as approved by NCAA. Checklists were not used. Occasionally, the call out for completion of checklist was made without checklist being read.



The analysis of the CVR recordings indicated that there were problems. The emergency/quick reference checklist were not used which always emphasize "land at the nearest suitable airfield". The pilots overflew Ilorin, Akure and Ibadan on their way to Lagos. These were the options available to the crew for emergency landing or they could have made an air return to Abuja. At one time the pilot asserted that the aircraft could not quit on them. At another time, the captain said declaring an emergency would make NCAA come after them. The delay to declare an emergency due to unexplained fear of the Regulatory Body compounded their problems. The Crew Resource Management (CRM) between the technical crew was poor as evident in the CVR transcript. Swear words were frequently used.

The pilots have their various duties as prescribed in the Dana Airlines policy manual; however, the cockpit gradient was steep, this made the co-pilot to be less assertive. The co-pilot made good contributions such as: "let's have a late descent" but the captain overruled him and asked for descent, also the co-pilot requested "want me to declare emergency?" and the captain said "yes". If the crew had maintained high altitude as suggested by the co-pilot, they would have had height advantage over Lagos for better speed and manoeuvring to enhance their chances of survival during the emergency landing.

At the time the crew did not get engine response from the throttle movement, appropriate checklists should have been used for the safe operation of the flight. Either of the pilots should have called for the dual engine failure Checklist; this Checklist would have helped to outline the commit points and prioritized their duties based on what to do and what not to do. The non-use or improper use of a Checklist can cause incidents/accidents. The purpose of these simple memory joggers is to improve aviation safety through crew co-ordination and proper accomplishment of multiple tasks. Instead, the captain requested that the co-pilot should give him "anything", "everything", "gear down and flaps". The gear and flap down changed the configuration and slowed the aircraft and reduced the stall speed. When it became obvious that the aircraft speed was dropping, the captain then requested for the gear and flaps to be



retracted, this increased the stall speed. The captain was heard saying "I don't want to stall, I don't want to stall". At a time the pilots were not sure which runway was nearer. The aircraft crashed into a built-up area in Lagos.

Inappropriate decision making was observed as deviation from regulatory and company procedures in considering diversion option to the officially filed alternate airport which was Ilorin. The crew also exhibited a lack of situation awareness which compounded their problem.

2.2.1 Captain Recruitment/Training Records

AIB carried out a comprehensive overview of the Captain's recruitment and training records both in the simulator and the flight line training, and the following findings were observed.

Before arrival of the captain in Nigeria, he was sent to Miami, Florida in USA for Ground School Programme and Simulator Recurrency. On arrival in Nigeria, he took the Air Law Examination and the medical test. Records of the above requirements were sighted by AIB and found satisfactory. The ground school training in PAIFA (Miami, Florida) and the simulator training at the centre were sighted and found to be acceptable.

The line training record of twenty-five hours (25hrs) was sighted by AIB, which was conducted within five days, from 26th April - 30th April 2012. There were adverse comments from the training captain which requested for a constant improvement in his flight line performance. However, there was no evidence that any corrections were made before the Captain was recommended for a final route check. On completion of the line training, he performed the recommended check for the final route check the following day which also contained some adverse comments that called for more improvement and with no other better grading or improvement. He was recommended for the final route check which was performed the same day and he was subsequently released on line as Pilot in Command (PIC).



Fourth observation was that there was no record showing any improvement in his performance before the final route check. The revalidated licence issued by NCAA to the Captain was stamped with NCAA official licencing stamp but not signed by any NCAA official. During the investigation, this was pointed out to NCAA but no satisfactory explanation was provided for this omission.

Furthermore, there was no documented evidence to confirm that the Captain performed the mandatory requirements before the recruitment which are general written test, selection interview, background check, appraisal check for 2hrs in the simulator and a record of company indoctrination which was not sighted. This was not in compliance with Nig CARs 8.10.1.9(a).

The above recruitment procedures and training record of the captain indicate that he was hurriedly hired. The performance assessment by all the training captains (on the accident captain) had always called for improvement which bordered on: inadequate cockpit discipline, non-standard ICAO phraseology and inadequate radio communications technique. Others included non-adherence to company/ICAO procedures, limited crew experience and inadequate line training on MD-83 aircraft type. The training was hurriedly performed.

In the course of this investigation, AIB discovered some deviations in the organizational policies in hiring and training of flight crew. Proper and adequate background checks needed to be carried out in the employment of foreign airline captains. Such checks needed to include review of cases of revocation, withdrawal and suspension of licences by Regulatory bodies, current and historical employment records, as there were no records of the mandatory company Procedures Indoctrination in compliance with Nig. CARs 8.10.1.9a.



2.3 Simulator Programme conducted at PAIFA

The simulator programme conducted at PAIFA in Florida, USA assumed the entire scenario relative to that of Dana Airlines MD-83 aircraft that crashed near Lagos airport, which assumed a take-off weight of 138,000lbs, fuel of 26,000lbs onboard and a landing weight of 130,000lbs. The simulated weather at Abuja was – wind calm, temperature 31⁰C and QNH 1013 hPa, while the Lagos weather was as passed to the crew according to CVR transcript.

After all the above stated manoeuvres were carried out, it became evident that if the crew had taken appropriate decisions and demonstrated adequate performance under the prevailing conditions, the accident could have been prevented, or at the worst, the number of casualties involved would have been minimized.

It was demonstrated in the Simulator that all the scenarios executed were within the limits of the aircraft performance and safe operations. However, the aggravating factors were lack of situation awareness, inappropriate decision making, and poor airmanship.

2.4 Similarities in Engine Inspection Reports of the Accident Aircraft 5N-RAM and the Air Return Aircraft 5N-SAI

5N-RAM No.1 Engine ESN 718142 (Fuel System Component Damage)

- Slight diameter reduction near nozzle No. 2 fittings.
- Fuel feeder lines attaching No.5 fittings were both (primary and secondary) fractured flush, exhibiting shear lips.

The left hand manifold exhibited the following damage and observations:

- Primary fuel transfer tube was pinched almost closed at the No. 8 fuel nozzle fitting and reduced diameter at fuel nozzle No.7 fittings.
- Engine was not responsive to throttle movement.
- The fuel-feeder lines attached to the No. 6 fittings were both fractured at the No.6 fitting while the secondary feeder tube was attached and twisted/crimped.

These are shown in Photos 21, 22, and 23 in Appendix A.



Engine was not in compliance with SB 6452 and was overhauled on 3rd August, 2011 at Millenium facility in Miami, USA.

5N-RAM No. 2 Engine ESN 728113 (Fuel System Component Damage):

- Secondary fuel feeder line to right hand manifold collapsed and bent.
- Right hand primary and secondary manifold supply tubes were bent at the No.5 fittings.
- Similar damage occurred on left hand primary and secondary manifold supply tube at the No. 6 fittings.
- The left hand primary manifold had a circumferential crack outboard of the fan bypass duct.
- Engine not responsive to throttle movement.
- Engine was in compliance with SB 6452 which was accomplished during one of the shop visits to Volvo Aero Engine Maintenance facility in Sweden on 27th September, 2005.
- Overhauled on 2nd December, 2011 in Millennium Engine Associates Inc.

5N-SAI No.1 Engine ESN P725851D (Fuel System Component Damage):

- Right hand fuel manifold inlet fairing improperly installed.
- Right hand fuel manifold assembly fractured at the secondary fuel inlet tube, No.5 fuel nozzle at 5 O'clock position.
- Secondary fuel manifold inlet tube, liberated adjacent to the No. 5 fuel nozzle coupling location.
- Fuel leak from lower fan discharge duct.
- Engine not responsive to throttle movement.
- Engine was not in compliance with SB 6452.
- Overhauled in April 11, 2013 in Global Engine Maintenance facility (formerly, Millenium Engine Associates).



Summary

- All three engines were overhauled by the same Repair Station, Millenium Engine Associates Inc.
- The accident aircraft engines were overhauled within a time frame of four (4) months in the same facility, while the air return aircraft engine was overhauled much later.
- Out of the three engines in consideration, two were not in compliance with SB 6452 while the third was SB 6452-compliant, with new tube material which has significantly greater fatigue life, reducing the occurrences of fractures.
- All engines had primary and secondary fuel manifold assemblies fractured, cracked, bent, twisted or pinched which led to fuel leaks, fuel discharge to bypass duct, loss of engine thrust and obvious failure of engine responding to throttle movement.

The work processes, ethics and culture in Global Engine Maintenance LLC formerly known as Millenium Engine Associates Inc. are subject of concern to Nigerian Civil Aviation Authority and AIB. This concern was as a result from the discovery made in the cause of investigation in the Air Return aircraft 5N-SAI, which shows the improper installation of the right hand fuel manifold inlet fairing. Installation of distorted manifolds and incorrect shimming of the manifold which are capable of aggravating the condition as stated in SB 6452. There was lack of engagement of the front and rear sections of the manifold fairings on the inboard side.

The engine suffered thermal stress and fractured secondary manifold feeder line resulting in loss of power and failure to respond to throttle movement.

The Nigerian Regulatory Authority (NCAA) directed on 18th December, 2013 after an audit was carried out on Dana Airlines, that all engines previously overhauled by Millenium Engines Associates Inc. be sent to other NCAA approved Engine Shop(s) for overhaul before they could be re-installed on any Dana Airlines aircraft. This was a clear safety concern by the Regulatory Authority.



Consequently, the loss of thrust and no response to throttle movement were common to failure sequence in all three engines with catastrophic result in 5N-RAM.

2.4.1 Fuel System Components (Engine No. 1)

The major components of the fuel system comprise: the main fuel pump, fuel heater, fuel control unit, fuel flow transmitter, fuel-oil cooler, pressurizing and dump valve, and the nine fuel nozzles, in addition to the fuel lines that connect these components. The parts of the fuel system that were available for examination were the fuel nozzles and left and right primary and secondary fuel manifolds which are located on the diffuser case. For this engine, the fuel nozzle documentation was covered in the combustion module section. There was no residual fuel remaining in the fuel system.

Both fuel manifolds were removed from the engine for evaluation. The right-hand manifold encompasses fuel nozzle positions Nos. 2 to 5 (the fuel supply to these manifolds is introduced through fittings on the back side of the nozzle No. 5 fittings) while the left-hand manifold encompasses fuel nozzle positions Nos. 6 to 9 and No. 1 (the fuel supply to these manifolds is introduced through fittings on the back side of the nozzle No. 6 fittings). The fuel right-hand manifold was intact and the fuel transfer tubes between the nozzle fittings were undamaged except for some slight diameter reduction/crushing in the primary manifold near the nozzle No. 2 fitting. The fuel-feeder lines that attach to the No. 5 fitting (primary and secondary) were both fractured flush with the No. 5 fitting and a piece of the fuel-feeder tubes remained within the No. 5 fittings in both manifolds (see **FIGURE 23**). These fractured fuel-feeder tubes both exhibited shear lips. The left-hand manifold exhibited the following damage and observations:

- 1) heavily sooted at fuel nozzle fitting Nos. 8, 9 and 1,
- 2) the primary fuel transfer tube was pinched almost closed at the No. 8 fuel nozzle fitting (see **FIGURE 24**), and
- 3) the primary fuel transfer tube diameter was reduced at the No. 7 fuel nozzle fitting.



The fuel-feeder lines that attach to the No. 6 fitting were both fractured at the No. 6 fitting with an appreciable piece of the secondary feeder tube still attached and twisted/crimped (see **FIGURE 25**).

Looking at Figures 23, 24 and 25, it is very clear that the tubes were either broken or bent, which will cause loss or restriction of fuel flow and will further translate into failure of the engines to respond to throttles movement.

2.4.2 Fuel System Components (Engine No. 2)

The secondary fuel flow feeder line that connects to the right hand manifold collapsed and bent downstream of the junction, neither of which completely blocked the fuel flow. The P & D valve B-nut end and fitting on the secondary line were not present.

The right-hand primary and secondary manifold supply tubes were bent at the No. 5 fittings. Similar damage was noted on the left-hand primary and secondary manifold supply tubes at the No. 6 fittings. Neither of these bends completely obstructed the fuel flow. The left hand primary manifold also had a circumferential crack just outboard of the fan duct pass through. Visual examination did not identify any blockages looking into the open ends of the tubes.

Both engines' fuel system components exhibited the same types of damage which was consistent with others that suffered lack of response to the throttles.

2.4.3 Fuel Nozzle

The fuel nozzles from both engines were quarantined for further evaluation and testing. Work scope, testing facility, and test dates were determined. However, test was carried out in the USA but the fuel nozzle testing did not explain why both engines would not respond to throttle movement. The fuel nozzles did not flow to the values set forth in the as-serviceable test, they flow to values lower than specified. But due to debris and environmental conditions (namely rust), this was somewhat expected.



2.4.4 Engine Audio Spectrum Analysis

The audio spectrum analysis carried out by the engine manufacturer (Pratt and Whitney) and NTSB as requested by AIB was inconclusive. No definitive outcome was established. According to the CVR transcript, at 1432:05hrs, it was evident that the problem started with the left hand engine of 5N-RAM, but no engine flameout was established.

2.4.5 Auxiliary Power Unit (APU)

The APU provides auxiliary power to the airplane. It is the same type as in an engine-driven generator. The APU generator is driven by a constant speed gas turbine engine installed in the aft accessory compartment of the airplane.

- ↔ It supplies electrical power to the dead buses if the engine driven generators fail during flight.
- ↔ It also supplies AC load buses when airplane is on the ground and external power is not available.
- ↔ On selection, it could also provide bleed air for engine start-up and air conditioning.

Through the use of control switches and relays, the auxiliary power can be supplied to all AC load buses at the same time or only to the LEFT or RIGHT AC buses, or GROUND service AC bus, provided the bus selected is not receiving power from an engine driven generator.

There was no evidence that the APU was on, however, on-site inspection of the unit and the CVR readout confirmed this assertion.

2.4.6 Battery Power

Two 14-Volt Batteries are installed in the Electrical/Electronic (E/E) compartments. They are connected in series to provide 28 Volt to the STARTER CONTROL RELAY of the APU and through an 80-ampere Circuit Breaker (CB) directly to the BATTERY DIRECT BUS.



- ↔ The Battery Direct Bus CB, located on the E/E compartment, can be manually reset from the flight compartment.
- ↔ Battery power is utilized to start the APU or for Refuelling operations when no other electrical power source is available.
- ↔ Also with a Proper air supply connected to the engine starter, the Battery can supply the necessary electrical power for starting an engine.
- ↔ If AC power is not available during flight, the Batteries are capable of supplying DC power to operate the Single-Phase Inverter and to the most important DC operated equipment, e.g. GPWS.

There was no evidence of emergency power supply usage from the battery and the inverter throughout the critical phase of the flight. It is evident that the engine-driven generators were supplying their respective buses.

2.4.7 Hydraulics

Up till the time of the accident there was no reported loss in any hydraulic systems. Though there was loss in engine power, there was no evidence of engine flameout since the crew were able to select flaps, lower and retract the landing gears as evident on the CVR transcript.

2.4.8 Engines

The engines teardown were successfully carried out without any core engine anomalies detected apart from the fuel manifold issues that would have made the aircraft mechanically unsafe. However, the observed damage to the engines was consistent with low-to no rotation speed at impact but no indications of core engine hardware pre-impact malfunction was revealed at the engines teardown.



2.4.9 Suction Feed Capability

The aircraft engines were certificated to be able to provide the engines with fuel under normal power-out situation as long as the battery switch is on. Test was performed to reach this conclusion. The certification dates are: Model DC-9 Series 10, 28 February, 1966 while the DC-9 Super 80 was 19 December, 1980.

The MD-80 certification test was conducted at 37,000 ft, maximum cruise thrust and at maximum continuous thrust at 0.72 and 0.77 Mach. Flight with 30 degree bank turns and manoeuvring were accomplished to the left and right. The engines operated satisfactorily for over 5 minutes as required by the test. No engine instability was noted.

The Aircraft Flight Manual (AFM) shows no restrictions for suction feed. Every MD-80 delivered was tested for suction feed capability on each engine during climb prior to delivery.

The engines were thus certified by the manufacturers with the above capabilities to enhance safety in an emergency situation.

2.5 The Dana Airlines Air Return (Related Incident)

On the other aircraft 5N-SAI that made an air return on 6th October, 2013, the shop and teardown investigation showed the same characteristics as the engines on DANACO 0992 which had a fatal crash in Lagos.

In the course of the internal investigation carried out by the airline, the captain of the air return asserted emphatically that there were other aircraft in the Operator's fleet that exhibited slow acceleration as in 5N-SAI.

NCAA Audit of Dana Airlines of between 9th and 12th December, 2013 highlighted the need for Dana to propose corrective action on the directive that all the previously overhauled engines by Millennium MRO should be re-certified by an NCAA approved engine shop(s) before re-installation on Dana aircraft.



The summary of the two problems is that they are common occurrences on the JT8D-217C and 219 engines as acknowledged by Pratt & Whitney. As a result, the manufacturer in October, 2003 issued a Service Bulletin (SB) 6452 on the JT8D engines.

Reason:

1. Problem: There have been several instances reported of secondary fuel manifold assembly fractures, causing fuel leaks, which resulted in 94 Unscheduled Engine Removals (UERs), one In-flight Shut Down (IFSD) and two Air Turn Backs (ATBs). There was also one contained fire in 2001 and the extent of the damage was confined to a dark streak of coked fuel on the Combustion Chamber Outer Case (CCOC), and fan duct damage.
2. Cause: Thermal expansion results in high stresses on the tubes, which do not have adequate fatigue life for those stresses. Also, installation of distorted manifolds and incorrect shimming of the manifold during installation can aggravate the condition.
3. Solution: Provide new secondary fuel manifold assemblies, incorporating tubes fabricated from new material which has a fatigue life that is approximately 2 times greater than the current tube material to improve the durability of the manifold assemblies.

Description:

Replace or modify the left and right secondary fuel manifold assemblies.

The incident which led to the issuing of Engineering Authorization No. MD83-EA-73-001 dated 28/01/2013 is one in so many incidents that brought to the fore, failure of engine to respond to throttle movement. The following were the reasons and shop findings:

Reasons:

Following a recent incident involving an air return for an engine failing to respond to throttle movement, the engine was subsequently removed for shop investigation after



inspection and troubleshooting revealed un-burnt fuel escaping in the fan duct section of the engine during ground run.

Shop findings indicate that one of the two fuel manifolds enclosing primary and secondary fuel supply lines in the fan air discharge section located approximately at 5 o'clock position was found not to be of standard configuration, with the secondary supply line severed. The investigation revealed that the improper installation of the manifold assembly resulted in high velocity bypass fan air stressing of the assembly due to its not being aerodynamically sealed.

The engine manufacturer knew that the problem existed and thus issued SB 6452 with compliance code '6' to take care of the problems. An Alert Service Bulletin would have been more appropriate since it makes the modification urgent and timely with higher level compliance category. Making the installation to fit only in one direction will eliminate the issue of incorrect shimming of the manifold during installation, which the manufacturer opined aggravates the condition.

2.6 Metallurgical Test of Fuel Manifold Component

The fuel manifold test that was performed at the NTSB laboratory in the USA, only involved the left engine fuel manifold. During the engine teardown in the USA, the organization that performed the teardown examination was supposed to have shipped the engines back to the Dana Airlines in Lagos. However, the engines were shipped without the right engine fuel manifold assembly. Hence, it was the left engine fuel manifold assembly that was available for testing.

The Fuel Manifold segment from Engine #1 of Pratt & Whitney JT8D-217C revealed, during examination using stereo microscope, that the fracture was consistent with overstress separations and bending load. According to the test report, it was asserted that there was no evidence that the fracture was pre-impact.



However, on the air return aircraft, the fracture was at the same position; “the right hand fuel manifold assembly showed a fracture on the secondary fuel inlet tube, #5 fuel nozzle at 5 o’clock position. The secondary fuel manifold inlet tube was liberated adjacent to the #5 fuel nozzle coupling location”. See Images 3 & 4 of Appendix F. Referencing SB 6452, this condition can be caused by Thermal expansion resulting in high stresses. Additionally as discovered, installation of distorted manifolds and incorrect shimming of the manifold can aggravate this condition. This was the case with air return aircraft where there was no accident or impact.

In the crashed aircraft 5N-RAM, AIB was unable to confirm leaks/restrictions or inadequate fuel supply to both engines, owing to crushed and fractured primary and secondary fuel feed lines of the fuel manifold assemblies, due to the absence of any recorded data or physical incontrovertible evidences, even though it was considered a factor in the subject Engine of the air return aircraft (5N-SAI).

This brings to focus the work process, ethics, skills and reliability of the Maintenance Repair and Overhaul (MRO) organization that overhauled the three engines in question, which were installed in both the crashed and air return aircraft. All displayed similar failure characteristics. The fundamental solution to the problem of fractures lies with installation and correct shimming of the fuel manifold assemblies during engines overhaul process. The SB 6452 compliance provides secondary fuel manifolds assemblies fabricated with tube material which have significantly greater fatigue life, but must be complemented with proper installation of the fairings.

A fool proof installation procedure is being recommended as part of manufacturer’s redesign to prevent incorrect installation by operator.



2.7 Witnesses

Witness accounts, from former Dana Airlines pilots, suggested an undesirable maintenance culture and defects not being entered in aircraft log books. They also mentioned other unhealthy work practices bordering on restricted background checks and references. AIB investigated these interview accounts and confirmed some of the alleged practices for which safety recommendations were issued.

However, the Bureau discovered that some of the former pilots of the Airlines were involved in some of these malpractices. These pilots failed to report these non-entries into the technical log book to the appropriate authorities when they were in the service of the Airline. If reports had been made to the Airline's Quality Department and NCAA, these would have led to sanctions and actions to improve air safety.

2.8 Nigerian Civil Aviation Authority (NCAA)

NCAA is charged with regulatory and oversight duties in Nigeria. In the Nigerian Civil Aviation Regulations (Nig. CARs), the requirement is very clear about engine inoperative as stipulated in section 8.8.1.10.- *The PIC shall land the aircraft at the nearest suitable aerodrome at which a safe landing can be made whenever an engine of the aircraft fails or is shut down to prevent possible damage.* The flight crew did not make any attempt to land at the nearest suitable airfield as prescribed in the Regulations or in Dana Operations Manual. There were no evidences to show that the crew either discussed or mentioned in the ATC recordings or the aircraft CVR.

NCAA emphasizes on checklist compliance in Nig.CARs 8.5.1.9 - *The PIC shall ensure that the flight crew follows the approved checklist procedures when operating the aircraft.* The flight crew did not use any of the checklists available to them, instead they acted inappropriately.

NCAA general validation requirements are clearly stated in **Nig. CARs. 2.2.4.1.** However, a thorough validation of the captain's foreign licence was omitted. The captain had issues that were unresolved with FAA USA and background checks by NCAA



were found to be inadequate. The validated licence was stamped but not signed by the authority. The authority should have looked more on the type of training given and the training required. The validation was done without compliance with the Nig. CARs, which stated that before validation is issued, the authenticity of the foreign licence would have been confirmed. The confirmation had not been concluded when the captain started flying for Dana Airlines. The Regulations state: *The Authority will verify the authenticity of the licence, ratings, authorizations and the medical certificate with the state of licence issue prior to issuing the validation.*

AIB investigation of the accident revealed that the Regulatory Authority's Questionnaires Form could be designed to adequately collect background information from flight crew seeking validation of foreign licences. It should oblige applicants to declare personal confidential and historical career information under oath/declaration in compliance with the requirement in Nig.CARs. There is need to maintain contact and exchange of confidential information among applicable Regulatory Authorities.

The Bureau further observed that NCAA needed to intensify its oversight functions on all overseas Maintenance Repairs and Overhaul (MROs) by monitoring their track records, work processes, and overall reputations prior to and during approval renewals and reviews of their authorizations.

2.9 Nigerian Airspace Management Agency (NAMA)

NAMA is in charge of the administration of Nigeria airspace. Air Traffic Controllers are charged with the responsibility of providing assistance to pilots at any time especially in emergency situations. The Airspace Manager at the Lagos airport in his report confirmed that everything about the flight went well until 1542:10hrs when the crew declared emergency. The crew delayed the declaration of Emergency. Declaring an Emergency generates maximum assistance from Air Traffic Controllers worldwide, but delay in declaring an Emergency may create confusion or narrow the pilots, options to manage the situation.



Extract from the CVR transcript of the Emergency declaration:

14:42:01

RDO-2 Lagos Tower Danaco zero niner niner two.

14:42:05

RAD Danaco zero niner niner two this is Lagos uh Radar. Go

14:42:10

RDO-2 mayday mayday mayday Danaco zero niner niner two, five November romeo alpha mike, dual engine failure.

14:42:16

RAD Danaco zero niner niner two how do you read?

14:42:18

RDO-2 I read you five by five, dual engine failure, negative response from throttle, requesting direct approach. Danaco zero niner niner two.

14:42:27

RAD position is one zero miles to touchdown one eight right, contact tower now one one eight one.

14:42:32

RDO-2 one one eight one good day.

The Radar was the last contact the aircraft made before the fatal crash. The Radar Control should have stayed with the aircraft rather than transferring it to Lagos Tower. The assertion of "how do you read?" by the Radar Control wasn't necessary at this point in time. Dual engine failure is a serious emergency that should be treated with the highest level of professionalism and urgency. Radar vector would have been ideal and most appropriate at this time.



3.0 CONCLUSIONS

3.1 Findings

1. The flight crew were certified to fly the aircraft.
2. The two pilots were foreigners.
3. The Captain was new in the company having been employed on the 14th March, 2012 and was checked out as a line Captain on 1st May, 2012.
4. The Captain had previous regulatory issues with the U.S.A Federal Aviation Administration (FAA) which led to his suspension at that time.
5. All the reference letters presented by the Captain to Dana Airlines were neither signed nor authenticated.
6. The background check on the Captain was inadequate.
7. The line training given to the Captain was hurriedly carried out.
8. There was no evidence that the deficiencies observed by the checkout Captain were addressed before the accident Captain was released for line operation.
9. The Co-pilot's first experience on a commercial jet airplane was with Dana Airlines.
10. The aircraft was airworthy at the time of departure.
11. The aircraft came out from a check and was released to service on 1st June, 2012.
12. All deferred defects were cleared during the last check.
13. The left aileron bus cable was replaced on 1st June, 2012.
14. A test flight was carried out on 2nd June, 2012 after the replacement of left aileron bus cable.
15. 5N-RAM Engine No.1 was not compliant with SB 6452 while Engine No. 2 was in compliance with the SB.
16. Both 5N-RAM Engines were overhauled in Millenium Engine Associates Inc. within a time frame of four (4) months.



17. The aircraft departed Abuja with three hours and thirty minutes fuel endurance.
18. The Engine number 1 lost power seventeen minutes into the flight.
19. There was no evidence that both normal and emergency Checklist were used throughout the duration of the flight before the crash.
20. The aircraft did not make any contact with the Control Tower before the crash.
21. The aircraft crashed five miles on the extended centreline of runway 18R.
22. The aircraft crashed into a residential area.
23. The aircraft first point of impact was an uncompleted building followed by a Mango tree, a Coconut tree, and finally three other buildings.
24. There was fire outbreak.
25. All 147 passengers and six crew were fatally injured.
26. There were other fatalities on ground.
27. The aircraft wreckage was concentrated in a small area.
28. The huge crowd of people at the crash site slowed down rescue efforts and investigation.
29. The Fire Service ran out of water and it was very difficult to replenish supply because of the crowd and poor road network.
30. Flight recorders (black boxes) were recovered but were badly burnt.
31. NCAA revalidation procedures were not followed before the captain's licence was issued.
32. The validated licence issued by NCAA to the captain was stamped but not signed.
33. There was a related incident involving 5N-SAI, an aircraft in Dana Airlines' fleet that led to an air return on 6th October, 2013 for which the Airline issued an Engineering Authorization No. MD83-EA-73-001.
34. Millenium Engine Associates Inc. (MRO) has changed its name to Global Engine Maintenance LLC with the same FAA certificate number Y2MR496Y.



35. 5N-SAI Engine No.1 was not compliant with SB 6452 and overhauled in Global Engine Maintenance LLC on 11th April, 2013.

3.2 Probable Causal Factors:

1. Engine number 1 lost power seventeen minutes into the flight, and thereafter on final approach, Engine number 2 lost power and failed to respond to throttle movement on demand for increased power to sustain the aircraft in its flight configuration.
2. The inappropriate omission of the use of the Checklist, and the crew's inability to appreciate the severity of the power-related problem, and their subsequent failure to land at the nearest suitable airfield.
3. Lack of situation awareness, inappropriate decision making, and poor airmanship.



4.0 SAFETY RECOMMENDATIONS

Safety Recommendations previously made in the Preliminary Report published on 5th September 2012.

Interim Safety Recommendations

1. AIB investigation so far, discovered that Dana Airlines aircraft operate in areas where fungal growth can be encountered, or where there is the possibility of temperature in the fuel tanks frequently rising to 25°C in tropical conditions, microbiological growths have been known to develop when the spores of the fungus are in contact with water in fuel at temperatures such as those reached when the aircraft or storage tanks are exposed to the sun for long periods in a tropical environment.

The dangers that exist in microbiological contamination of fuel tanks include fuel tank corrosion, erratic fuel content indication, obstruction of fuel filters and fuel pipes within the tanks.

4.1 Safety Recommendation 2013 – 001

Dana Airlines should ensure that prior to resumption of flights, visual fuel tanks inspection for evidence of fungal growth or contamination followed by biocide treatment be carried out in all operating MD-83 aircraft. The fungicide additives used in the fuel must be approved by aircraft and engine manufacturers. The frequency of treatment and the dilutions prescribed by the aircraft and engine manufacturers must be adhered to. The aircraft maintenance schedule or programme should be amended to include the exercise in accordance with the aircraft and engine manufacturers' requirement.



2. According to evidence available to the Bureau, Dana Airlines was practicing a peculiar fuel management system in the flight operation of the MD83-217C aircraft. It was discovered that the centre fuel tank remained completely depleted in most flights arriving at destinations, while wing tanks remained full and unused. The Bureau has reviewed this operational change with the operator.

4.2 Safety Recommendation 2013 – 002

Dana Airlines should ensure that for all its flight operations with MD-83, a minimum of 2000lbs of fuel must be maintained in the centre fuel tank of the aircraft on landing at any destination, while AIB investigation goes on.

3. Accident Investigation Bureau has discovered inadequacy in the background checks of newly employed foreign flight crew members and safety critical staff. There is also need to help newly employed foreign captains to be conversant with Airline's routes and Nigerian Airspace to ensure confidence and safety in operation.

4.3 Safety Recommendation 2013 – 003

Dana Airlines should ensure;

(a) Adequate background check is conducted in the employment of foreign airline captains and safety critical employees. Such checks should include review of cases of revocation, withdrawal and suspension of licences by regulatory bodies in the applicant's current or historical employment records where applicable.

(b) Any newly employed foreign captain must fly with a competent senior first officer who is familiar with Nigerian Airspace and routes for at least the first 100 flight hours, to enable the new captain be conversant with the operations of the airlines within Nigerian Airspace.



4. The on-going investigation by AIB revealed that the Regulatory Authority's questionnaire/form designed to collect background information from foreign flight crew seeking validation of the foreign licences, is not adequate. It does not oblige the applicant to declare personal confidential and historical career information under oath/declaration.

4.4 Safety Recommendation 2013 – 004

NCAA should;

- (a) As an essential aspect of its oversight function review CPL/ATPL/issue/renewal/validation forms to include background check with the view to discover cases of revocation, withdrawal or suspension of flight crew licences issued to applicants by any other regulatory authority.
- (b) Validation of foreign licences should be effected when all confidential details have been received from previous employers and appropriate regulatory authority including satisfactory aero-medical reports and a return of due diligence form/document carried out by the airline.
- (c) Appropriate declaration should be included in the questionnaire/form to oblige applicants to declare all relevant information as requested.

Safety Recommendations made in this Report:

4.5 Safety Recommendation 2015 – 001

FAA should ensure that Pratt & Whitney considers the following:

- a) Revise Service Bulletin JT8D 6452 making it mandatory within a given time-frame, thereby upgrading the Compliance Category.
- b) Re-design the installation and shimming procedures of the manifold assembly to remain foolproof to prevent incorrect installations.



4.6 Safety Recommendation 2015 – 002

Dana Airlines should ensure the following:

- a) Any remarks or deviations from Company Standard Procedures noted by the Training Captain on the Trainee during Line Training must be addressed before final checkout as a Line Captain.
- b) All training procedures must be in compliance with approved Company Operations Manual, SOPs and Nig. CARs.

4.7 Safety Recommendation 2015 – 003

NCAA should consider the following:

- a) Monitoring closely the work processes, ethics and conducts of foreign Maintenance Repair and Overhaul (MROs) facilities approved to overhaul and repair Nigerian registered aircraft, airframes, powerplants, propellers or appliances.
- b) Oversight Functions on MROs should include but not limited to review of track records, reputation, and audit reports by appropriate national regulatory authority before approval or renewal of NCAA authorization.
- c) NCAA should ensure that for any checkout of a new line captain, a type-rated NCAA Inspector must be involved as an observer.

4.8 Safety Recommendation 2015 – 004

NAMA Quality Assurance Management (QAM) should ensure that all Air Traffic Controllers strictly adhere to the ethics of their profession, which is, providing assistance to flight crewmembers in emergency/critical situations.



RESPONSES TO INTERIM SAFETY RECOMMENDATIONS

Dana Airlines accepted interim safety recommendations 2013-001, 2013-002, and 2013-003.

“Various safety recommendations under reference i.e. 2013-001, 2013-002, 2013-003 and 2013-004, have been duly incorporated into the SOPs of relevant departments of Dana Airlines Ltd. These safety recommendations have since become operationally implemented.”

NCAA response on AIB Interim Safety Recommendation 2013-004

NCAA accepts recommendation 2013-004.

“In response to the AIB Interim Safety Recommendations Reference Safety Rec. 2013-004, it is important to note that this is a welcome development.

This already is a part of the Processes and Procedures for Issue/Renewal/Validations of CPL/ATPL licence by the Authority. All these recommendations are already practiced by the Authority.”

SAFETY ACTIONS TAKEN

Engineering Authorization – Dana Airlines Nigeria Limited

As part of Dana Airlines Safety Action, an Engineering Authorization Ref:

MD-83 – EA – 73 – 001 was issued mandating the implementation of inspection of the left hand and right hand fuel manifold assemblies on all currently installed JT8D – 200 series engines in the Airlines’ MD-83 aircraft. This is to verify the integrity and correct installation of the fuel manifold assembly using a flexible or rigid Borescope probe. The procedures and the pictorial guidance, as well as certification for release to service of the aircraft are clearly stated in Appendix G.



APPENDICES

Appendix A

ENGINE EXAM AND DISASSEMBLY FIELD NOTES **OCTOBER 12, 2012**

A. ACCIDENT

Location: Lagos, Nigeria

Date: Jun 3, 2012

Time: 15:45 local

Aircraft: Boeing MD-83, registration number 5N-RAM, Dana Air Flight 0992

B. POWERPLANTS GROUP

National Transportation Safety Board:

[REDACTED] Powerplant Lead Engineer
Washington D.C.

[REDACTED] Powerplant Engineer
Washington D.C.

Pratt & Whitney:

[REDACTED] Accident and Incident
Investigator
East Hartford, Connecticut

Boeing:

[REDACTED] Flight Safety Investigator
Long Beach, California

[REDACTED] Powerplant Engineer
California

Federal Aviation Administration:

[REDACTED] Air Safety Investigator Washington,
D.C.

Nigerian Accident Investigation Bureau:

[REDACTED] Air Safety Investigator Nigeria



C. Summary

On June 3, 2012, at about 1545 local time, Dana Airlines flight 0992, a Boeing MD-83 airplane, registered in Nigeria as 5N-RAM, crashed into a residential area of Lagos, Nigeria after a loss of power in both engines. The airplane was equipped with two Pratt & Whitney (P&W) JT8D-217C turbofan engines. The pilots radioed to Lagos Radar, "Mayday, Mayday, Mayday, Danaco zero niner niner two, five november romeo alpha mike, dual engine failure." The pilots subsequently reported that they had "negative throttle response." The airplane crashed into a woodworking shop, a paper printing shop, and two apartment buildings. The airplane was destroyed by impact forces and fire. The 2 pilots, 4 flight attendants, and 147 passengers on board the airplane as well as an unknown number of people on the ground were killed. The airplane was operating as a regularly scheduled domestic flight from Abuja, Nigeria to Lagos.

A Powerplant group comprised of members from the Nigeria Accident Investigation Bureau, the National Transportation Safety Board, Federal Aviation Administration, P&W, and Boeing convened at the Millennium Engine Associates engine facility in Miami, Florida to disassemble and exam both engines involved in the Dana Airlines accident. The group commenced work on October 8, 2012 and completed the engine disassembly and examination on October 12, 2012.

Examination and disassembly of the No. 1 engine did not identify any mechanical condition which would have prevented normal operation of the engine at the time of impact. There were no signs of case ruptures, uncontainments, in-flight fire, internal hardware failures, core foreign object ingestion, or main bearing compartment fires. Continuity of the low pressure and high pressure rotor systems was confirmed and all the main shaft bearings were in good condition, intact, shiny, and oil wetted. None of the engine cases were crushed inwards or ovalized to produce clashing damage between the static and rotating components to provide indications of relative rotation. There were no indications that the engine fan or core was turning at a high rotational speed at the time of impact. However, fan blade foreign object damage (leading edge



nicks, tears, some round bottom dents) and sporadic fan blade bending in the direction opposite rotation and in the direction of rotation was consistent with the fan rotating at low-to-no appreciable speed. Rub noted on the No. 3 bearing housing aft cover, high pressure compressor (HPC) stage 7 disk forward aft face, forward ends of the HPC tie-rods, and the high pressure turbine (HPT) blade tip shrouds and blade outer air seal was consistent with core turning most likely at a low rotation speed at the time of impact. The lack of fuel system components still attached to the engine prevented any detailed examination and overall assessment of the condition of the fuel system pre- and post-impact. However, examination of the combustor and the fuel nozzles did not reveal thermal distress and the fuel nozzles tips did not appear blocked. Using shop air, a flow test of the fuel manifolds showed them to flow freely; however, a flow test of the nozzles was not performed.

Examination and disassembly of the No. 2 engine did not identify any mechanical condition which would have prevented normal operation of the engine at the time of impact. There were no signs of case ruptures, uncontainments, in-flight fire, internal hardware failures, core foreign object ingestion, or main bearing compartment fires. Continuity of the low pressure and high pressure rotor systems was confirmed and all the main shaft bearings were in good condition, intact, shiny, and oil wetted. None of the engine cases were crushed inwards or ovalized to produce clashing damage between the static and rotating components to provide indications of relative rotation. There were no indications that the engine fan or core was turning at a high rotational speed at the time of impact. However, static fan blade impact marks in the fan blade rub strip panels were consistent with the fan rotating at low-to-no appreciable speed. Rub noted on the HPT blade tip shrouds and blade outer air seal was consistent with core turning most likely at a low rotation speed at the time of impact. The lack of fuel system components still attached to the engine prevented any detailed examination and overall assessment of the condition of the fuel system pre- and post-impact. However, examination of the combustor and the fuel nozzles did not reveal thermal distress and the fuel nozzles tips did not appear blocked. Using shop air, a flow test of the available



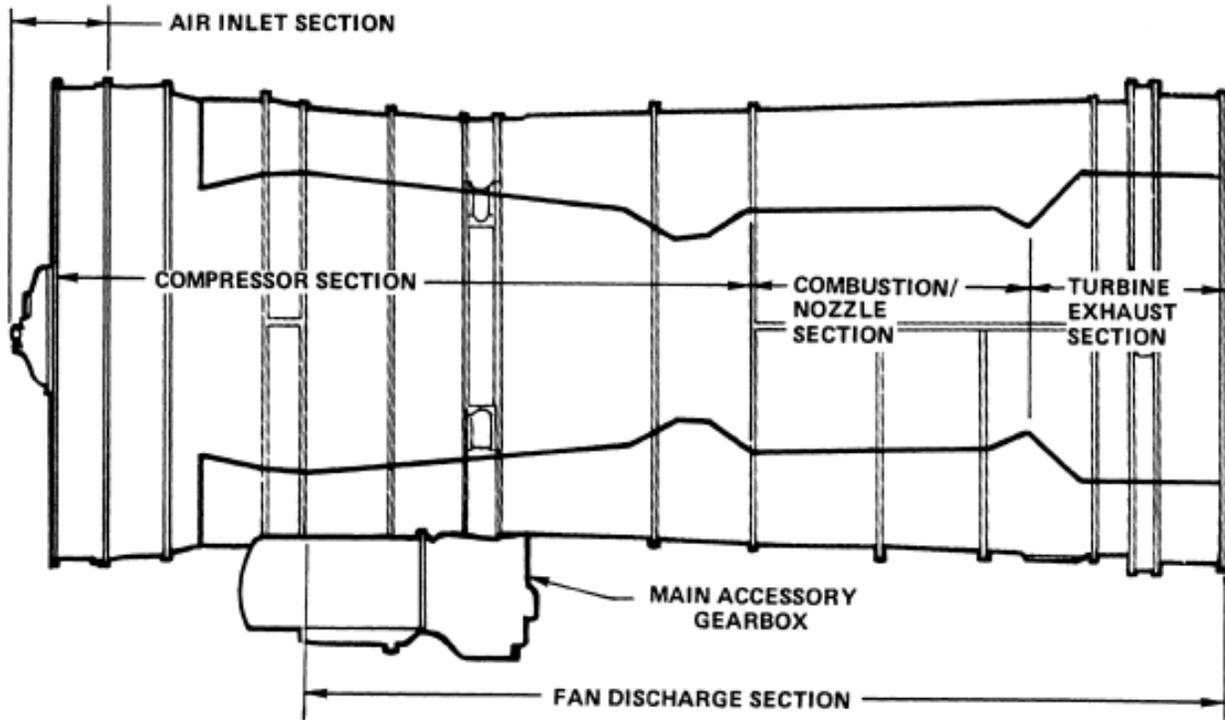
fuel system plumbing showed them to flow freely but some restriction was noted when the fuel nozzles were flowed.

The fuel nozzles from both engines were quarantined for further evaluation and testing. Work scope, testing facility, and test dates are to be determined.

D. DETAILS OF THE INVESTIGATION

1.0 ENGINE DESCRIPTION

The JT8D-217C series engine is an axial-flow front turbofan engine having a fourteen stage split compressor, a nine can (can-annular) combustion chamber, and a split four stage reaction impulse turbine. The engine has six general sections, the air inlet section, the compressor section, the combustion section, the turbine and exhaust section, the accessory drives, and the fan discharge section (**FIGURE 1**) and seven main shaft bearings listed in **TABLE 1** and shown in **FIGURE 2**. The engine is equipped with a full length annular fan discharge duct. The low pressure system is made up of the front compressor rotor and the stages 2, 3, and 4 turbine rotors and is mechanically independent of the high pressure system which consists of the rear compressor rotor and the stage 1 turbine rotor (**FIGURE 2**).



L-60496 (0000)

FIGURE 32: SECTION IDENTIFICATION

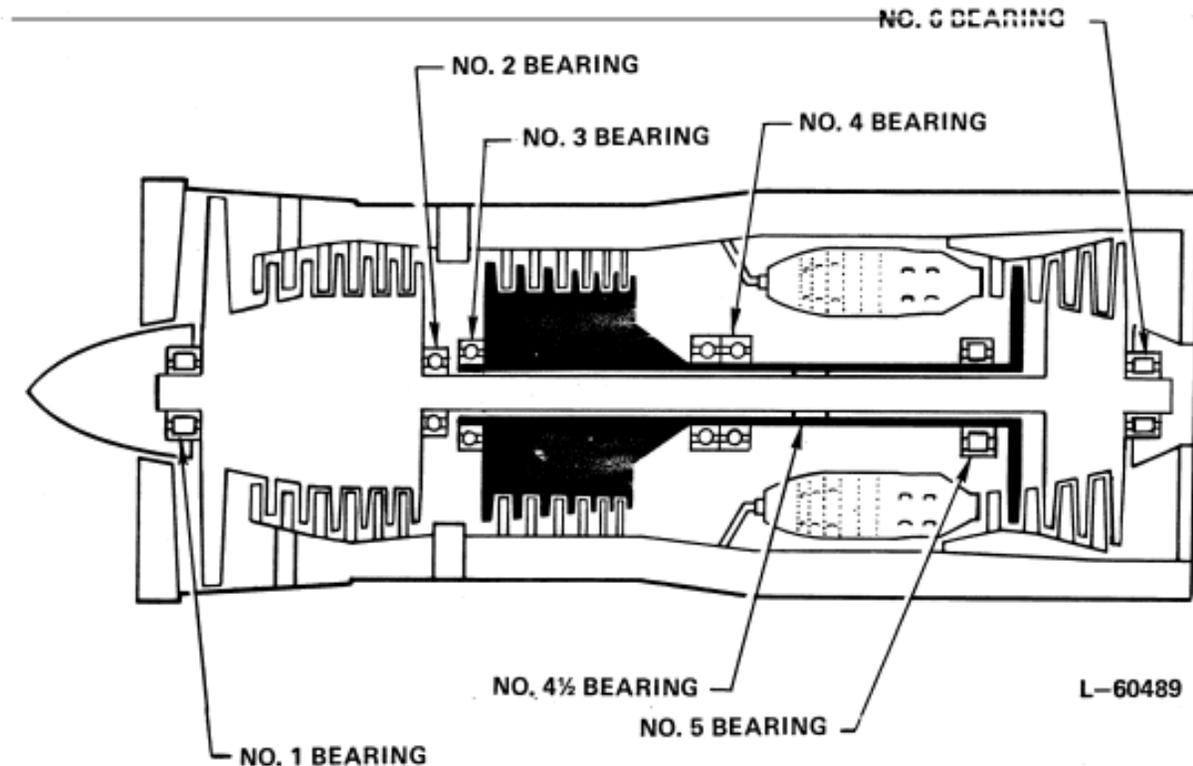


FIGURE 33: ENGINE BEARING AND INTERNAL DIAGRAM

The engine is mounted from two points. The front mount is located at the fan discharge intermediate case. The engine rear mount is located at the turbine exhaust section outer duct. According to the FAA Type Certificate Data Sheet E9NE, Revision 12, dated December 13, 2010, the sea level static thrust takeoff rating of the JT8B-217C engine is 20,850 pounds and the sea level static thrust maximum continuous rating is 18,000 pounds, both are flat rated to 77°F (25°C)²

FIGURE 3 provides the identification of the engine flanges. They are designated by letter. Interruptions in the lettering sequence may result when development changes have removed or added flanges.

² Flat-rated to a specific temperature indicates that the engine will be capable of attaining the rated thrust level up to the specified inlet temperature.



TABLE 1: MAIN BEARING NUMBERING AND LOCATION			
Name	Location	Number	Type
Front Compressor Front	Inlet case; Front compressor front hub	1	Roller
Front Compressor Rear	Compressor (intermediate) case front; Front compressor rotor rear hub	2	Ball
Rear Compressor Front	Compressor (intermediate) case rear; Main accessory drive gear	3	Ball
Rear Compressor Rear	Diffuser case; Rear compressor rotor rear hub	4	Duplex Ball
Turbine Inter-shaft	In line with mid-point of combustion chamber case; Outer race within rear compressor drive turbine shaft; Inner race and rollers on front compressor drive turbine shaft	4½	Roller
Turbine Front	In line with combustion chamber case rear flange; Inner race on rear compressor drive turbine shaft	5	Roller
Turbine Rear	Turbine exhaust case; Front compressor drive turbine rear hub	6	Roller

All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF). The direction of rotation of the engine is clockwise. All numbering starts with the No. 1 position at the 12:00 o'clock location and progresses sequentially clockwise ALF.

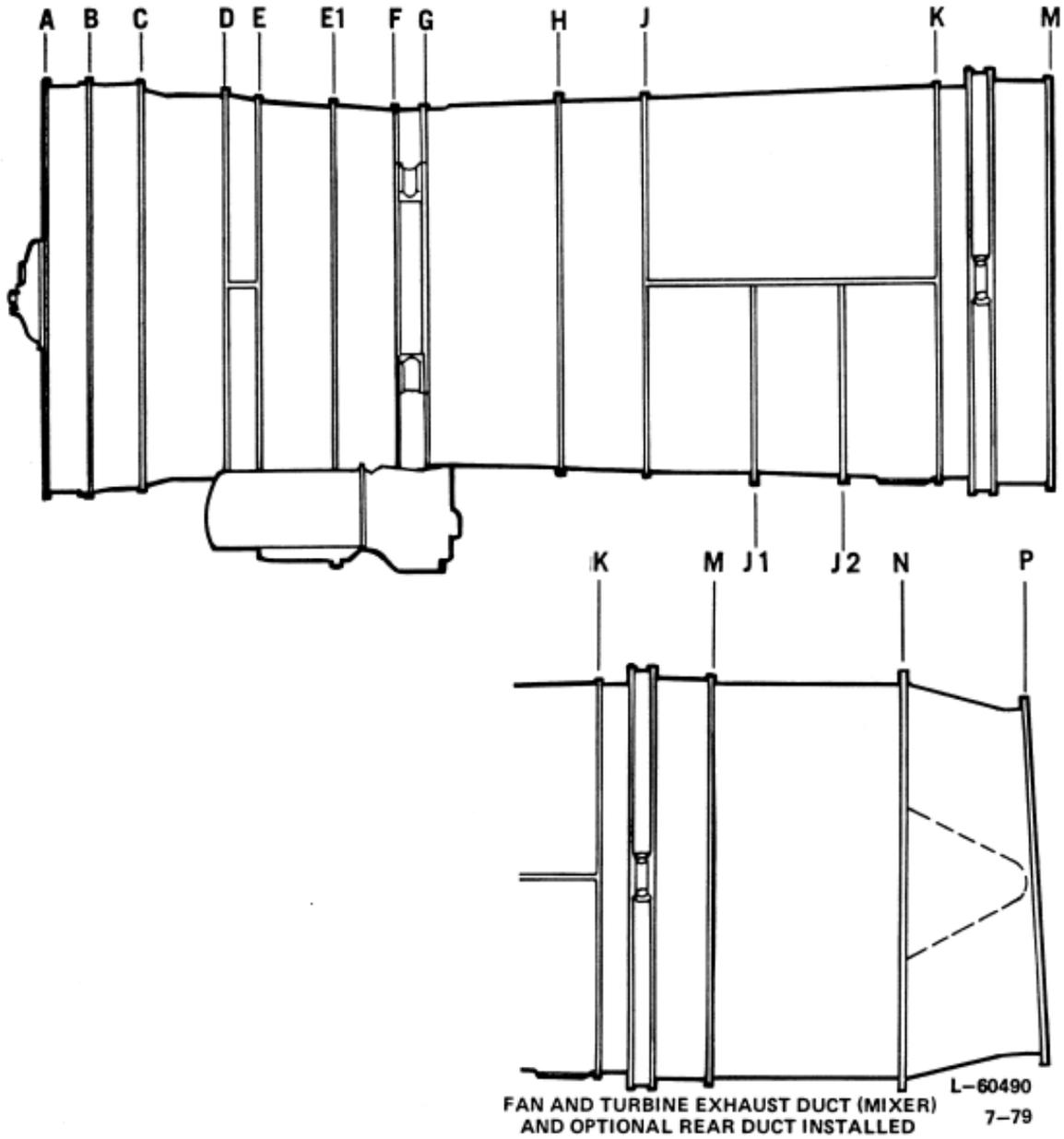


FIGURE 34: ENGINE FLANGE DESIGNATIONS

2.0 Left Engine (No. 1) – Serial Number (SN) 718142

2.1 AS-RECEIVED

The engine was un-crated and placed on pallets for examination and disassembly (**PHOTO 1**). The inlet case, and the front and rear fan cases were attached as a unit, but were no longer attached to the rest of the engine. This unit was clocked approximately 120° clockwise direction relative to the core of the engine. The fan and exhaust ducting was missing from the "D"-flange (aft flange of the rear fan case) aft except for a section of the front compressor fan duct that was still attached to the D-flange and ranged from 9 to 13-inches axially and approximately 100° circumferentially.



PHOTO 1: TOP VIEW OF THE NO. 1 ENGINE SN 718142

The inlet case, and the rear fan case were intact but the front fan case was missing material from the 5:00 to 10:00 o'clock position. The part of the front fan case that remained exhibited signs of thermal distress and melted material. The inlet case and the front fan case did not exhibit any significant distortion; however, the rear fan case exhibited inward distortion/deformation at the 7:30 o'clock position and also at the 11:00 o'clock position with part of the "D"-flange (approximately 5 bolt holes in length) missing. The "C"-flange (front flange of the rear fan case) was fractured at approximately the 11:00 o'clock position, which was in-line axially with the rear fan case stiffening rib and "D"-flange fractures. All the flange fractures were deformed in the aft direction (**PHOTO 2**).

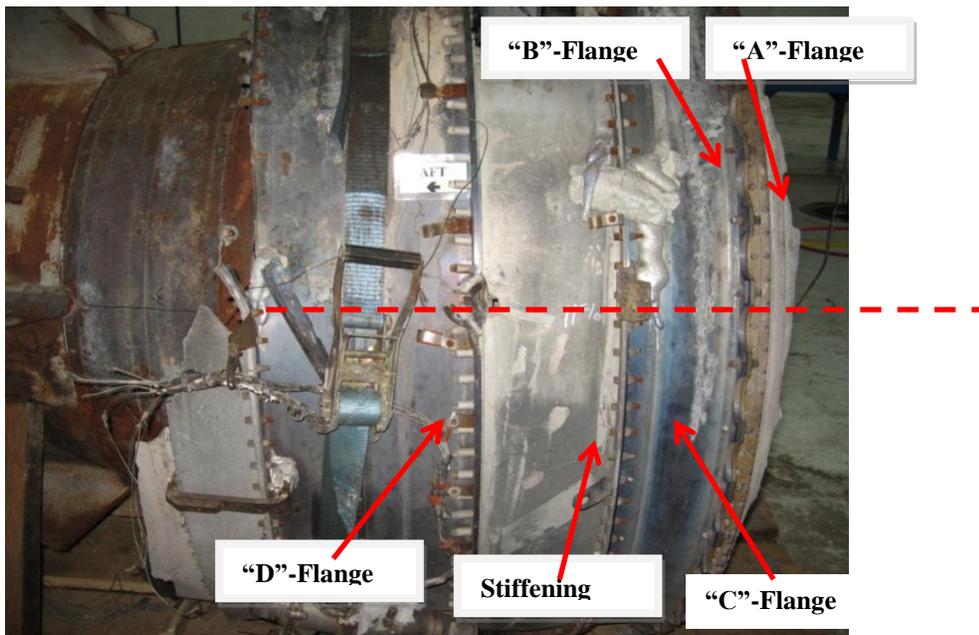


PHOTO 2: DAMAGED TO THE FRONT AND REAR FAN CASES AT THE 11:00 O'CLOCK POSITION

The nose bullet and the front accessory drive cover were both missing, exposing the No. 1 bearing and N1 tachometer (tach) drive gear. Molten material was observed in the area of the front accessory drive attachment flange. All the No. 1 bearing rollers were present and appeared cylindrical but were covered in rust.³ The cage was shiny and appeared to be intact (**PHOTO 3**). The N1 tach drive was intact and

³ After the accident, both engines were removed from the accident site and stored outdoors and were exposed to the environment prior to being shipped to the US for the detailed engine exam and disassembly.

undamaged but also covered in rust. The inlet guide vanes (IGVs) were all fractured at their inner diameter (center body location) with three of the IGVs missing. The IGVs that remained were bent in the direction of rotation (clockwise) at their ID relative to their OD, many were buckled at their outer diameter attachment point, and none exhibited any significant impact damage (**PHOTO 4**). Based on the location of the 6:00 strut, where the No. 1 bearing oil tubes are located, the outer ring of the inlet case with the IGVs still attached was rotated approximately 120° clockwise from the matching center body strut location.

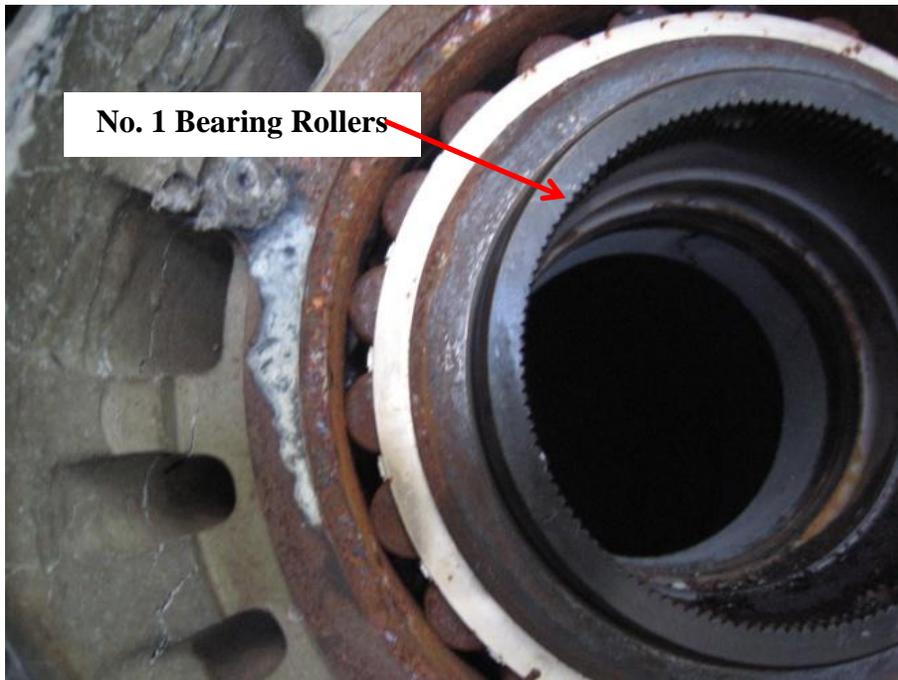


PHOTO 3: NO. 1 ROLLER BEARING INTACT AND COVERED IN RUST

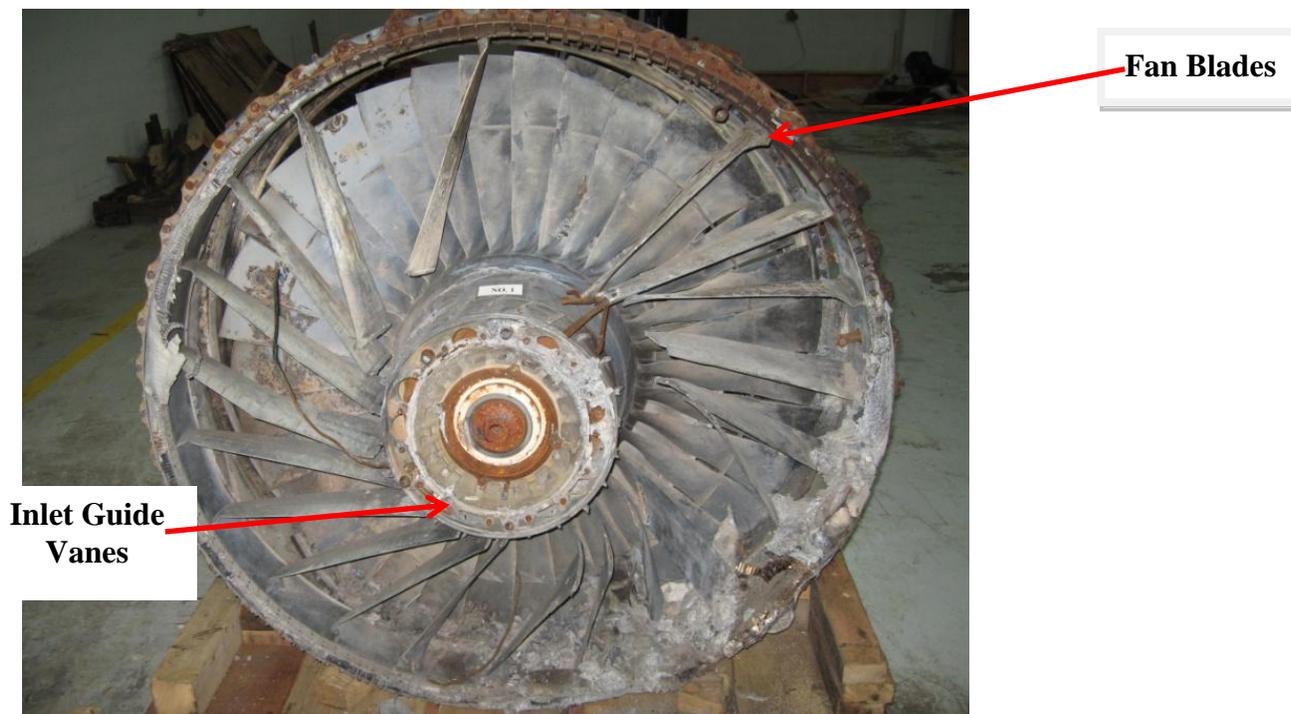


PHOTO 4: INLET CASE WITH FRACTURED AND DAMAGED INLET GUIDE VANES

All the fan blades were present and secured in the fan hub. Numerous blades exhibited small leading edge nicks, tears, and dents with some exhibiting leading edge round bottom impact marks with material transfer. The material deformation associated with this damage was in the direction of rotation and/or aft. A single fan blade was fractured at the leading edge corner tip. Three randomly blade tips were curled/bent in the direction opposite rotation and five random blades (2 were adjacent to each other) were bent in the direction of rotation. One fan blade exhibited appreciable forward blade tip corner bending while a different blade exhibited appreciable aft bending. Four adjacent blades exhibited blade spanwise buckling. Several sets of blades exhibited mid-span shroud shingling.

Seven of the tangential fan exhaust duct strut rods that connect the turbine exhaust case to the exhaust duct were still secured to the turbine exhaust case at their inner ends. Five were fractured at their inner end (turbine exhaust case mount rail location), two were almost entirely intact (one at the 2:00 o'clock and one at the 10:00 o'clock position) and fractured at their outer end; the eighth rod was missing. The exhaust mixer remained attached to the turbine exhaust case. At the 6:00 o'clock position, exhaust mixer was deformed inwards with longitudinal/axial scrape marks. The majority of the remainder of the mixer was pushed/buckled inwards and forward. The turbine exhaust inner duct and tail cone were still attached to the turbine exhaust case center body (No. 6 bearing housing). The turbine exhaust duct was dented and cracked at the 6:00 o'clock position, in-line with inward deformation of the tail cone. The deformed area of the tail cone also exhibited axial scrape marks (**PHOTO 5**). No other significant damage was noted on the exhaust duct or tail cone.



PHOTO 5: EXHAUST CASE, INNER DUCT, CONE AND MIXER DAMAGE AT THE 6:00 O'CLOCK POSITION



2.2 DISASSEMBLY

2.2.1 Front Compressor Module

The inlet case, and the front and rear fan cases were cut at approximately the 5:00 and 12:00 o'clock positions to facilitate removal from the fan module (front compressor module). The right-hand section (12:00 to 5:00 o'clock) had no fan rub strip material present and all the exit guide vanes were missing. The left-hand side (5:00 to 12:00 o'clock) had 7 ½ fan rub strip panels present – from approximately the 2 to 5 o'clock position. No circumferential rubbing or gouging was observed; however, a couple of panels located at approximately the 3 o'clock position exhibited what appeared to be longitudinal static marks at angles and spacing not consistent (tighter) with typical fan blade static marks. These panels also exhibited more physical and thermal distress than the other panels still present. The acoustic liners located forward and aft of the fan blade running position exhibited slicing and gouging marks more consistent with typical fan blade static marks. The impact marks in the forward acoustic liner were approximately 5-inches forward of the normal fan blade running position and the impact marks in the aft acoustic liner were approximately 7-inches aft the fan blade normal running position. Ten exit guide vanes, around the 2:00 to 3:00 o'clock position, remained attached to the outer ring and all the vanes were bent over in the direction of rotation (clockwise) at their ID relative to their OD (**PHOTO 6**).

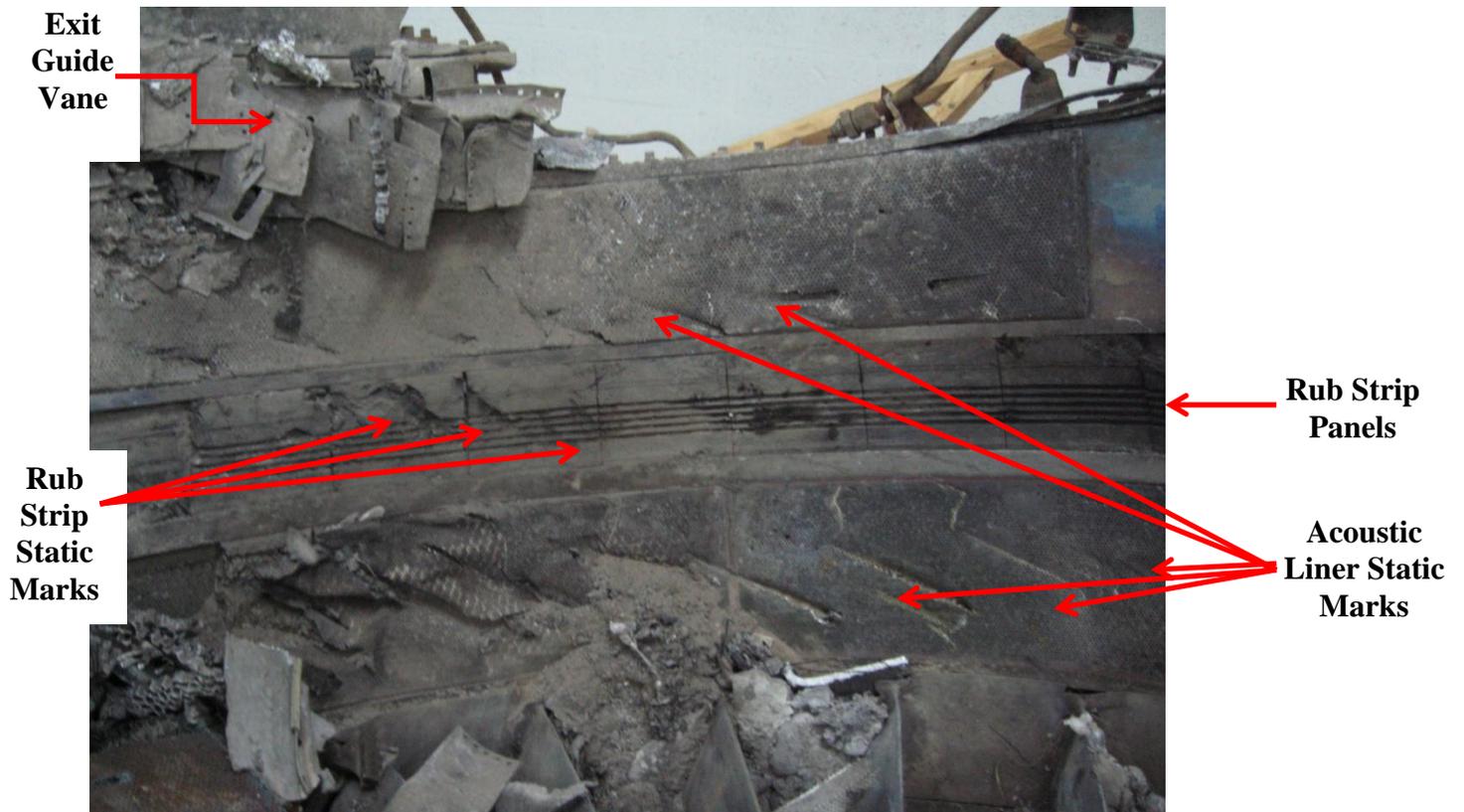


PHOTO 6: FAN CASE DAMAGE

The front compressor rotor and stator assembly consists of a seven-stage front compressor rotor and the stator, stages through stage six, for documentation purposes (**PHOTO 7**). The numbering of the front compressor stages is 1 through 6, with a 1.5 stage following the stage 1 so that the total of the stages is seven. For documentation purposes the No. 2 bearing will be included in this section. The front compressor was removed from the core of the engine and was not disassembled further. The fan blades were documented in the "As-Received" section and will not be described here. The front outer compressor cases stages 1 through 3 were melted from approximately the 3:00 to 10:00 o'clock position exposing the following rotor stages: stages 1.5 and 2 approximately 75% visible and stages 3 and 4 approximately 50% visible. Stage 6 was fully visible from the aft side of the module. The general condition of all the visible front compressor rotors blades were that they were all present, full length and straight, secured to their respective disks/hub, and exhibited no noteworthy airfoil or tip



damage. The melted front outer compressor cases stages 1 through 3 also exposed the stators as follows: 1) stage 1, vanes missing from the 3:00 to 10:00 o'clock position, 2) stage 1.5, vanes missing from the 3:00 to 9:00 o'clock position, 3) stage 2, vanes missing from the 4:00 to 8:00 o'clock position and 4) stage 3, vanes missing from 5:00 to 7:00 o'clock position. In each of these stages, the vanes that remained exhibited thermal distress and melting. In stage 4, vanes were visible from approximately the 4:00 to 7:00 o'clock position looking through the stage 4 blades and in stage 5 all the vanes were visible looking through the stage 6 rotor blades. In general, the stage 4 and 5 vanes were present, in good condition and did not exhibit airfoil damage. The stage 4 and 5 outer shroud rings were intact and did not exhibit thermal distress.



PHOTO 7: FRONT COMPRESSOR ROTOR AND STATOR BLADE, VANE, AND OUTER CASE DAMAGE

The No. 2 bearing spun freely and smoothly when turned by hand. The rolling elements were all intact, in place, round, and secured in their cage.

2.2.2 Rear Compressor Module

The rear compressor group (High Pressure Compressor - HPC) consists of seven rotor stages, with a stage of stator vanes following every rotor stage. The rotor stages are numbered 7 through 13 from front to rear. The last rotor stage, stage 13, is followed by the compressor exit stator, which is part of the diffuser case group. For documentation purposes the No. 3 bearing is covered in this section.

The HPC was removed from the core to facilitate examination. All the stator cases were intact and exhibited no punctures; however, the stage 8 stator outer shroud exhibited circumferential cracking approximately 2-inches in length at the location of two of the positioning lugs. The stage 7 blades were all present, full length, and exhibited no leading edge damage or tip rub. The stage 7 disk exhibited two distinctive intermittent superficial circumferential scoring marks (**PHOTO 8**). The SN on the HPC stage 7 disk was **BENCAS6409** and it match what was recorded in the maintenance records. The forward ends of the HPC tie-rods exhibited light contact rub. Looking through the stage 7 blades, the stage 7 vanes were visible; all were intact and exhibited no leading edge impact damage. The stage 13 blades were all present, full length, and exhibited no trailing edge damage or tip rub (**PHOTO 9**). Looking through the stage 13 blades, the stage 12 vanes were visible; all were intact and exhibited no trailing edge impact damage.

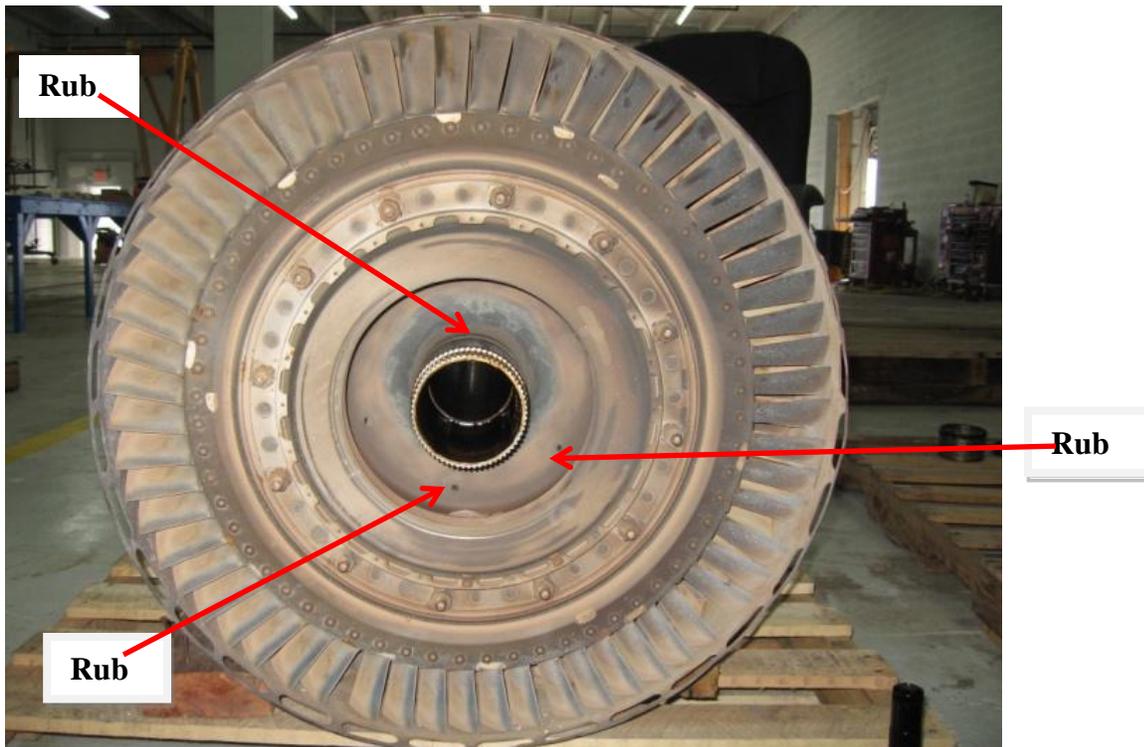


PHOTO 8: HPC STAGE 7 DISK RUB



PHOTO 9: HPC STAGE 13 BLADE - UNDAMAGED

The No. 3 bearing spun freely and smoothly when turned by hand. The oil from the No. 2/3 compartment was dark in color but did not exhibit an acrid odor. The No. 3 bearing housing aft cover exhibited light 360° circumferential scoring with the heaviest located between the 3:00 and 6:00 o'clock positions. In this area, the washers underneath the aft cover attachment bolts at 3 locations were also rubbed (**PHOTO 10**). Reviewing the engine cross-section, the washer and aft housing cover rub was in-line with the forward end of the HPC tie-rods.

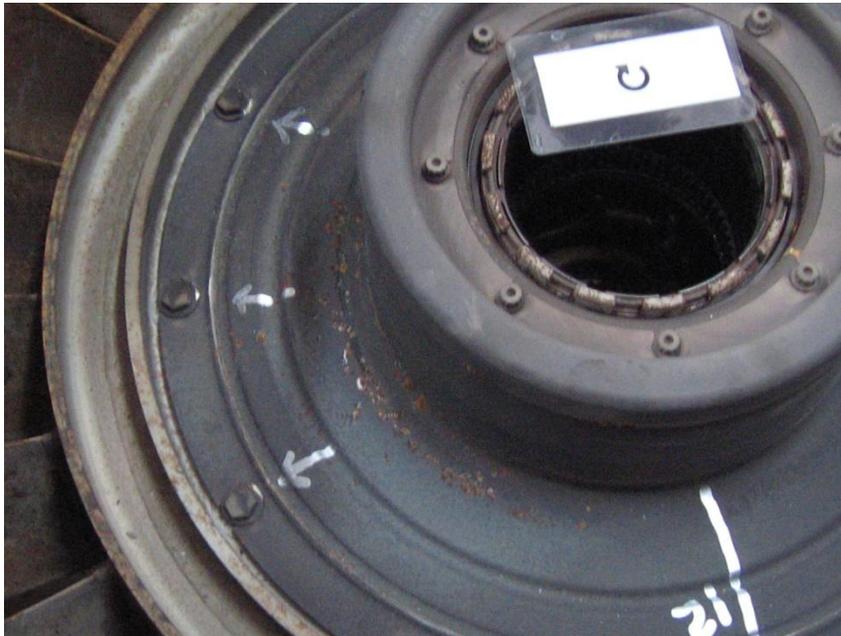


PHOTO 10: No. 3 BEARING HOUSING AFT COVER CONTACT RUB

The No. 4 duplex ball bearing spun freely and smoothly when turned by hand. All balls were present, shiny, oil-wetted, and secured in their cages which were also intact (**PHOTO 11**). The inner races were shiny, oil wetted, and in good condition.



PHOTO 11: NO. 4 BEARING - GOOD CONDITION

2.2.3 Combustion Module

The combustion chamber outer case is secured to the rear flange of the diffuser case and the front flange of the combustion chamber outer rear case and encloses the combustion chamber. Two igniter plug bosses are present, at the 4:00 and 8:00 o'clock positions on the case. Both igniter plugs were removed to facilitate removal of the combustion chamber outer case. Both igniters were intact, in good condition, and exhibited light grooving at the igniter tip. This rub is typical of in-service wear. The combustion chamber outer case was intact and exhibited no punctures, breaches, or impact damage. The combustion chamber outer case was removed to expose the combustion chambers.



Nine one piece combustion chambers (or burner cans) are located between the combustion chamber outer cases and the combustion chamber inner case in a can-annular arrangement. All nine combustion chambers were present, secure, intact, and exhibited no thermal distress (burn-through or erosion), cracking in the louvers or dilution holes, burn-through, or impact damage (**PHOTO 12**). All nine combustion chambers were secured at the front by positioning pins that were intact and safety wired. The aft ends of the combustion chambers were secured into the front of the combustion chamber rear support assembly. All the interconnecting cross-over tubes were present, secured, and lockwired. The combustion chambers were removed to expose the interior of the chambers and the fuel nozzles. All nine combustion chambers exhibited a similar condition: 1) no thermal distress (burn-through or erosion), 2) no localized sooting, or evidence of nozzle streaking in the ID of the chambers, 3) some minor flaking/chipping of the thermal barrier coating on the ID of the chambers, 4) no significant contact wear on the pin support, fuel nozzle port, cross-over tubes, or rear skirt, and 5) no significant cracking of the dilution holes or louvers. Some of the combustion chambers exhibited a white fibrous growth on the ID of the chambers. Tactilely the growth lacked structure and felt soft. All the combustion chamber support pins were intact and no appreciable wear was noted. The combustion chamber rear support assembly was in good condition and no wear or thermal distress was noted on the combustion chamber supports.

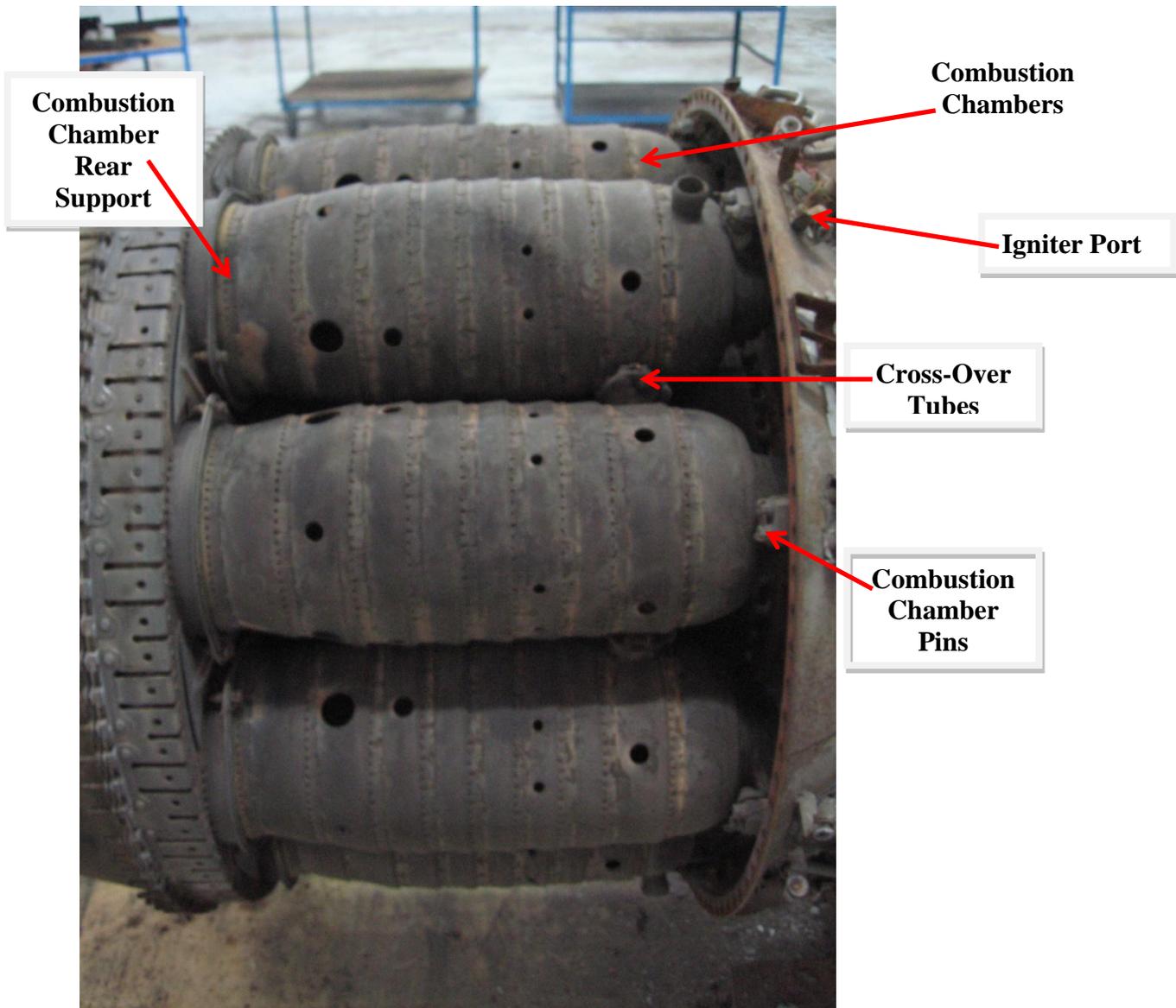


PHOTO 12: COMBUSTION CHAMBERS STILL INSTALLED IN THE ENGINE - NO VISIBLE THERMAL DISTRESS

The combustion chamber inner case is secured to the diffuser case inner rear flange and to the outer flange of the No. 5 bearing housing. It forms the inner wall of the combustion chamber and serves to position the No. 5 bearing through the bearing housing. The combustion chamber inner case was intact and exhibited no punctures, breaches, or impact damage.

All the fuel nozzles were intact and secure in the diffuser case (**PHOTO 13**). No wear or thermal distress was noted on any of the fuel nozzle shields and all the air flow holes were unobstructed. None of the nozzle tips appeared blocked but varied in appearance - some were clean, some exhibited rust, while others were black in appearance. In general all the fuel nozzles were coated in a light brown residue that was easily removed by hand. Removal of the fuel nozzles from the diffuser case revealed that most of the nozzles exhibited rust on the swirler vanes and that some of the nozzles exhibited rust and or debris in the fuel passages (primary and secondary); however, no significant blockage was observed.

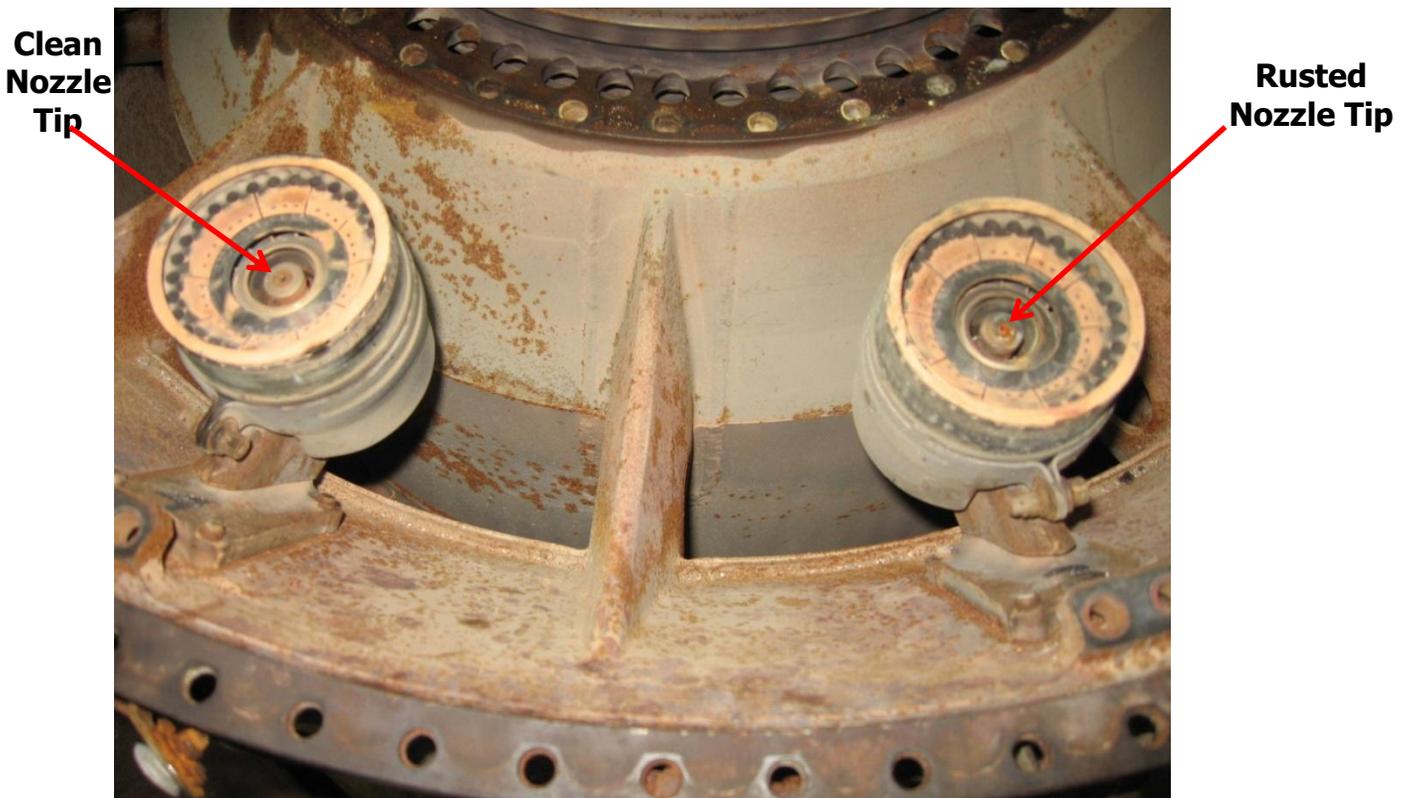


PHOTO 13: FUEL NOZZLES INSTALLED AND SECURE IN THE DIFFUSER CASE



2.2.4 High Pressure Turbine Module

The high pressure turbine module is comprised of a single rotor, supported by the No. 5 bearing, and a rear compressor drive turbine shaft bolted to the disk, and for documentation purposes, a single stage of nozzle vanes located ahead of the rotor. The vanes are attached to the combustion chamber rear support assembly. The serial number HPT disk was **BKLBCL7170** and that matched with what was recorded in maintenance records for the HPT installed in the No. 1 engine. The HPT shaft serial number was **BKLBDA5672** it also matched the maintenance records.

The HPT case exhibited an inward impact mark and associated case puncture at the 4:00 to 4:30 o'clock location (**PHOTO 14**). All the HPT stage 1 vanes were present, intact, and secure. No signs of thermal distress, no leading edge erosion, and no trailing edge cracks were observed. The thermal barrier coating on the nozzles was in good condition. All the HPT stage 1 blades were present, full length, and no signs of thermal distress were observed. The tip shrouds exhibited a light 360° circumferential rub (**PHOTO 15**). The HPT outer air seal ring exhibited a 360° circumferential rub of the honeycomb that was dull and matted consistent with normal engine break-in, as well as a fresh shiny thin light 360° circumferential rub consistent with a more recent contact. The shiny rub was more distinctive around the bottom of the engine. On the aft side of the HPT disk, a light 360° circumferential rub was noted on the stage 1 vane inner rotating air seal land. The HPT shaft did not exhibit any circumferential contact rub.



PHOTO 14: PUNCTURED HPT CASE



PHOTO 15: HPT BLADE TIP RUB

All the No. 5 bearing rollers were present, shiny, oil wetted, and secured in their cage which was also intact. The No. 5 bearing spun freely and smoothly when turned by hand. The No. 5 bearing inner race was shiny and in good condition (**PHOTO 16**). The oil from the No. 5 bearing compartment was dark brown in color with no acrid smell. Coke build-up was noted on the ID of the No. 5 bearing compartment on the top half.

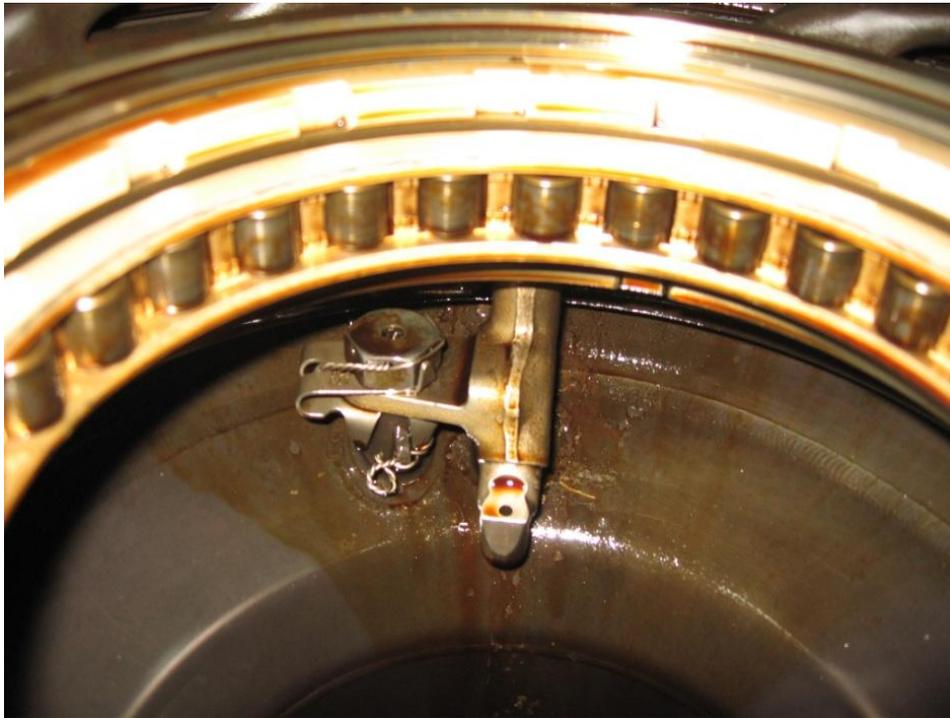


PHOTO 16: No. 5 ROLLER BEARING AND OIL JET IN GOOD CONDITION

2.2.5 Low Pressure Turbine (LPT) Module

The low pressure turbine module is comprised of the front compressor drive rotor and stator assembly. The front compressor drive turbine rotor includes the front compressor drive turbine shaft, stages 2, 3, 4 turbine disks and blades, the turbine hub, and the airseals between the disks. Sixteen tierods secure the disks to each other and to the rear flange of the rotor shaft, and a No. 4½ and No. 6 bearing assembly is positioned on the shaft. In each turbine stage, nozzle guide vanes precede the turbine blades and direct the flow of gases into the blades at the proper angle and velocity.

The LPT module was removed from the core of the engine and was not disassembled further. No circumferential rubs were noted on the LPT shaft. All the No. 4½ bearing rollers were present, shiny, and secured in the cage, which was also intact with no noted distress (**PHOTO 19**). The No. 4½ bearing spun freely and smoothly when turned by hand. The No. 4½ bearing carbon seal and coupling nut were both present and



intact. The LPT stage 2 vanes were all present, in good condition, and no leading edge damage was noted (**PHOTO 17**). Looking through the LPT stage 2 vanes, the stage 2 turbine blades were visible. All the stage 2 turbine blades were present and appeared undamaged and straight. The LPT stage 4 blades were all present, straight, in good condition, and no trailing edge damage was noted (**PHOTO 18**). No visible wear or trenching of the honeycomb was noted on the LPT stage 4 outer air seal ring. Looking through the LPT stage 4 blades, the stage 4 vanes were visible. All the stage 4 turbine vanes were present and appeared undamaged. There were no indications of rub on the LPT stage 4 blade outer air seal. All the No. 6 bearing rollers were present, shiny, and secured in their cage which was also intact. The No. 6 bearing spun freely and smoothly when turned by hand (**PHOTO 19**). The No. 6 bearing carbon seal was present and intact. All the LPT disk tie-rods were present, and the tie-rods were secure.

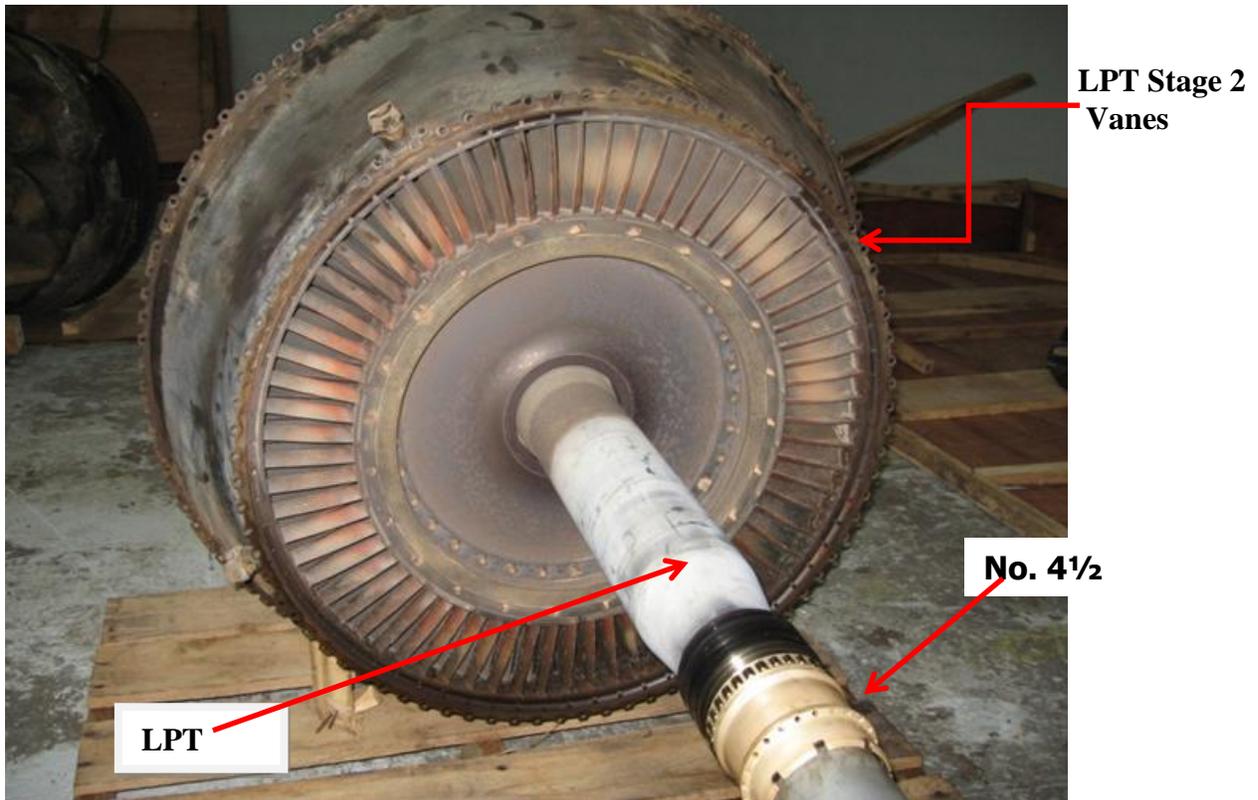
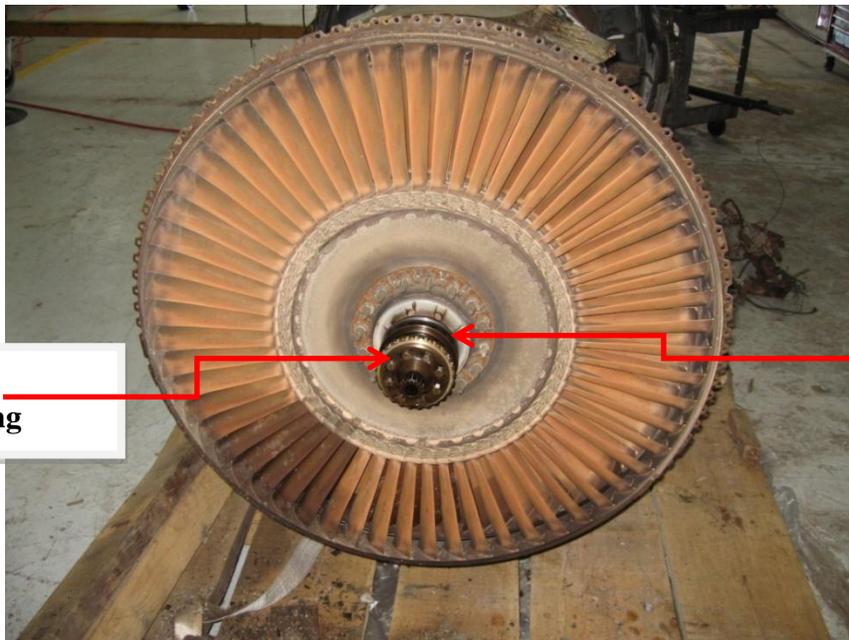


PHOTO 17: LPT STAGE 2 VANES IN GOOD CONDITION AND NO LPT SHAFT CIRCUMFERENTIAL SCORING



No. 6
Bearing

Tie-Rods

PHOTO 18: ALL THE LPT STAGE 4 BLADES FULL LENGTH AND UN DAMAGED AND ALL TIE-RODS SECURE

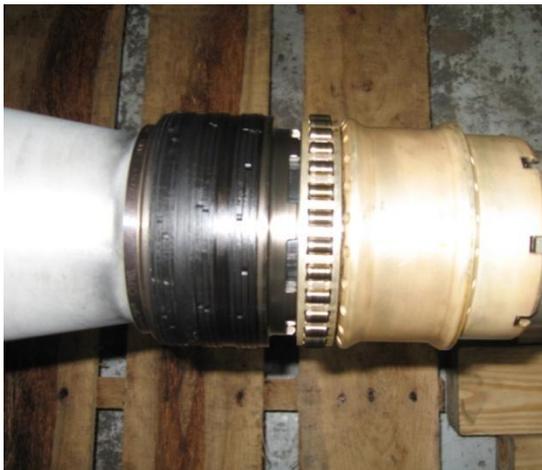


PHOTO 19: No. 4 1/2 BEARING, CARBON SEAL AND INNER RACE LOCK NUT

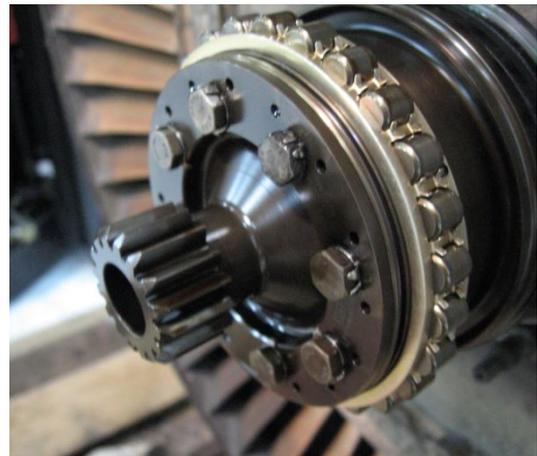


PHOTO 20: No. 6 BEARING AND SCAVENGE DRIVE GEAR



2.2.6 Turbine Exhaust Case Module

The turbine exhaust case is bolted to the rear flange of the turbine rear case. The exhaust case inner diameter was nearly cylindrical and serves to straighten the turbine exhaust gases. Eight integral exhaust struts in the gas-path shield the No. 6 bearing support strut rods which support the No. 6 bearing housing. The turbine exhaust case was removed from the rest of the engine. No punctures, exit holes, or tears were noted. All eight exhaust struts were intact and no buckling or leading edge damage was observed. The center body (No. 6 bearing housing) was undamaged, and oil wetted – the oil was dark brown in color with no acrid smell, the No. 6 bearing inner race was shiny and in good condition, and the scavenge pump gear turned freely by hand.

2.2.7 Fuel System Components

The major components of the fuel system are comprised of: the main fuel pump, fuel heater, fuel control unit, fuel flow transmitter, fuel-oil cooler, pressurizing and dump valve, and the nine fuel nozzles, in addition to the fuel lines that connect these components. The only parts of the fuel system that were available for examination were the fuel nozzles, and left- and right-hand primary and secondary fuel manifolds, which are located on the diffuser case. For this engine, the fuel nozzle documentation was covered in the combustion module section. There was no residual fuel remaining in the fuel system.

Both fuel manifolds were removed from the engine for evaluation. The right-hand manifold encompasses fuel nozzle positions Nos. 2 to 5 (the fuel supply to these manifolds is introduced through fittings on the back side of the nozzle No. 5 fittings) while the left-hand manifold encompasses fuel nozzle positions Nos. 6 to 9 and No. 1 (the fuel supply to these manifolds is introduced through fittings on the back side of the nozzle No. 6 fittings). The fuel right-hand manifold was intact and the fuel transfer tubes between the nozzle fittings were undamaged except for some slight diameter

reduction/crushing in the primary manifold near the nozzle No. 2 fitting. The fuel-feeder lines that attach to the No. 5 fitting were both (primary and secondary) fractured flush with the No. 5 fitting and a piece of the fuel-feeder tubes remained within the No. 5 fittings in both manifolds (**PHOTO 21**). These fractured fuel-feeder tubes both exhibited shear lips. The left-hand manifold exhibited the following damage and observations: 1) heavily sooted at fuel nozzle fitting Nos. 8, 9 and 1, 2) the primary fuel transfer tube was pinched almost closed at the No. 8 fuel nozzle fitting (**PHOTO 22**), and 3) the primary fuel transfer tube diameter was reduced at the No. 7 fuel nozzle fitting,. The fuel-feeder lines that attach to the No. 6 fitting were both fractured at the No. 6 fitting with an appreciable piece of the secondary feeder tube was still attached and twisted/crimped (**PHOTO 23**).



PHOTO 21: RIGHT-HAND FUEL MANIFOLD WITH FRACTURED FEEDER TUBE



PHOTO 22: PINCHED TRANSFER TUBE



PHOTO 23: FRACTURED FEEDER LINE

A flow test of the fuel manifolds were conducted using shop air at approximately 130psi. On the left-hand manifold, shop air was introduced into the primary No. 1 fuel nozzle fitting and a steady stream of air was felt at all the fuel nozzles positions with the No. 7 and 8 positions flowed at a noticeably reduced rate. The same flow test was conducted on the right-hand secondary, and both the primary and secondary on the left-hand manifold (air introduced at the No. 2 fitting) and all flowed steadily. No significant debris came out during the flow test but some residual water did flow out.

3.0 RIGHT ENGINE (NO. 2) – SN 728113

3.1 AS-RECEIVED

The engine was uncrated and placed on pallets for examination and disassembly (**PHOTO 24**). The engine was intact from the nose bullet aft to the exhaust tail cone with all major modules in place. Engine cases appeared round and did not exhibit signs of structural deformation or case breach. Fan and exhaust ducting was missing from the "E"-flange (aft flange of the fan exit guide vane (FEGV) Outer Case) aft to the "F"-flange (forward flange intermediate case outer diameter ring) and from the "G"-flange (aft flange of the intermediate case outer diameter ring) to the "K"-flange (forward flange of the turbine case outer diameter ring). Some wiring, and pneumatic and oil

system plumbing along with crash debris were removed to facilitate teardown (**PHOTO 25**).



PHOTO 24: RIGHT-HAND SIDE OF THE NO. 2 ENGINE SN 728113

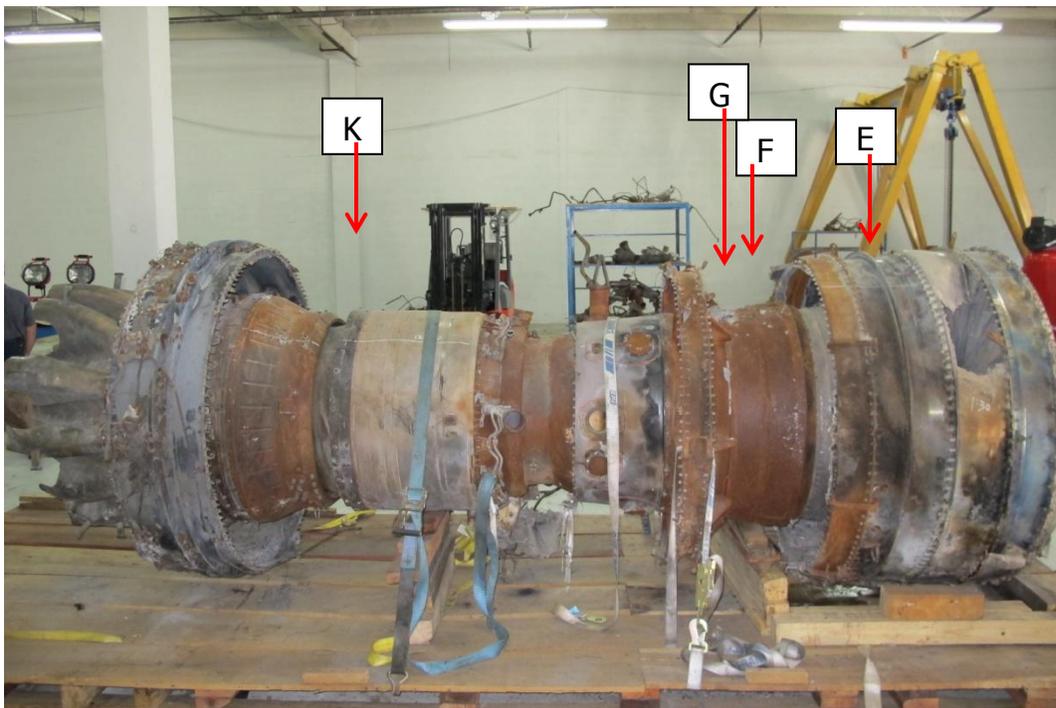


PHOTO 25: RIGHT-HAND SIDE OF NO. 2 ENGINE WITH FLANGE LOCATIONS

The inlet area was inspected and it was noted that the inlet nose bullet was partially melted exposing the front accessory drive cover. All the IGV's were in place and secure with five vanes, located between the 10:00 o'clock and 12:00 o'clock positions, buckled at the mid-span (**PHOTO 26**). No significant leading edge impact damage was noted.

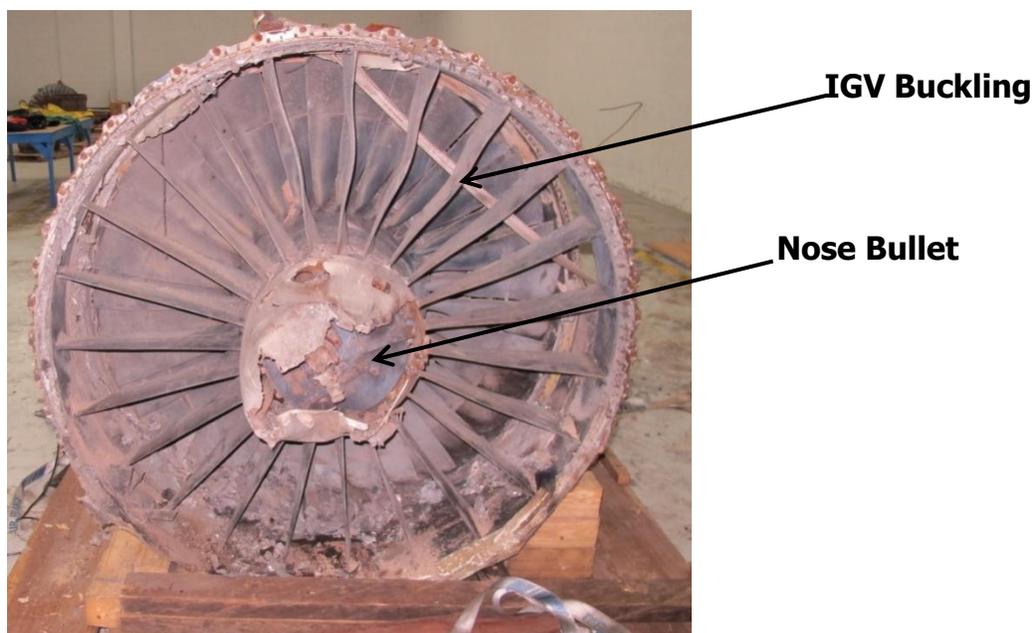


PHOTO 26: ENGINE INLET

The forward fan case exhibited damage in three locations. Case material was missing circumferentially from the 12:00 to 1:30 positions and from the 8:00 to 11:00 o'clock positions, the edges of these holes exhibited thermal distress and indications of melting. An inward puncture with associated case deformation was present at the 4:00 o'clock position, approximately 4 inches in diameter with indications of melting around the fracture surfaces (**PHOTO 27**).



PHOTO 27: FORWARD FAN CASE THERMAL AND IMPACT DAMAGE

The exhaust mixer lobes exhibited crushing damage both radially inward and forward from the 6:00 to 9:00 o'clock positions. The tail cone and inner exhaust duct were both present and undamaged (**PHOTO 28**). There was no distress noted in the exhaust duct mount rails.



PHOTO 28: EXHAUST CASE AND MIXER

3.2 DISASSEMBLY

3.2.1 Front Compressor Module and Intermediate Case Module

The front accessory drive cover was removed exposing the No. 1 bearing. All rollers were present, intact, shiny, and oil wetted. No damage was noted on the bearing cage or races (**PHOTO 29**). The front compressor was removed from the core of the engine and not disassembled further. Except for the stator 1 case and shroud, the low pressure compressor cases and shrouds were round without indication of deformation or breach. A uniform coating of light gray ash was found throughout of the observable gaspath hardware in the LPC. The ash coated easily brushed or blown off (**PHOTO 30**).



PHOTO 29: No. 1 BEARING



PHOTO 30: LPC STAGE 6 BLADES WITH ASH COATING

The aft fan case was removed from the LPC. Two sets of static witness marks were present on the abradable panels between the 4:30 and 6:00 position. The distance between the individual marks in a given set were measured and were consistent with

the measured distance between the fan blade tips (**PHOTO 31**). Two separate sets of witness marks slightly offset from each other consistent with multiple impacts.



PHOTO 31-FAN RUB STRIP STATIC WITNESS MARKS

The fan blades were all present, full length and straight, secured in their respective hub slots, and exhibited no noteworthy airfoil or tip damage. There were no indications of rub on the fan blade tips. Fan blade mid-span shroud shingling was noted on one pair of blades. The stage 1 stator outer case exhibited thermal damage and was almost completely missing, as were the vanes from the 6:00 to 9:30 position (**PHOTO 32**). The visible stage 1.5 blades (approximately 75%) all appeared straight and full length and did not exhibit any notable distress. All of the LPC stage 6 blades were present and secured in their disk slots. The airfoils were all straight and full length and did not exhibit any notable distress. The holes in the rear compressor hub were round and were not ovalized or distorted.



PHOTO 32-LPC Stage 1 Stator Case Melted and Missing Vanes

The No. 2 bearing spun freely and smoothly when turned by hand. The rolling elements were all intact, in place, round, and secured in their cage. The No. 2 bearing carbon seal was in good condition with minimal damage.

The intermediate case was documented after removal from the engine. The case was intact. The core vanes were in place and intact with no noted distress and exhibited a light coating of gray ash. The outer struts were intact with no noted distress. The lower forward mount lug was fractured at its base and bent forward. The upper forward mount lug was bent forward. The upper and lower aft lugs did not exhibit any notable distress. A sheared mount bolt was present in the upper aft lug.

3.2.2 Rear Compressor Module

The HPC was removed from the core to facilitate examination and was not further disassembled (**PHOTO 33**). All the stator cases were round, intact, and exhibited no punctures. The outside of the module had a black oily residue that could be removed with medium finger pressure. The stage 7 blades were all present, full length, and exhibited no leading edge damage or tip rub. The stage 7 blade shroud did not exhibit

any circumferential rub. Looking through the stage 7 blades, the stage 7 vanes were visible; all were intact and exhibited no leading edge impact damage. The stage 13 blades were all present, full length, and exhibited no trailing edge damage or tip rub **(PHOTO 33)**. Looking through the stage 13 blades, the stage 12 vanes were visible; all were intact and exhibited no trailing edge impact damage. The stage 13 blade shroud (located in diffuser case, but discussed here for documentation purposes) did not exhibit any circumferential rub. The visible airfoils in the HPC exhibited a uniform coating of light gray ash.

The serial number on the HPC stage 7 disk was BENCAW0971. This serial number matched what was recorded in the maintenance records.



PHOTO 33- HPC STAGES 7 AND 13 BLADES IN GOOD CONDITION

The No. 3 bearing spun freely and smoothly when turned by hand. The oil from the No. 2/3 compartment was dark in color but did not exhibit an acrid odor. The tower shaft bevel gear within the compartment spun freely when turned by hand.

The No. 4 duplex ball bearing spun freely and smoothly when turned by hand. All balls were present, shiny, oil-wetted, and secured in their cages which were also intact (**PHOTO 11**). The inner races were shiny, oil wetted, and in good condition.



PHOTO 34: No. 4 BEARING - GOOD CONDITION



3.2.3 Diffuser and Combustion Module

The diffuser case was round with no notable damage. All the stage 13 stators were in place and intact with no notable damage. Oil drained from the No. 4/5 compartment scavenge line was dark but did not exhibit an acrid odor.

Both igniter plugs were removed to facilitate removal of the combustion chamber outer case. The igniter plug located at the 4:00 o'clock position was intact but coated with a layer consistent with rust. The igniter plug located at the 7:00 o'clock position was in good condition with no notable distress. No tip wear was noted on either igniter plug.

The combustion chamber outer case was intact and exhibited no punctures, breaches, or impact damage. The combustion chamber outer case was removed to expose the combustion chambers. All nine combustion chambers were present, secure, intact, and exhibited no thermal distress, cracking in the louvers or dilution holes, burn-through, or impact damage (**PHOTO 35**). The outside of all nine combustion chambers had a light gray coating of ash. All nine combustion chambers were secured at the front by positioning pins that were intact and safety wired. The aft ends of the combustion chambers were secured into the front of the combustion chamber rear support assembly. All the interconnecting cross-over tubes were present, secured, and lockwired. The combustion chambers were removed to expose the interior of the chambers and the fuel nozzles. All nine combustion chambers exhibited a similar condition: 1) no thermal distress, 2) no localized sooting, or evidence of nozzle streaking in the ID of the chambers, 3) some minor flaking/chipping of the thermal barrier coating on the ID chamber, 4) no significant contact wear on the pin support, fuel nozzle port, cross-over tubes, or rear skirt, and 5) no significant cracking of the dilution holes or louvers. Loose dirt and mud were present in the combustion area. All the combustion chamber support pins were intact and no appreciable wear was noted.

The combustion chamber rear support assembly was in good condition and no wear or thermal distress was noted on the combustion chamber supports.



PHOTO 35- COMBUSTION CHAMBER INSTALLED IN THE ENGINE- NO VISIBLE THERMAL DISTRESS

All the fuel nozzles were intact and secure in the diffuser case with no notable distress (see section 3.2.7 for details) (**PHOTO 36**).



PHOTO 36: FUEL NOZZLES INSTALLED AND SECURE IN THE DIFFUSER CASE

The combustion chamber inner case was intact and exhibited no punctures, breaches, or impact damage.

3.2.4 High Pressure Turbine Module

All HPT stage 1 vanes were present, intact, and secure. No signs of thermal distress, no leading edge erosion, and no trailing edge cracks were observed. The thermal barrier coating on the nozzles was in good condition. All the HPT stage 1 blades were present, full length, and no signs of thermal distress were observed (**PHOTO 37**). The OD surface of the tip shrouds exhibited a light, shiny 360° circumferential rub on the cooling air channel and the forward seal land (**PHOTO 38**). The HPT outer air seal ring exhibited a light shiny 360° circumferential rub of the honeycomb, as well as an approximately 4 inch rub through the honeycomb that was dark and oxidized suggesting a pre-existing rub. HPT shaft serial number, BKLBBW1127 was recorded from the outer diameter of the HPT flange and it did not match maintenance records. A serial number could not be located on the HPT disk. HPT airfoils exhibited a coating of light gray ash. The HPT shaft was intact and did not exhibit any rubs or circumferential scoring.



PHOTO 37- HPT STAGE 1 DISK



PHOTO 38-HPT STAGE 1 BLADE TIP RUB

All the No. 5 bearing rollers were present, shiny, oil wetted, and secured in their cage which was also intact. The No. 5 bearing spun freely and smoothly when turned by hand. The No. 5 bearing inner race was shiny and in good condition (**PHOTO 39**). The oil from the No. 5 bearing compartment was dark brown in color but did not have an acrid odor.

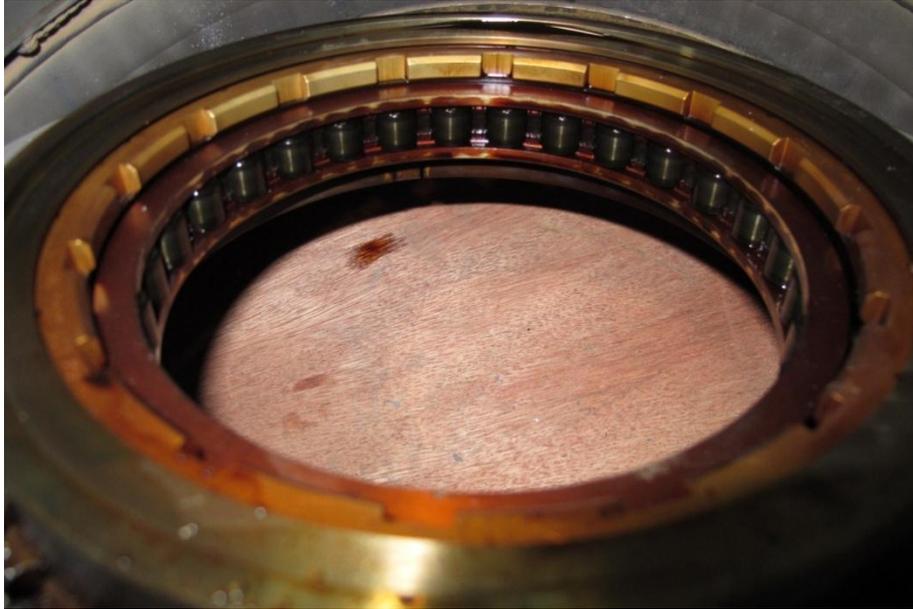


PHOTO 39-No.5 ROLLER BEARING- GOOD CONDITION

3.2.5 LPT Module

The LPT module was removed from the core of the engine and was not disassembled further. No circumferential rubs were noted on the LPT shaft. All the No. 4½ bearing rollers were present and secured in their cage, which was also intact with no noted distress (**PHOTO 40**). The No. 4½ bearing spun freely and smoothly when turned by hand. The No. 4½ bearing carbon seal and inner race coupling nut were both present and intact. Soot was noted on the forward part of the LPT shaft as well as on the No. 4½ bearing inner race lock nut. The LPT stage 2 vanes were all present, in good condition, and no leading edge damage was noted (**PHOTO 41**). The stage 2 vanes outer air sealing ring spacer was fractured at the 9:00 o'clock position and part of the



ring was deformed inward, into the gas path. The deformed end exhibited contact wear and the fracture surface was oxidized consistent with a pre-existing fracture. The bent material was in a position that would not interfere with normal engine operation **(PHOTO 42)**.

Looking through the LPT stage 2 vanes, the stage 2 turbine blades were visible. All the stage 2 turbine blades were present and appeared undamaged and straight. The stage 2 blade and vane airfoils visible exhibited a coating of light gray ash. The LPT stage 4 blades were all present, straight, in good condition, and no trailing edge damage was noted **(PHOTO 43)**. There were no indications of rub on the stage 4 blade tip shroud or outer air seal to the extent that could be observed in the assembled condition. Melted aluminium had pooled and subsequently solidified around the stage 4 turbine blades at the 6 o'clock position. Looking through the LPT stage 4 blades, the stage 4 vanes were visible. All the stage 4 turbine vanes were present and appeared undamaged. All the No. 6 bearing rollers were present, shiny, and secured in their cage which was also intact. The No. 6 bearing spun freely and smoothly when turned by hand. The No. 6 bearing carbon seal was present and intact. All the LPT disk tie-rods were present, and the tie-rods were secure.

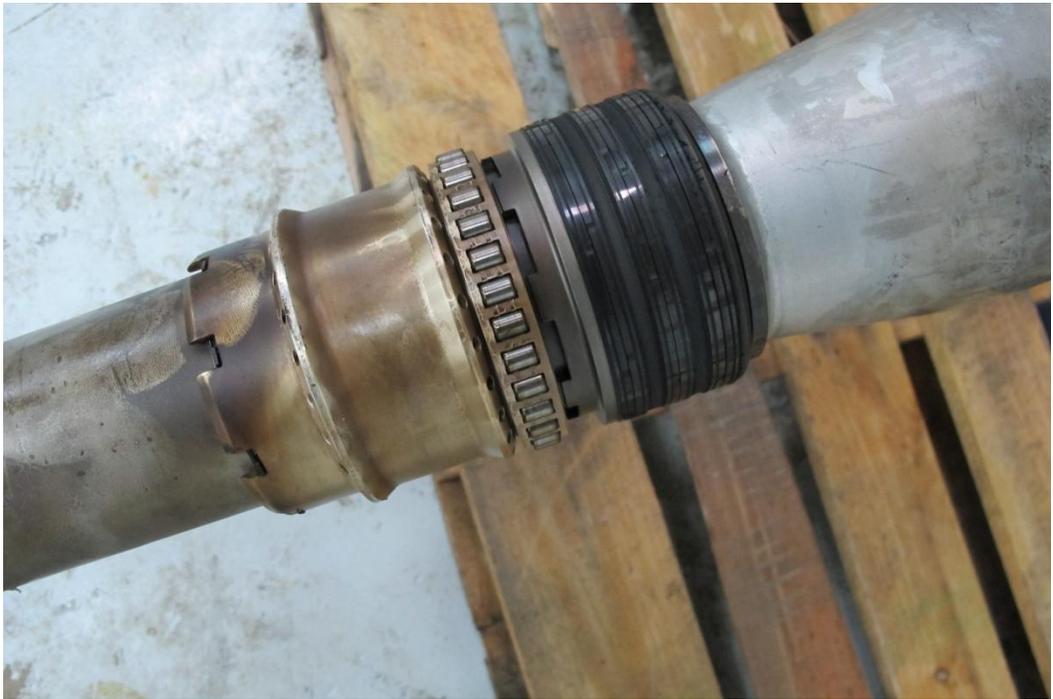


PHOTO 40-COUPLING NUT, No. 4 1/2 BEARING, CARBON SEAL- GOOD CONDITION



PHOTO 41-LPT STAGE 2 VANES



PHOTO 42-STAGE 2 OUTER AIR SEALING RING SPACER FRACTURE

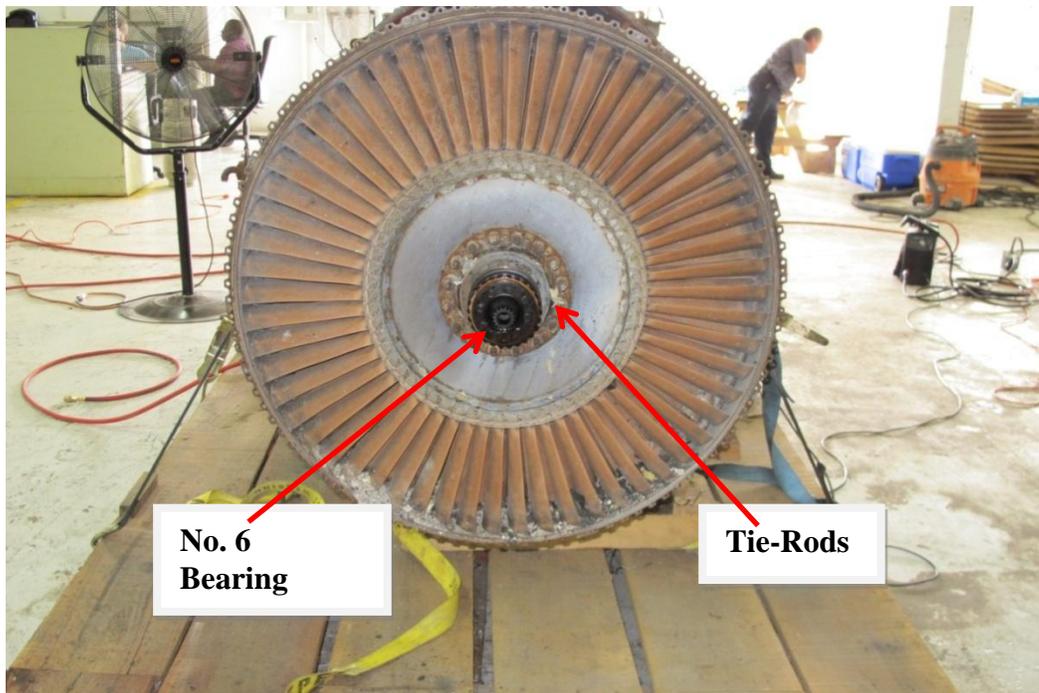


PHOTO 43-LPT STAGE 4 BLADES- GOOD CONDITION

3.2.6 Turbine Exhaust Case Module

The turbine exhaust case was removed from the rest of the engine. No punctures, exit holes, or tears were noted. No damage was found on the exhaust struts, No. 6 bearing support strut rods or tangential fan exhaust duct strut rods that connect the turbine exhaust case to the exhaust duct.

The No. 6 bearing compartment was undamaged and essentially dry and matte black in color with only a small amount of residue oil remaining (**PHOTO 44**). The residual oil was dark in color but did not have an acrid odor. The scavenge pump gear was dry and unable to be turned by hand. Oil staining was noted on the No. 6 bearing carbon seal land and the No. 6 bearing outer race.



PHOTO 44-No. 6 BEARING COMPARTMENT



3.2.7 Fuel System Components

The parts of the fuel system that were available for examination were: the fuel nozzles, the fuel manifolds, the P&D valve-to-fuel manifold feeder tubes, fuel oil cooler-to-P&D valve tube, and fuel control-to-fuel flow transmitter tube. There was no residual fuel remaining in the fuel system.

A series of flow tests were conducted to check for fuel nozzle, fuel manifold and fuel feeder tube blockages using shop air at approximately 130psi. The fuel system was left intact "as received". For the first test shop air was introduced into the P&D valve-to-fuel manifold primary and secondary lines and relative air flow from the fuel nozzles was recorded. Air was introduced first into the left-hand primary line, and air flow was felt flowing from the Nos. 7 and 8 nozzles, low flow was felt from the Nos. 6 and 9 nozzles and no flow was detected from the No. 1 nozzle. Air was then introduced into the left-hand secondary line and there was no air flow through the Nos. 1, 6, 7, 8 or 9 nozzles. Next air was introduced into the right-hand primary line and there was air flow felt from the Nos. 3 and 4 nozzles, low air flow felt through the No. 2 nozzle and no flow through the No. 5 nozzle. Finally, air was introduced into the right hand-hand secondary line and no flow was detected from the Nos. 2, 3, 4 or 5 nozzles.

After removal of the P&D valve-to-fuel manifold feeder tubes, air was blown directly into the fuel manifolds. The results of this series of tests were the same as the testing described above.

All the fuel manifolds were then removed from the engine, and a final flow test was conducted on the fuel manifolds and the P&D valve-to-feeder line tubes. Air flowed freely through all the lines.



The fuel control unit-to-fuel flow transmitter line was flattened and bent over a majority of its length but was not collapsed to the point of complete blockage. No line breaches were noted. A piece of melted fuel control housing flange was still attached to the fuel control unit end of the line. No obstructions were observed during a visual inspection into both ends of the tube.

The fuel oil cooler-to- P&D valve line had two dents, one at the oil cooler attachment end and the other at approximately the mid-span. The line was not collapsed, no breaches were present, and no obstructions were observed during a visual inspection into both ends.

The primary fuel flow feeder line that connects the P&D valve to the fuel flow manifolds had multiple dents downstream of the junctions between the left and right manifolds. The P&D valve end B-nut and fitting were still present. No obstructions were observed during a visual inspection into both ends. The secondary fuel flow feeder line that connects to the right hand manifold was collapsed and bent downstream of the junction, neither of which completely blocked flow. The P&D valve end B-nut and fitting on the secondary line were not present.

The right-hand primary and secondary manifold supply tubes were bent at the No. 5 fittings. Similar damage was noted on the left-hand primary and secondary manifold supply tube at the No. 6 fittings. Neither of these bends completely obstructed flow. The left hand primary manifold also had a circumferential crack just outboard of the fan duct pass through. Visual examination did not identify any blockages looking into the open ends of the tubes.

Fuel nozzles were intact with varying amounts of discoloration. The appearance of the nozzle tips also varied, some were clean, others exhibited a dark colored material that was quickly dislodged when shop air was blown through the nozzles. Several fuel

nozzles exhibited a soft black residue in the primary and secondary fuel inlet ports that crumbled to the touch.

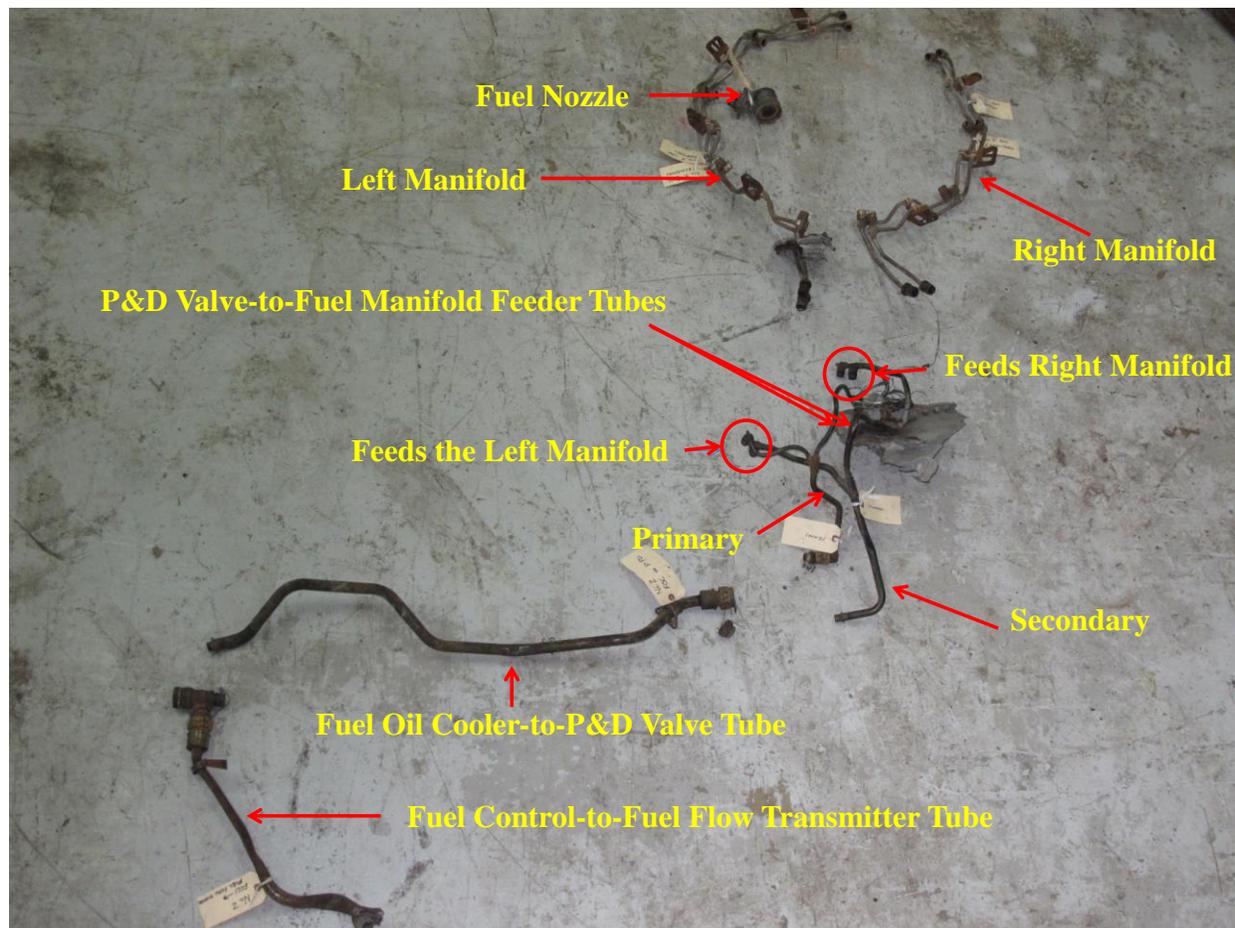


PHOTO 45-FUEL SYSTEM TUBING

4.0 CONTINUING WORK

- The fuel nozzles from the both engines have been quarantined for further evaluation and testing. Work scope, testing facility, and test dates are to be determined.



Appendix B

Extract from Dana Airlines Operations Manual Part A (Captain's Authority)1.17.1.3

The authority of a Dana Air Captain comes from two sources, namely Nigerian Law, and his status within Dana Air. Nigerian Law requires that every person in an aircraft must obey the lawful commands of an aircraft Captain for the purpose of securing the safety of the aircraft and all persons and property on board. The Captain also has legal authority to maintain good order and discipline in the aircraft.

Dana Air Management has a statutory responsibility for the safe operation of the airline which is delegated to the Managing Director who, in turn, entrusts it to Departmental Heads within their particular area of activity. The Captain is thus empowered through the Flight Operations Department to exercise authority and is accountable for his actions in so doing.

The Captain's authority and responsibility in respect of safety is the same within Dana Air as under Nigeria Law. Additionally, he is responsible to Flight Operations Department managers for compliance with instructions and regulations relating to his duties.

When exercising his command, the Captain is responsible for ensuring that the licences of each flight crew member have been issued or rendered valid by the State of Registry, contain the proper ratings, and that all the flight crew members have maintained recency of experience. The Captain is also responsible for ensuring that. personnel subordinate to him perform the duties assigned to them by Dana Air in accordance with the standards and procedure established by Dana Air. No flight crew member shall perform duties during a critical phase of flight except those required for the safe operation of the aircraft. The Captain shall not permit a flight crew member to engage in any activity during a critical phase of flight which could distract or interfere with the performance of their assigned duties.



Aircrew Fitness for duty

a. The Captain shall be responsible for ensuring that a flight is not commenced if any flight crewmember is incapacitated from performing duties by any cause such as injury, sickness, fatigue, the effects of alcohol or drugs or continued beyond the nearest suitable aerodrome if a flight crewmember's capacity to perform functions is significantly reduced by impairment of faculties from causes such as fatigue, sickness or lack of oxygen.

b, The Captain is to prohibit a flight crew from flying or continuing beyond the nearest suitable aerodrome if found to be unfit for duty. In determining fitness for duty, the following factors shall be considered:

- i. alcohol and psychoactive substance use;
- ii. pregnancy;
- iii. illness or use of medication(s);
- iv. blood donations;
- v. surgery;
- vi. deep diving;
- vii. fatigue.

Co-pilot Responsibilities

The Co-pilot's responsibilities include continuous monitoring of the Captain, the instrument panel, reading the checklist and being mindful of the two 'Call Rule', communications, advising the Captain as at when required, etc.

The Co-pilot's responsibilities include ensuring the following:

Pre-flight:

He is fully aware of the flight-planned route, contents of briefing sheets, and the forecast meteorological conditions and runway states at the destination and alternate aerodromes. By delegation of the commander, the co-pilot will usually:



- calculate the take-off data and the operational flight plan and file the corresponding ATS flight plan (whenever those tasks have been delegated to others, he shall cross-check these documents before handing them over to the commander for signature),
- check that the prescribed manuals, maps, charts, documents and forms are on board and cover the aircraft's intended operation until return to a home base,
- check the radio and navigation equipment for proper functioning,
- ascertain that fuel on board and fuel assumed for take-off data calculation are identical, and equal to or higher than the minimum fuel specified by the Operational Flight Plan (OFP),
- at Stations without qualified personnel, check use of the correct fuel type, and supervise the fuelling of the aircraft, and ensure proper distribution of fuel.

In Flight:

Notwithstanding the overriding authority of the commander, it is of the utmost importance that the co-pilot draw the attention of the commander to facts, circumstances or unfavourable variables which may impair the safety of the flight and which may not yet have been noticed by the commander.

Such facts and circumstances may be:

exceedance of limitations, abnormal indication, changes in meteorological conditions enroute or at alternates/destination, ambiguous ATS clearances, deficiencies in navigation or the aeroplane's handling, abnormal response of the aeroplane to controls input, etc. Specifically, the co-pilot:



Situational Awareness & Decision Making

- Monitors developments (fuel, weather, ATC, etc.)
- Anticipates required actions
- Asks the right questions
- Tests assumptions, confirms understanding
- Monitors workload distribution and fellow crew members
- Reports fatigue, stress and overload in self and others

Decision Making

- Fly the aircraft
- Obtain all pertinent information
- All crew members state recommendations
- Better idea suggested? Abandon yours
- Clearly state plan or intentions
- Establish "Bottom Line"
- Resolve conflicts and doubts quickly



Appendix C

Extract from Dana Airlines Operations Quick Reference Checklist (QRC) 1.17.1.5

The Quick Reference Checklist is used to stabilize emergency conditions that are considered time-critical. This card provides step-by-step guidance assuring timely and accurate execution of the emergency action steps. After all QRC checklist items are accomplished, the last line on the QRC checklist concludes with "Checklist Completed", or transitions you to the QRH by means of a gray Reference Bar. The PM reads the Reference Bar. After transitioning from the QRC to the QRH, continue the QRH from the gray Reference Bar marked "Continue from QRC". It is not necessary to repeat the steps already performed in the QRC. There were no records that checklist, Normal, Non-normal and Emergency were used at anytime throughout the duration of the flight.

Quick Reference Handbook (QRH)

All Emergency and Abnormal Checklists are in the form of a self-contained QRH. All checklist items, notes and amplification are contained within the applicable QRH checklist.

The QRH is divided into the following:

- Emergency Checklist Section
- Abnormal Checklist Section
- Reference Cards Section
- CB List
- Alphabetical Index
- Annunciator Lights Reference Page



There are three ways to locate a QRH procedure:

- 1) The Emergency checklists are listed and grouped by the red tab numbers (E#) on the front cover. An Abnormal checklist is located by system title on any of the numbered tab dividers (1 thru 12). Abnormal tab provides a "Table of Content" for each system.
- 2) Additionally, an index section provides an alphabetized list of all QRH checklist. Emergency Checklist are bolded in the index.
- 3) An Annunciator Light Reference Page locator is found on the back cover of the QRH.

RECALL Action items

RECALL BOXED action are performed without reference to the checklist to ensure the safety of the aircraft and/or personnel.

These steps are methodically accomplished by or at the command of the Pilot Flying (PF). After the the RECALL actions are accomplished, the PF calls for the appropriate QRC checklist. The monitoring (PM) reads aloud, in sequence, each checklist item, including the response. Recall items are rechecked by the PM to ensure the challenge action (i.e., switch position, instrument configuration, etc) has been accomplished.

NUMBERED Action Steps

NUMBERED action steps are accomplished by reference to the checklist (read and do). The PM reads aloud both challenges and response from the QRC/QRH. The PF should accomplish those items affecting aircraft controls, such as disconnecting the autopilot and auto-throttles. Items such as moving a Throttle to idle, moving a Fuel Lever to OFF,



or pulling an Engine Fire Handle are accomplished by the PM. The items accomplished by the PM are performed in a deliberate and unhurried manner.

EMERGENCY AND ABNORMAL PROCEDURES

Flight crews shall properly manage non-normal situations through the use of prioritization, task sharing, division of PM/PF duties and crew coordination. During the execution of abnormal/non-normal and emergency procedures, across check and verbal confirmation by the two flight crew members (dual response) must be ensured before the actuation of any critical aircraft system controls, as defined by the OEM, The critical aircraft system controls include:

- a) Engine thrust levers;
- b) Fuel master or control switches;
- c) Engine fire handles or switches;
- d) Engine fire extinguisher switches;
- e) IDG/CSD disconnect switch.

ENGINE FAILURE DURING FLIGHT

Only in exceptional circumstances should the Captain of a twin-engined aircraft not land at the nearest suitable airfield following the loss of engine in flight. A Captain electing not to land at the nearest aerodrome, is to state the reasons for his decision on the Flight Crew Voyage Report and the Air Safety Report.



QUALIFICATION REQUIREMENTS:

DESCRIPTION OF LICENCE, QUALIFICATION /COMPETENCY, TRAINING AND CHECKING.

Dana Air shall not allow any person to act as a pilot flight crewmember of its aircraft unless a valid licence or validation certificate is held showing compliance with the specifications of Nig. CARs Part 2 and appropriate to the duties to be performed by that person.

- a) No person, shall be employed as a flight crew member unless prior to being employed, such a person is screened for the purpose of reviewing and/or assessing:
 - i) technical competencies and skills;
 - ii) aviation experience;
 - iii) credentials and licenses;
 - iv) interpersonal skills;
 - v) medical fitness;
 - vi) security background;
 - vii) English language fluency as all flight crew members are required to use the English language for communication on the flight deck during line operations, between the flight crew training and evaluation activities.



- 1. EMERGENCY POWER.....ON**
- 2. IGNITION.....OVRD**

**CAUTION: EGT or N1 response to throttle movement may indicate
LOSS OF ALL GENERATORS(TAB E6, Pg. E6.3)**

- 3. CABIN ATL CONTROL.....MANUAL/FULL FWD**
- 4. OXYGEN MASKS.....AS REQUIRED**
- 5. EMERGENCY POWER.....CHECKED**

*Pull the BAD DIRECT BUS FEED C/B RESET (CENTER PEDESTAL)if required.

CONTINUE FROM QRC

CAUTION: Immediately select a landing site.

- 6. AIRSPEED.....MINIMUM MANEUVERING**
*Windmill start may NOT be successful below 180KIAS or above FL 240
- 7. THROTTLES.....IDLE**
- 8. ENGINE ANTI-ICE SWITCHES.....ON**
- 9. BATT SWITCH CHECK.....ON**
- 10. DC START PUMP SWITCH.....ON**
*Optimum attitude for scavenging fuel is 0° pitch and 1.5" right wing up.
- 11. L & R ENG GEN SWITCHESOFF**
- 12. L & R ENG HYD PUMP SWITCHES.....OFF**
- 13. FUEL CONTROL LEVERS.....ON**
- 14. MAIN & CENTER TANK BOOST PUMPS.....ALL ON**
- 15. FUEL X-FEED LEVER.....OFF**

NO RESTART

ONE OR BOTH RESTART



- 16. APU MASTER SWITCH.....START**
- 17. APU L & R BUS SWITCHES(ONE AT A TIME).....ON**

JUST PRIOR TO LANDING

- 18. EMER LTS SWITCH.....ON**
- 19. L & R ENG HYD PUMP SWITCHESON**
*Use alternate landing gear handle if APU not available.
- 20. CABIN ALT CONTROL WHEEL..... FULL AFT**



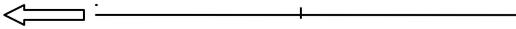
21. FLAPS.....AS REQUIRED

AT 500 FEET AGL:

22. PA ANNOUNCEMENT.....COMPLETE

**"BRACE - BRACE"
*CHECKLIST COMPLETE***

ONE OR BOTH RESTART



- 16. ELECTRICAL SYSTEM.....AS REQUIRED**
- 17. CABIN ALT CONTROL LEVER.....AUTO**
- 18. DC START PUMP SWITCH.....OFF**
- 19. L & R ENG HYD PUMP SWITCHES.....AS REQUIRED**
- 20. ENGINE ANTI-ICE SWITCHES.....AS REQUIRED**
- 21. ENG IGN SWITCH.....AS REQUIRED**

IF ONLY ONE ENGINE RELIGHTS:

- 22. COMPLETE THE ENGINE IN FLIGHT SHUTDOWN PROCEDURE
(TAB E5, Pg. E5.3)**
 - 23. LAND AT THE NEAREST SUITABLE AIRPORT.**
- *DUEL ENGINE FAILURE CHECKLIST COMPLETE***

CHECKLISTS ACCOMPLISHMENT

The NORMAL checklist is used as a verification to ensure that certain critical or essential steps of the preceding procedure have been accomplished. The expanded checklists of this section serve the dual purpose of defining the procedure to be accomplished for each phase of flight and providing expanded notes appropriate to checklist accomplishment.

The procedure defined for each phase of flight will be accomplished by recall (flow) prior to the reading of the applicable checklist. In all cases the checklist will be read



from the printed checklist card. At no time is the use of a checklist from memory acceptable.

The Pre-flight check list is to be completed by the operating crew on their first Sector. Only the *items on the Pre-flight checklist need to be completed on subsequent (transit) sectors.

If the flight deck is left unsupervised (all pilots away from the flight deck) prior to the BEFOFE START checklist, all previously accomplished checklists must be re-accomplished in their entirety. If a non-crewmember is present on the flight deck during the absence of one or more crew members, the non-crew member must be supervised by a remaining crew member or any previously accomplished checklist must be re-accomplished.

The Captain will call for all checklists during ground operations. The Pilot Flying will call for all checklists in flight.

Normally a flow will be accomplished before the checklist is read. The point at which the associated flow may be initiated is defined in the preamble of each checklist. However, no flight control will be moved or positioned until called for.

Each item will be challenged out loud by the designed crew member unless otherwise noted. The responding crew member will visually confirm that the challenged action has been properly accomplished and will respond appropriately to the challenge, confirming the action or describing the configuration. Items which have an associated numerical value or switch position (i.e. reference speeds, altimeter settings, etc.), will have the value or switch position stated as described in the expanded section. Any item listing an "AS REQUIRED" response will be responded to by the actual configuration or condition as described in the expanded section



If a checklist item is not installed in a particular aircraft, the crew member will nevertheless challenge the item and the response will be "NOT INSTALLED". Any action, which has not been performed or completed when challenged, must be completed before the next challenge is read. If performance of the challenged action cannot be completed immediately, the crew member responding will reply "STANDBY" or other suitable response to indicate that further reading of the checklist will be suspended until the item can be accomplished.

Checklist Completion

An unwritten last step of any checklist for the pilot accomplishing the checklist to call the checklist complete. Calling the checklist is complete is a last safeguard that everything is in order. When a checklist is complete, the announcement of "**(title) CHECKLIST COMPLETE**" mentally closes the loop on the process that began when the checklist was called for. This also mentally opens the door for the next activity.

Appendix D



NIGERIAN CIVIL AVIATION AUTHORITY

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

NCAA/DAWS/AD.1125/VOL.III/03

18th December, 2013

The Accountable Manager,
Dana Airlines
Murtala Muhammed Airport
Ikeja, Lagos.

Attention: Quality Manager

RE: AUDIT OF DANA AIRLINES

Sequel to the audit carried out by the NCAA between 9th – 12th December, 2013. Please find attached the related non-conformance findings forms.

Dana is to propose and submit corrective actions that will also address the root cause(s) of these findings

Findings that are categorized as level 1 must be closed before Dana will be permitted to resume operations while level 2 findings are to be closed within sixty days (60) of NCAA's acceptance of your proposed corrective actions.

NCAA also hereby directs that all the engines that have been previously overhauled by Millennium MRO are to be sent to an NCAA approved engine shop(s) for overhaul before they can be re-installed on any of your aircraft that may be allowed to commence operations.

Please be guided accordingly.



Director, Airworthiness Standards
For: Director General

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



Appendix E

Final Report on the Forensic Investigation of Bodies Recovered from the Dana Air Crash (Flight 0992. 5N-RAM)

The bodies of the victims of the air crash started arriving at TOS Funerals late on Sunday June 3, 2012 and this continued till Tuesday, June 5, 2012. A so-called identification took place at the crash site and subsequently at TOS Funerals, which unfortunately created problems later. The latter was aggravated by the fact that most of the items allegedly retrieved from or around the bodies never accompanied same to the autopsy room. Ideally, the forensic pathology team should be part of the recovery team and certain processing should start from the scene barring the Nigerian factor of miscreants and thieves invading a crash site.

The Chief Medical Examiner instructed (through TOS Funerals) that the bodies be tagged DANA/1/12.....up to DANA/152/12. The body parts/fragments were tagged DANA/BP/1/12.....up to DANA/BP/16/12. In addition there were 7 human bone fragments tagged DANA/HT/1.....up to DANA/HT/7. These identification numbers were retained throughout the entire procedure and were subsequently used to determine the identity of the victims following correlations with supposedly closely-linked family members.

The post-mortem investigations of the mass disaster victims of the DANA AIR crash took place within the Department of Pathology and Forensic Medicine of the Lagos State University Teaching Hospital. The forensic pathology investigating team comprised five units working simultaneously, apart from the radiology and odontology (dental) teams. In addition, a DNA Collection Centre was set up within the department, for the sole purpose of victim identification. To hasten the whole investigation, forensic pathologists were invited from the University of Abuja, Obafemi Awolowo University at Ife, and the University of Ibadan. [REDACTED]

[REDACTED]



[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

The radiology team led by Prof. [REDACTED] commenced the investigation process by taking full skeletal (including dental) X-rays of the bodies of the victims, highlighting any pattern of bone fractures/injuries, apart from the identification of any peculiar features geared towards identification. The latter includes bone moldings, prostheses, implants and dental patterns among others.

The forensic pathology teams then received the bodies and took detailed photographs of the bodies with video recordings in some of the bodies. Each victim was accompanied by documentation sheets and charts which were contained in water-proof transparent jackets. The teams described the clothing, jewellery, scars, and recorded other external features that could assist with subsequent identification. The team thereafter performed detailed forensic dissections on all the bodies, charted and documented the pattern of skeletal and soft tissue injuries, and took toxicological samples. The latter comprised specimens from the vitreous humour (eye fluid), blood and urine. In the absence of blood, samples of bone marrow were taken in cases where this was readily available. Routine histological (tissue samples) for further evaluation under the microscope were also taken. The team then took DNA samples from bones (ribs or long bones), muscle and pulled hair, depending on the state of the body. Finally, the Pathologists made conclusions as to the cause of death, based on gross morphological findings.

The bodies were passed on to the odontology team [REDACTED] [REDACTED] who did the dental charting following prior exposure of the maxilla and mandible by the pathology teams. The dental charts were used as



additional identification tools by comparing the findings with the victims' ante mortem dental records where available.

Following the entire autopsy procedures the bodies were returned to TOS Funerals where they were cleaned, embalmed and refrigerated in preparation for subsequent release.

The collection of DNA reference samples was anchored by [REDACTED] a forensic science graduate and National Youth Service Corp Member attached to the department. She was assisted by the Graduate students in the Forensic Science programme run by the department. Two relations of each suspected victim were invited to provide DNA samples; primary emphases were laid on the parents, siblings and offspring, in that decreasing order of preference. The provision of reference samples was done using buccal (mouth) smears after taking necessary standard precautions. These included taking of individual pictures of the sample donors, an exercise handled by the Public Relations Unit of LASUTH. Explanations were provided to the donors about the process of sample collection and informed signed consents were obtained before proceeding with the collection of the samples.

In conducting this investigation, the teams started with the supposedly better preserved bodies which were 49 in number; this was completed on Wednesday 6th June 2012. The remaining charred and largely partial bodies (which form the vast majority) were processed thereafter and the post-mortem procedures were completed on Thursday 14th June 2012. In all a total of 152 complete/partial bodies were examined with two bags of 16 body parts and 7 bone remains. A total of 323 buccal smears were collected from family members as reference DNA samples.

A debriefing meeting took place on Friday 15th June 2012 where the five pathology teams met and discussed the entire operations. The meeting touched on such issues as



the ideal way for investigating fatalities resulting from mass disasters. This included the setting up of a standing committee, regular rehearsals, body recovery at scenes, roles of the Chief Coroner and Chief Medical Examiner, storage, processing of bodies, identification procedures, determination of the cause of death, and the release of the bodies. The session also discussed various handicaps including problems with storage, transportation and radiological examinations. However, the procedure so far was generally considered a success and surely future investigations (God forbid) would be much better handled.

The pathology team collated various photographs and images taken at autopsy including those of radiology and dental examination. All these were burnt on individual CDs for each victim.

The Histology samples collected during the post-mortem examination were grossed, processed and microscopically examined by the Pathology teams.

The DNA samples were sent in six installments to Orchid-Cellmark in the United Kingdom; the last batch was on 10/12/12. The samples include those from the victims and reference samples from the 323 family members; 154 families providing two reference samples each, 5 families provided only one, another provided four reference samples while one provided 5 reference samples. One family also submitted a personal item (tooth brush) of the victim for DNA extraction.

The toxicology samples (where available) were sent to the Forensic Toxicology Laboratory of St. Louis Chief Medical Examiner's Office in Missouri, USA. The reports (84) of the toxicology analyses have been received and analysed. Some of the samples were insufficient for analysis. Thirty four were positive for alcohol but most were essentially due to post-mortem endogenous production. One victim had apparently used marijuana sometime before boarding the plane. Though there were 9 results indicating



the presence of carbon monoxide poisoning (smoke inhalation), the post-mortem examination indicated that 27 victims had died of suspected carbon monoxide poisoning. This suggests that the victims were alive for some time in the fire that probably followed the crash, that is, they did not die immediately after the impact.

In all, the Pathology teams discovered '152' partial to complete bodies with over two-thirds being moderately to severely charred, as well as, body parts and bone fragments. Out of the '152' bodies, four bags were shown by DNA analysis as actually representing two bodies only; in other words **only 150 bodies (complete/partial)** had been recovered. Of a total of 150 recovered bodies, 147 (98.0%) of them were positively identified through the DNA analysis in combination with other ancillary investigations like the dental imaging. Another victim was identified from a combination of the recovered bone fragments. On the whole, **148** victims of the DANA Air Crash were positively identified. The list is herewith attached as Appendix 2.

The list of identified victims was conspicuously pasted for family members to see; phone calls were made to notify some of them. The bodies have since been released and Death Certificates issued to the next-of-kin. All these were done based on guidelines agreed with the Coroner and the Lagos State Ministry of Justice.

There are three (3) 'bodies' that remain unidentified. Orchid-Cellmark have done exhaustive and repeated tests with, cross-referencing and came to the conclusion that there are no further matches with the submitted reference DNA samples.

Going through the Manifest provided by DANA Air (Appendix 3), 153 people were on board the flight (including the Pilot, Co-Pilot, 4 other Crew members and one Flight Engineer). Of these, only 144 victims were identified from the Manifest; this represents 94% of those supposedly on board the plane and who used their real names. This



means that 9 individuals on the Manifest cannot be accounted for. The explanations for these include the following:

1. Absence of such individuals aboard the plane;
2. Individuals other than those who bought the tickets might have boarded the plane using an adopted name;
3. The victim might have been completely incinerated;

It is noteworthy that both the Pilot and Co-Pilot could not be identified among the bodies, body parts and bone fragments that were recovered. Orchid-Cellmark was very emphatic on this, following repeated tests and cross-referencing. It is noteworthy that the 4 flight attendants and, a flight engineer who was apparently just travelling on the plane were among those identified.

Another observation in the manifest is the fact that names were often spelt incorrectly and perhaps incompletely.

There were at least three (3) suspected ground victims among the 148 bodies identified.

At the moment there are three (3) unidentified bodies, labeled as:

1. DANA/29/12
2. DANA/66/12 and
3. DANA121/12.

The last two are charred while the first is fairly complete with better preservation.

From all available records, there were 15 foreign nationals representing 9 countries, aboard the ill-fated flight. These include the under listed:



1. Canadian 1
2. Chinese 4
3. Indians 2 (One, the Co-Pilot, was not identified)
4. Indonesian 1
5. Lebanese 1
6. German 1
7. French 1
8. American 3 (One, the Pilot, was not identified)
9. Beninois 1.

[REDACTED]

Chief Medical Examiner



Appendix F



Preliminary Inspection Report

W.O. 800715, JT8D-217C, ESN: P725851D

January 14th, 2014

Reason for Removal: Fuel leaking from lower fan discharge duct. Engine not responsive to throttle movement.

Workscope: Disassemble engine to the extent necessary to expose damage of fuel manifold assembly and related components, advise.

The following was found and confirmed upon disassembly:

Upon removal of the fan discharge ducts it is noted that the R/H fuel manifold inlet fairing is improperly installed due to lack of engagement of the front and rear sections on the inboard side. Image 1 shows assembly as installed on engine. Image 2 shows assembly as removed from engine.

The R/H fuel manifold assembly shows a fracture on the secondary fuel inlet tube, No. 5 fuel nozzle at 5 o'clock position. The secondary fuel manifold inlet tube is liberated adjacent to the No. 5 fuel nozzle coupling location. Images 3 and 4 show fuel manifold assembly as installed on engine. Images 5, 6, 7, 8, 9, 10 and 11 show fuel manifold assembly as removed from engine. Referencing SB6452, page 3, this condition can be caused by thermal expansion resulting in high stresses. Also, installation of distorted manifolds and incorrect shimming of the manifold during installation can aggravate the condition. It is noted that fuel manifold assembly is pre-SB6452 (to provide secondary fuel manifold assemblies fabricated with new tube material, which have a significantly greater fatigue life).

Images 12, 13, 14, 15, 16 and 17 show typical assembly of fairing assemblies with grommets.

The 13th stage bleed valve assembly at the 7 o'clock position exhibits a hot air leak suggesting an improper bleed valve operation with heat related damage to surrounding areas. The diffuser liner segment at this location shows heat damage resulting in loss of face sheet and damage to honeycomb sound attenuation. See Image 18.

Receiving borescope inspection reveals 1ea. sixth stage blade with T/E indentation exceeding engine manual permitted damage limits. A 0.010" indentation is permitted in this area. The C-6 blade damage is within engine manual blend / rework limits. See Image 19.





JT8D-217C 727 Installations
Engine Serial Nos. P725001 thru P725018

JT8D-219
Engine Serial Nos. P716701 thru P716800

JT8D-219
Engine Serial Nos. P718025 thru P718290

JT8D-217C/219
Engine Serial Nos. P725351 thru P726350

JT8D-217C/219
Engine Serial Nos. P726801 thru P726999

JT8D-217C/219
Engine Serial Nos. P728001 thru P728268*

JT8D-217C/219 727 Installations
Engine Serial Nos. P726111 thru P726139

JT8D-217C/219 727 Installations
Engine Serial Nos. P726143 thru P726220*

JT8D-217C/219 707 Installations
Engine Serial Nos. P715861 thru P715865*

* This estimate of engine serial numbers will be revised, if necessary, when parts are installed in engines at Pratt & Whitney.

NOTE: The notation "All Engines" applied to an engine model indicates that these engine models are no longer being manufactured. This Service Bulletin is applicable to all of the engines in that model.

Concurrent Requirements

There are no concurrent requirements.

Reason

1. Problem: There have been several instances reported of secondary fuel manifold assembly fractures, causing fuel leaks, which resulted 94 UERs, one IFSD and two ATBs. There was also one contained fire in 2001 and the extent of the damage was confined to a dark streak of coked fuel on the Combustion Chamber Outer Case (CCOC), and fan duct damage.
2. Cause: Thermal expansion results in high stresses on the tubes, which do not have adequate fatigue life for these stresses. Also, installation of distorted manifolds and incorrect shimming of the manifold during installation can aggravate the condition.
3. Solution: Provide new secondary fuel manifold assemblies, incorporating tubes fabricated from new material which has a fatigue life that is approximately 2 times greater than the current tube material to improve the durability of the manifold assemblies.

Description

Replace or modify the left and right secondary fuel manifold assemblies.

October 10/03

JT8D 6452

Page 3

Images:

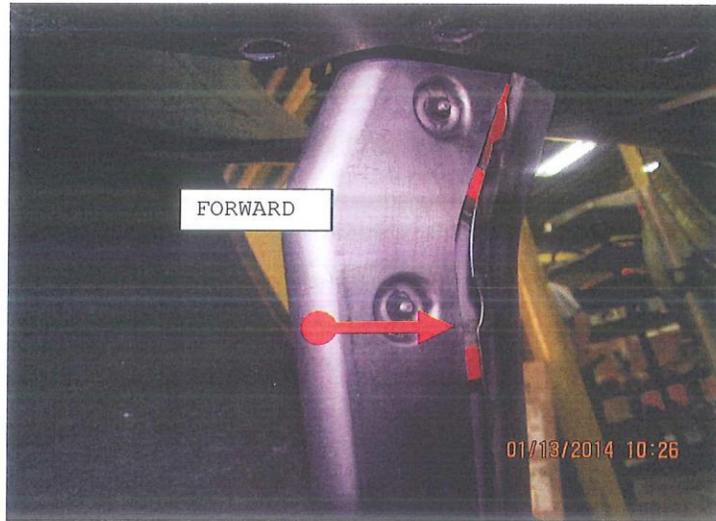


Image 1: Fuel manifold inlet tube fairing not engaged at split-line

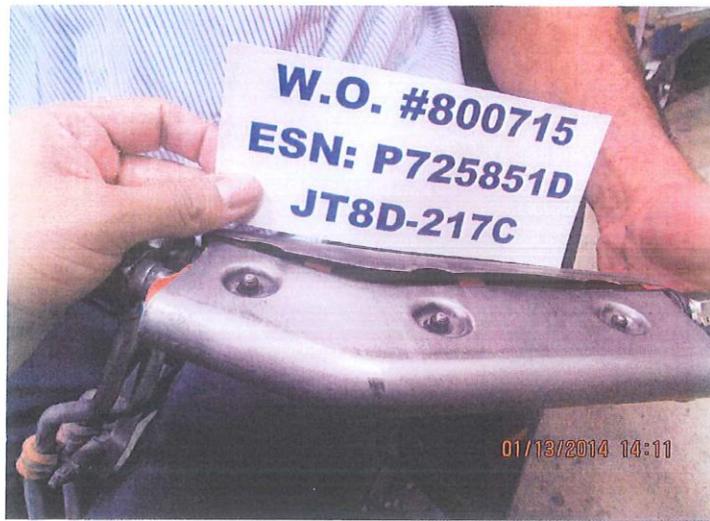


Image 2: Fuel manifold assembly as removed from engine

Images cont'd:



Image 3: R/H fuel manifold assembly shows a fracture on the secondary fuel inlet tube

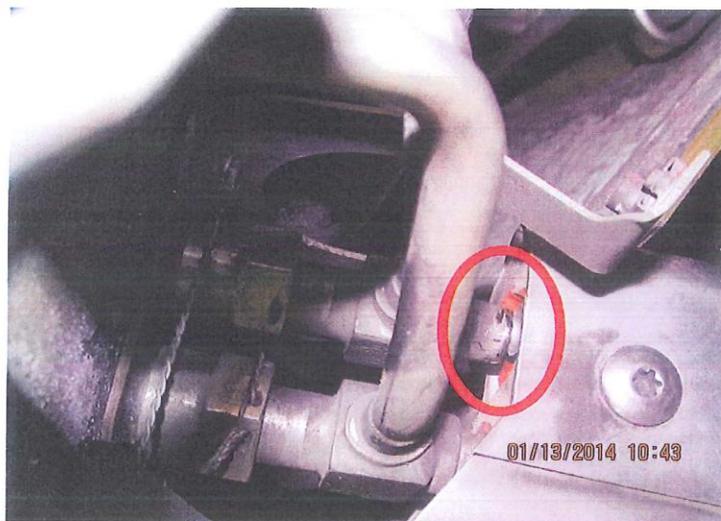


Image 4: R/H fuel manifold assembly, fracture of secondary fuel inlet tube

Images cont'd:



Image 5: Fracture on the secondary fuel inlet tube



Image 6: Note liberation of manifold and fuel inlet tube

Images cont'd:



Image 7: R/H fuel manifold assembly, aft fairing removed



Image 8: R/H fuel manifold assembly, forward and aft fairing removed

Images cont'd:



Image 9: Forward and aft fairing removed, note damage on upper most grommet

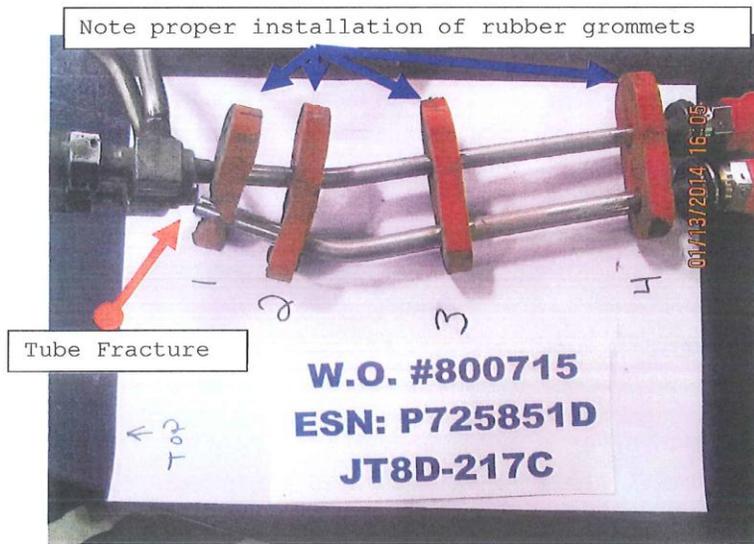


Image 10: R/H fuel manifold assembly fuel inlet tubes as exposed without fairings

Images cont'd:



Image 11: R/H fuel manifold assembly fuel inlet tubes

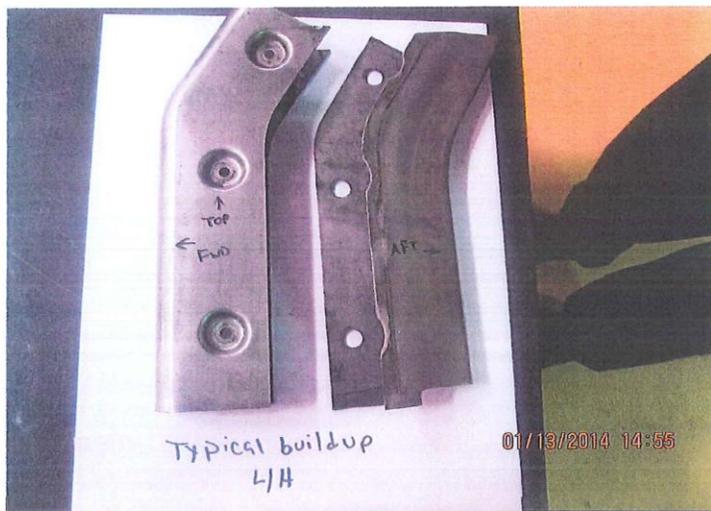


Image 12: Typical assembly procedure of L/H fairing

Images cont'd:

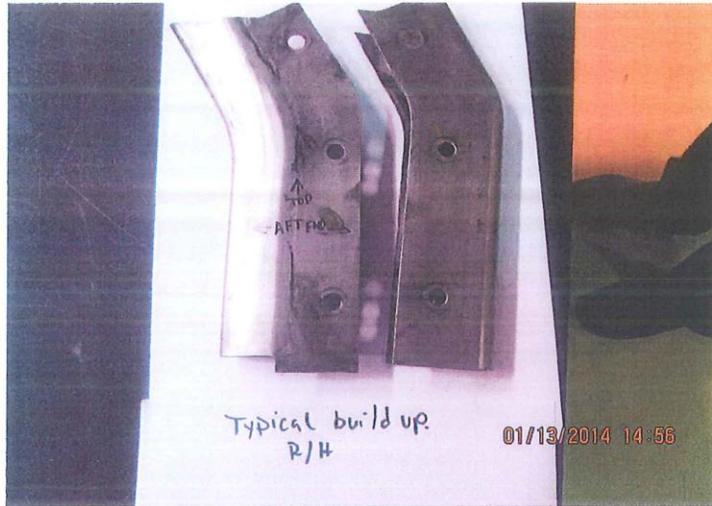


Image 13: Typical assembly procedure of R/H fairing



Image 14: Typical assembly, note proper engagement of forward and aft fairing

Images cont'd:

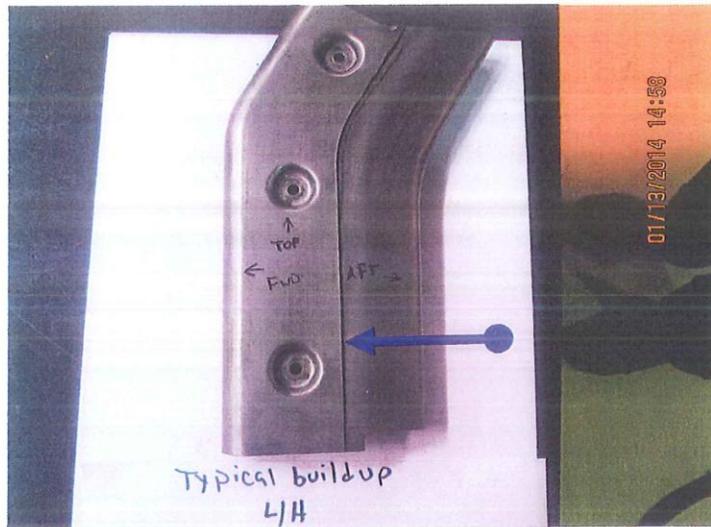


Image 15: Note proper engagement of forward and aft fairings

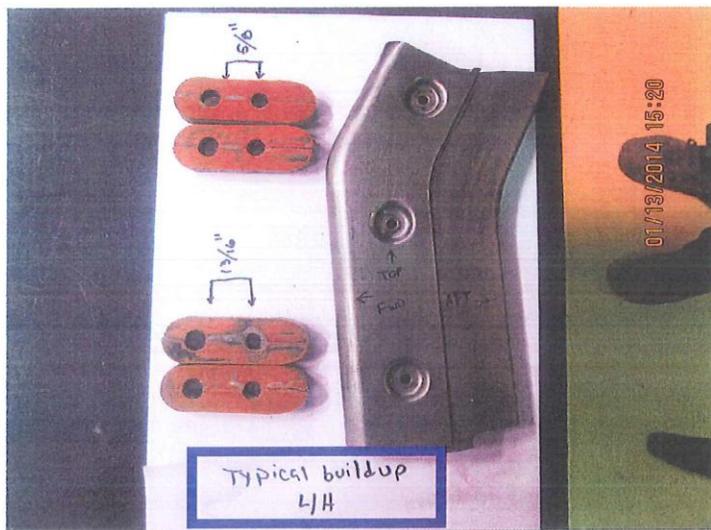


Image 15: Note distance of inlet tube holes in grommets for proper installation sequence

Images cont'd:

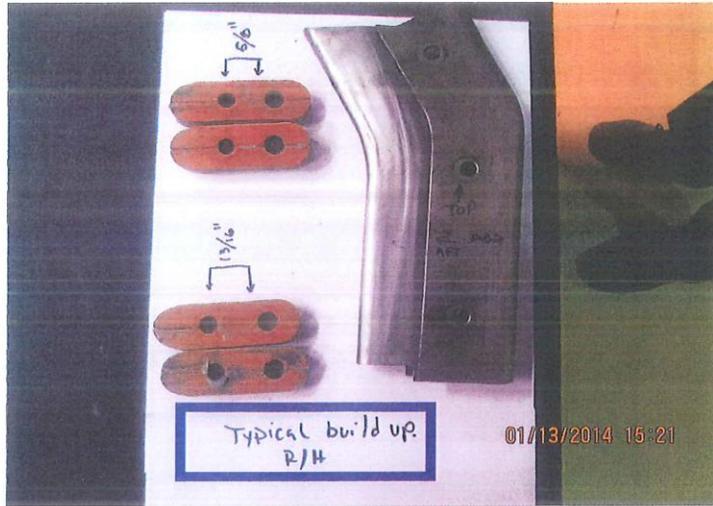


Image 17: Note distance of inlet tube holes in grommets for proper installation sequence

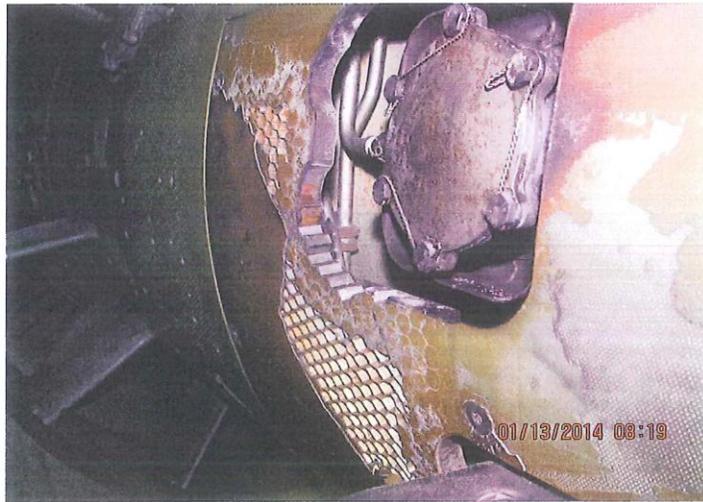


Image 18: Diffuser liner segment at 9 o'clock position exhibit heat related damage due to hot air leak

Images cont'd:

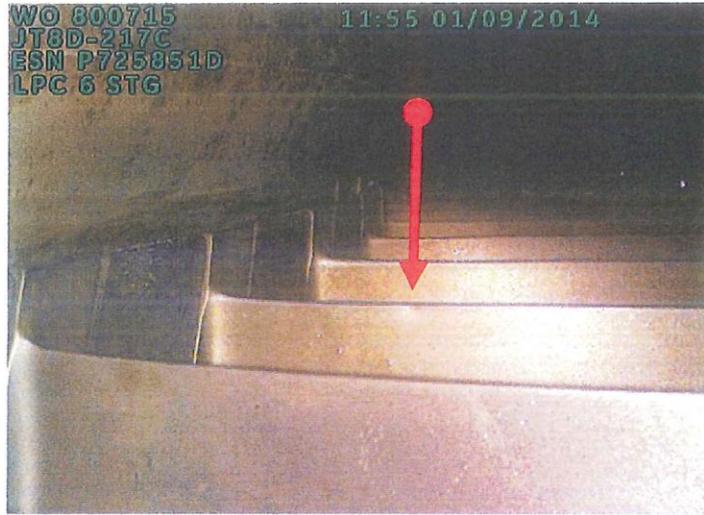


Image 19: C-6 blade T/E impact damage



ENGINEERING AUTHORIZATION																			
NO :	MD80-EA-73-001	DATE :	January 28th, 2014																
<p><u>EFFECTIVITY</u> This EA is effective to all the listed Engine Serial Numbers on Page 1</p> <p><u>PUBLICATION AFFECTED</u> - NIL</p> <p><u>REFERENCES</u> - AMM 73-11-02; 72-00-00; PPBU MANUAL 71-00-1</p> <p><u>SPECIAL TOOL & EQUIPMENT</u> NIL</p> <p><u>MATERIAL INFORMATION</u> NIL</p> <p><u>ACCOMPLISHMENT INSTRUCTIONS</u></p> <p>PLEASE NOTE : ENSURE ENGINE THROTTLE AND FUEL LEVERS ARE TAGGED "DO NOT OPERATE" WHILE WORKING ON ENGINES.</p> <p>Work Instructions</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 5%;">No.</th> <th style="width: 55%;">Description</th> <th style="width: 15%;">Mech.</th> <th style="width: 25%;">ENG.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1.</td> <td>Gain access to the Engine by opening the forward and aft lower engine cowls per AMM Ref 71-00-00</td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">2.</td> <td>Access the Generator Inlet Cooling duct and loosen clamp at shroud cover on the back of the generator See Figure 1</td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">3.</td> <td>Access the mount of Inlet cooling duct to engine case and cooling air pad Remove locking wire, loosen, remove and retain the removed bolts and washers</td> <td></td> <td></td> </tr> </tbody> </table>				No.	Description	Mech.	ENG.	1.	Gain access to the Engine by opening the forward and aft lower engine cowls per AMM Ref 71-00-00			2.	Access the Generator Inlet Cooling duct and loosen clamp at shroud cover on the back of the generator See Figure 1			3.	Access the mount of Inlet cooling duct to engine case and cooling air pad Remove locking wire, loosen, remove and retain the removed bolts and washers		
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FORM DAL-ME-001 Rev.01 Date 10 December,2010		PAGE 2 OF 5																	



ENGINEERING AUTHORIZATION			
NO : MD80-EA-73-001		DATE : January 28th, 2014	
No.	Description	Mech.	ENG.
4.	Remove or reposition the cooling air inlet duct from the opening on Engine bleed pad/case		
5.	Setup Borescope equipment utilizing flexible or rigid probes to enter through open area in engine case and position rearwards to view the fuel manifolds NB. The fuel manifolds are fin like shrouds extending in the bypass area of the outer casing in 5 & 7 O'Clock positions		
6.	Thoroughly examine both manifold assemblies to ensure <ol style="list-style-type: none"> 1. No evidence of misalignment 2. No evidence of cracks or other damages 3. No evidence of any fuel seepage from assembly 4. Shroud is properly enclosed with no openings 5. No evidence of corrosion on assembly 6. Fastners & tube connections secure 		
7.	Record the results of inspection below(attach pictures) _____ _____ _____ _____ NOTE : Any abnormality noticed must be reported for further investigation prior to flight.		
8.	Remove Borescope probe and carefully restore the disturbed area by reconnecting the Generator Cooling Inlet duct by repositioning the duct and bleed pad to the engine casing (see figure 1)		
9.	Secure bleed pad by mount bolts and torque to 60 – 65 Inch/lbs and secure by locking wire		
10.	Perform Engine ground run at idle power per AMM Ref. 72-00-00 and check for leaks around disturbed areas and close engine cowls on satisfactory completion of leak checks(AMM 71-00-00)		
11.	Make Technical Logbook entry for the accomplishment of this Engineering Authorization.		



ENGINEERING AUTHORIZATION

NO : **MD80-EA-38-003**

DATE : **October 18th, 2011**



TOP LEFT INCORRECTLY FITTED; TOP RIGHT/BOTTOM – CORRECT INSTALLATION

CERTIFICATE OF RELEASE TO SERVICE

I HEREBY CERTIFY THAT THE WORK SPECIFIED IN THIS DOCUMENT WAS CARRIED OUT IN ACCORDANCE WITH CURRENT REGULATIONS AND IN RESPECT TO THIS WORK, THE AIRCRAFT/AIRCRAFT COMPONENT IS CONSIDERED APPROVED FOR RELEASE TO SERVICE.

NAME _____ LIC/APP NO. _____ DATE _____

SIGNATURE _____

Appendix H



NIGERIAN AIRSPACE MANAGEMENT AGENCY
MURTALA MUHAMMED INTERNATIONAL AIRPORT
PMB 21084 IKEJA LAGOS NIGERIA
Tel: +234 (01)7618376, 2120512, 7767185, (0709)8001337
Email: info@namahqtr.net

NAMA/MMA/GM/701/2/VOL.II

04TH JUNE, 2012

The Managing Director/CEO
Nigerian Airspace Management Agency
NAMA - Headquarter

Through Director_of operations [REDACTED]

Through: Airspace Manager (MMIA) [REDACTED]

REPORT ON DAN 0992 --5N RAM, MD83

DAN 0992, MD83 with registration number 5N-RAM departed Abuja at 1358 UTC with 153 persons on board including 6 crew members and fuel endurance of 0330 hrs.

The aircraft first got contact with Lagos Area Control Centre (ACC at 1418 UTC. At 1430 UTC Lagos ACC transferred the aircraft to Radar Lagos Terminal Approach Radar Control.

Everything about the aircraft went well until 1442 UTC at 11NM to touch down Runway 18R when the pilot suddenly declared Mayday giving dual engines failure as reason.

The aircraft was transferred to Aerodrome Control tower immediately.

The pilot never contacted Aerodrome Control Tower

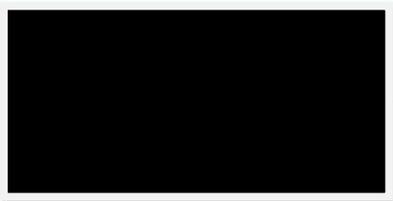
At 1445 UTC 5NM to touch down at the extended Center line of runway 18R, the aircraft blip disappeared from the Radar Controller Working Position (CWP)

At 1447 UTC Airport fire service and all other security agencies notified of the incident.

Telephone operators were also notified for their necessary action.

Attached documents are:

- 1 The duty Air Traffic Controllers Report
- 2 The Strips
- 3 Tape transcript
- 4 Voice on DVD
- 5 Radar playback DVD
- 6 The Radar and Tower Log books



AIR TRAFFIC CONTROL OPS MANAGER



Appendix I

Metallurgical Test of the Fuel Manifold Component Report

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



March 31, 2016

MATERIALS LABORATORY FACTUAL REPORT

Report No. 16-035

A. ACCIDENT

Place : Lagos, Nigeria
Date : June 3, 2012
Vehicle : Boeing MD-83, 5N-RAM
NTSB No. :
Investigator : 

B. COMPONENTS EXAMINED

Fuel Manifold Segments from the #1 engine a Pratt and Whitney JT8D-217C

C. DETAILS OF THE EXAMINATION

The as-received fuel manifold segments are displayed in figure 1, looking from the front of the engine to the rear. Each segment contained connectors to primary and secondary fuel nozzles. The segment on the right connected 10 fuel nozzles (5 primary 5 secondary) with the left segment containing connections for 8 nozzles (4 primary, 4 secondary). Nozzle connections were numbered 1 through 9 from the top of the engine counterclockwise as shown in figure 1. Three pieces of the incoming fuel line fairings were also received. The fairings were deformed but otherwise intact.

The fuel segments were mostly intact except for fractures of all four incoming fuel tubes, as indicated in figure 2 and shown closer in figure 3 and 4.. Three of the four fractures were adjacent to the brace line at the "T" fittings. The fourth fracture was slightly away from the braze line, as shown in the upper view of figure 4.

Magnified optical examination using a stereo microscope revealed fracture features and deformation patterns consistent with overstress separations of all four tubes. The three fractures adjacent to the braze lines had deformation indicative of bending loads. The fourth tube fracture had deformation consistent with combined bending and twists loads during fracture.

No indications of preexisting cracking such as fatigue were observed.


Senior Metallurgist

DCA12RA084

Report No. 16-035
Page No. 2

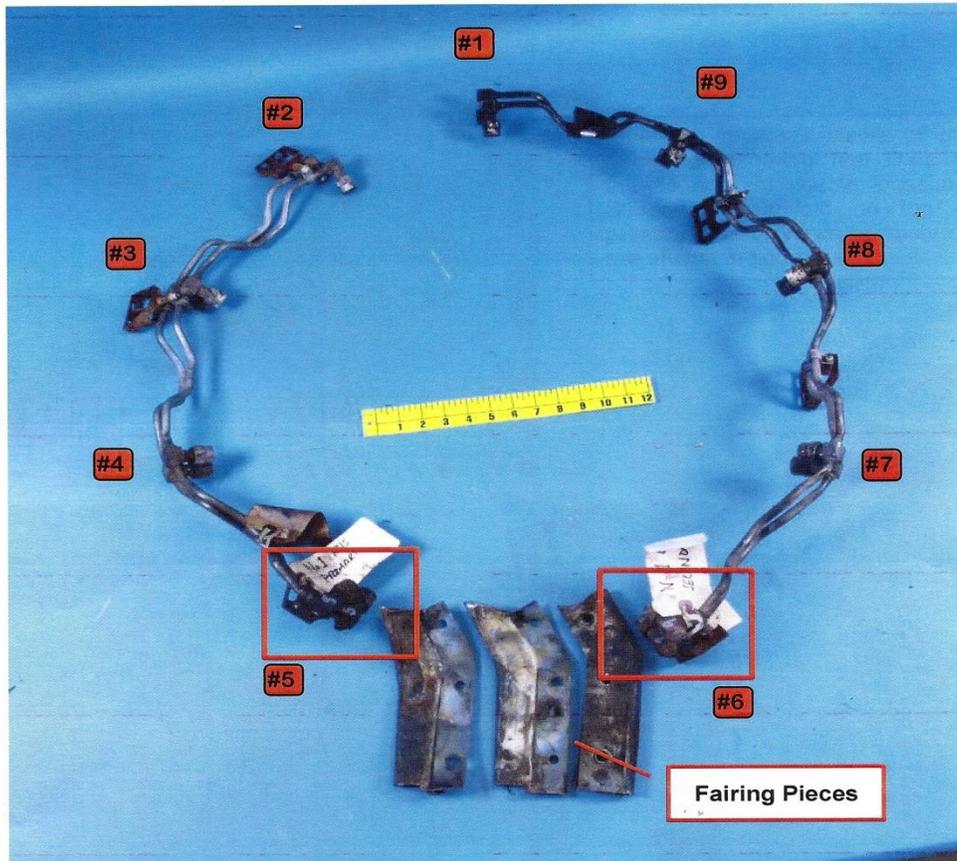


Figure 1. An overall view of the fuel manifold segments, viewed from the front looking aft. Fractured incoming lines are denoted by the red boxes and shown in figure 2. Nozzles numbered from engine top.

DCA12RA084

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Figure 2. Closer views of the fractured incoming fuel lines at the #5 and #6 nozzle locations. Secondary manifold on top of primary. Closer views of fractures are shown in figure 3.



DCA12RA084

Report No. 16-035
Page No. 4

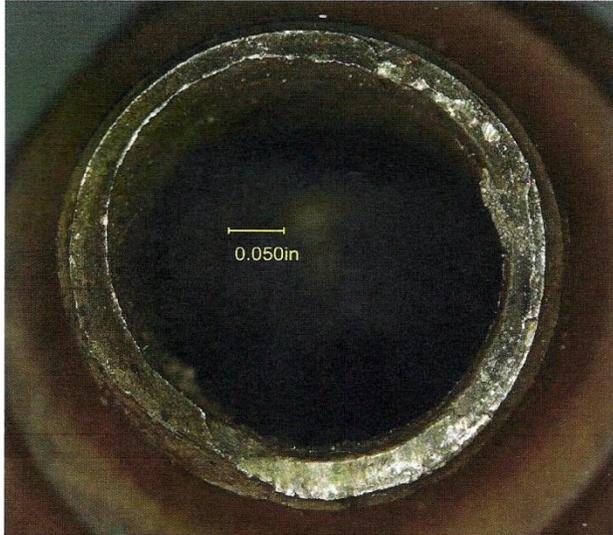
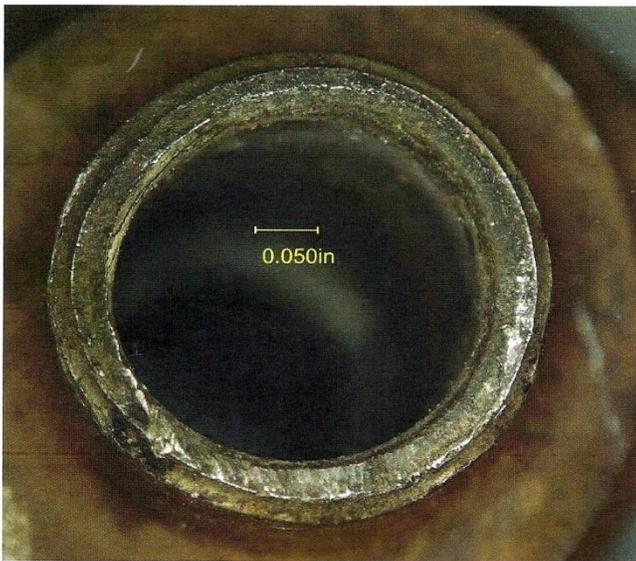


Figure 3. Magnified views of the fuel line fractures at the #5 nozzles with features indicative of bending overstress fractures. Upper fracture from secondary manifold segment and primary manifold below.



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Page No. 5

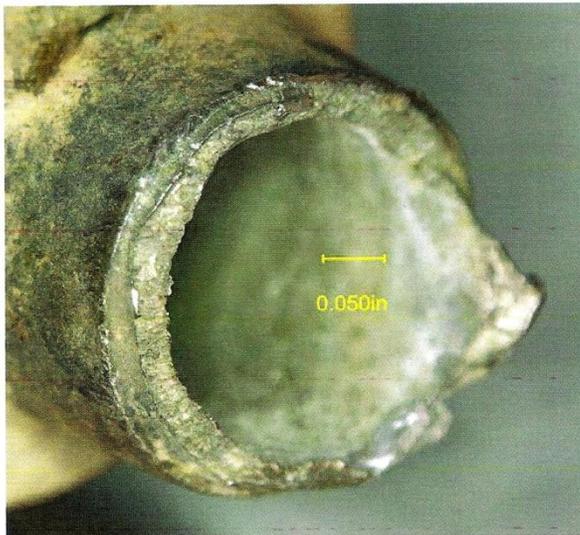
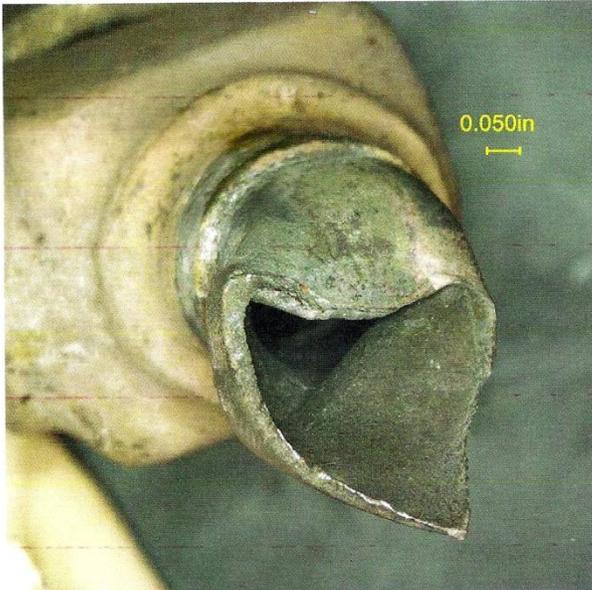


Figure 4. Magnified views of the fuel line fractures at the #6 nozzles with features indicative of bending overstress fractures. Upper fracture from secondary manifold segment and primary manifold below.



i **END NOTE**

Numbering philosophy used in the body of this Report is simple and sequential and in no way contradicts the references in the Tear Down Report (Engine Exam and Disassembly Field Notes) as contained in Appendix B.