SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident and Incident Investigations Division** Form Number: CA 12-12b

AIRCRAFT INCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/3/2/1273		
Aircraft Registration	ZS-ZWE	**Date of Incident**	8 July 2019		**Time of Accident**	1112Z	
Type of Aircraft	Boeing 737-800NG		**Type of Operation**		Commercial (Part 121)		
Pilot-in-command Licence Type	Airline Transport Pilot Licence			**Age**	41	**Licence Valid**	Yes
First Officer Licence Type	Airline Transport Pilot Licence			**Age**	30	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	10569	Hours on Type	6879			
First Officer Flying Experience	Total Flying Hours	3459	Hours on Type	1012.5			
Last Point of Departure	Cape Town International Aerodrome (FACT), Western Cape Province						
Next Point of Intended Landing	Lanseria International Aerodrome (FALA), Gauteng Province						
Location of the incident site with reference to easily defined geographical points (GPS readings if possible)							
In-flight south of Potchefstroom Aerodrome (FAPS) FAR75 at position 30nm from FALA							
Meteorological Information	Wind: 220°/09kt; Temperature: 17°C; Visibility: 9999 and QNH: 1027						
Number of People On-board	2+4+194	**No. of People Injured**	0	**No. of People Killed**	0		
Synopsis							

On Sunday, 7 July 2019, a Boeing 737-800 aircraft with registration marks ZS-ZWE experienced a starter failure on engine number 1 during start-up at George Aerodrome (FAGG) while preparing for departure to Cape Town International Aerodrome (FACT). The aircraft was grounded and a provision for a serviceable starter was made. The starter was installed on the same day by an available aircraft maintenance engineer (AME); and the aircraft was signed out thereafter. The flight from FAGG to FACT was uneventful.

The next day, on 8 July 2019, while the aircraft was on its third leg of the day from FACT to Lanseria International Aerodrome (FALA), the crew reported a significant in-flight engine number 1 oil loss. The crew contacted the maintenance control centre (MCC) which advised them to continue flying with the number 1 engine running until the oil quantity indicator reached 0%; thereafter, shut engine number 1 down and divert to O.R. Tambo International Aerodrome (FAOR).

When engine number 1 oil quantity reached 0%, the crew shut it down as advised by MCC before making a request to divert to FAOR, which was granted. The aircraft landed safely at FAOR and was escorted to the apron by emergency services on standby during landing.

The investigation revealed that the starter oil drain/fill magnetic plug had separated during a flight from FACT to FALA as it was not locked after maintenance which was undertaken the previous day. This resulted in the oil leaking from the engine number 1 through the starter oil drain/fill port.

SRP Date	14 July 2020	Publication Date	31 July 2020

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ABBREVIATION	DESCRIPTION
°	Degrees
°C	Degrees Celsius
AIID	Incident and Incident Investigations Division
AME	Aircraft Maintenance Engineer
AMO	Aircraft Maintenance Organisation
ASL	Air Service License
CAR	Civil Aviation Regulations
CAVOK	Ceiling and Visibility OK
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
E	East
ft.	Feet
FAR75	Restricted Area 75 near Potchefstroom
FALA	Lanseria International Airport
FACT	Cape Town International Airport
FAOR	O.R. Tambo International Airport
GPS	Global Positioning System Coordinates
hPa	Hectopascal (1 hPa = 100 Pa)
km	Kilometres
kt	Knots
L	Litres
m	Metres
MPI	Mandatory Periodic Inspection
MSG	Meteos at Second Generation image
MCC	Maintenance Control Centre
S	South
SACAA	South African Civil Aviation Authority
SAAT	South African Airways Technical
QNH	Q code indicating the atmospheric pressure adjusted to mean sea level
QA	Quality Assurance
UTC	Co-ordinated Universal Time

Reference Number	**:** CA18/3/2/1273
Name of Owner/Operator	**:** Comair Limited
Manufacturer	**:** Boeing Aircraft Company
Model	**:** Boeing 737-800NG
Nationality	**:** South African
Registration Marks	**:** ZS-ZWE
Place	**:** During flight at position 30nm south of FALA
Date	**:** 8 July 2019
Time	**:** 1112Z

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 incident was notified to the Accident and Incident Investigations Division (AIID) on 9 July 2019 at about 0810Z. The investigator/s dispatched to George on 16 July 2019. The investigator/s co-ordinated with all authorities on-site by initiating the incident investigation process according to CAR Part 12 and investigation procedures. The AIID of the SACAA is leading the investigation as the Republic of South Africa is the State of Occurrence.

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

- *Incident – this investigated incident*
- *Aircraft – the Boeing 737-800 involved in this incident*
- *Investigation – the investigation into the circumstances of this incident*
- *Pilot – the pilot involved in this incident*
- *Report – this incident report*

2. Photos and figures used in this report were 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 were 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 8 July 2019, a Boeing 737-800 aircraft with registration marks ZS-ZWE, which is owned by Comair Limited and operated by Kulula, took off from Cape Town International Aerodrome (FACT) on a commercial flight (flight number CAW494) to Lanseria International Aerodrome (FALA). On-board the aircraft were two pilots, four crew members and 194 passengers (consisting of 188 adults and six infants). According to the pilot, 10 nautical miles (nm) prior to initiating a descent for landing at FALA, the crew noticed that the engine number 1 oil quantity indication warning caption read 17%. The pilots followed the emergency check list requirements and contacted FAOR Area Control (ATC) to request an early descent from flight level (FL) 330 (or 33000) feet (ft) above mean sea level (AMSL) to FL210. The pilots also contacted the South African Airways Technical (SAAT) Maintenance Control Centre (MCC), which advised them to continue to FALA whilst monitoring the aircraft's engine number 1 oil quantity. The MCC further advised the crew that should the oil quantity reach 0%, they should shut down engine number 1 and divert to O.R. Tambo International Aerodrome (FAOR).

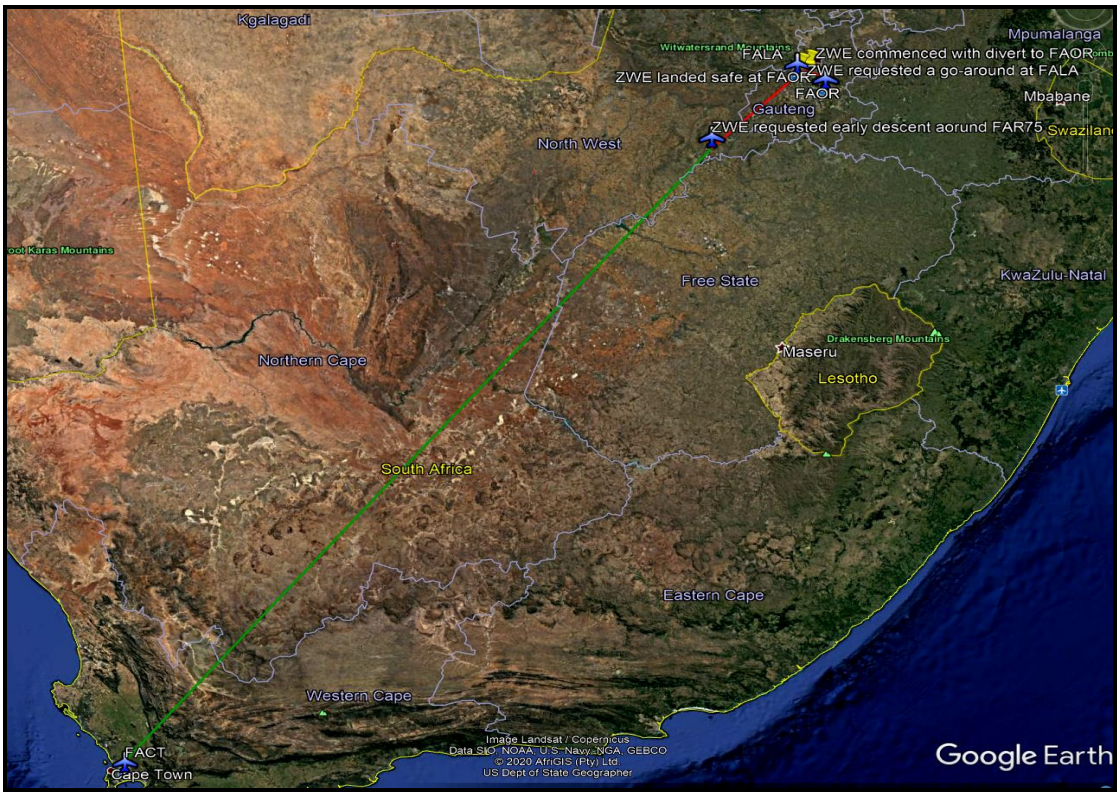


Figure 1: The aircraft route from FACT to FAOR.

1.1.2 The pilots started their descent to FALA as per the MCC's advise while monitoring the aircraft's engine number 1 oil quantity. The engine number 1 oil quantity continued to drop until it reached 0% and, at that point, the crew shut down engine number 1. They then requested to divert to FAOR and their request was granted. The aircraft diverted to FAOR whilst the pilots continued with further in-flight engine shutdown procedures.

1.1.3 The aircraft proceeded to FAOR whilst maintaining FL110 under radar control. Upon reaching FAOR, the pilots conducted an emergency landing procedure and landed safely on Runway 21L. The aircraft was escorted to the apron by emergency services on standby during landing. The aircraft's occupants did not sustain injuries; and the aircraft's damage was limited to the starter.

1.1.4 The aircraft incident occurred during daylight meteorological conditions while the aircraft was airborne south of Potchefstroom Airport (FAPS) FAR75, 30nm from FALA.

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	4	194	-

1.3. Damage to Aircraft

1.3.1 None.

1.4. Other Damage

1.4.1 None.

1.5. Personnel Information

Pilot-in-command (PIC)

Nationality	South African	Gender	Male	Age	41
Licence Number	0270427313	Licence Type	Airline Transport Pilot Licence (Aeroplane)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Night				
Medical Expiry Date	31 March 2020				
Restrictions	Corrective lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	10569
Total Past 90 Days	157
Total on Type Past 90 Days	157
Total on Type	6879

First Officer (FO)

Nationality	South African	Gender	Male	Age	30
Licence Number	0272365958	Licence Type	Airline Transport Pilot Licence (Aeroplane)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Night & Instructor Grade II				
Medical Expiry Date	31 August 2019				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	3459.2
Total Past 90 Days	194
Total on Type Past 90 Days	194
Total on Type	1012.5

Aircraft Maintenance Engineer (AME)

Nationality	South African	Gender	Male	Age	55
Licence Type	Aircraft Maintenance Engineer				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	A340-212/313/642, B737-200/300/400, CFM56-3/5 series, P&W JTBD series and R R RB211-524, B737-800 (CFM56-7BE)				
Licence Expiry Date	2 October 2020				
Restrictions	None				
Previous Accidents	None				

1.5.1 The aircraft maintenance engineer (AME) who conducted maintenance on the aircraft is qualified, rated and licensed to conduct maintenance on the aircraft type in accordance with approved regulatory procedures and the South African Airways Technical (SAAT) procedures.

An interview with the AME, as well as evidence provided by the air traffic control (ATC) revealed the following sequence of events on the date of maintenance, 7 July 2019:

(i) The AME, who was permanently based in Cape Town, was the only person on duty on that day. He was standing-in (on a relief basis) for a local AME at George line station.
(ii) The ZS-ZWE aircraft landed at FAGG on Sunday, 7 July 2019 at 0646Z. The aircraft was pushed back from the bay at 0720Z. The engine number 1 starter failed during start up, and thus, the aircraft was returned to the bay.
(iii) The AME phoned the MCC in Johannesburg and advised them of the starter failure on the aircraft. There was no spare starter available in the stores in Johannesburg, however, there was one available on a serviceable engine, which was in the engine shop. The AME was then advised that the starter would be available, and that it would be shipped to FAGG for installation on the aircraft the same day. An aircraft from Johannesburg with registration marks ZS-ZWB arrived at 1125Z with the starter.
(iv) The AME had to first accomplish the turnaround checks on the aircraft ZS-ZWB upon its arrival at FAGG in preparation for departure at 1155Z.
(v) Another Kulula aircraft, ZS-ZWJ, arrived at FAGG at 1149Z. The AME accomplished the turnaround checks on ZS-ZWJ and the aircraft departed at 1223Z.
(vi) The AME then began removing the defect starter. It was then that he noticed that the starter had a different part number from the one supplied. At that point, he communicated with MCC to confirm interchangeability.
(vii) The Mango aircraft, ZS-SJB, arrived at FAGG at 1225Z. The AME had to attend to that aircraft as he was responsible for the turnaround of that aircraft as well. The aircraft departed at 1300Z and the AME went back to continue working on changing the starter on ZS-ZWE aircraft.
(viii) While busy with the starter change, a SAFAIR aircraft landed. SAAT provides only standby assistance for SAFAIR aircraft, and as such, the aircraft requested assistance with an oxygen bottle. However, the AME informed the crew that he was unable to assist them as his tasks on the day were beyond his capabilities.
(ix) After completing changing the starter, the ZS-ZWE aircraft departed at 1329Z.
(x) The AME reported that he completed the paperwork on the label and briefed MCC after ZS-ZWE had departed. He scanned a copy of the TL/36 (Defect Report) and mailed it to MCC. He also completed a GT/79 (Delay Report) and submitted it.
(xi) The last aircraft for the day was ZS-ZWC, which arrived at 1457Z and departed at 1730Z.

1.6. Aircraft Information

1.6.1 The Boeing 737-800NG aircraft was first produced in 1996 by Boeing Commercial Airplanes known as the next generation (NG) type of aircraft. They are short to medium range, narrow-body jet

airliners powered by two engines. The production series includes four variants and can seat between 110 and 210 passengers.

ZS-ZWE Boeing B737-800

Figure 2: The Boeing B737-800aircraft.

Airframe:

Type	Boeing B737-800 LD	
Serial Number	40854	
Manufacturer	Boeing Aircraft Company	
Date of Manufacture	2015	
Total Airframe Hours (At time of Incident)	11460	
Last Inspection (A-Check) (Date & Hours)	22 June 2019	11325
Hours Since Last MPI	135	
Certificate of Airworthiness (Expiry Date)	17 August 2019	
Certificate of Registry (Issue Date) (Present owner)	19 August 2015 Comair Limited	
Operating Categories	Standard Part 121	

Engine 1:

Type	CFM56-7BE
Serial Number	863206
Hours Since New	11460
Hours Since Overhaul	Modular type

1.6.2 A review of the aircraft maintenance records was conducted during the investigation. In relation to the reported incident, an intensive review of specific engine maintenance record revealed the following: On 7 July 2019, the engine number 1 starter change was conducted at FAGG after the ZS-ZWE aircraft starter failure on engine number 1. The aircraft proceeded with flight to FACT following the fitment of a replacement starter and a sign off by a qualified AME on the same day of installation (7 July 2019). On 8 July 2019, the engine experienced a loss of engine oil during a flight from FACT to FALA, which led to an in-flight engine number 1 shutdown, followed by the aircraft diverting to FAOR where it landed safely.

The aircraft starter:

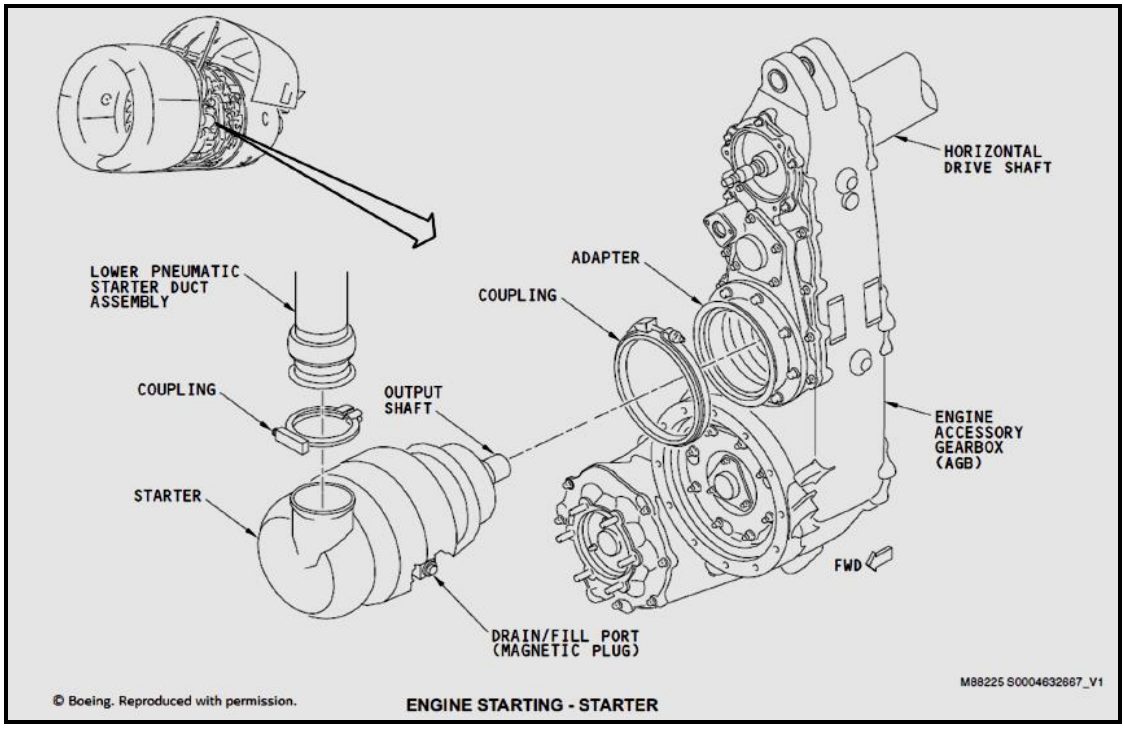


Figure 3: The aircraft engine starter attachment. (Extracted from GMM-1130041-02-A)

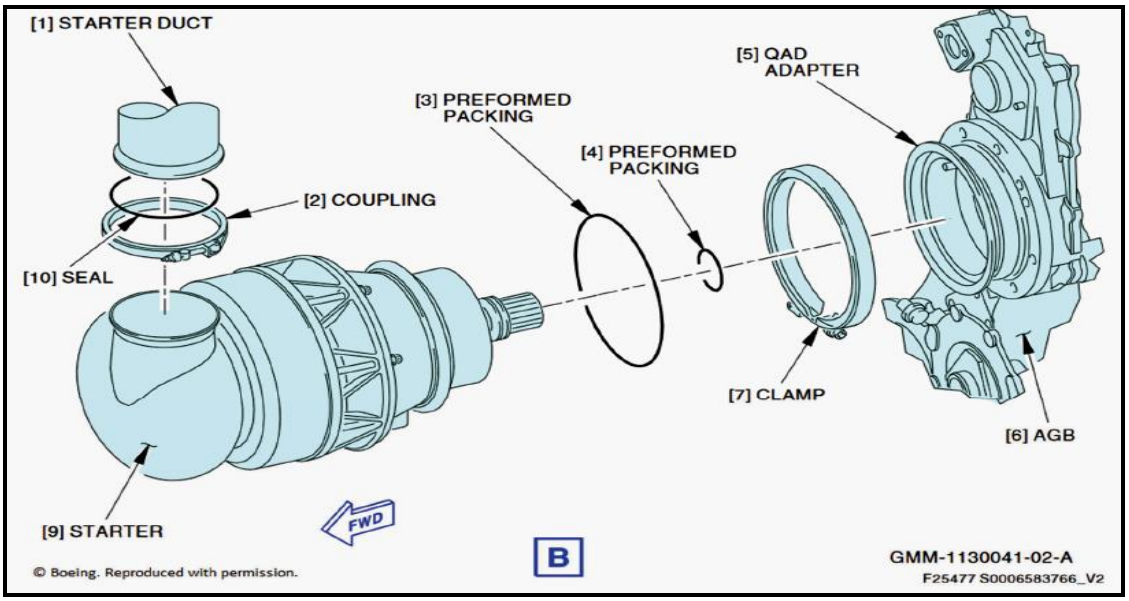


Figure 4: The starter installation diagram. (Extracted from GMM-1130041-02-A)

1.6.3 There was no maintenance conducted on the starter or any replenishment of the oil in engine number 1 after the aircraft arrived at FACT on 7 July 2019. There was also no evidence of oil replenishment or further maintenance on engine number 1 whilst the aircraft was in FACT.

1.6.4 There was also no evidence of reported/recorded failures with any of the aircraft components at FAGG on 7 July 2019 or at FACT on 7 and 8 July 2019.

Engine 2:

Type	CFM56-&BE
Serial Number	863212
Hours since New	11460
Hours since Overhaul	Modular type

1.7 Meteorological Information

1.7.1 Meteorological conditions are as per the mandatory occurrence reporting by the Air Traffic Navigation Systems (ATNS) on that day.

Wind direction	220°	Wind speed	09kt	Visibility	9999
Temperature	17°C	Cloud cover	None	Cloud base	None
Dew point	0°C	QNH	1027		

1.8 Aids to Navigation

1.8.1 The aircraft was fitted with the standard navigational aids as approved by the Regulator (SACAA) for this aircraft type. There were no defects recorded prior to this flight.

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment approved by the Regulator for this aircraft type. No defects were recorded with communication system prior to this flight.

1.10 Aerodrome Information

1.10.1 The aircraft incident occurred in-flight south of FAPS FAR75 at position 30nm from FALA. The aircraft landed uneventfully at FAOR Runway 21L following a flight diversion due to an in-flight shut down of engine number 1. FAOR is situated approximately 21nm south-east of FALA at GPS co-ordinates S 26° 8'25.93", E 028°14'34.07".

1.11 Flight Recorders

1.11.1 The aircraft is equipped with a quick access recorder (QAR), a digital flight data recorder (D-FDR) and a cockpit voice recorder (CVR). Both solid state type recorders – D-FDR and the CVR data – were downloaded by the investigation team with the assistance of the SAAT data downloading facility.

1.11.2 D-FDR and CVR information

Equipment	D-FDR	CVR
Part Number	980-4750-003	980-6022-001
Serial Number	FDR-06156	CVR120-07-492

1.11.3 D-FDR Recordings

The D-FDR downloaded information analysis revealed the following:

- The first indication of a reduction in engine number 1 oil quantity was at 11:11:25, with 12.8 units recorded. The previous recording was at 11:07:53 which indicated 13.3 units of oil quantity (recorded 04min 28seconds earlier).
- The engine number 1 oil quantity continued to drop at a constant rate during the cruise until 3 units remained at 11:54:01. Then the engine number 1 oil quantity began to drop at a slower rate during the descent until 1 unit remained at approximately 12:10:29.
- The oil quantity dropped to 0 during a go-around at approximately 12:14:37 over FALA. After

this, the engine number 1 fuel flow was reduced to 0 at approximately 12:17:32 which was 02 minutes and 55 seconds after the oil quantity reached 0 units indication on the cockpit display.

- The engine number 1 oil pressure dropped to 0 at approximately 12:18:12 which was 40 seconds after the fuel flow was shut down.
- The engine number 1 oil drained from 13.3 units to 0 units in approximately 1hr 6min and 44sec (from 11:07:53 to 12:14:37).

1.11.4 Further testing of the engine was carried out by the SAAT team, which required engine ground runs. This exercise led to the CVR being overwritten. An investigation as to why the engine testing was conducted without the knowledge of the investigating authorities was carried out by the SAAT Quality Assurance (QA) department. The investigation revealed that the AME, having the knowledge of the procedures to follow after an incident, disregarded the procedure and continued to conduct the engine testing without informing the SAAT QA department. Their procedure requires that they pull the CVR circuit breaker for the recording to stop. This was not done by both the pilots and the AME.

1.12 Wreckage and Impact Information

1.12.1 Not applicable.

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 during the incident.

1.15 Survival Aspects

1.15.1 The incident was considered survivable as the aircraft did not sustain damage to the cabin and cockpit that could have caused serious injuries to the occupants.

1.16 Tests and Research

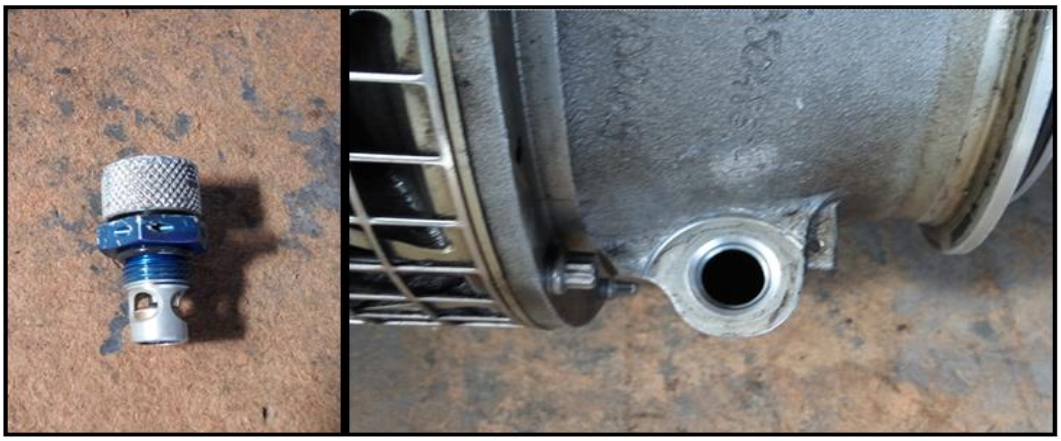


Figure 5: The drain/fill magnetic plug and the starter without locking wires.

1.16.1 According to the SAAT, during post-incident inspection, oil was found on the inside of the engine cowlings. Also, the starter drain/fill magnetic plug housing was found to have separated, and inside the cowlings and also without a wire lock.

1.16.2 A review of the maintenance procedure on how to remove and to install a serviceable starter was carried out.

The starter with part number (PN) 3505945-12 and serial number (SN) A1825C was removed from the engine number 1 with PN CFM56-7B26 and SN 875183 by SAAT and was inspected and tested in accordance with the Boeing 737-600-700-800-900 Aircraft Maintenance Manual (AMM) Rev#68 dated 15 February 2019. The starter was removed on 17 March 2019 and was then installed on ZS-ZWE on 7 July 2019.

According to the B737-600/700/800/900 AMM CML D633A101-CML Rev 69-15 June 2019

- *Task 80-11-01-000-801-F00 of the Starter removal in reference to the applicable sub tasks provides the starter removal procedure.*
- *Task 80-11-01-680-801-F00 Starter servicing (Oil drain) (P/B301), the following important tasks are highlighted*
  (a) Drain the oil for starter servicing upon removal.
  (b) Fill oil for starter installation.

Two methods are used in securing magnetic plug type. The method below is the relevant one for this engine.

1 CML all pre-SB 737-CFM56-7B-80-0011airplane with magnetic drain plug assembly PN:572-8510-9008and (tighten the magnetic plug housing (3) to 65.0in-lb(7.3Nm)-85.0in-lb(9.6Nm)
2 CML all post SB 737-CFM56-7B-80-0011, airplanes with magnetic drain plug assembly PN:3507975-1 (tighten the magnetic plug housing (3) to 20.00in-lb(2.26Nm)-40.00in-lb(4.56Nm).
3 Install the G02345 safety wire (CP8001) or the G50065 cable (CP8006) on the magnetic plug housing (3).

Starter Installation:
Task 80-11-01-400-801-F00 provides instruction on how to install starter procedure with the applicable sub-tasks reference.

1.17 Organisational and Management Information

1.17.1 The aircraft is operated by Comair Limited's Kulula as a scheduled commercial transportation flight between George, Cape Town International, Lanseria and O.R. Tambo International aerodromes. The operator had a valid Air Operator's Certificate (AOC) number FO 13653 issued by the Regulator on 30 April 2019. The aircraft had a valid certificate of airworthiness at the time of the incident. The operator also had a valid Air Service Licence issued by the Department of Transport.

1.17.2 The aircraft's maintenance service is conducted by SAAT as per the available contractual agreement between the operator and the SAAT. The maintenance service extends to the line services within the South African border for the operator's contracted routes and for several other operators. The aircraft maintenance organisation (AMO) number 1287 was issued a Part 145 Approval Certificate on 19 October 2018, with an expiry date of 30 October 2019.

1.17.3 A follow-up investigation relating to ZS-ZWE incident at George line maintenance station revealed the following:

(a). On 7 July 2019, the day before the incident, the AME had to deal with the following tasks, as well as with the starter change:

(i) The AME reported that he experienced difficulties opening the Comair B737-800 AMM on the computer in the SAAT office with the online system available at George (this was demonstrated to the investigators on 16 July 2019). The AME then called a colleague at SAAT Maintenance in Cape Town to assist him with the AMM reference and the torque values required for installing the clamps on the starter. The values and AMM reference were verbally provided over the telephone.

(ii) There was no torque wrench available in George to accomplish the starter change due to limited tools available at his disposal. He requested that the SAAT staff in Cape Town send a torque wrench to George on any flight. The torque wrench arrived in George at 15:00 on a SA Airlink aircraft.

(iii) The AME reported that he did not have a syringe available to service the starter, which requires a prescribed amount of oil to be injected into the starter.

(iv) The SAAT MCC dispatched the starter to George with only two O-rings supplied – the shaft O-ring and the casing O-ring. The O-ring for the magnetic drain plug housing required for servicing the starter was not supplied.

(v) Upon completion of the starter installation, he had to complete a Delay Report to explain the reason for the aircraft being delayed.

1.18 Additional Information

1.18.1 None.

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 incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.2

2.2.1 The crew was qualified and licensed for the flight in accordance with the regulatory approved procedures. The crew demonstrated good workmanship during the emergency. Their knowledge of the aircraft limitations was sufficient.

2.2.2 The PIC was issued a Class 1 medical certificate on 26 March 2019 with an expiry date of 31 March 2020. His licence renewal was conducted on 23 March 2019 after a proficiency check, with an expiry date of 31 May 2020.

2.2.3 The first officer (FO) was issued a Class 1 medical certificate on 22 August 2019 with an expiry date of 31 August 2020. His licence was renewed on 23 January 2019 after a proficiency check, with an expiry date of 31 January 2020.

2.2.4 The aircraft maintenance engineer (AME) was also qualified and licensed by the Regulator (SACAA) in accordance with stipulated procedures. He had over 30 years of experience as an AME and he was rated on the aircraft type. His licence was issued on 2 October 2019 with an expiry date of 2 October 2020.

2.2.5 The aircraft's last inspection was an A-check which was carried out on 22 June 2019 at 11325 hours. The aircraft was issued a certificate of registration (C of R) on 19 August 2015. The aircraft was also initially issued a certificate of airworthiness (C of A) on 18 August 2015 with an expiry date of 17 August 2019.

2.2.6 On 7 July 2019, the aircraft experienced engine number 1 starter failure during start-up at George Aerodrome (FAGG) whilst preparing for departure to Cape Town International Aerodrome (FACT). An AME changed the starter after seeking advice from MCC. During the starter change, the AME could not access the aircraft's maintenance manual (AMM) and had to consult with a base station in FACT. The AME followed the instructions given to him on how to change the starter. He did not have a copy of the procedure with him during the starter change. This may have caused the AME to omit correctly locking the oil drain/fill magnetic plug, and hence, its separation in-flight.

2.2.7 On 8 July 2019, the aircraft was on its third leg of the day which started at FACT outbound for Lanseria International Aerodrome (FALA) when it experienced a loss of oil in engine number 1. This loss of oil was caused by the starter oil drain/fill magnetic plug separating from its pot because it was not wire locked. The crew reported the incident to the MCC and they were advised to continue with the flight and with the engine number 1 running until the oil quantity indicator reached 0%, thereafter, shut down the engine number 1 and divert to O.R. Tambo International Aerodrome (FAOR).

2.2.8 It is likely that the starter oil drain/fill magnetic plug started moving out of its port during a flight from FAGG on 7 July 2019 (as well as during the first two legs of the flights conducted at FACT on 8 July 2018). On the third leg of the day (flight from FACT to FALA), the magnetic plug separated, and the oil started escaping from the engine number 1 through the starter oil drain/fil port.

2.2.9 The engine number 1 oil quantity reached 0% and the crew shut down the engine number 1 as advised by MCC before making a request to divert to FAOR, which was granted. The aircraft landed safely at FAOR and was escorted to the apron by emergency services on standby during landing.

2.2.10 Post-incident inspection revealed oil in the engine number 1 bay with the starter oil drain/fill magnetic plug separated from its attachment and located inside the engine bay on the bottom cowling. The separation of the starter oil drain/fill plug was determined to be the cause of the oil leaking from the engine number 1.

3. CONCLUSION

3.1. General

From the evidence available, the following findings, causes and contributing factors were made with respect to this 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 incident. The findings are significant steps in this 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 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 accident or 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 initially issued an ATPL on 14 December 2018. After his skill test on 12 December 2019, he was reissued an ATPL with an expiry date of 31 May 2020. He held the necessary ratings to operate the aircraft and had flown a total of 6879 hours on type. He was also issued a Class 1 aviation medical certificate on 26 March 2019 with an expiry date of 31 March 2020.

3.2.2 The FO was issued an ATPL on 23 January 2019 after his last skill test on both instrument ratings and competency test were carried out between 22 and 23 January 2019. The FO's ATPL was reissued on 23 January 2019 with an expiry date of 31 January 2020. He was rated to operate the aircraft and had flown a total of 1012.5 hours on type. The FO was also issued a Class 1 aviation medical certificate on 22 August 2018 with an expiry date of 31 August 2019.

3.2.3 The aircraft maintenance engineer (AME) was issued an AME Licence on 2 October 2019 with an expiry date of 2 October 2020. He had over 30 years' experience and was rated on the aircraft type.

3.2.4 The aircraft's last maintenance inspection was an A-check, which was carried out on 22 June 2019 at 11325 hours. The aircraft was issued a certificate of registration (C of R) on 19 August 2015. The aircraft was initially issued a certificate of airworthiness (C of A) on 18 August 2015 with an expiry date of 17 August 2019.

3.2.5 The ZS-ZWE starter was changed after it had failed to start-up engine number 1 on 7 July 2019. The starter was then fitted to the aircraft without correctly following the requirements of the maintenance manual.

3.2.6 Engine number 1 oil quantity was depleting due to a leak because of an oil drain/fill plug that had separated. After the oil quantity had reached 0%, the crew shut down engine number 1 in-flight and diverted to FAOR.

3.2.7 During the starter change and incident flight, MCC was consulted and gave advice to the AME and the crew.

3.2.8 The AME's inability to access the aircraft maintenance manual (AMM) resulted in him omitting to properly lock the starter oil drain/fill magnetic plug. This resulted in its separation from its port and the subsequent oil leak.

3.2.9 The investigation revealed that the starter oil drain/fill magnetic plug separated during a flight from FACT to FALA as it was not locked after maintenance which was undertaken the previous day. This resulted in the oil leaking from engine number 1 through the starter oil drain/fill port.

3.3. Probable Cause/s

3.3.1 The starter oil drain/fill magnetic plug separated during a flight from FACT to FALA as it was not locked after maintenance which was undertaken the previous day. This resulted in the oil leaking from the engine number 1 through the starter oil drain/fill port.

3.3.2 **Contributory Factors:**

3.3.2.1 The AME, when performing a starter change, relied on the information he was given by the base station in FACT, and not the AMM.

3.3.2.2 The AME was overwhelmed with work on 7 July 2019 due to extra maintenance required on the defected engine number 1 starter.

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 Given that the incident occurred because the maintenance personnel was unable to access the electronic aircraft maintenance manual, it is therefore, recommended that the DCA require maintenance organisations using electronic maintenance manuals/procedures to have offline systems (or hard copies) that could be accessed in instances where electronic maintenance manuals/procedures are unavailable to personnel.

4.2.2 Safety Message: Aircraft maintenance organisations must ensure that offline systems (or hard copies) are available to maintenance personnel in instances where personnel are unable to access electronic maintenance manuals/documentation.

5. APPENDICES

5.1 Appendix A: Engine Parameter reading

This Report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

Appendix A: Engine parameter read out FDR Data

ZS-ZWE DFDR DATA 8 July 2019.

DFDR Data – Summary

Part number: 980-4750-003

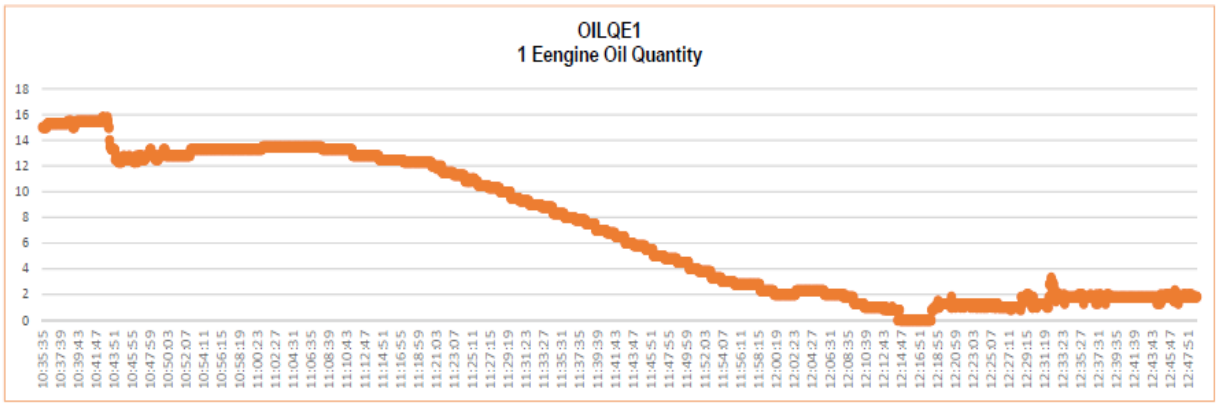
Serial number: FDR-06156

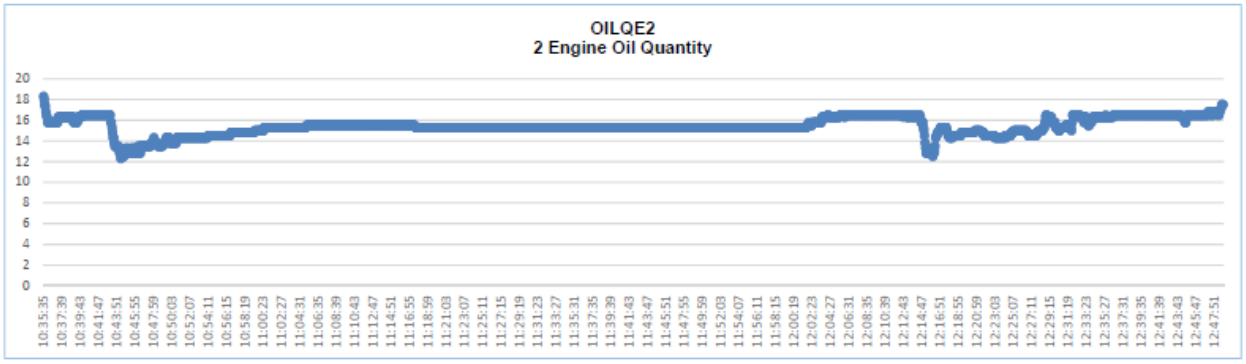
TIME	DELTA TIME	PALT	CAS	N1E 1	N1E 2	N2E 1	N2E 2	EGTE 1	EGTE 2	FFE 1	FFE 2	OILPE 1	OILPE 2	OILQE 1	OILQE 2	OILTE 1	OILTE 2
10:52:41	X	19318	283	98,88	98,88	98,75	98,63	804	801	6144	6144	58	62	13,3	14,3	84	83
11:05:01	12:20	33000	268	86,00	86,13	91,88	91,88	624	626	2656	2640	43	50	13.5	15.3	101	100
11:07:53	02:52	32994	269	86,38	86,38	92,13	92,13	618	619	2688	2656	43	50	13.3	15.5	101	100
11:11:25	06:24	32997	270	85,88	85,88	91,88	91,88	614	615	2640	2624	43	50	12,8	15,5	100	99
11:20:33	09:08	32996	268	86,38	86,38	92,13	92,13	619	621	2672	2672	43	50	12	15,3	98	97
11:24:21	03:48	32998	271	85,50	85,50	91,63	91,50	613	614	2608	2592	43	50	11	15,3	97	96
11:28:25	04:04	32999	268	85,63	85,50	91,75	91,63	613	615	2608	2592	42	50	10	15,3	97	96
11:31:49	03:24	33005	268	86,25	86,38	92,13	92,00	621	622	2672	2672	43	50	9	15,3	96	96
11:35:53	04:04	33003	270	85,75	85,75	91,88	91,75	618	619	2640	2608	42	50	8	15,3	96	95
11:39:29	03:36	33003	269	85,88	86,00	92,00	91,88	619	621	2640	2624	42	50	7	15,3	96	95
11:42:53	03:24	32998	269	86,00	86,13	92,00	92,00	621	622	2656	2640	42	50	6	15,3	95	95
11:46:09	03:16	33003	268	85,88	85,88	91,88	91,75	618	620	2624	2608	42	50	5	15,3	95	95
11:50:17	04:08	33004	270	85,50	85,50	91,75	91,63	615	616	2592	2576	42	50	4	15,3	95	95
11:54:01	03:44	33000	266	86,50	86,50	92,25	92,13	624	625	2688	2672	42	50	3	15,3	95	95
12:00:05	06:04	29559	291	77,63	77,50	89,75	89,50	548	551	2144	2128	40	48	2	15,3	99	98
12:10:29	10:24	10225	248	30,75	30,88	72,75	72,50	433	433	720	720	29	31	1	16,5	115	114
12:14:37	04:08	6005	142	49,63	51,50	84,38	85,00	492	497	2032	2064	37	39	0	16,5	113	111
12:17:32	02:55	7603	217	16,38	63,50	43,88	88,88	365	529	0	2512	12	49	0	15.3	98	92
12:18:12	00:40	7637	220	13,13	87,13	15,63	95,13	285	697	0	5632	0	56	0	14.3	99	90

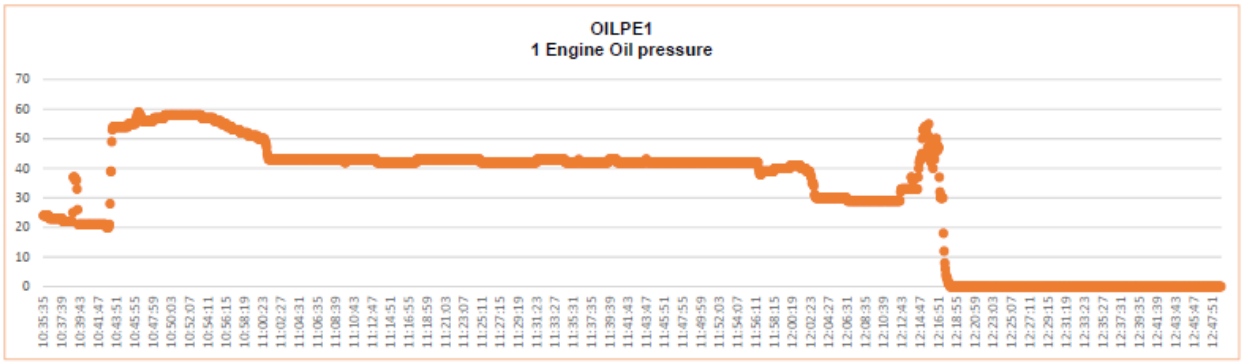
Summary

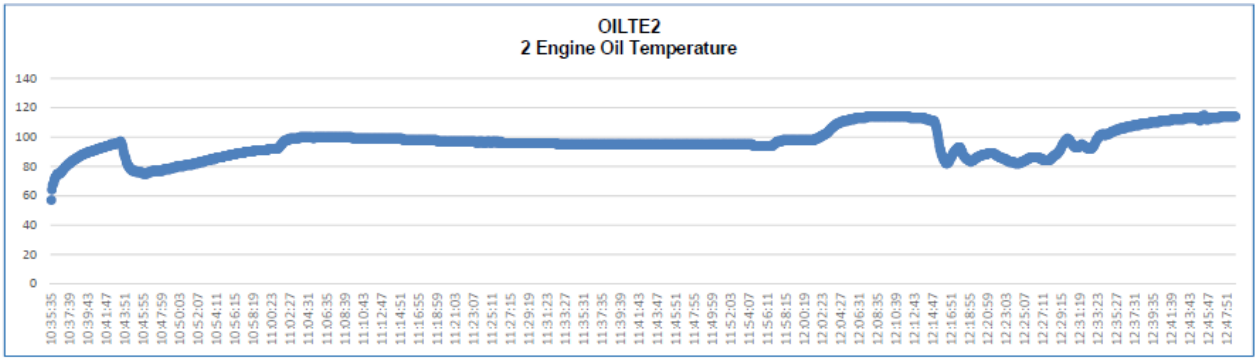
1. The first indication of a reduction in number 1 engine oil quantity was at 11:11:25, with 12.8 units recorded. The previous recording was at 11:07:53, which was 06min 24sec earlier with 13.3 units of oil recorded.
2. The number 1 engine oil quantity continued to drop at a constant rate during the cruise up to 3 units remaining at 11:54:01. The number 1 engine oil quantity dropped at a slower rate during the descent to 1 unit at 12:10:29.
3. The number 1 engine oil quantity dropped to 0 units during the go-around at 12:14:37. Number 1 engine fuel flow was reduced to 0 at 12:17:32, which was 02min 55sec after the oil quantity was 0 units.
4. The number 1 engine oil pressure dropped to 0 at 12:18:12, which was 40sec after the fuel flow was shut down.
5. The number 1 engine oil drained from 13.3 units to 0 units in 1hr 6min 44sec (from 11:07:53 to 12:14:37).

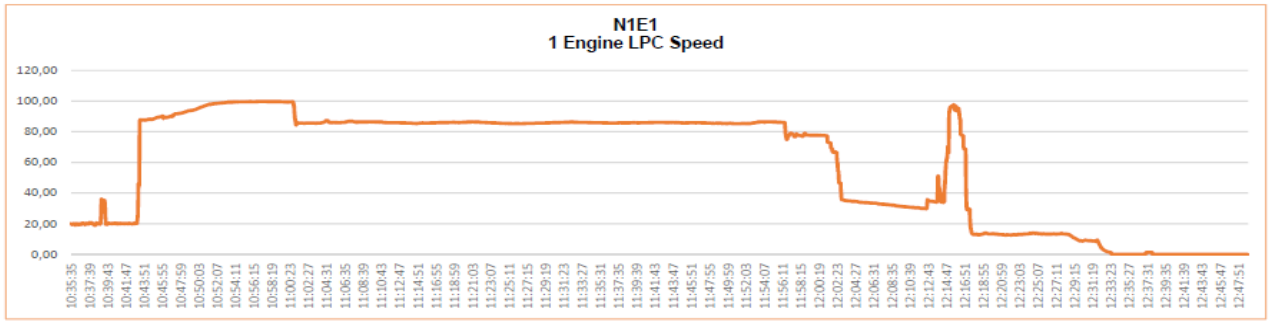
DFDR Graphs – Summary.

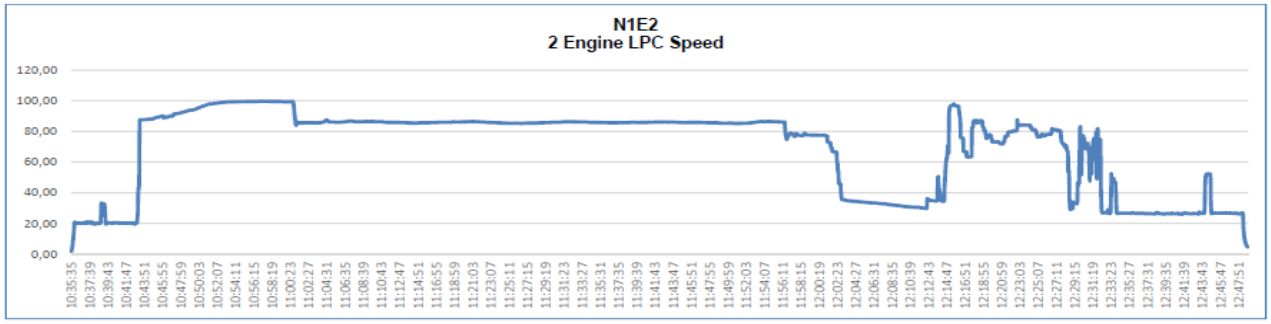


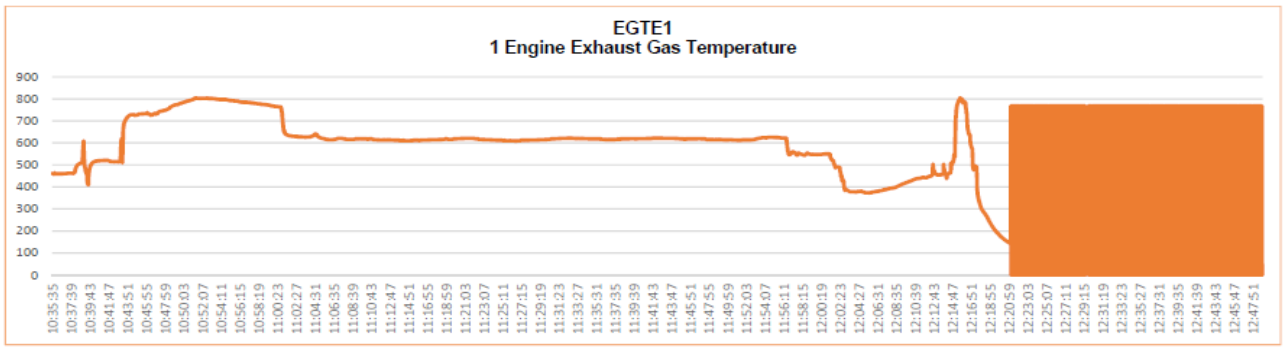


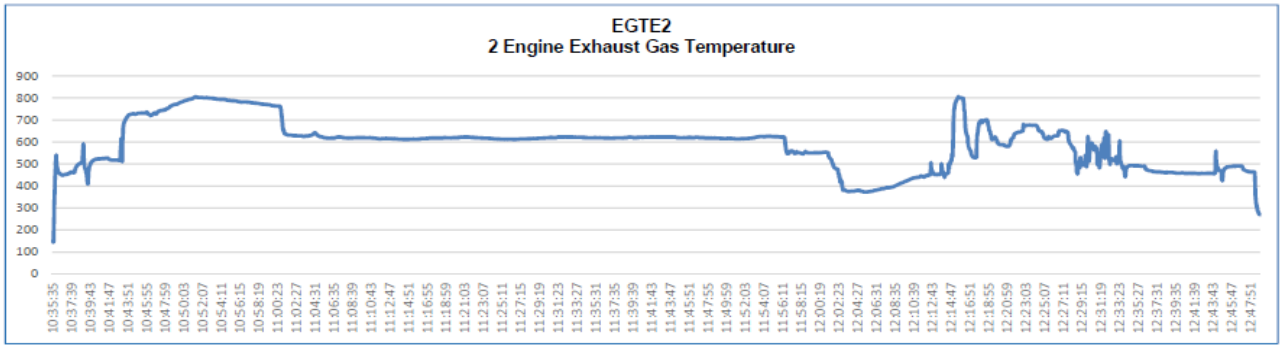


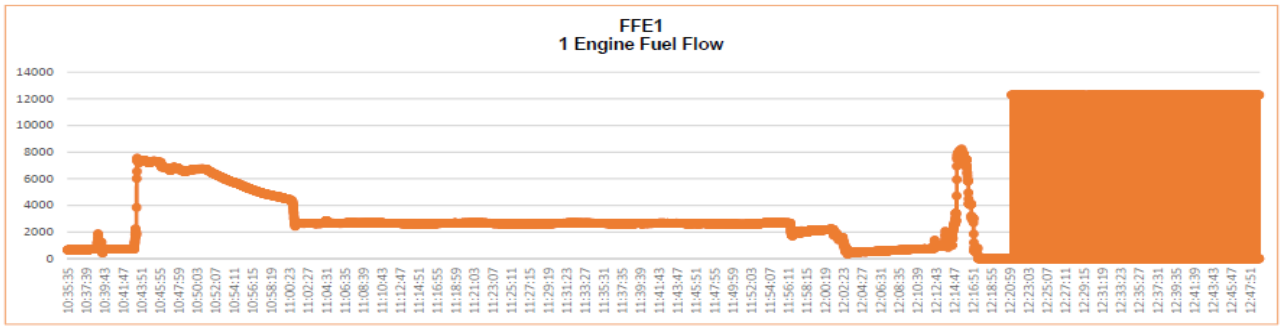

OILTE2
2 Engine Oil Temperature

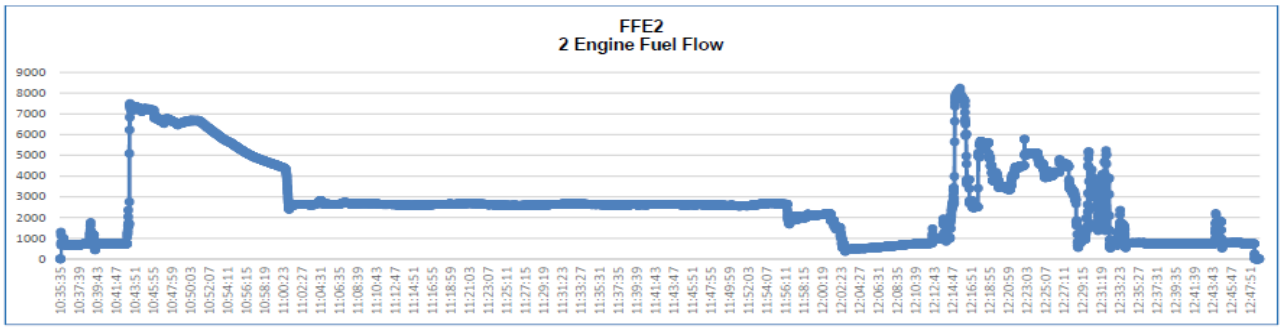

N1E1
1 Engine LPC Speed

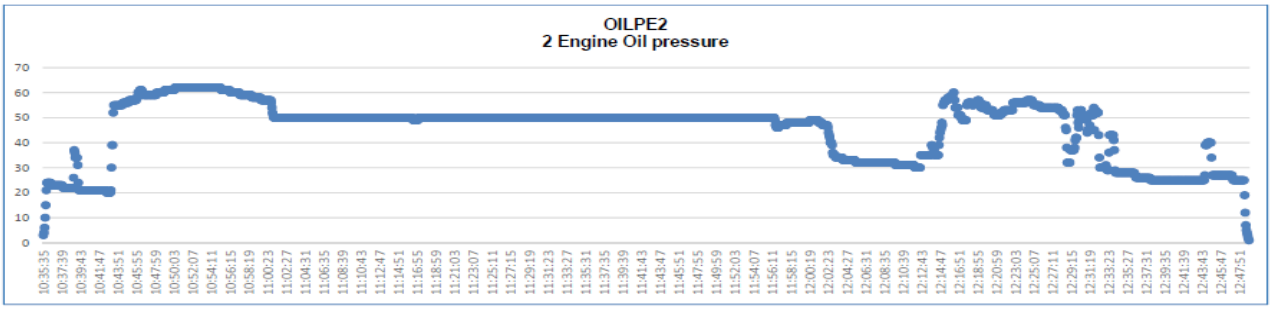

N1E2
2 Engine LPC Speed

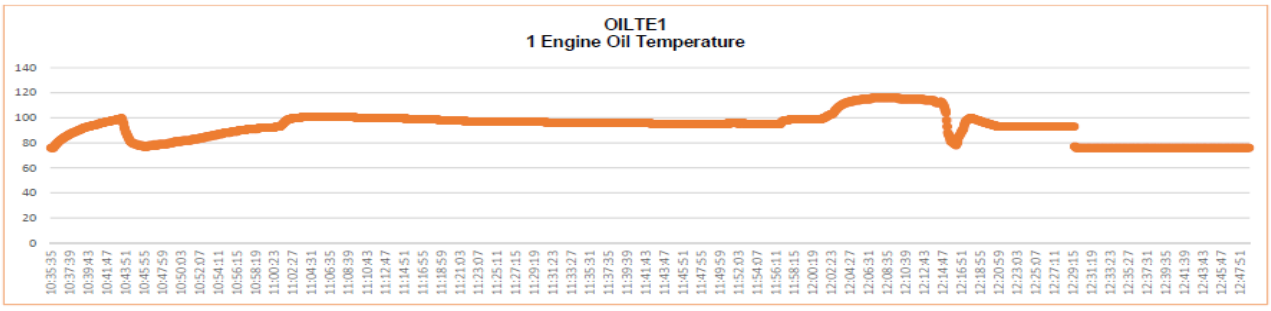

EGTE1
1 Engine Exhaust Gas Temperature

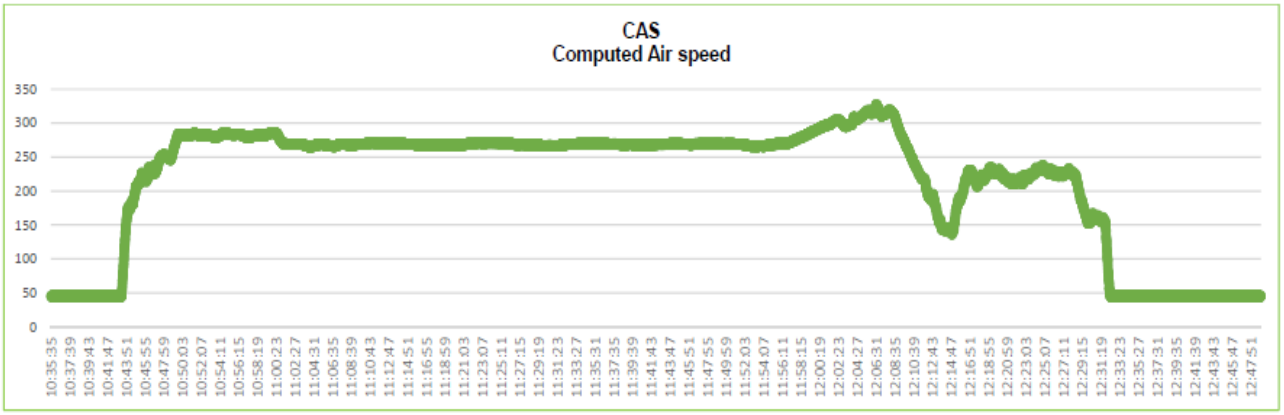

EGTE2
2 Engine Exhaust Gas Temperature


FFE1
1 Engine Fuel Flow


FFE2
2 Engine Fuel Flow


OILPE2
2 Engine Oil pressure


OILTE1
1 Engine Oil Temperature


CAS
Computed Air speed
350
300
250
200
150
100
50
0
10:35:35
10:37:39
10:39:43
10:41:47
10:43:51
10:45:55
10:47:59
10:50:03
10:52:07
10:54:11
10:56:15
10:58:19
11:00:23
11:02:27
11:04:31
11:06:35
11:08:39
11:10:43
11:12:47
11:14:51
11:16:55
11:18:59
11:21:03
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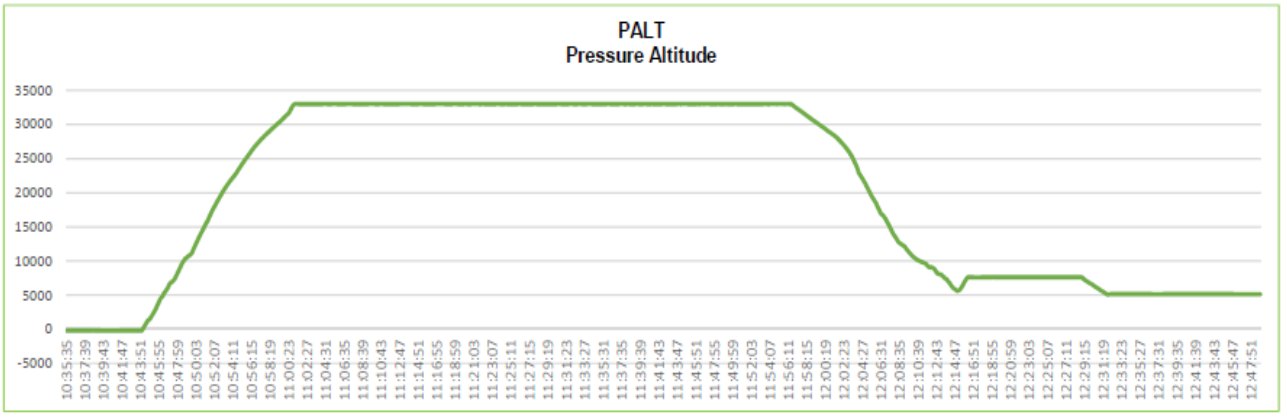
PALT
Pressure Altitude
35000
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25000
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