AIRCRAFT SERIOUS INCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/3/2/1298	
Aircraft Registration	**ZS-MIN**	**Date of Incident**	4 December 2019	**Time of Incident**	1035Z
Type of Aircraft	Beechcraft King Air B200		**Type of Operation**	Commercial (Part 135)	
Pilot-in-command Licence Type	Airline Transport Pilot Licence	**Age**	48	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	9 140		Hours on Type	2 388
Last Point of Departure	Virginia Aerodrome (FAVG): Kwa-Zulu Natal Province				
Next Point of Intended Landing	Hoedspruit Aerodrome (FAHT): Limpopo Province				

Location of the incident site with reference to easily defined geographical points (GPS readings if possible)

En-route from FAVG to FAHT at flight level (FL) 250, at position R025 DME50nm from King Shaka International Aerodrome (FALE)

Meteorological Information	Wind: Westerly at 70kts; Temperature: -15˚C, Visibility: 9999m, Cloud: Overcast and Layered at FL250				
Number of People On-board	2 + 9	**No. of People Injured**	0	**No. of People Killed**	0

Synopsis

On Wednesday afternoon, 4 December 2019 at 1000Z, a Beechcraft King Air B200 aircraft with registration ZS-MIN departed Virginia Aerodrome (FAVG) in KwaZulu-Natal province on a domestic charter flight to Hoedspruit Aerodrome (FAHT) in Limpopo province. On-board the aircraft were two crew members and nine passengers. The flight was conducted under Instrument Flight Rules (IFR) by day and a flight plan was filed with Johannesburg Information.

The pilot-in-command (PIC) stated that while cruising at flight level (FL) 250 as they approached clouds, they deployed the ice vanes with the intent to prevent ice from entering the engines. Shortly thereafter, the number 2 engine (right-side) compressor stalled and the Inter-Turbine Temperature (ITT) exceedance was observed on the instrument panel. The crew then referenced and followed the Aircraft Flight Manual (AFM) checklist actions for ITT exceedance which required that the engine be shut down. The crew then decided to divert to King Shaka International Aerodrome (FALE). The landing at FALE was uneventful.

The investigation determined that the engine ice vanes were not activated on time during operation in temperature below +5°C, which caused ice particles to enter the engine, disturbing the air flow in the engine compressor. This resulted in the compressor stalling and the subsequent ITT exceedance.

Probable cause/s and/or contributory factors

The engine ice vanes were not activated on time during operation in temperature below +5°C, which caused ice particles to enter the engine, disturbing the air flow in the engine compressor. This resulted in the compressor stalling and the subsequent ITT exceedance.

SRP Date	19 January 2021	Publication Date	4 February 2021

ABBREVIATION	DESCRIPTION
°	Degrees
AD	Airworthiness Directive
AIID	Accident and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
AMSL	Above Mean Sea Level
C	Celsius
CAR	Civil Aviation Regulations
CT	Compressor Turbine
CTVR	Compressor Turbine Vane Ring
E	East
FADEC	Full Authority Digital Engine Control
FAHT	Hoedspruit Aerodrome
FALE	King Shaka International Aerodrome
FAVG	Virginia Aerodrome
FL	Flight Level
FO	First Officer
FOD	Foreign Object Damage
GPS	Global Positioning System
HSI	Hot Section Inspection
IFR	Instrument Flight Rules
ITT	Interstage Turbine Temperature
kts	Knots
LH	Left-hand
MM	Maintenance Manual
MHz	Megahertz
nm	Nautical Miles
No	Number
PF	Pilot Flying
PIC	Pilot-in-command
P/N	Part Number
PT	Power Turbine
S	South
SB	Service Bulletin
SED	Small Exit Duct
S/N	Serial Number
UTC	Co-ordinated Universal Time
TBA	To Be Advised
TT	Total Time
TC	Total Cycles
TSO	Time Since Overhaul
TSN	Time Since New
CSN	Cycles Since New
CSO	Cycles Since Overhaul
PWC	Pratt & Whitney Canada

Reference Number	**:** CA18/3/2/1298
Name of Owner	**:** Mkhombe Investments (PTY) LTD
Name of Operator	**:** KZN Aviation (PTY) LTD
Manufacturer	**:** Beechcraft Aircraft Corporation
Model	**:** B200
Nationality	**:** South African
Registration Marks	**:** ZS-MIN
Place	**:** En-route at FL250 from Virginia Aerodrome (FAVG) to Hoedspruit Aerodrome (FAHT)
Date	**:** 4 December 2019
Time	**:** 1035Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to apportion blame or liability****.*

Investigations process:

The serious incident was reported to the Accident and Incident Investigations Division (AIID) on 4 December 2019 at about 1130Z. The investigator/s did not dispatch to the site. The AIID of the South African Civil Aviation Authority (SACAA) is leading the investigation as the Republic of South Africa is the State of Occurrence.

Notes: Whenever the following words are mentioned in this report, they shall mean the following:

1. *Incident — this investigated serious incident*
   Aircraft — the Beechcraft King Air B200 involved in this serious incident
   Investigation — the investigation into the circumstances of this serious incident
   Pilot — the pilot involved in this serious incident
   Report — this serious incident report

2. *Photos and figures used in this report are taken from different sources and may be adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report are limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows or lines.*

Disclaimer:

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On Wednesday afternoon, 4 December 2019 at 1000Z, a Beechcraft King Air B200 aircraft with registration ZS-MIN took off from Runway 23 at Virginia Aerodrome (FAVG) in Kwa-Zulu Natal province on a commercial charter flight to Hoedspruit Aerodrome (FAHT) in Limpopo province. There were two crew members and nine passengers on-board the aircraft. The flight was conducted under Instrument Flight Rules (IFR) by day. The pilot-in-command (PIC) was the pilot monitoring (PM) and the first officer (FO) was the pilot flying (PF). The take-off and climb phases of the flight to flight level (FL) 250 were uneventful. After being airborne for approximately 30 minutes, the aircraft approached clouds during cruise, and the crew stated that they decided to deploy the engine ice vanes to prevent possible ice particles from entering the engine. Shortly thereafter, the number 2 engine compressor stalled, and the crew noticed that the Inter-Turbine Temperature (ITT) indicator had increased to 950°C and had remained in that level for approximately 5 seconds, which exceeded the maximum limit of 850°C. The PF retarded the throttle lever to reduce the engine power and the possible damage to the engine. The crew decided to shut down the engine as per the Airplane Flight Manual (AFM) and then opted to divert to King Shaka International Aerodrome (FALE) for a precautionary landing.

Note: The ITT sensing system (T5) provides the pilot with an accurate indication of engine operating temperature at a point between the compressor turbine and the first-stage power turbine. The system consists of a bus-bar and probe assembly, and a harness assembly. A trim thermocouple connected parallel with the T5 harness provides a consistent T5 temperature by minimising system readout errors. (Source: Pratt Whitney Canada Maintenance Manual Part No. 3021442, Chapter 77-20-00)

1.1.2 The aircraft was vectored to FALE and landed safely on Runway 24. None of the occupants were injured during the serious incident. The flight was conducted under the provisions of Part 135 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.3 The incident occurred at FL 250, position R025 DME50NM from FALE.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other (on ground)
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	2	-	9	11	-
Total	2	-	9	11	-

1.3 Damage to Aircraft

1.3.1 Damage was limited to the number 2 engine.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command

Nationality	South African	Gender	Male	Age	48
Licence Number	0270262512	Licence Type	Airline Transport Pilot Licence (ATPL)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Test Pilot Class 2 and Flight Instructor Grade 2				
Medical Expiry Date	31 October 2020				
Restrictions	Wear suitable corrective lenses				
Previous Incidents	None				

Flying Experience:

Total Hours	9 140
Total Past 90 Days	76
Total on Type Past 90 Days	35
Total on Type	2 388

1.5.2 The PIC was initially issued an Airline Transport Pilot Licence (ATPL) on 24 October 2019 in accordance with Part 61 of the South African Civil Aviation Regulations (CAR) 2011 as amended. The licence had an expiry date of 31 October 2020. The pilot was also issued a Class 1 medical certificate on 15 August 2019 with an expiry date of 29 February 2020, with a restriction to wear corrective lenses.

First Officer (FO)

Nationality	South African	Gender	Male	Age	44
Licence Number	0270507114	Licence Type	Commercial Pilot Licence (CPL)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Medical Expiry Date	31 October 2020				
Restrictions	None				
Previous Incidents	None				

Flying Experience:

Total Hours	2 565
Total Past 90 Days	55
Total on Type Past 90 Days	27
Total on Type	1 860

1.5.3 The FO was initially issued a Commercial Pilot Licence (CPL) on 22 January 2008. He completed his last skills test on 28 October 2019 and was reissued a CPL with an expiry

date of 31 October 2020. The pilot was also issued a Class 1 aviation medical certificate on 18 August 2019 with an expiry date of 31 August 2020.

Aircraft Maintenance Engineer (AME) experience:

Nationality	South African	Gender	Male	Age	71
Licence Type	Aircraft Maintenance Engineer				
Licence Number	0272001885				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	P & W PT6A Series				
Restrictions	None				
Previous Accidents	None				

1.5.4 The aircraft maintenance engineer (AME) who released the aircraft to service was initially issued an AME Licence on 20 April 1979. Pratt & Whitney PT6A engine series was initially endorsed on his licence on 2 September 1988. The AME had completed his revalidation and was reissued a licence on 19 December 2018 with an expiry date of 9 February 2021, and the PT6 series engine was endorsed on it.

1.6 Aircraft Information

Figure 1: The aircraft ZS-MIN. (Source: www.airliners.com)

1.6.1 Source: libertyjet.com › private_jets › BE-B200

The King Air 200 Large Turboprop was manufactured by Beechcraft between 1981 and 2007. The cabin measures 16.7 feet long by 4.5 feet wide by 4.8 feet tall, giving it a total cabin volume of 303 cubic feet, making it comfortable for nine passengers, with the maximum configuration seating of nine.

1.6.2 Source: www.globalair.com › aircraft-for-sale › Specifications

King Air B200 Specifications, Cabin Dimensions, Performance

The King Air B200 is equipped with PT6A-42 engines rated at 850 shaft horse power (shp), as well as increased maximum pressurisation to 6.5 pounds per square inch (psi). Other modifications include the installation of a hydraulic ram powered revised landing gear retraction mechanism. In 1995, Beechcraft developed a variant of the Model B200, the

B200SE Super King Air, with Electronic Flight Instrument System avionics. Other variants to the original B200 include the B200T, B200C and B200GT with new Pratt & Whitney PT6A-52 engines for higher altitudes.

Airframe:

Type	Beechcraft 200	
Serial Number	BB-941	
Manufacturer	Beech Aircraft Corporation	
Year of Manufacture	1981	
Total Airframe Hours (at time of Incident)	12 874.2	
Last MPI (Hours & Date)	12 830.1	19 September 2019
Hours Since Last Phase Inspection (3 & 4)	44.1	
C of A (Issue Date)	20 June 2014	
C of A (Expiry Date)	30 June 2020	
C of R (Issue Date) (Present owner)	21 May 2019	
Operating Categories	Standard Normal	
Recommended Fuel	Jet A1	

1.6.3 The aircraft's last maintenance/phase inspection was carried out on 19 September 2019 at 12 830.1 airframe hours. A Certificate of Release to Service was issued on 19 September 2019 with an expiry date of 18 September 2020 or at 13 830.1 hours, whichever occurs first. Examination of the available logbook copies indicated that all applicable recurring Service Bulletins (SBs) and Airworthiness Directives (Ads) were complied with as recommended by the aircraft manufacturer.

Engine No. 1:

Type	Pratt & Whitney PT6A-42
Serial Number	PCE-93770
Hours Since New	9 363
Hours Since Overhaul	2 610

Engine No. 2:

Type	Pratt & Whitney PT6A-42
Serial Number	PCE-93214
Hours Since New	12 532.2
Hours Since Overhaul	2 610.5

1.6.4 The number 2 engine was last overhauled on 31 October 2005 and had accumulated a total of 2610.5 hours since the last overhaul. The last Hot Section Inspection (HSI) was carried out on 10 August 2011 at 11 421.7 total engine hours since new and 1 500 hours since last overhaul. The engine had accumulated a total of 1 110.5 hours since its last HSI. Engine overhaul is due every 3 000 hours and HSI is due every 1 500 hours.

Note: An HSI involves examining the condition of a number of key engine parts, including the turbine blades, the combustion chamber, the stators, the vane rings, the compressor turbine disk and the shroud segments. A hot section inspection is performed on a PT6A-42 engine at 1 500-hour intervals.

1.6.5 According to available evidence (logbook entries), both engines were subjected to a scheduled compressor wash and borescope HSI. The last borescope inspection was carried out on 19 September 2019 at 12 830.1 airframe hours. There were no defects noted on the number 1 engine during this inspection. The last compressor wash was carried out on 21 October 2019 at 12 853.6 airframe hours.

1.6.6 During a borescope HSI carried out prior to the serious incident on 19 September 2020, the following observations were made on the number 2 engine:

- Small cracks on the power turbine stator on 3 blades
  - One small crack of approximately 0.3 inches was found at *6 o'clock* position.
  - Two cracks of approximately 0.3 inches were found at *7 o'clock* position
- These cracks were found to be within limits as per the Pratt & Whitney PT6A-42 maintenance manual part number (P/N) 3021442. These blades were not replaced between the time of inspection and the time of the serious incident flight.

1.6.7 There were no recorded damages or defects on the Compressor Turbine (CT) blades during the 19 September 2019 borescope inspection and the number 2 engine had flown a further 44.1 hours since its last borescope inspection. (See copy of engine logbook page 90 attached as Appendix A)

Propeller No. 1:

Type	Hartzell (HC-D4N-3A)
Serial Number	FY-2809
Hours Since New	2 610.9
Hours Since Overhaul	938.6

Propeller No. 2:

Type	Hartzell (HC-D4N-3A)
Serial Number	FY-2807
Hours Since New	2 610.9
Hours Since Overhaul	938.6

1.7 Meteorological Information

1.7.1 The weather information entered in the table (below) was obtained from the PIC questionnaire. This was the weather at altitude FL 250.

Wind direction	Westerly	Wind speed	70kts	Visibility	9999m
Temperature	-15˚C	Cloud cover	Overcast	Cloud base	Layered
Dew point	Unknown				

1.8. Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational equipment as approved by the Regulator (SACAA) for the aircraft type. There were no defects reported with the navigational equipment during the flight.

The aircraft was fitted with the following navigational aids:

- Transponder
- ADF-60(Automatic Direction Finder)
- DME-40 (Distance Measuring Equipment)
- VOR (Variable Omni Range) finder
- Magnetic compass
- Panel-mounted Garmin GPS
- Mode S transponder
- Instrument landing system (ILS)
- Collins Weather Radar

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment as approved by the Regulator (SACAA) for the aircraft type. There were no defects reported with the communication equipment during the flight. The PIC communicated his intention to divert to FALE for a precautionary landing and established radio contact with FALE radar approach on the very high frequency (VHF) 125.75 megahertz (MHz), which later handed them over to the tower frequency 118.45 MHz.

1.10 Aerodrome Information

1.10.1 The serious incident occurred at FL 250 position R025 DME50NM from FALE.

1.10.2 Eshowe Aerodrome was the nearest aerodrome to the aircraft's location at the time, but there was no technical support, and the crew had decided to divert to FALE.

Aerodrome Location	La Mercy, KwaZulu-Natal
Aerodrome Co-ordinates	29° 36' 42.38" S / 31° 7' 9.53" E
Aerodrome Elevation	304.0 feet Mean Sea Level
Runway Designations	06/24
Runway Dimensions	3701.5 x 61m
Runway Used	24
Runway Surface	Asphalt
Approach Facilities	VOR, ILS and DME

1.11 Flight Recorders

1.11.1 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), and none of these recorders was required by regulation.

1.12 Wreckage and Impact Information

1.12.1 None.

1.13 Medical and Pathological Information

1.13.1 None.

1.14 Fire

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The serious incident was considered survivable as there was no structural damage to the aircraft. All occupants made use of the aircraft's equipped safety harnesses.

1.16 Tests and Research

1.16.1 On 10 December 2019, the representative of Dallas Airmotive, which is situated in Lanseria Aerodrome (FALA) in Gauteng province, had travelled to FALE to carry out a borescope inspection on the number 2 engine of ZS-MIN with serial number PCE-93214. The inspection was carried out with the engine still mounted on the aircraft. The inspection concluded as follows:

- Cold Section: No oil leakages, noted minor paint flaking from the inlet, no foreign object and/or debris (FOD) noted on the compressor blades.
- Hot Section: No major heat erosion or cracks noted on the compressor turbine vane ring (CTVR) and small exit duct (SED), shroud intact with no major rub observed between compressor turbine (CT) blades and shrouds, low carbon content in combustion chamber (CC) liner with no visible cracks noted, no FOD or heat erosion noted on the power turbine (PT) blades, open cracks noted on the CT blade tips. (See full report attached as Appendix B)

1.16.2 The bleed valve did not deploy as the differential pressure in the compressor section did not affect the entire section. The difference in pressure led to disturbance of the airflow in the compressor section which, in turn, resulted in the increase in ITT.

1.17 Organisational and Management Information

1.17.1 This was a commercial passenger charter domestic flight which was conducted under the provisions of Part 135 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.17.2 The operator held a valid Air Operating Certificate (AOC) number CAA/N887D, which was issued on 25 September 2019 with an expiry date of 31 August 2020.

1.17.3 The last maintenance inspection that was carried out on the aircraft was certified on 19 September 2019 by an approved Aircraft Maintenance Organisation (AMO) number 1500 in accordance with Part 145 of the Civil Aviation Regulations (CAR) 2011 as amended. The AMO was in possession of an approved AMO certificate which was issued on 31 July 2019 with an expiry date of 31 July 2020.

1.18 Additional Information

Source: https://www.centex.aero/wp-content/themes/centex/assets/files/afm-006-2a-hw-ir-reference.pdf

1.18.1 King Air B200 Airplane Flight Manual (AFM):

ICING LIMITATIONS

The limitations and information presented in this subsection have been changed from the basic Airplane Flight Manual and Pilot Operation Handbook. The changes are considered by the FAA to be essential in ensuring the safe operation of the airplane in icing conditions.
Minimum Ambient Temperature for Operation of De-icing Boots……...-40˚C
Minimum Airspeed for Sustained Icing Flight…… 148kts

Sustained flight in icing conditions with flaps extended is prohibited except for approach and landing.

ENGINE ANTI-ICE shall be ON for operations in ambient temperature of +5˚C or below when flight free of visible moisture cannot be assured.

ENGINE ANTI-ICING shall be OFF for all take-off and flight operations in ambient temperatures above +15˚C

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 General

From the evidence available, the following analysis was made with respect to this serious incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.1.1 The PIC was issued an ATPL with the aircraft type endorsed on it. He had flown a total of approximately 9 140 hours, of which approximately 2 388 hours were on the aircraft type. He was also issued a Class 1 aviation medical certificate with a restriction to wear corrective lenses.

2.1.2 The FO was issued a CPL with the aircraft type endorsed on it. He had flown a total of approximately 2 565 hours, of which approximately 1 860 hours were on the aircraft type. He was also issued a Class 1 aviation medical certificate with no restrictions.

2.1.3 The aircraft was maintained by an approved AMO number 1500 which was in possession of an AMO approval certificate issued on 31 July 2019 with an expiry date of 31 July 2020. The last inspection that was carried out on the aircraft was certified on 19 September 2019 with an expiry date of 18 September 2020 or at 13830.1 hours, whichever occurs first.

2.1.4 The AME who released the aircraft to service was initially issued a licence on 20 April 1979. Pratt & Whitney PT6A engine series was initially issued on 2 September 1988. He did his revalidation and was reissued a licence and the PT6 series engine was endorsed on it. The licence was reissued on 19 December 2018 with an expiry date of 9 February 2021.

2.1.5 The crew stated that they approached clouds while at FL 250 and they had decided to deploy the ice vanes on both engines to prevent ice particle ingestion. According to the King Air 200 MM, engine anti-ice shall be set on ON position for operations in ambient temperature of +5°C or below when a flight free of visible moisture cannot be assured. The aircraft was cruising at FL 250 and the ice vanes were deployed at a temperature of -15°C as stated by the PIC in the pilot questionnaire, which was way beyond the limit. It is probable that the engine compressor developed ice on the stator aerofoils/blade, thus, disturbed the airflow in the compressor section. This resulted in the engine surge/stall and the high ITT.

2.1.6 According to the over-temperature limit in *Figure 501* in the engine report attached as Appendix B, if an engine had an ITT which is beyond allowable temperature between 0 and 30 seconds which is in the “D” area of the graph, the operator should remove the engine and ship it to the approved overhaul facility for HSI. According to the engine maintenance manual part number 3021442, most significant blade tip damages increases ITT, and even if the ITT is below maximum and CT blades damage is beyond the limit shown in *Figure 608* of Appendix B, it is recommended that the operator conducts an HSI. Post serious incident, the right-side engine was subjected to a borescope inspection and it was noted that there were open cracks on the CT blade tips. It is possible that the CT blades were already cracked, and ingestion of ice particles contributed in the ITT which had increased beyond limits.

2.1.7 When the compressor stalls, there is a reversal of the air flow in the engine (i.e. air comes back out the inlet of the engine). This, in turn, does not allow for sufficient air flow to the combustion/hot section, yet fuel is still being introduced into the engine. Thus, with more fuel than air, the ITT will increase. Depending on the operating condition, it could cause an ITT exceedance.

2.1.8 If the surging continues, it is more likely that the ITT will increase (continued loss of air flow into the engine). Noting that the throttle had to be reduced to stop the surging suggests that the compressor stall was severe. There was a possibility that the late activation of the ice vanes had already allowed for ice particles to enter the engines, which in turn generated inefficiencies in the compressor, resulting in the compressor stalling and the subsequent ITT exceedance.

2.1.9 The investigation determined that the engine ice vanes were not activated on time during operation in temperature below +5°C, which caused ice particles to enter the engine, disturbing the air flow in the engine compressor. This resulted in the compressor stalling and the subsequent ITT exceedance.

3. CONCLUSION

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this serious incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions heading:

- **Findings —** are statements of all significant conditions, events or circumstances in this serious incident. The findings are significant steps in this serious incident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this serious incident.

  Contributing factors — are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 The PIC was issued an ATPL on 24 October 2019 with an expiry date of 31 October 2020. The pilot was issued a valid Class 1 aviation medical certificate with an expiry date of 31 October 2020.

3.2.2 The FO was issued a CPL on 22 October 2019 with an expiry date of 31 October 2020. The FO was in possession of a valid Class 1 aviation medical certificate with an expiry date of 31 August 2020.

3.2.3 The AME who released the aircraft to service was initially issued an AME licence on 20 April 1979. Pratt & Whitney PT6A engine series was initially issued on 2 September 1988. The AME completed his revalidation and was reissued a licence and the PT6 series engine was endorsed on it. The licence was reissued on 19 December 2018 with an expiry date of 9 February 2021.

3.2.4 The aircraft Certificate of Airworthiness was issued on 20 June 2014 with an expiry date of 30 June 2020.

3.2.5 The aircraft was issued a Certificate of Registration on 21 May 2019.

3.2.6 The last phases 3 & 4 inspection on the aircraft were completed on 19 September 2019.

3.2.7 Examination of the available logbook copies indicated that all applicable recurring SBs and ADs were complied with as recommended by the aircraft manufacturer.

3.2.8 The Certificate of Release to Service was issued on 19 September 2020 at 12 830.1 aircraft hours with an expiry date of 18 September 2020 or at 13 830.1 hours, whichever occurs first.

3.2.9 Following a compressor stall on the number 2 engine, an ITT exceedance was observed, and the PF decided to shut down the engine and diverted to FALE as a precautionary measure where the aircraft landed safely.

3.2.10 The investigation determined that the engine ice vanes were not activated on time during operation in temperature below +5°C, which caused ice particles to enter the engine, disturbing the air flow in the engine compressor. This resulted in the compressor stalling and the subsequent ITT exceedance.

3.2.11 It is possible that the CT blades were already cracked, and ingestion of ice particles contributed in the ITT which had increased beyond limits.

3.3 Probable Cause/s

3.3.1 The engine ice vanes were not activated on time during operation in temperatures below +5°C, which caused ice particles to enter the engine, disturbing the air flow in the engine compressor. This resulted in the compressor stalling and the subsequent ITT exceedance.

3.4 Contributory Factors

3.4.1 Non-adherence to standard operating procedures.

3.4.2 It is possible that the CT blades were already cracked, and ingestion of ice particles contributed in the ITT which had increased beyond limits.

4. SAFETY RECOMMENDATIONS

4.1 General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report; the AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2 Safety Recommendation/s

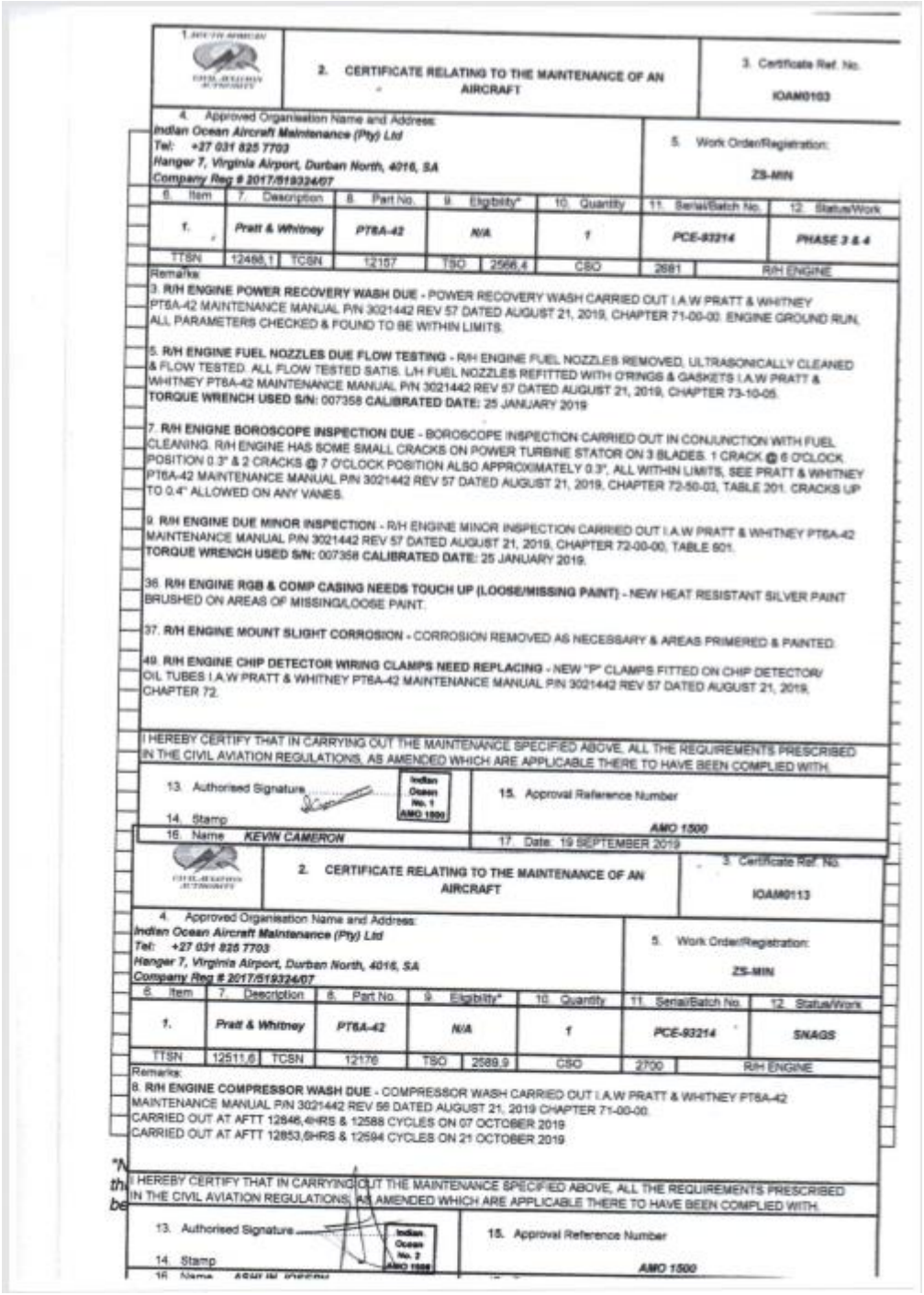
4.2.1 **Safety message:** Operator/s should, through their training programme, ensure that their pilots adhere to the manufacturers' prescripts in particular when operating in abnormal conditions such as icing conditions.

5. APPENDICES

5.1 Appendix A (Copy of right-hand engine logbook)
5.2 Appendix B (Engine evaluation / condition report (Borescope).

This Report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

Appendix A



2. CERTIFICATE RELATING TO THE MAINTENANCE OF AN AIRCRAFT

3. Certificate Ref. No.: IOAM0103

4. Approved Organisation Name and Address:
Indian Ocean Aircraft Maintenance (Pty) Ltd
Tel: +27 031 925 7703
Hanger 7, Virginia Airport, Durban North, 4016, SA
Company Reg # 2017/519324/07

5. Work Order/Registration: **ZS-MIN**

6. Item	7. Description	8. Part No.	9. Eligibility*	10. Quantity	11. Serial/Batch No.	12. Status/Work
1.	Pratt & Whitney	PT6A-42	N/A	1	PCE-93214	PHASE 3 & 4

TTSN	12468,1	TCSN	12157	TSO	2566,4	CSO	2691	R/H ENGINE

Remarks:

3. **R/H ENGINE POWER RECOVERY WASH DUE** - POWER RECOVERY WASH CARRIED OUT I.A.W PRATT & WHITNEY PT6A-42 MAINTENANCE MANUAL P/N 3021442 REV 57 DATED AUGUST 21, 2019, CHAPTER 71-00-00. ENGINE GROUND RUN, ALL PARAMETERS CHECKED & FOUND TO BE WITHIN LIMITS.

5. **R/H ENGINE FUEL NOZZLES DUE FLOW TESTING** - R/H ENGINE FUEL NOZZLES REMOVED, ULTRASONICALLY CLEANED & FLOW TESTED. ALL FLOW TESTED SATIS. L/H FUEL NOZZLES REFITTED WITH O'RINGS & GASKETS I.A.W PRATT & WHITNEY PT6A-42 MAINTENANCE MANUAL P/N 3021442 REV 57 DATED AUGUST 21, 2019, CHAPTER 73-10-05.
TORQUE WRENCH USED S/N: 007358 **CALIBRATED DATE:** 25 JANUARY 2019

7. **R/H ENGINE BOROSCOPE INSPECTION DUE** - BOROSCOPE INSPECTION CARRIED OUT IN CONJUNCTION WITH FUEL CLEANING. R/H ENGINE HAS SOME SMALL CRACKS ON POWER TURBINE STATOR ON 3 BLADES. 1 CRACK @ 6 O'CLOCK POSITION 0.3" & 2 CRACKS @ 7 O'CLOCK POSITION ALSO APPROXIMATELY 0.3", ALL WITHIN LIMITS, SEE PRATT & WHITNEY PT6A-42 MAINTENANCE MANUAL P/N 3021442 REV 57 DATED AUGUST 21, 2019, CHAPTER 72-50-03, TABLE 201. CRACKS UP TO 0.4" ALLOWED ON ANY VANES.

9. **R/H ENGINE DUE MINOR INSPECTION** - R/H ENGINE MINOR INSPECTION CARRIED OUT I.A.W PRATT & WHITNEY PT6A-42 MAINTENANCE MANUAL P/N 3021442 REV 57 DATED AUGUST 21, 2019, CHAPTER 72-00-00, TABLE 601.
TORQUE WRENCH USED S/N: 007358 **CALIBRATED DATE:** 25 JANUARY 2019.

36. **R/H ENGINE RGB & COMP CASING NEEDS TOUCH UP (LOOSE/MISSING PAINT)** - NEW HEAT RESISTANT SILVER PAINT BRUSHED ON AREAS OF MISSING/LOOSE PAINT.

37. **R/H ENGINE MOUNT SLIGHT CORROSION** - CORROSION REMOVED AS NECESSARY & AREAS PRIMERED & PAINTED.

49. **R/H ENGINE CHIP DETECTOR WIRING CLAMPS NEED REPLACING** - NEW "P" CLAMPS FITTED ON CHIP DETECTOR/ OIL TUBES I.A.W PRATT & WHITNEY PT6A-42 MAINTENANCE MANUAL P/N 3021442 REV 57 DATED AUGUST 21, 2019, CHAPTER 72.

I HEREBY CERTIFY THAT IN CARRYING OUT THE MAINTENANCE SPECIFIED ABOVE, ALL THE REQUIREMENTS PRESCRIBED IN THE CIVIL AVIATION REGULATIONS, AS AMENDED WHICH ARE APPLICABLE THERE TO HAVE BEEN COMPLIED WITH.

13. Authorised Signature: Indian Ocean No. 1 AMO 1500
14. Stamp
15. Approval Reference Number: **AMO 1500**
16. Name: **KEVIN CAMERON**
17. Date: 19 SEPTEMBER 2019

2. CERTIFICATE RELATING TO THE MAINTENANCE OF AN AIRCRAFT

3. Certificate Ref. No.: IOAM0113

4. Approved Organisation Name and Address:
Indian Ocean Aircraft Maintenance (Pty) Ltd
Tel: +27 031 925 7703
Hanger 7, Virginia Airport, Durban North, 4016, SA
Company Reg # 2017/519324/07

5. Work Order/Registration: **ZS-MIN**

6. Item	7. Description	8. Part No.	9. Eligibility*	10. Quantity	11. Serial/Batch No.	12. Status/Work
1.	Pratt & Whitney	PT6A-42	N/A	1	PCE-93214	SNAGS

TTSN	12511,6	TCSN	12176	TSO	2589,9	CSO	2700	R/H ENGINE

Remarks:

8. **R/H ENGINE COMPRESSOR WASH DUE** - COMPRESSOR WASH CARRIED OUT I.A.W PRATT & WHITNEY PT6A-42 MAINTENANCE MANUAL P/N 3021442 REV 56 DATED AUGUST 21, 2019 CHAPTER 71-00-00.
CARRIED OUT AT AFTT 12846,4HRS & 12588 CYCLES ON 07 OCTOBER 2019
CARRIED OUT AT AFTT 12853,6HRS & 12594 CYCLES ON 21 OCTOBER 2019

I HEREBY CERTIFY THAT IN CARRYING OUT THE MAINTENANCE SPECIFIED ABOVE, ALL THE REQUIREMENTS PRESCRIBED IN THE CIVIL AVIATION REGULATIONS, AS AMENDED WHICH ARE APPLICABLE THERE TO HAVE BEEN COMPLIED WITH.

13. Authorised Signature: Indian Ocean No. 2 AMO 1500
14. Stamp
15. Approval Reference Number: **AMO 1500**

Appendix B

Engine Evaluation / Condition Report

DallasAirmotive

A BBA Aviation company

Engine Evaluation / Condition Report

CUSTOMER:	INDIAN OCEAN AIRCRAFT MAINTENANCE	WORK ORDER NO:	TBA
CUSTOMER PH:	0737100434	ENGINE MODEL:	PT6A-42
AIRCRAFT REG. NO:	ZS-MIN	ENGINE S/N:	PCE-93214
AIRCRAFT TT:	TBA	AIRCRAFT TC:	TBA
REASON FOR INSPECTION:		Perform Engine Evaluation as per PWC M.M. and (or) Customer P.O. Requirements.	
INSTALLED ON AIRCRAFT S/N:		BB-941	
INSPECTION DATE:	10 DEC 2019	ENGINE POSITION:	RH
TSN:	12532.2	CSN:	12198
TSO	2610.5	CSO	2722
ISSUED BY:	J. VORSTER		

PEOPLE YOU TRUST PERFORMANCE YOU COUNT ON.

NOTE: Given the nature of borescope instrumentation it is often not possible to make observations and examine all areas of an individual engine as part of an inspection. Based on this limitation, Dallas Airmotive, Inc. cannot and does not warrant its findings for borescope evaluations (pre-purchase and otherwise) against the possibility that hidden damage may exist that was not observable and reported by our technician at the time of the evaluation.

Engine Evaluation / Condition Report

Areas Evaluated During Borescope Evaluation

Inlet & Compressor Area / Cold Section

- ✓ *Inlet Housing.*
- ✓ *1st Stage Compressor Blades.*

Turbine & Exhaust Area / Hot Section

- ✓ *CTVR and SED*
- ✓ *CT Blades and Shrouds*
- ✓ *Combustion Liner*
- ✓ *PT Blades*

Engine Evaluation Findings

Cold Section – No Oil leakage noted. Minor Paint Flaking from Inlet. No FOD noted on Compressor Blades.

Hot Section – No Major heat erosion or cracks noted on CTVR and SED. Shrouds intact with no major rub observed between CT Blades and Shrouds. Low carbon content in CC liner with no visible cracks noted. No FOD or heat erosion noted on PT Blades. Open cracks noted on the CT Blade tips.

Hot section repair (Light Overhaul as per PWC Maintenance requirements for Overtemp condition) is required at this time due to the condition of the CT Blade tips. Crew reported engine Stall at cruise. The throttle was retarded to reduce the stall condition. The crew then noticed a climb in ITT, they noticed 950 deg C for 5 seconds. The Prop was feathered, and engine shut down at this time.

NOTE: Given the nature of borescope instrumentation it is often not possible to make observations and examine all areas of an individual engine as part of an inspection. Based on this limitation, Dallas Airmotive, Inc. cannot and does not warrant its findings for borescope evaluations (pre-purchase and otherwise) against the possibility that hidden damage may exist that was not observable and reported by our technician at the time of the evaluation.

MAINTENANCE MANUAL

MODEL(S): PT6A-38, PT6A-41, PT6A-42, PT6A-42A

MANUAL PART NO. 3021442, REVISION NO. 57.1, DATED AUG-21-2019

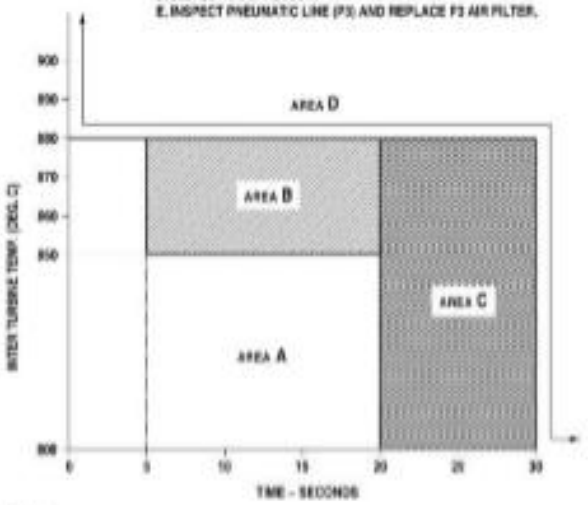
Figure 501 Overtemperature Limits - All Conditions Except Starting (sheet 3 of 3)

AREA A NO ACTION REQUIRED.

AREA B 1. DETERMINE AND CORRECT CAUSE OF OVERTEMPERATURE (REF. CHAP. 72-00-00, INSPECTION, UNSCHEDULED INSPECTION)
2. RECORD IN ENGINE LOG BOOK.

AREA C DO HOT SECTION INSPECTION.

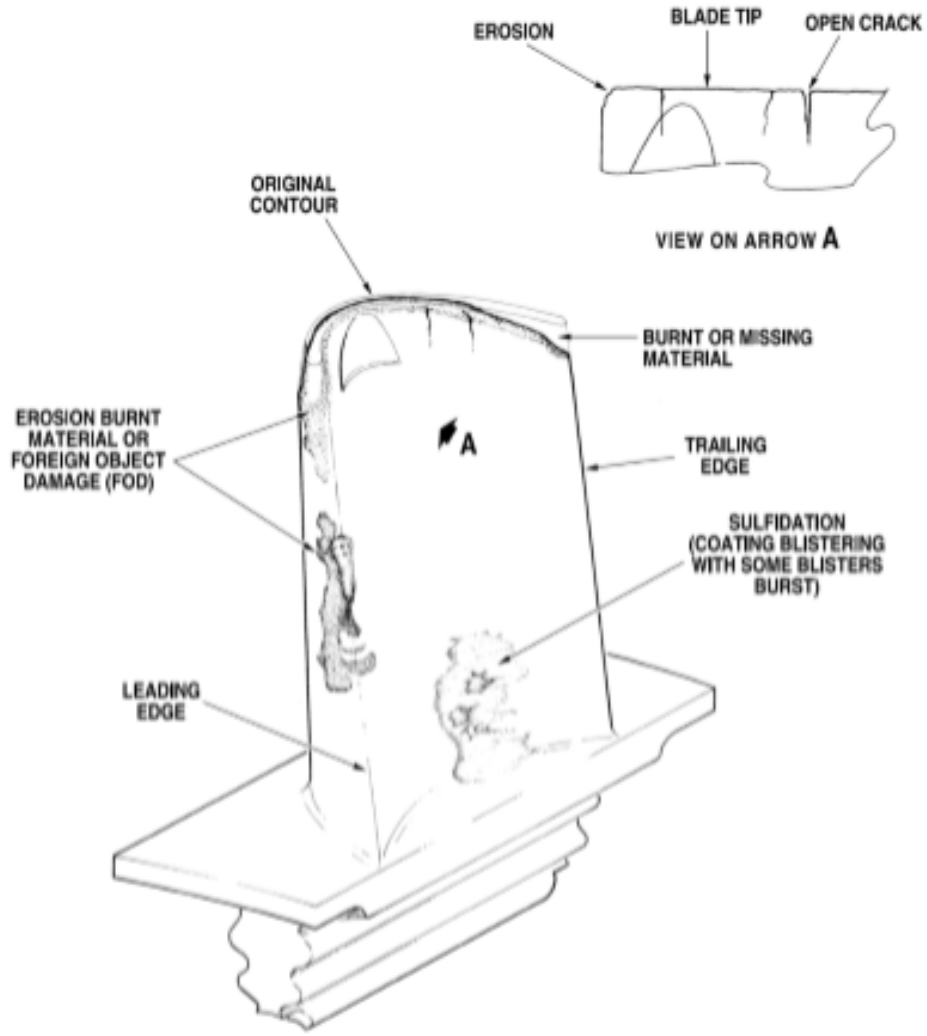
AREA D 1. RETURN ENGINE TO AN APPROVED OVERHAUL FACILITY,
2. FOR OPERATORS UTILIZING THE MODULAR PROGRAM:
A. DO HOT SECTION INSPECTION.
B. RETURN POWER SECTION TO OVERHAUL FACILITY.
C. RETURN FUEL CONTROL UNIT TO OVERHAUL FACILITY.
D. INSPECT COMPRESSOR.
E. INSPECT PNEUMATIC LINE (P3) AND REPLACE P3 AIR FILTER.



NOTE:
INTERTURBINE TEMPERATURES SHOWN MAKE NO ALLOWANCE FOR INSTRUMENT ERRORS

PT6A-42/42A Engines icn-00198-g000006558-001-01

Figure 608 CT Blade Damage - Unacceptable



Engine Evaluation / Condition Report

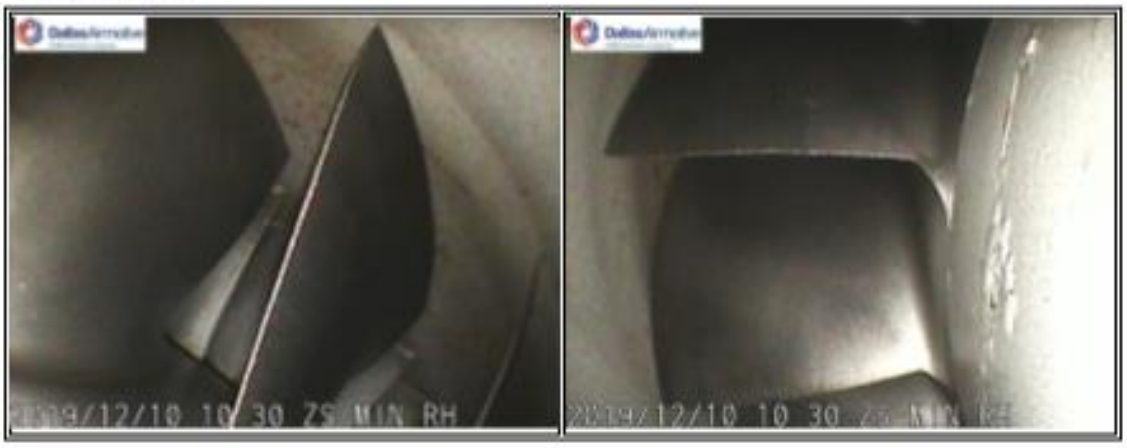
Aircraft Reg

Data Plate

Inlet Case

Compressor blades

Compressor Blades



Engine Evaluation / Condition Report

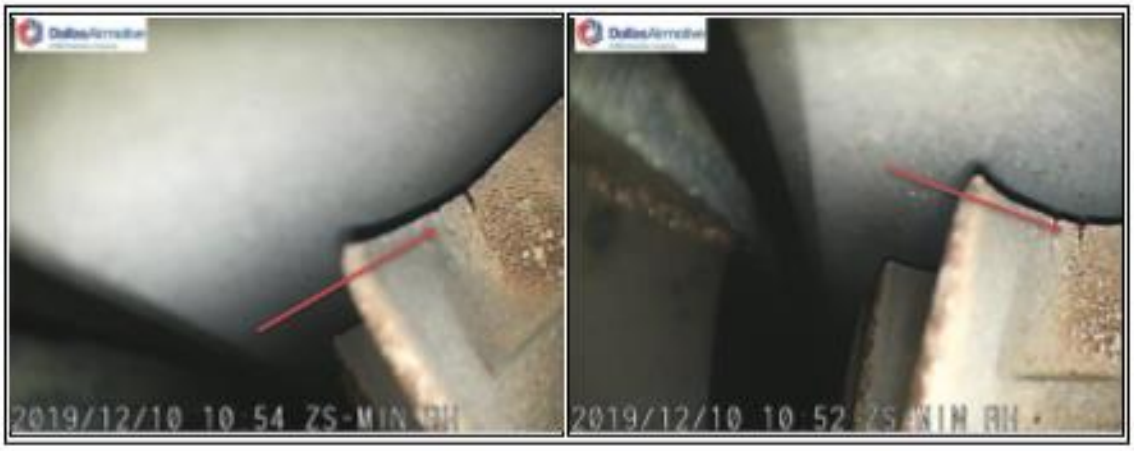
Compressor

CTVR and 8ED

CTVR and 8ED

Engine Evaluation / Condition Report

CT Blades and shrouds



CT Blades and shrouds

CT Blades

Engine Evaluation / Condition Report

Combustion Liner

PT Blades

PT Blades Firtree Area