



# AIRCRAFT ACCIDENT REPORT

UNA/2021/11/17/F

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**Nigerian Safety Investigation Bureau**

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**Final Report on the Serious Incident involving Embraer 145LR aircraft operated by United Nigeria Airlines Limited with nationality and registration marks 5N-BWW, which occurred at about 4000 feet climbing out of Nnamdi Azikiwe International Airport, Abuja, Nigeria on 17 November 2021.**



This report is produced by the Nigerian Safety Investigation Bureau, (NSIB) formerly the Accident Investigation Bureau, Nigeria (AIB), Nnamdi Azikiwe International Airport, Abuja.

The report is based on the investigation carried out by Nigerian Safety Investigation Bureau, in accordance with Annex 13 to the Convention on International Civil Aviation, Nigerian Safety Investigation Bureau (Establishment) Act, 2022, and Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2023.

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

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

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

Safety Recommendations in this report are addressed to the Regulatory Authority of the State (NCAA) as well as other stakeholders, as appropriate. This authority ensures enforcement. © **Nigerian Safety Investigation Bureau Nigeria, 2024**



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## **GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT**

NSIB	Nigerian Safety Investigation Bureau
DNAA	Nnamdi Azikiwe International Airport
DNMM	Murtala Muhammed International Airport
PM	Pilot Monitoring
PF	Pilot Flying
AGC	Abuja Ground Control
EICAS	Engine Indicating and Crew Alerting System
QHR	Quick Reference Handbook
ATC	Air Traffic Control
VMC	Visual Meteorological Conditions
FADEC	Full Authority Digital Electronic Controls
FDR	The Flight Data Recorder
CVR	Cockpit Voice Recorder
UNACL	United Nigeria Airlines Company Limited
AOC	Air Operator Certificate



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Nig. CARs	Nigeria Civil Aviation Regulations
QRH	Quick Reference Handbook
MCDs	Magnetic chip detectors
ITT	Inter Turbine Temperature
PMA	Permanent Magnet Alternator
OpSpecs	Operations specifications
MM	Maintenance Manual
CMC	Centralized maintenance computer





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<b>Aircraft accident report number</b>	UNA/2021/11/17/F
<b>Registered owner:</b>	Private Airlines Services Limited
<b>Operator:</b>	United Nigeria Airlines Company Limited
<b>Aircraft type and model:</b>	EMB-145LR
<b>Manufacturer:</b>	Yabora Industria Aeronautica S.A. Brazil
<b>Year of manufacture:</b>	2002
<b>Nationality and registration marks:</b>	5N-BWW
<b>Serial number:</b>	145553
<b>Location:</b>	At about 4000 Feet Climbing out of Nnamdi Azikiwe International Airport, Abuja
<b>Date and Time:</b>	17 November 2021 at about 08:45h

*(All times in this report are local  
equivalent to UTC+1)*

## SYNOPSIS

The Nigeria Airspace Management Agency (NAMA) notified the Accident Investigation Bureau (AIB) of the incident on 17 November 2021. Investigators were dispatched to the incident site the same day. They commenced post-occurrence assessments under the provisions of the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2019 and International Civil Aviation Organization (ICAO) Annex 13.



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As the aircraft lined up for takeoff, an advisory light "impeding bypass" illuminated for the number one engine. During the takeoff roll, a loud bang was heard from the rear of the aircraft.

The takeoff was continued and at 4000ft, another bang was heard, and the Engine flamed out, necessitating an air return to Nnamdi Azikiwe International Airport.

**One Safety Recommendation was made.**



## **1.0 FACTUAL INFORMATION**

### **1.1 History of the flight**

On 17 November 2021 at about 08:29 h, an EMB-145LR aircraft operated by United Nigeria Airlines Company Limited with nationality and registration marks 5N-BWW, was scheduled to depart Nnamdi Azikiwe International Airport (DNAA) Abuja for Murtala Muhammed International Airport (DNMM) Lagos as flight NUA0505 on an Instrument Flight Rule (IFR) flight plan. On board were 47 persons including four crew members (Captain, First officer and two Cabin crew), with 3 hours and 17 minutes of fuel endurance. The Captain was the Pilot Monitoring (PM), while the First officer was the Pilot Flying (PF)

The aircraft was scheduled to operate six sectors for that day. The first sector, Lagos to Abuja, was uneventful.

At about 08:30 h, NUA0505 requested startup clearance from Abuja Ground Control (AGC) for the second sector of the day. AGC granted approval for NUA0505 to start with the squawk code 0417.

At 08:33 h, NUA0505 requested taxi clearance, and AGC acknowledged and cleared the aircraft for taxi to the holding point runway 22. NUA0505 commenced taxi and reported to AGC. The AGC then transferred NUA0505 to Abuja Tower on the frequency 118.6 Mhz.

At about 08:37 h, NUA0505 reported ready in sequence. The tower instructed NUA0505 to line up and wait on runway 22 and prepare for immediate takeoff.

At about 08:39 h, Tower cleared NUA0505 for takeoff runway 22 and to maintain runway heading after departure. While the aircraft was lining up for takeoff, an Engine



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Indicating and Crew Alerting System (EICAS) advisory message "E1 OIL IMP BYP" came ON. The crew consulted the Quick Reference Handbook (QHR) for the Embraer 145, Emergency/Abnormal procedure, which says it was a crew awareness message.

At 08:40 h, NUA0505 flight crew commenced the takeoff roll. After takeoff, the Tower transferred NUA0505 to radar on frequency 127.9 Mhz, which was acknowledged. Radar instructed NUA0505 to turn right direct position VONUK, climb, and maintain FL 280. NUA0505 acknowledged.

According to the flight crew, "During the climb, there was a loud bang from the rear, and all engine parameters were checked and all in green. At about 4,000 ft, we heard another noise followed by a flameout."

At 08:43 h, the Pilot declared MAYDAY and requested to turn direct Runway 04, DNAA, for approach. Radar instructed NUA0505 to turn and establish runway 04, cleared for visual approach runway 04, and report field insight and squawk 7700.

Air Traffic Control (ATC) reports indicated that NUA0505 executed a hold for over 5 minutes between 2NM and 5NM before establishing final for runway 04. The Tower then cleared NUA0505 to land runway 04. At 08:53 h, NUA0505 landed safely, taxied to the apron, and parked. All occupants of the aircraft disembarked normally without injury. After landing, ATC cancelled the emergency.

The incident occurred in daylight at about 08:42 h and in Visual Meteorological Conditions (VMC).



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## 1.2 Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
<b>Fatal</b>	Nil	Nil	Nil	Nil
<b>Serious</b>	Nil	Nil	Nil	Nil
<b>Minor</b>	Nil	Nil	Nil	Nil
<b>None</b>	4	43	47	Nil
<b>TOTAL</b>	4	43	47	Nil

## 1.3 Damage to aircraft

Nil.

## 1.4 Other damage

Nil.

## 1.5 Personnel information

### 1.5.1 Captain

Nationality:	Nigerian
Age:	35
License type:	Airline Transport Pilot License (Aeroplane)



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License validity:	Valid till 28 February 2022
Aircraft ratings:	Part 1: Embraer-135/145, Part 2: Boeing 737-NG
Medical certificate validity:	Valid till 28 February 2022
Total flying time:	3,900 h
Total on type:	306:00 h
Total on type (PIC):	306:00 h
Last 90 days:	266:00 h
Last 28 days:	63:00 h
Last 7 days:	8:40 h
Last 24 hours:	2:00 h

### 1.5.2 First officer

Nationality:	Nigerian
Age:	30
License type:	Commercial Pilot License (Aeroplane)
License validity:	Valid till 7 March 2022
Aircraft ratings:	Part 2: Embraer-135/145, Part 1: Beech baron-58 & Tampico clubTB-9
Medical certificate validity:	Valid till 7 March 2022
Total flying time:	1046 h
Total on type:	810 h
Last 90 days:	159 h



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Last 28 days:	72 h
Last 7 days:	17:40 h
Last 24 hours:	2 h

### 1.5.3 Engineer

Nationality:	Ghanaian
Age:	34
License type:	Aircraft Maintenance Engineer License
License validity:	Valid till 6 December, 2021
Aircraft ratings:	Embraer-135/145 (Rolls Royce 3007-A1)

During post-occurrence visual inspection, it discovered that the Engine No.1 magnetic chip detector on the oil tank was covered with metallic chips.



**Figure 1:** Magnetic Plug with chips

#### **1.5.4 Quality & safety manager**

Nationality: Nigerian

Educational Qualification: Industrial Maintenance Engineering, YABA  
College of Technology 2004

Industrial and Production Engineering, 2009

Records available to the Bureau indicate that the quality and safety manager had training on;





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- Quality Assurance and Auditing in Civil Aviation Course
- Safety Management System for Airline Course
- Aircraft Maintenance Planning & Control Course
- Flight Data Monitoring Smart FDM User Training
- IATA Quality Management (QMS) for Airlines
- General Health, Safety and Environment Training
- Introduction to IOSA Audit
- Emergency Preparedness and Response for Airlines Training

## **1.6 Aircraft information**

### **1.6.1 General information**

Type:	EMB-145LR
Manufacturer:	Yabora Industria Aeronautica S.A Brazil
Year of manufacture:	2002
Serial Number:	145553
Certificate of Airworthiness:	Valid till 26 January, 2022
Certificate of Insurance:	Valid till 9 February 2022
Certificate of Registration:	Issued 2 November 2020
Total Airframe Time:	41340:33 h
Total Landing Cycles:	32330



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**Figure 2:** The aircraft parked at Apron of Nnamdi Azikiwe International Airport after the incidence

Correspondence regarding the no.1 engine between Rolls Royce and United Nigeria Airlines showed that an impending bypass advisory message was registered on the centralized maintenance computer (CMC) on 24 August 2021. This prompted United Nigeria Airline Limited to contact Rolls Royce, the Engine manufacturer, for advice. Rolls Royce advised the United Nigeria Maintenance team to inspect all the diagnostic chip collector plugs for metal chips as per FIM 79-37-00-810-801.

According to the maintenance team, this was done on 14 September 2021, with no debris found.

On 15 September 2021, the Oil Debris message reappeared. The diagnostic plugs were re-inspected, and no debris was found for the second time.



However, on 4 October 2021, the United Nigeria maintenance team informed Rolls Royce that chips were found at the collector plugs during the inspection.

Rolls Royce replied "If you found metal only on the tank chip detector and the indicating plug, then it shows that the metal is most probably generated inside the gearbox. Please inspect the gearbox per the attached Maintenance Manual (MM) reference". Rolls Royce also advised United Nigeria to use a X10 magnifier glass to inspect the harness. Rolls Royce further advised borescope inspection of the oil pump screen, inspection of the midspan bearing and the inspection of the Permanent Magnet Alternator (PMA) gear shaft for movement.

On 21 October 2021, United Nigeria informed Rolls Royce that their maintenance team carried out a borescope inspection of the Engine as advised, and no findings were found. The Engine continued in service until the incident occurred on 17 November 2021.

### 1.6.2 Engines

Engine	Number 1	Number 2
Manufacturer	Rolls Royce, UK	Rolls Royce, UK
Type/Model	AE3007A1P	AE3007A1P
Serial number	312038	312037
Time since new	36119:26 h	37104:09 h
Cycles since new	28824	29810

Fuel Used: Jet A1



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The aeroplane is powered by two fuselage-mounted Allison Turbofan engines.

The AE3007 is a high bypass ratio, two-spool axial-flow turbofan engine. The main design features include:

- A single-stage fan.
- A 14-stage axial-flow compressor with inlet guide vanes and five variable-geometry stator stages.
- A 2-stage high-pressure turbine to drive the compressor
- A 3-stage low-pressure turbine to drive the fan
- Dual, redundant, Full Authority Digital Electronic Controls (FADEC).
- Accessory gearbox
- Air system for aircraft pressurization and Engine starting.

Redundant FADECs control each Engine.

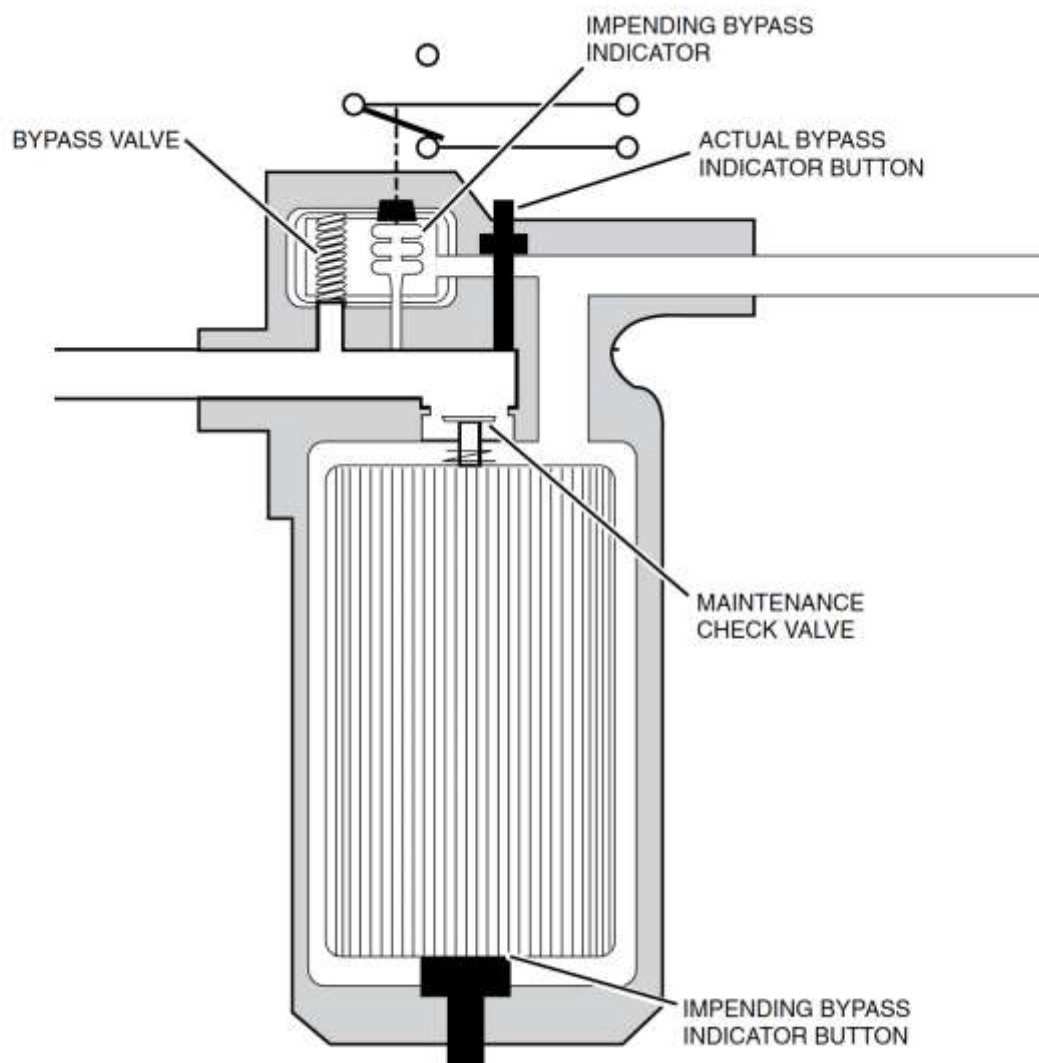
The FADECs also provide information to the EICAS, although some parameter signals are provided directly from engine sensors. The EICAS indicates all powerplant parameters and provides warning, caution, and advisory messages.

The cockpit control stand has two thrust levers, one for each Engine, and four buttons for selecting the engine thrust rating.

The overhead panel houses c

ontrols for ignition, FADECs takeoff data setting, takeoff rating selection, and engine start/stop.

### 1.6.3 Oil Filter Unit



**Figure 3:** Oil Filter Assembly

**Source:** Embraer 145 Training Manual

*The filter unit, mounted to the outer bypass duct, includes a replaceable 3-micron filter element, visual and electrical impending bypass indicators, and a visual actual bypass indicator. When there is a 28 to 32 psi pressure differential across the filter, such as*



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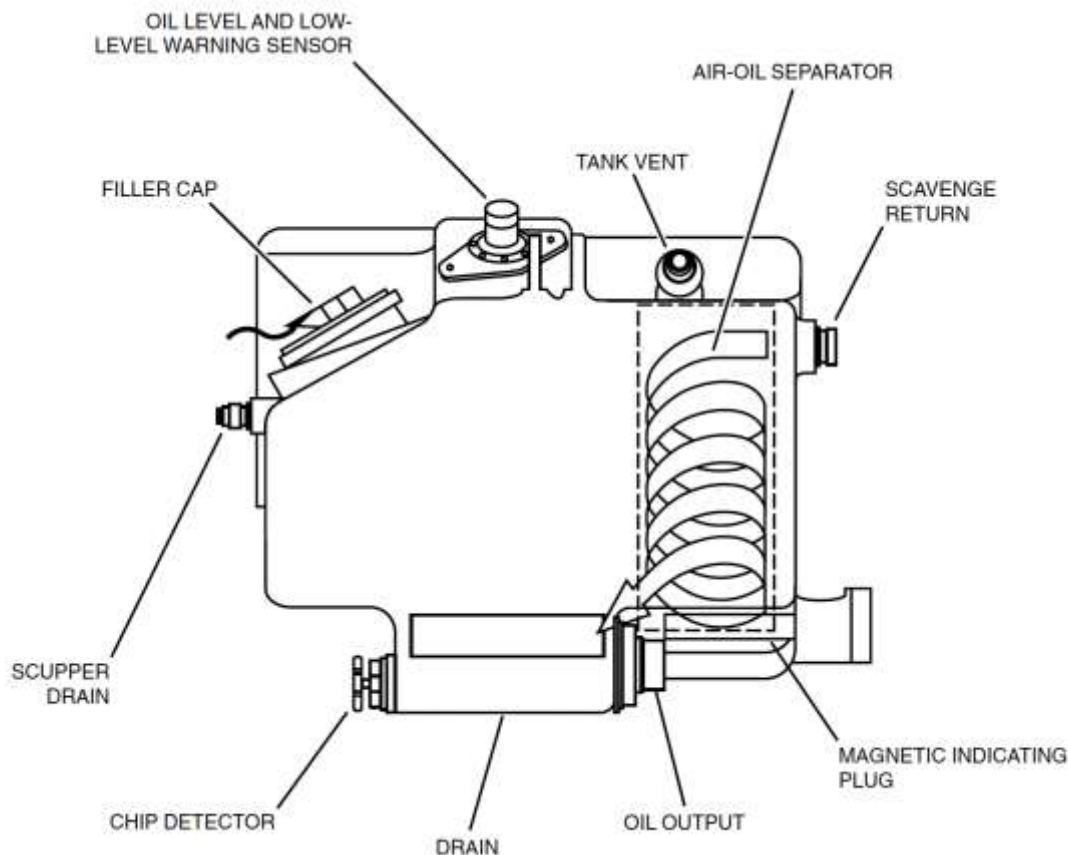
*during cold starts or when the filter is contaminated, a bypass valve opens to allow oil to bypass the filter.*

*The visual and electrical impending bypass indicators activate when the pressure differential across the filter is 19 to 25 psi. The visual indicator can only be reset by removing the filter bowl, while the electrical impending bypass indicator resets automatically.*

### ***Advisory Messages***

*E1 or E2 OIL IMP BYP – The differential pressure across the oil filter has exceeded 22 psi, and the oil is about to bypass the filtering element. This is an advisory message to the crew.*

### 1.6.4 Oil Indicating System



**Figure 4:** Oil Tank Indicating Components

*Oil system quality is indicated by metal particle sensors (chip detectors) that monitor the oil for metal debris and, when detected, report their presence to the EICAS. There are four chip detectors, one in each sump return line. Two impending bypass indicators and an actual bypass indicator monitor the pressure difference across the oil filter element.*

*The actual bypass indicator and one impending bypass indicator are pop-up type sensors. These sensors indicate by extending a pop-out pin on the filter assembly*



housing. The filters must be removed to reset these indicators. One impending bypass indicator is electrical and reports to the EICAS.

### **Magnetic Indicating Plug**

The magnetic indicating plug (Figure 4) is located in the oil tank. The magnetic plug contacts are normally open and are electrically closed when conductive material bridges the gap between the contacts.

### **Visual and Electrical Oil Filter Impending Bypass Indicators**

These indicators are located on the oil filter assembly (Figure 4) and activate when the pressure drop across the filter exceeds 22  $\frac{1}{2}$  psid. Both indicators have a thermal lockout when temperatures are below 55  $\frac{1}{2}$   $\frac{1}{2}$  F (13  $\frac{1}{2}$   $\frac{1}{2}$  C). When activated, the electrical indicator sends a signal to the EICAS.

### **Actual Bypass Indicator**

The actual bypass indicator, shown in Figure 4, is a pop-up indicator which activates when the pressure drop across the filter is 30  $\frac{1}{2}$  psid. This information is not provided to the EICAS.

## **1.7 Meteorological information**

**DNAA      0700z**

Wind:      340/02

Visibility:    10km

Weather:    Nil





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Cloud: NSC

Temp/Dew: 25/23

QNH: 1013

**DNAA 0730z**

Wind: 310/02

Visibility: 10km

Weather: Nil

Cloud: NSC

Temp/Dew: 26/23

QNH: 1013

**DNAA 0800z**

Wind: 240/02

Visibility: 10km

Weather: Nil

Cloud: FEW 300m



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Temp/Dew: 28/23

QNH: 1013

## **1.8 Aids to navigation**

The status of the navigational aids at Nnamdi Azikiwe International Airport on the day of the occurrence was as follows:

"ABC" VOR/DME 116.3MHz - 'Serviceable'

"IAB" ILS/DME 109.3MHz - 'Serviceable'

"IAC" ILS/DME 111.9MHz - 'Serviceable'

## **1.9 Communication**

There was two-way communication between the aircraft and air traffic control.

## **1.10 Aerodrome information**

The Nnamdi Azikiwe International Airport, Abuja (DNAA), has aerodrome reference points 9°00'25"N, 7°15'47"E, and elevation 1123 ft with runway orientation 04/22. The runway has dimensions 3610m×60m in length and width, respectively, with an asphalt/concrete surface and a blast pad of 65m at both ends.



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### 1.11 Flight recorders

The aircraft was fitted with Solid-State Flight Data and Cockpit Voice Recorders with the following particulars.

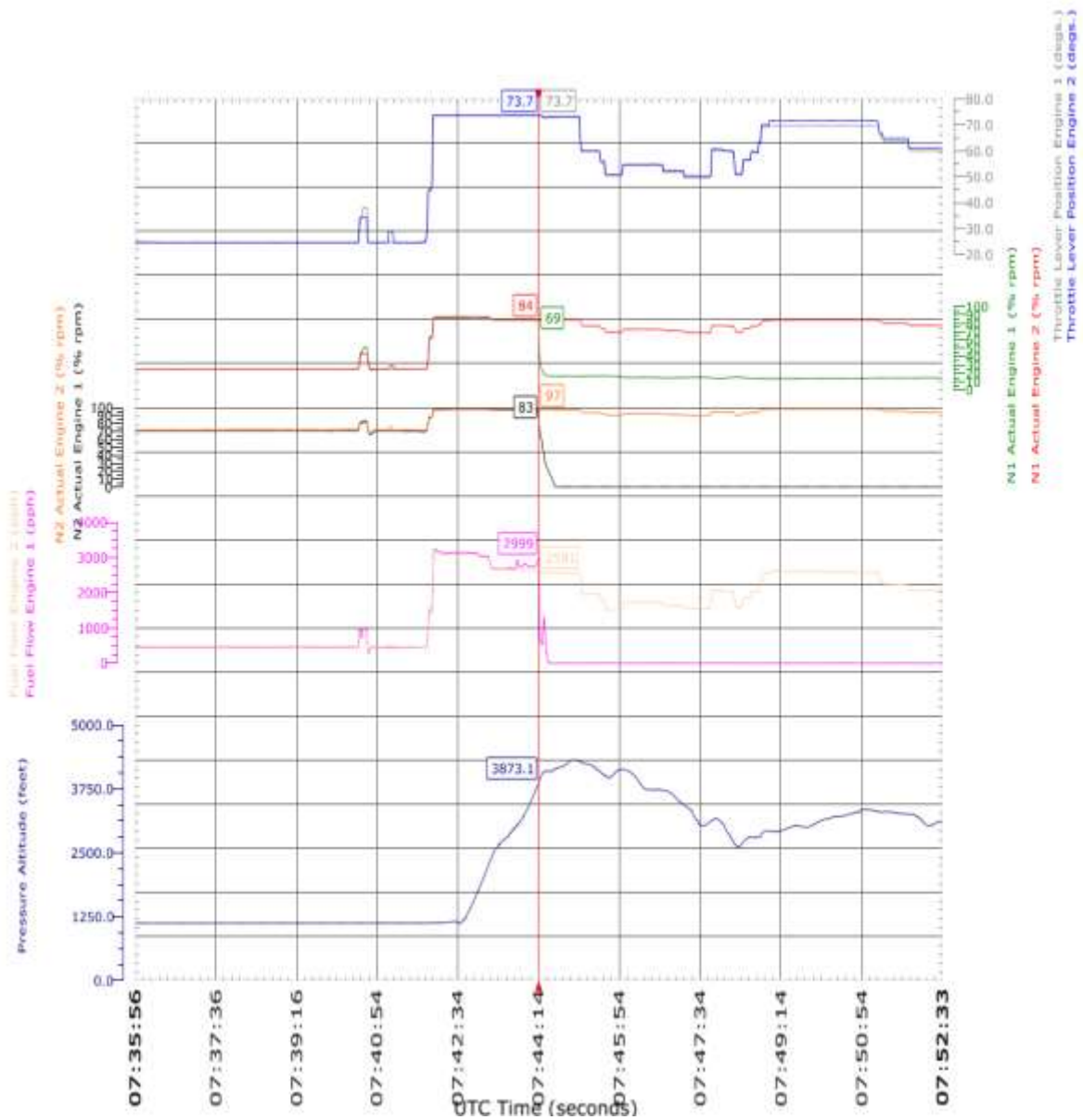
Recorders	Flight Data Recorder	Cockpit Voice Recorder
<b>Manufacturer</b>	Honeywell, USA	Honeywell, USA
<b>Model</b>	SSFDR	SSCVR
<b>Part Number</b>	980-4700-042	980-6022-001
<b>Serial Number</b>	08762	CVR120-05078

The Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) were successfully retrieved and downloaded at the Flight Safety Laboratory of the Accident Investigation Bureau (AIB) in Abuja, Nigeria.





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**Figure 6: FDR Readout 2**



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### **1.12 Wreckage and impact information**

Not applicable.

### **1.13 Medical and pathological information**

No medical test was conducted.

### **1.14 Fire**

There was no fire.

### **1.15 Survival aspect**

Nil.

### **1.16 Test and research**

The affected Engine removed from 5N-BWW was sent to Standard Aero Facility, an engine repair shop, with work order EN18523. Following disassembly, it was discovered that the #4 bearing had become seized, leading to a bearing failure. Upon further inspection, the damage from the failed bearing was discovered throughout the Engine. See Appendix A for the preliminary report on the Engine.



## **1.17 Organizational and management information**

### **1.17.1 United Nigeria Airlines Company Limited**

United Nigeria Airlines Company Limited (UNACL) is a registered airline with its head office in Enugu and its main operational base in Ikeja, Lagos. It holds an Air Operator Certificate (AOC) with number: UNA/AOC/10-21/001 issued per the requirements of the existing Nigeria Civil Aviation Regulations (Nig. CARs 2015). It is authorized to perform scheduled commercial air operations and non-scheduled air operations (charter flight) as defined in the company's operations specifications (OpSpecs) per the operations manual and the Nigeria Civil Aviation Regulations part 9.

UNACL operates a fleet of four Embraer 145 (ERJ-145) aircraft. Its operations are guided by its Operations Manual and the Company's Standard Operating Procedures (SOP).

### **1.17.2 United Nigeria Airline Operations Manual (Part B)**

Section 3 Emergency and Abnormal Procedures Preamble

Defines Crew Awareness Message as *These do not have a Quick Reference Handbook procedure and are identified in the QRH*

*index as 'Crew Awareness'. If a crew awareness message is displayed on the EICAS, takeoff is prohibited unless:*

- *The message is the expected result of an intentional Operation.*
- *Flight Crew action is taken to clear the message.*
- *Maintenance action is taken to clear the message.*
- *The aircraft is dispatched per the company MEL*



### **1.17.3 Excerpts from AMM on EICAS MESSAGE: E1/E2 OIL IMP BYP (TASK 79-37-00-810-802-A02)**

#### *DESCRIPTION:*

*This message occurs when the circuit for the electrical impending-bypass indicator is open, or the circuit for the magnetic indicating plug (oil tank) is completed. It indicates an impending bypass of the oil filter or the presence of metallic debris on the magnetic indicating plug.*

#### *POSSIBLE CAUSES:*

- 1. Oil filter element blocked*
- 2. Metallic debris on oil tank magnetic indicating plug*
- 3. Electrical impending-bypass indicator/circuit*
- 4. Magnetic indicating plug/circuit fault*
- 5. Aircraft system, signal conditioning fault*

### **1.17.4 Embraer 145 Quick Reference Handbook (QRH145) EMERGENCY/ABNORMAL PROCEDURES**

*Some EICAS messages do not have an associated QRH procedure. In those cases, "Crew Awareness" identifies the EICAS message, as noted in the Index Table. If a Crew Awareness message is displayed on the EICAS, takeoff is prohibited unless at least one of the following conditions is met:*

- The message is an expected result of an intentional operation;*
- Flight crew action is taken to clear the message;*
- Maintenance personnel take action to clear the message;*
- The aeroplane is dispatched per all approved company MEL provisions.*

*If one of the following Crew Awareness messages is presented after gate departure, the flight may continue only to the intended destination without further action:*





- *AHRS BASIC MODE,*
- *D.U.D.U. 1 (2, 3, 4, 5) FAN FAIL,*
- *E1 (2) OIL IMP BYP,*
- *ENG A/ICEOVERPRES,*
- *I.C.I.C. 1 (2) FAN FAIL or*
- *GEN 1 (2, 3, 4) BRG FAIL.*

## **1.18 Additional information**

### **1.18.1 Magnetic chip detector**

#### **Extract from Skybrary on Magnetic Chip Detector**

Magnetic chip detectors (MCDs) detect metal chips, shavings, or particles in aircraft engine lubrication systems, hydraulic systems, and gearboxes. The presence of metal particles may indicate wear. MCDs can indicate that maintenance is needed or an early warning of impending failure. The MCDs contain magnets incorporated into an electronic circuit. The magnets attract and collect metal particles until the circuit is closed, which results in a remote indication, such as a caution light on an instrument panel, that chips have been detected.

### **1.18.2 Compressor surge**

It is most important to provide an understanding of compressor surge. In modern turbofan engines, compressor surge is a rare event. If a compressor surge occurs during high power at takeoff, the flight crew will hear a loud bang accompanied by yaw and vibration. The bang will likely be far beyond any engine noise or other sound the crew may have previously experienced in service. A surge from a turbofan engine results from instability in the Engine's operating cycle. Compressor surge may be



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caused by engine deterioration, the result of ingestion of birds or ice, or the final sound from a "severe engine damage" type of failure.

### **1.18.3 Single self-recoverable surge**

The flight crew hears a very loud bang or double bang. The instruments will fluctuate quickly, but the fluctuation might not be noticed unless someone was looking at the engine gauge at the time of the surge.



## **2.0 ANALYSIS**

### **2.1 General**

The flight crew was certified to conduct the flight. The aircraft had a valid Certificate of Airworthiness at the time of the occurrence. This analysis focuses on engine health monitoring/advisory for 5N-BWW, filter bypass system and compressor surge.

### **2.2 Engine Health Monitoring/Advisory for 5N-BWW**

Correspondence regarding the no.1 engine between Rolls Royce and United Nigeria Airlines showed that an impending bypass advisory message was registered on the Centralized Maintenance Computer (CMC) on 24 August 2021. This prompted United Nigeria Airline Limited to contact, the Engine manufacturer (Rolls Royce), for advice. The investigation found that Rolls Royce advised the United Nigeria Maintenance team to inspect all the diagnostic chip collector plugs for metal chips as per the Fault Isolation Manual (FIM) 79-37-00-810-801, which was carried out. No debris was found.

On 15 September 2021, the Oil Debris message reappeared. The investigation also discovered that maintenance action was carried in accordance with FIM 79-37-00-810-801. The diagnostic plugs were re-inspected, and no debris was found for the second time. Hence, this allowed United Nigeria Airlines to continue operating the aircraft as the manufacturer advised.

However, on 4 October 2021, the United Nigeria maintenance team informed Rolls Royce that chips were found at the collector plugs during the inspection.

Rolls Royce advised United Nigeria to inspect the gearbox, use an X10 magnifier glass to inspect the harness, inspect the oil pump screen with a borescope, inspect the midspan bearing, Permanent Magnet Alternator (PMA), and gear shaft for movement.



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On 21 October 2021, United Nigeria informed Rolls Royce that their maintenance team carried out a borescope inspection of the Engine as advised, and nothing was found.

According to the investigation, borescope inspection alone was insufficient to determine the cause of the impending bypass advisory light. Hence, further investigation was needed to detect the root cause of the engine problem. The Engine should have been removed and taken for a shop visit, where the root cause would have been detected. This could have prevented the Engine from flaming out.

The Engine continued service until the incident occurred on 17 November 2021.

### **2.3 Filter bypass system of 5N-BWW**

An Engine Indicating and Crew Alerting System (EICAS) advisory message, "E1 OIL IMP BYP," came ON while the aircraft lined up for takeoff. The crew consulted the Quick Reference Handbook (QHR) for the Embraer 145, Emergency/Abnormal procedure, which says it was a crew awareness message. Therefore, the crew continued with the takeoff roll.

The oil filter on engine No. 1 of 5N-BWW was clogged by metal particles (debris) in the oil, sending a message to the EICAS. The impending bypass functions as a safety measure to prevent the Engine moving part from lubricating oil starvation when the oil filter becomes clogged, allowing unfiltered oil to go into the Engine for lubrication. The impending bypass indication will be illuminated when the differential pressure switch in the engine oil filter is actuated.



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Numerous drilled or core passages usually lead to various lubrication points on the Engine. These passages are usually small and easily clogged by impurities when unfiltered oil is allowed to pass through them.

The EICAS message "E1 OIL IMP BYP" will be illuminated when the pressure differential across the oil filter exceeds 22 psi and the oil is about to bypass the filtering element when the filter is contaminated.

Also, the visual and electrical impending bypass indicators will be activated when the pressure differential across the oil filter reaches 19 to 25 psi.

In the case of 5N-BWW, the persistent advisory messages of oil impending bypass show evidence of impurities of metal particles on the affected Engine, the cause of which was not determined by the operator. This led to the mechanical failure, which resulted in engine flameout.

## **2.4 Compressor surge during climb**

If a compressor surge occurs during high power at takeoff, the flight crew will hear a loud bang accompanied by yaw and vibration. A surge from a turbofan engine results from instability in the Engine's operating cycle. Compressor surges may also be caused by engine deterioration.

The flight crew stated, "During the climb, there was a loud bang from the rear, and all engine parameters were checked and all in green."

According to the FDR data, there was an Inter Turbine Temperature (ITT) spike at the start of the flight, and the control loop went into surge avoidance for a second. This



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phenomenon is known as a single self-recoverable surge. The fluctuation in engine parameters might not be noticed unless someone looked at the gauges at the time of the surge. This might have been a surge that caused the loud bang from the rear, as reported by the flight crew. Although the crew couldn't notice the fluctuation, they said all parameters were checked, and all were in green.

At about 4,000 ft, the flight crew further stated they heard another bang followed by a flameout.

Data from the FDR shows that engine no.1 failed at 4000ft, followed by N2 RPM, which indicated zero. The no. 1 engine failure necessitated an air return by the flight crew.

The preliminary finding of the affected Engine, which was taken to a maintenance facility in Standard Aero, USA, revealed that the #4 bearing seized, leading to a bearing failure.

The bearing might have seized because metal debris entered its clearances.



## **3.0 CONCLUSION**

### **3.1 Findings**

1. The flight crew were licensed and qualified to conduct the flight.
2. The aircraft had a valid Certificate of Airworthiness.
3. The aircraft was scheduled for six sectors for that day.
4. The incident occurred in the second sector.
5. An EICAS Advisory Message "E1 OIL IMP BYP" came ON while the aircraft lined up for takeoff.
6. The flight crew heard a loud bang from the rear during the takeoff roll.
7. At about 4,000 ft, the flight crew heard another bang.
8. At 08:43 h, the flight crew declared MAYDAY
9. Emergency services were duly informed at 08:45 h.
10. The ATC later cancelled the Emergency alert.
11. NUA0505 landed safely on runway 04 at 08:53 h.
12. At the engine repair facility, Standard Aero, USA, no. 4 bearing failure was discovered.

### **3.2 Causal factor**

Failure of the no. 4 bearing of engine no. 1 leading to the engine flameout at 4,000 ft.

### **3.3 Contributory factors**

The inability to probe beyond borescope inspection is the cause of the impending bypass advisory message.



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## **4.0 SAFETY RECOMMENDATIONS**

### **4.1 Safety Recommendation 2024-026**

United Nigeria Airlines should Always Ascertain the Root cause of a Problem by every Approved means





## APPENDICES

### Appendix A



Preliminary Condition Report

Engine Serial Number: CAE312038

Engine Model: AE3007A1P

Manufacturer: Rolls Royce, Inc

Operator: UNITED NIGERIA AIRLINES COMPANY LIMITED

Time Since New: 36119.4 Time Since Last Shop Visit: 2855.63

Cycles Since New: 28824 Cycles Since Last Shop Visit: 2785

Work Order: EN185203

Report Number: PCR-23-002

Date: 5 April 2023



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Rolls-Royce AE 3007

NOTE: This Condition Report serves as a Work Order Summary as required by US FAR 43-13 Appendix B, Para (b) for all FAR 145 Repair Stations. WORK SCOPE / REASON FOR REMOVAL: OIL SYSTEM CONTAMINATION

MODULE INFORMATION:

P/N 23063061, S/N MW63504 - Rotor Assy, Fan:

The Fan Module was removed, disassembled as necessary, and inspected.

-Two (2) Fan Blades were found with nicks beyond serviceable limits.

P/N NPN, Air Inlet (Front Frame and Sump):



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The Air-Inlet Module was removed, disassembled as necessary, and inspected.

- Three (3) Inlet Guide Vanes were found with pitting beyond serviceable limits.
- The Mid-Span Bearing was found with banding beyond serviceable limits.
- One (1) P2.5 Sensor was found dented beyond serviceable limits.
- The Total Temperature Sensor was found a torn gasket on the connector.
- The No. 2B Bearing was found chattering when spun.
- The Front Sump Housing was found with fretting beyond serviceable limits.

P/N 23073388, S/N A19939 - Rotor Assy, High-Pressure Compressor:

The High-Pressure Compressor (HPC) Rotor Module was removed, disassembled as necessary, and inspected.

- The HPC Stub Shaft was found with scoring beyond serviceable limits.
- The 4th-14th Stage HPC Wheels were damaged beyond serviceable limits due to the No.4 Bearing failure.
- All HPC Blades were damaged beyond serviceable limits due to the No. 4 Bearing failure.
- The 4th-14th Stage HPC Vanes were damaged beyond serviceable limits due to the No. 4 Bearing failure.

P/N TBD, Liner Assy, Combustion (Effusion):



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The Combustion and Diffuser Module was removed, disassembled as necessary, and inspected.

- The No. 5 and 6 Carbon Seals were grooved beyond serviceable limits.
- The No. 4 Bearing was found seized
- The Combustion Liner was found with damage due to the No. 4 Bearing failure.

P/N NPN, H.P.H.P. Turbine - Vane and Support:

The 1st Stage High Pressure Turbine (HPT) Vane and Support Module was removed, disassembled as necessary, and inspected.

- Two (2) 1st Stage HPT Vanes were found with erosion beyond serviceable limits.

P/N 23074700, S/N A71635 - Rotor Assy, High-Pressure Turbine:

The HPT Rotor Module was removed, disassembled as necessary, and inspected.

- All 1st Stage HPT Blades were found with erosion beyond serviceable limits.
- All 2nd Stage HPT Vanes were damaged beyond serviceable limits due to the No. 4 Bearing Failure.
- All 2nd Stage HPT Blades were damaged beyond serviceable limits due to No. 4 Bearing failure.

P/N 23067890, S/N A81609 - Turbine Assy, Low Pressure:

The Low Pressure Turbine (LPT) Module was removed and inspected.



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-The No. 7 Carbon Seal was found leaking beyond serviceable limits.

P/N 23086770, S/N 2975 - Gearbox Assy, Accessory Drive:

The Accessory Drive Gearbox was removed, disassembled as necessary, and inspected.

-All of the bearings and all of the Magnetic Carbon Seals were found contaminated.

-The Bevel Gearshaft was found worn beyond serviceable limits.

P/N NPN, Bypass Ducts:

The Bypass Ducts, Controls and Accessories, and External Hardware were removed, disassembled as necessary, and inspected.

-The External Engine Indication Harness was found with a broken EMI Band.

-The Lube and Scavenge Pump was found contaminated.

-The Bypass Flowpath was found worn beyond serviceable limits.



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Part Description	Part Number	Reason for removal	Qty
WASHER, CUP LOCK	23035323	100% REPLACEMENT	1
NUT, SPANNER-END SLOTS-CUPWASHER LKD	23035420	COATING LOSS	1
NUT, SPANNER-END SLOTS, CUPWASHER LOCKED	23035422	COATING LOSS	1
GASKET, METAL	23037622	100% REPLACEMENT	1
GASKET, METAL- CDT SENSOR	23038911	100% REPLACEMENT	1
THERMOCOUPLE ASSY, TURBINE INTERSTAGE	23039952	FAILED TEST	1
SPACER, BEARING - NO. 4	23050530	SCRATCHED	1
SMASHPLATE, TURB-STG 2 - 2 SPAN	23050938	100% REPLACEMENT	1
WEIGHT, BALANCE - COMPRESSOR REAR	23051330	REQUIRED AT BALANCE	1
WASHER, CUP LOCK-SPANNER 4.500 DIA	23052219	BROKEN	1
WASHER	23054335	100% REPLACEMENT	1
SPACER, CENTER SUMP-AFT	23054899	NICKS	1
SENSOR P2.5	23059920	DENTED	1
SEAL, LABYRINTH CENTER SUMP	23056662	DAMAGED	1
BEARING, BALL - NO. 2B	23056839	ROUGH SURFACE	1
BEARING BALL, ANNULAR 87 X 108 X 11 MM	23056839	CHATTER	1
GASKET, WIRE-1ST STAGE TURBINE	23057940	100% REPLACEMENT	1



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HARNESS, THERMOCOUPLE WIRING (A)	23059920	FRETTING	1
RING SEAL, 1ST STAGE TURBINE WHEEL	23060273	GOUGING	1
RUNNER, NUMBER 6 CARBON SEAL	23061706	GROOVED	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
BEARING, ROLLER-FLANGED 20 X 42 X 12 M	23062537	METAL IN OIL	1
CAGE, BEARING - POWER TURBINE THRUST	23063285	CHIPPED	1
KIT, NO. 7 CARBON SEAL REPLACEMENT	23063487	100% REPLACEMENT	1
BEARING (PUAD), BALL, 17 X 35 X 10 MM (ID #18)	23064220	METAL IN OIL	1



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BEARING, CONRAD-30 X 62 X 16 MM	23064226	CHATTER	1
TUBE ASSY, SCAV OIL FRONT SUMP TO PUMP	23065949	CHAFING	1
CLEVIS, ACTUATOR RING-IGV	23066240	PITTING	1
BRACKET ASSY, OIL FILTER MOUNTING	23066449	WORN	1
VANE ASSY, COMPRESSOR-14TH STAGE	23066794	EMBEDDED MATERIAL	1
SPACER, NO.4 BEARING-THRUST	23067052	NICKS	1
E-SEAL, METALLIC, HPT INNER CASING	23067946	CHAFED	1
PUMP ASSY, LUBE & SCAVENGE	23068052	CONTAMINATION	1
E-SEAL, METALLIC, GAS GENERATOR TURBINE INNER CASING	23068161	DIMENSIONAL REJECT	1
TUBE ASSY, CENTER SUMP	23068441	WORN	1
TUBE ASSY, CENTER SUMP	23068441	SERVICE BULLETIN	1
BEARING, ROLLER CYL 25 X 47 X 12 MM	23069576	BANDING	1
BRACKET, MOUNTING-TORQUE TUBE ASSY	23069612	WORN	1
SEAL, TEFLON LIP FAN	23072308	WARPED	1
PACKING, PREFORMED O-RING	23072329	100% REPLACEMENT	1
SEAL ASSY, TEFLON	23072579	100% REPLACEMENT	1
SEAL ASSY, TEFLON	23073073	100% REPLACEMENT	1





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EXTENSION, FLOWPATH-INLET HOUSING HUB	23073167	CORROSION	1
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Part Description	Part Number	Reason for removal	Qty
SEAL ASSY, CARBON NO.5	23073831	EMBEDDED MATERIAL	1
PACKING	23073882	100% REPLACEMENT	1
PACKING	23073882	100% REPLACEMENT	1
VANE ASSY, INLET GUIDE	23074090	DAMAGE IN AREA F	3
NUT, PLAIN, ROUND 4.625-16UNJ-3B	23074208	GROOVED	1
PACKING, PREFORMED O-RING (ENGINE SET) PACKAGE CO	23074229	100% REPLACEMENT	1
SEAL ASSY, CARBON-NO. 6	23074239	GROOVED	1
RUNNER, CARBON SEAL-NUMBER 5	23074575	SCORING	1
FLOWPATH ASSY, BYPASS	23075062	MATERIAL BROKEN OUT	1
INSERT, NO. 6 BEARING	23075462	FRETTING	1
HOUSING ASSY, FRONT SUMP	23075578	FRETTING	1
SEAL RING, COMBUSTION LINER-INNER	23075871	WARPED	1
SUPPORT AND SEAL ASSEMBLY-HP TURBINE	23076121	FRETTING	1
SEAL, AIR - REAR COMPRESSOR	23076434	DISTORTED	1
SEAL ASSEMBLY, TEFLON	23076741	100% REPLACEMENT	1
SEAL ASSEMBLY, TEFLON	23076742	100% REPLACEMENT	1
HARNESS ASSY, EXT-ENG INDICATING (W9)	23077618	CONNECTOR DETERIORATE	1



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PUMP ASSY, LUBE & SCAVENGE WITH REG VLV	23079382	CONTAMINATION	1
BEARING, BALL-SPLIT INNER RACE 120 X 180	23080325	SEIZED	1
WHEEL, COMPRESSOR - 4TH STAGE	23084159	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR 5TH STAGE	23084160	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 6TH STAGE	23084161	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 7TH STAGE	23084162	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 8TH STAGE	23084163	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 9TH STAGE	23084164	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 10TH STAGE	23084165	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 11TH STAGE	23084166	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 12TH STAGE	23084167	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 13TH STAGE	23084168	DOMESTIC OBJECT DMG	1
WHEEL, COMPRESSOR - 14TH STAGE	23084169	DOMESTIC OBJECT DMG	1
CONE ASSY, SHAFT - COMPRESSOR	23084170	DOMESTIC OBJECT DMG	1
SENSOR, P2.5 PRESS TRANSDUCER - ABSOLUTE	23085153	DENTED	1
SHAFT, COMPRESSOR STUB	23087970	DOMESTIC OBJECT DMG	1
PLUG ASSY, MAGNETIC INDICATING	23087999	BROKEN	1
SEAL, LABYRINTH - STATIONARY	23088073	BENT	1



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RETAINER ASSEMBLY, BEARING HP THRUST	23088998	BELOW MIN THICKNESS	1
IMPELLER, OIL-FWD CENTER SUMP	23089048	WARPED	1
SENSOR, RTD TOTAL TEMP DUAL ELEMENT	23089515	TEARS	1
VANE ASSY, COMPRESSOR - 12TH STG	23090301	RUBBED	1
GASKET	23090504	100% REPLACEMENT	1
VANE ASSY, COMPRESSOR - 7TH STG	23090580	RUBBED	1
VANE ASSY, COMPRESSOR - 8TH STG	23090581	RUBBED	1
VANE ASSY, COMPRESSOR - 9TH STG	23090582	RUBBED	1
LINER ASSY, COMBUSTION	23090634	EMBEDDED MATERIAL	1
FRONT SUMP HOUSING	23090801	FRETTING	1
PARTS KIT, NO.4 LIP SEAL & NO. 4 CARBON SEAL	23091250	BROKEN	1
RTBS	23093155	FAILED TEST	1
PARTS KIT, MAG SEAL	23093279	METAL IN OIL	1
PARTS KIT, MAG SEAL	23093279	METAL IN OIL	1
PARTS KIT, MAG SEAL	23093279	METAL IN OIL	1
PARTS KIT, MAG SEAL	23093279	METAL IN OIL	1
PARTS KIT, MAG SEAL HYDRAULIC PUMP	23093309	METAL IN OIL	1
ELEMENT, FUEL FILTER	77878508	CONTAMINATION	1



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CONNECTOR, MECHANICALLY ATTACHED	23035406-06	SERVICE BULLETIN	1
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Part Description	Part Number	Reason for removal	Qty
CONNECTOR, MECHANICALLY ATTACHED	23035406-06	WORN	1
STUD, LOCKED IN-KEY LOCKED	23053385-201-10	DAMAGE THREADS	1
SLEEVE, PISTON RING WEAR	23055435-28	CORROSION	1
SLEEVE, PISTON RING WEAR	23055435-48	CORROSION	1
PACKING, PREFORMED BRAIDED CERAMIC ROPE	23057101-018	100% REPLACEMENT	1
BLADE TRACK ASSY-1ST STG, TURBINE	23071574-105	CRACKS	1
PACKING, PERFLUOROELASTOMER - O-RING	23078077-5	100% REPLACEMENT	1
PACKING, PERFLUOROELASTOMER - O-RING	23078077-7	100% REPLACEMENT	1
GEARSHAFT ASSY- BEVEL SPUR - STARTER DR	42520-157	WEAR STEPS	1
NUT, SELF LOCKING - STARTER	42520-170	GALLING	1
BEARING, BALL - SPL IN RACE, INPT PINION	42520-32	METAL IN OIL	1
BALL BEARING - STARTER	42520-36	METAL IN OIL	1
ROLLER BEARING - STARTER, PINION	42520-39	METAL IN OIL	1
ROLLER BEARING - STARTER, PINION	42520-39	METAL IN OIL	1
RETAINER, BEARING	42520-67	METAL IN OIL	1
NUT, SELF LOCKING - INPUT PINION	42520-73	GALLING	1
RING, RETAINING-INTERNAL, CRES	6842758-550	100% REPLACEMENT	1



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ADAPTER, PORT CONNECTION-RING LOCKED	AS1986-04	NICKS	1
ADAPTER, PORT CONNECTION-RING LOCKED .37	AS1986-08	WORN	1
O-RING	AS3209-008	100% REPLACEMENT	1
O-RING	AS3209-008	100% REPLACEMENT	1
O-RING	AS3209-010	100% REPLACEMENT	1
O-RING	AS3209-012	100% REPLACEMENT	1
O-RING	AS3209-014	WORN	1
O-RING	AS3209-016	100% REPLACEMENT	1
O-RING	AS3209-019	100% REPLACEMENT	1
PACKING, PREFORMED	AS3209-026	100% REPLACEMENT	1
PACKING	AS3209-111	100% REPLACEMENT	1
PACKING, PREFORMED O RING	AS3209-135	100% REPLACEMENT	1
PACKING, PREFORMED	AS3209-137	100% REPLACEMENT	1
PACKING, PREFORMED O RING	AS3209-138	100% REPLACEMENT	1
PACKING	AS3209-147	100% REPLACEMENT	1
PACKING, PREFORMED O RING	AS3209-155	100% REPLACEMENT	1
PACKING, PREFORMED O RING	AS3209-157	100% REPLACEMENT	1
PACKING, PREFORMED, O-RING	AS3209-159	100% REPLACEMENT	1



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PACKING, PREFORMED	AS3209-168	100% REPLACEMENT	1
PACKING, PREFORMED O RING	AS3209-233	100% REPLACEMENT	1
PACKING, PREFORMED O-RING	AS3209-235	WORKSCOPE DIRECTION	1
PACKING, PREFORMED O-RING	AS3209-239	100% REPLACEMENT	1
PACKING, PREFORMED O RING	AS3209-276	100% REPLACEMENT	1
RING, RETAINING	AS3217-147	100% REPLACEMENT	1
RING, RETAINING	AS3217-147	100% REPLACEMENT	1
RING, RETAINING-SPIRAL	AS3217-156	100% REPLACEMENT	1
RING, RETAINING-SPIRAL	AS3217-180	100% REPLACEMENT	1
RING, RETAINING-SPIRAL	AS3217-191	100% REPLACEMENT	1
RING, RETAINING-SPIRAL	AS3217-212	100% REPLACEMENT	1
RING, RETAINING-SPIRAL	AS3217-244	FRETTING	1
FLANGED SLEEVE PER DRAWING - EN72251608 REV. E	EN72251608	DIMENSIONAL REJECT	1
STRAP	MS25083-2BB8	CHAFING	1
STUD ASSY	MS51833A201-10	DAMAGE THREADS	1
STUD FOR GEARBOX	MS51833A203-14	WORN	1
PIN, COTTER	MS9245-26	REQUIRED FOR KITTING	1
WASHER	MS9276-19	100% REPLACEMENT	1





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GASKET	MS9373-013	100% REPLACEMENT	1
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Part Description	Part Number	Reason for removal	Qty
BOLT	MS9696-05	100% REPLACEMENT	1
WASHER, CUP LOCK - SPANNER	MS9952-27	100% REPLACEMENT	1
PACKING	MS9967-153	WORKSCOPE DIRECTION	1
RECEPTACLE ASSY, FLOATING	23052965	BROKEN	2
IGNITER ASSY, RECESSED ELECTRODE	23062672	EMBEDDED MATERIAL	2
VANE, COMPRESSOR VARIABLE-4TH STAGE	23064794	EMBEDDED MATERIAL	2
VANE, COMPRESSOR VARIABLE-5TH STAGE	23064795	EMBEDDED MATERIAL	2
ELEMENT ASSY, OIL FILTER	23069424	100% REPLACEMENT	2
BLADE TRACK, 1ST STG HPT SET	23071574	CRACKS	2
PACKING, PREFORMED O-RING	23072328	100% REPLACEMENT	2
PACKING, PREFORMED O-RING	23072328	DIMENSIONAL REJECT	2
RING SEGMENT ASSY, INNER-2ND STG COMPR	23072434	GROOVED	2
RING SEGMENT ASSY, INNER-3RD STG COMPR	23072435	GROOVED	2
RING SEGMENT ASSY, INNER-4TH STG COMPR	23072436	EMBEDDED MATERIAL	2
RING SEGMENT ASSY, INNER-5TH STG COMPR	23072437	EMBEDDED MATERIAL	2
PLUG ASSY, MAGNETIC INDICATING	23075504	LOOSE TIP	1
SUPPORT ASSY, REAR TURBINE BEARING	23077731	FAILED TEST	2



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INSERT OUTER BYPASS DUCT SUPPORT - REAR	23078547	DIMENSIONAL REJECT	2
VANE, HP TURBINE - 1ST STAGE	23080747	EROSION	2
BLADE, FAN	23089651	NICKS	2
VANE ASSY, COMPRESSOR - 6TH STAGE	23090078	RUBBED	2
VANE ASSY, COMPRESSOR-7TH STAGE	23090079	RUBBED	2
VANE ASSY, COMPRESSOR - 8TH STAGE	23090080	RUBBED	2
VANE ASSY, COMPRESSOR 9TH STAGE	23090081	RUBBED	2
VANE ASSEMBLY, COMPRESSOR 10TH STAGE	23090082	RUBBED	2
VANE ASSY, COMPRESSOR 12TH STAGE	23090084	RUBBED	2
VANE ASSY, COMPRESSOR 13TH STAGE	23090085	RUBBED	2
VANE ASSY, COMPRESSOR - 11TH STAGE	23090187	RUBBED	2
RING SEGMENT ASSY, INNER - 1ST STAGE COMP	23092871	GROOVED	2
WEIGHT, BALANCE-TURBINE 1ST, 2ND & 3RD STAGE	23038853-2	REQUIRED AT BALANCE	2
WEIGHT, BALANCE-TURBINE 1ST, 2ND & 3RD STAGE	23038853-5	REQUIRED AT BALANCE	2
STUD, KEY LOCKED (FRONT FRAME AFT FLANGE)	23053378-202-23	DAMAGE THREADS	2
COVERPLATE, TURBINE-1ST STAGE, FWD-4 SPAN	23055240-3	FIT&CLEAR OUT OF TOL	2
BOLT, SLEEVE (INNER DUCT)	23056545-2	DAMAGE THREADS	2
COVERPLATE, TURBINE-STG 1 AFT, 4 SPAN	23057395-3	FIT&CLEAR OUT OF TOL	2



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WEIGHT, BALANCE-TURB 1ST STAGE	23060274-2	REQUIRED AT BALANCE	2
WEIGHT, BALANCE-TURB 1ST STAGE	23060274-7	REQUIRED AT BALANCE	2
COVERPLATE, TURBINE - 2ND STAGE, 2 SPAN	23064436-103	FIT&CLEAR OUT OF TOL	2
ADAPTER, PORT CONNECTION RING LOCKED	AS1986-06	WORN	2
O-RING	AS3209-008	100% REPLACEMENT	2
O-RING	AS3209-009	100% REPLACEMENT	2
O-RING	AS3209-012	WORN	2
O-RING	AS3209-015	100% REPLACEMENT	2
PACKING, PREFORMED O RING	AS3209-108	100% REPLACEMENT	2
O-RING	AS3209-114	100% REPLACEMENT	2
O-RING	AS3209-131	100% REPLACEMENT	2
PACKING, PREFORMED O RING	AS3209-153	100% REPLACEMENT	2
PACKING, PREFORMED O RING	AS3209-153	100% REPLACEMENT	2
PACKING, PREFORMED O RING	AS3209-157	100% REPLACEMENT	2
PACKING, PREFORMED O RING	AS3209-167	100% REPLACEMENT	2
Steel Sleeve per drawing EN72251609 REV. B	EN72251609	DIMENSIONAL REJECT	2
PACKING, O RING	M83485/1-047	100% REPLACEMENT	2
NUT, SELF LOCKING, CASTELLATED	MS21224-4	WORN	2



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GROMMET, NONMETALLIC	MS35489-149	100% REPLACEMENT	2
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Part Description	Part Number	Reason for removal	Qty
INSERT	MS51830CA202L	DIMENSIONAL REJECT	2
BOLT	MS9110-15	CORROSION	2
VANE ASSY, INLET GUIDE	23074090	CORROSION	3
RING SEGMENT ASSY, INNER 1ST STAGE	23077348	GROOVED	2
ARM AND BALL ASSY, VANE ACTUATION - IGV	23080250	BENT	3
BOLT, MACH-12 PT HD, EXT WASHER HEAD, SE	23075843-08	100% REPLACEMENT	3
O-RING	AS3209-009	100% REPLACEMENT	3
O-RING	AS3209-011	100% REPLACEMENT	3
O-RING	AS3209-012	100% REPLACEMENT	3
PACKING, PREFORMED	AS3209-110	100% REPLACEMENT	3
O-RING	AS3209-112	100% REPLACEMENT	3
O-RING	AS3209-114	100% REPLACEMENT	3
NUT	MS21043-6	100% REPLACEMENT	3
SCREWS	MS24693-C26	DIMENSIONAL REJECT	3
BOLT	MS9110-13	CORROSION	3
WASHER	MS9582-09	100% REPLACEMENT	3
GASKET, SPARK IGNITER MOUNTING	6816047	100% REPLACEMENT	4



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BOLT, MACH-DBL HEX EXT HD	23034166-05-11	DAMAGE THREADS	4
PACKING, PREFORMED	AS3209-110	100% REPLACEMENT	4
PACKING, PREFORMED	AS3209-156	100% REPLACEMENT	4
RIVET, TUBULAR-COUNTERSUNK	AS3230-054	100% REPLACEMENT	4
NUT, SELF-LOCKING	MS21043-3	REQUIRED AT BALANCE	4
GASKET	MS9142-041	100% REPLACEMENT	4
BOLT	MS9432-06	REQUIRED AT BALANCE	4
SCREW, MACHINE - FLAT 100 DEGREE HEAD	NAS1102E3R8	100% REPLACEMENT	4
BOLT, SLEEVE	23056545-4	DAMAGE THREADS	5
NUT, SELF LOCKING, CASTELLATED	MS21224-4	CORROSION	5
PIN, COTTER	MS9245-26	REQ'D FOR HIGHER ASSY	5
INSERT, SCREW THREAD - LOCKED IN, KEY LOCKED	23037309-01	DAMAGE THREADS	6
INSERT	MS51830CA201L	WORN	6
BOLT, AXIS-G	MS9489-09	100% REPLACEMENT	6
WASHER	MS9581-09	100% REPLACEMENT	6
GROMMET, RING RETAINING (INNER DUCT)	23056546-3	100% REPLACEMENT	7
NUT, SELF LOCKING 12 PT 800 DEG F .190-3	6870327-3	100% REPLACEMENT	7
WASHER	AML-100-700-6	100% REPLACEMENT	7



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FLOWPATH ASSY, BYPASS	23064906		1
VANE, BYPASS, 3-SPAN	23067033	TRAIL/LEAD EDGE DMG	8
BOLT, TEE HD-CHAMFERED 190-32 X .625	6847906-1008	100% REPLACEMENT	8
NUT, SELF LOCKING 12 PT 800 DEG F .190-3	6870327-3	100% REPLACEMENT	8
O-RING	AS3209-112	100% REPLACEMENT	8
INSERT	MS51830CA202L	WORN	8
PIN, COTTER	MS9245-26	100% REPLACEMENT	8
INSERT, SELF LOCKING - BOTTOM LOCK	23061465-202	DIMENSIONAL REJECT	10
NUT, SELF LOCKING 12 PT 800 DEG F .190-3	23087278-09	100% REPLACEMENT	10
NUT, SELF-LOCKING	AS3477-09	100% REPLACEMENT	10
BOLT	MS9432-06	100% REPLACEMENT	10
WASHER, FLAT	NAS1149C0332R	CORROSION	10
WASHER, FLAT	NAS1149C0532R	REQUIRED AT BALANCE	10
BUSHING, SLEEVE-FLANGE INNER.439 X 1.445	23074237	TEARS	11
BOLT, MACH SLAB HD-SELF RET.250-28X.860LG	23034092	DOMESTIC OBJECT DMG	12
WASHER, KEY LOCKING-DOUBLE TAB	23050323	100% REPLACEMENT	12
O-RING	AS3209-010	100% REPLACEMENT	12
NUT, SELF-LOCKING	AS3477-10	DOMESTIC OBJECT DMG	12





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RETAINER, IGV HUB-POLYMER	23052131	WEAR STEPS	13
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Part Description	Part Number	Reason for removal	Qty
WASHER	MS9276-10	100% REPLACEMENT	14
LINER ASSY, COMBUSTION	23090634	RUBBED	15
NUT, SELF LOCKING 12 PT 800 DEG F .375-2	6870327-6	100% REPLACEMENT	15
WASHER	MS9276-16	100% REPLACEMENT	15
STRIP SEAL - TURBINE 2ND VANE - OUTER	23067905	100% REPLACEMENT	16
STRIP SEAL - TURBINE 2ND VANE - INNER	23067906	100% REPLACEMENT	16
PIN, RETAINING - 2ND STAGE BLADE TRACK	23068155	100% REPLACEMENT	16
SEAL, STRIP - 2ND STAGE BLADE TRACK	23068156	100% REPLACEMENT	16
CLIP, RETAINING - 2ND STAGE BLADE TRACK	23068194	100% REPLACEMENT	16
CLIP, RETAINING - 2ND STAGE BLADE TRACK	23068194	100% REPLACEMENT	16
STRIP, SEAL - TURBINE 2ND VANE - INNER	23069418	100% REPLACEMENT	16
BLADE TRACK, 2ND STAGE-HP TURBINE	23070332	DIMENSIONAL REJECT	16
VANE ASSY, HP TURBINE-STAGE 2	23070987	EMBEDDED MATERIAL	16
GASKET, FUEL NOZZLE, REFLEX	23073810	100% REPLACEMENT	16
VANE ASSY, COMPRESSOR - 6TH STG	23090579	RUBBED	16
VANE ASSY, 2ND STG HPT	23090907	EMBEDDED MATERIAL	16
NUT, SELF LOCKING 12 PT 800 DEG F .190-3	23087278-09	100% REPLACEMENT	16



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BOLT	AS3237-14	100% REPLACEMENT	16
STRIP, SEAL - 1ST TURBINE VANE	23061727	100% REPLACEMENT	18
STRIP, SEAL-1ST STG VANE BAND OUTER	23062281	100% REPLACEMENT	18
STRIP, SEAL-1ST STG VANE INNER BAND, RAD	23062282	100% REPLACEMENT	18
BUSHING, SLEEVE-FLANGE OUTER-.384 X .820	23074236	TEARS	18
NUT, SELF-LOCKING	AS3477-09	100% REPLACEMENT	23
BOLT, MACH, SLAB HD, INTERFERENCE FIT	23054737	DOMESTIC OBJECT DMG	24
SEAL, STRIP - 1ST STAGE BLADE TRACK COOL	23068150	100% REPLACEMENT	24
SEAL, STRIP-1ST STAGE TURBINE GAS PATH	23070178	100% REPLACEMENT	24
CLAMP, RETAINING 1ST STAGE BLADE TRACK	23071406	100% REPLACEMENT	24
NUT, SELF-LOCKING	23087278-11	DOMESTIC OBJECT DMG	24
WASHER, KEY	MS9276-09	100% REPLACEMENT	24
BLADE, COMPRESSOR - 1ST STAGE	23079367	DOMESTIC OBJECT DMG	26
GASKET, THERMOCOUPLE-METALLIC	23035688	100% REPLACEMENT	32
BLADE, COMPRESSOR-2ND STAGE	23076704	DOMESTIC OBJECT DMG	33
BLADE, COMPRESSOR - 3RD STAGE	23076705	DOMESTIC OBJECT DMG	40
NUT, SELF-LOCKING	MS21043-3	CORROSION	40
BLADE, COMPRESSOR-4TH STAGE	23073720	DOMESTIC OBJECT DMG	47



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BLADE, COMPRESSOR-5TH STAGE	23073721	DOMESTIC OBJECT DMG	54
SENSOR, RTD TOTAL TEMP - DUAL ELEMENT	23059750		56
HARNESS, THERMOCOUPLE WIRING (A)	23059920		56
VANE, COMPRESSOR VARIABLE-4TH STAGE	23063764	EMBEDDED MATERIAL	56
VANE, COMPRESSOR VARIABLE-5TH STAGE	23063765	EMBEDDED MATERIAL	56
BLADE, 1ST STAGE HPT	23091281	EROSION	58
BLADE, COMPRESSOR-6TH STAGE	23073722	DOMESTIC OBJECT DMG	72
SEAL, TURBINE - 2ND STG PLATFORM	23064453	100% REPLACEMENT	76
BLADE ASSY, TURBINE - 2ND STAGE	23076978	GOUGING	76
SCREW, FLAT HEAD .250-28 UNJF X .625 LG	23062555	100% REPLACEMENT	80
NUT, SELF LOCK-DBL HEX, SILVER PLTD THDS	23073711	100% REPLACEMENT	80
BLADE, COMPRESSOR-7TH STAGE	23073723	DOMESTIC OBJECT DMG	83
BLADE, COMPRESSOR-11TH STAGE	23073727	DOMESTIC OBJECT DMG	87
BLADE, COMPRESSOR-12TH STAGE	23073728	DOMESTIC OBJECT DMG	87
BLADE, COMPRESSOR-13TH STAGE	23073729	DOMESTIC OBJECT DMG	87
BLADE, COMPRESSOR-14TH STAGE	23073730	DOMESTIC OBJECT DMG	87
BLADE, COMPRESSOR - 3RD STG	23073719	DOMESTIC OBJECT DMG	95
BLADE, COMPRESSOR-9TH STAGE	23073725	DOMESTIC OBJECT DMG	95



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BLADE, COMPRESSOR-10TH STAGE	23073726	DOMESTIC OBJECT DMG	95
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Part Description	Part Number	Reason for removal	Qty
BLADE, COMPRESSOR - 2ND STG	23073718	DOMESTIC OBJECT DMG	96
BLADE, COMPRESSOR-8TH STAGE	23073724	DOMESTIC OBJECT DMG	96
WASHER, NONMETALLIC THRUST, VAR VANE	23074235	100% REPLACEMENT	280
BUSHING, SLEEVE-FLANGED, STAGE 1-5	23074238	100% REPLACEMENT	280
WASHER, KEY	MS9276-09	100% REPLACEMENT	280
RING, RETAINING	AS3217-156	100% REPLACEMENT	1



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PRIMARY FAILURE/REASON FOR REMOVAL:

Engine CAE312038 was received due to reported oil contamination. Following disassembly, it was discovered that the No. 4 Bearing had become seized, leading to bearing failure. Upon further inspection, damage from the failed bearing was discovered throughout the Engine.

JOSEPH PALLO

AE3007    Service    Engineering    Standard    Aero    (Alliance)    Inc.    Phn:    865.983.2992



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## Photos



Fig 1: ENGINE OVERVIEW



Fig 2: ENGINE CHIP DETECTOR





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Fig 3: OIL TANK CHIP COLLECTOR



Fig 4: FAN BLADE - DETAIL



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Fig 5: P2.5 SENSOR - OVERVIEW



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Fig 6: TOTAL TEMPERATURE SENSOR - DETAIL





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Fig 7: FRONT SUMP HOUSING (FRETTING) - DETAIL



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Fig 8: HIGH-PRESSURE COMPRESSOR STUB SHAFT - DETAIL





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Fig 9: HIGH-PRESSURE COMPRESSOR WHEEL - DETAIL



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Fig 10: HIGH-PRESSURE COMPRESSOR BLADES



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Fig 11: HIGH-PRESSURE COMPRESSOR VANES





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Fig 12: CENTERSUMP - DETAIL



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Fig 13: 1ST STAGE HIGH-PRESSURE TURBINE VANES - OVERVIEW



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Fig 14: 1ST STAGE HIGH-PRESSURE TURBINE BLADES - DETAIL



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Fig 15: 2ND STAGE HIGH-PRESSURE TURBINE VANES - DETAIL





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Fig 16: 2ND STAGE HIGH-PRESSURE TURBINE BLADES - DETAIL



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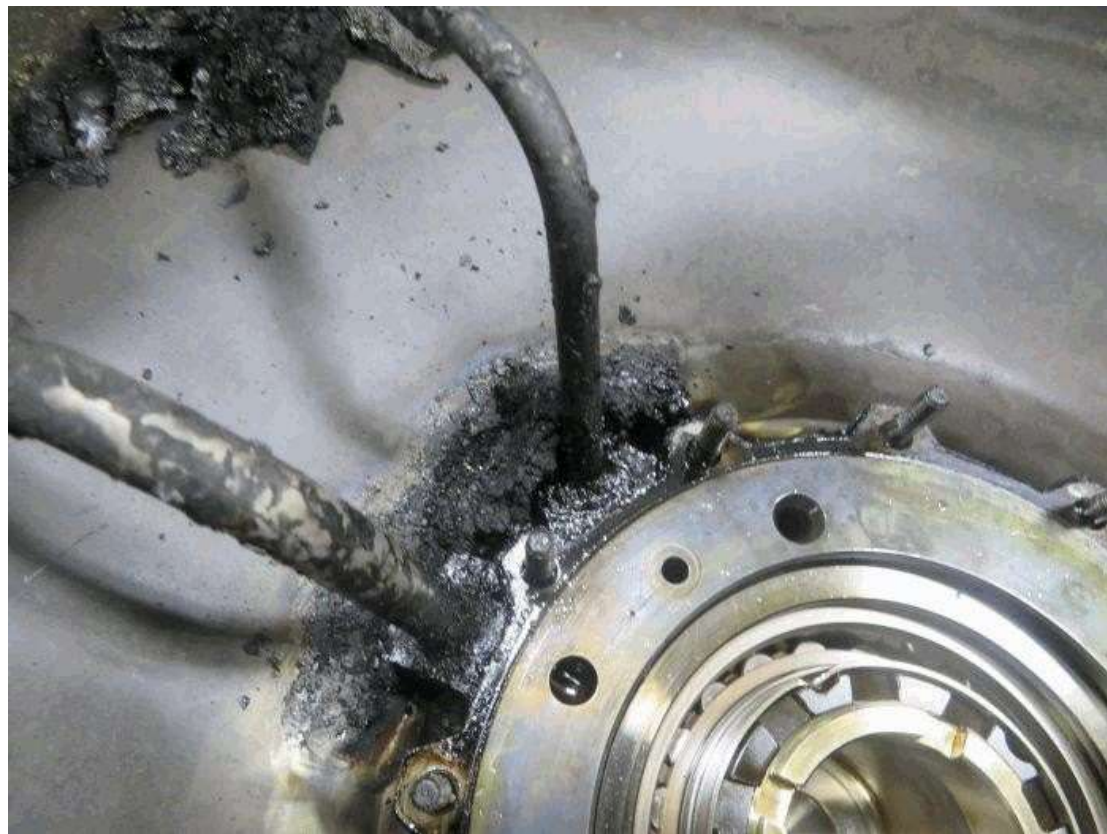


Fig 17: AFT SUMP



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Fig 18: ACCESSORY DRIVE GEARBOX (CONTAMINATION) - DETAIL





Fig 19: No. 4 BEARING - OVERVIEW

Fig 20: EXTERNAL ENGINE INDICATION HARNESS (BROKEN EMI BAND) – DETAIL