AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:		CA18/2/3/10017		
Aircraft Registration	**ZS-MZV**	**Date of Accident**	28 June 2021		**Time of Accident**	0925Z	
Type of Aircraft	Cessna 182P (Serial No. 182-61343)		**Type of Operation**		Private (Part 91)		
Pilot-in-command Licence Type	Private Pilot Licence		**Age**	31	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	**Total Flying Hours**		115.5		**Hours on Type**	42.7	
Last Point of Departure	Hoedspruit Civil Aerodrome (FAHT), Limpopo Province						
Next Point of Intended Landing	Rand Aerodrome (FAGM), Gauteng Province						
Damage to Aircraft	Substantial						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Swampland in Wadeville (GPS position: 26°17'18.20" South 028°10'19.40" East), elevation 5 047 feet (ft)							
Meteorological Information	Surface wind; 350°/16kts, temperature; 17°C, dew point; -1°, CAVOK						
Number of People On-board	1 + 3	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0
Synopsis							

On Monday morning, 28 June 2021, a pilot accompanied by three passengers took off on a private flight from a private game reserve to Hoedspruit Civil Aerodrome (FAHT) to refuel the aircraft. The private game reserve is located 12 nautical miles (nm) north-east of FAHT. After a 30-minute (0.5 hours) flight, the aircraft landed on Runway 35 at FAHT, thereafter, the pilot backtracked to the fuel bay, which was stationed near the threshold of Runway 35 to refuel the aircraft.

According to available information, 55 litres of Avgas was uplifted (50 litres in the left tank and 5 litres in the right tank). Thereafter, the pilot filed a flight plan for the flight from FAHT to Rand Aerodrome (FAGM). According to the closed-circuit television (CCTV) footage obtained from FAHT, the aircraft took off from Runway 35 at 0740Z. The pilot was given a squawk code (#7342) and was cleared by air traffic control (ATC) to climb to 8 500 feet (ft). At 0837Z while positioned abeam north-west of Loskop Dam, the pilot commenced with his descent to 6 500ft. The aircraft approached FAGM from the north and flew past Grand Central Aerodrome (FAGC) to the west of the N1 Highway at approximately 0912Z. The pilot then joined FAGM from the north-west and was cleared to land Runway 35 by ATC. The prevailing wind provided by ATC was 360° at 16 knots (kts). At 0921Z, the pilot performed a go-around following an unstable approach. He then turned out left to reposition the aircraft for a second approach for Runway 35. Approximately 3 minutes later while turning base leg, the engine stopped. The pilot broadcasted a *Mayday* on the FAGM tower frequency and subsequently opted for a forced landing in a swampland, aiming for a small clearing. However, after touchdown, the aircraft veered off to the right and came to rest in a left-wing low attitude in a dense reed area. The occupants on-board the aircraft were not injured during the accident, but the aircraft sustained substantial damage.

Probable Cause

The pilot's fuel management practise resulted in a complete loss of engine power due to fuel exhaustion; the pilot had no choice but to perform a forced landing in a swampland, which caused substantial damage to the aircraft.

SRP date	7 June 2022	Publication date	17 June 2022

DESCRIPTION OF THE ACCIDENT

Reference Number	**:** CA18/2/3/10017
Name of Owner	**:** Mike Zulu Victor (Pty) Ltd
Name of the Operator	**:** Mike Zulu Victor (Pty) Ltd
Manufacturer	**:** Cessna Aircraft Company
Model	**:** 182P
Nationality	**:** South African
Registration markings	**:** ZS-MZV
Place	**:** Swampland in Wadeville, Gauteng Province
Date	**:** 28 June 2021
Time	**:** 0925Z

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****.*

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.

Investigation Process:

The accident was notified to the Accident and Incident Investigations Division (AIID) on 28 June 2021 at approximately 1000Z. An investigator was dispatched to the accident scene on the same day to conduct an on-site investigation. The investigator co-ordinated with all authorities on site by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID 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:

- *Accident — this investigated accident*
- *Aircraft — the Cessna 182P involved in this accident*
- *Investigation — the investigation into the circumstances of this accident*
- *Pilot — the pilot involved in this accident*
- *Report — this accident report*

2. Photos and figures used in this report were taken from different sources and may have been 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.

Abbreviation	Description
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
AMSL	Above Mean Sea Level
ATC	Air Traffic Control
CAR	Civil Aviation Regulations
CCTV	Closed-circuit Television
CVR	Cockpit Voice Recorder
˚C	Degrees Celsius
FAGC	Grand Central Aerodrome
FAGM	Rand Aerodrome
FAHS	Hoedspruit Aerodrome (Air Force Base)
FAHT	Hoedspruit Civil Aerodrome
FANS	Nelspruit Aerodrome
FAVG	Virginia Aerodrome (Durban)
FDR	Flight Data Recorder
FL	Flight Level
ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
IOC	Investigator-on-call
kg	Kilograms
kts	Knots
L	Litre
lbs	Pounds
m	Metres
METAR	Meteorological Aerodrome Report
MHz	Megahertz
mph	Miles per Hour
MPI	Mandatory Periodic Inspection
MTOW	Maximum Take-off Weight
N/A	Not Applicable
nm	Nautical Miles
PIC	Pilot-in-command
PPL	Private Pilot Licence
QNH	Barometric Pressure Adjusted to Sea Level
qts	Quarts
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
SSR	Secondary Surveillance Radar
TBO	Time Between Overhaul
USA	United States of America
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VHF	Very High Frequency
Z	Zulu (Term for Coordinated Universal Time – Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On Friday, 25 June 2021, the pilot and three passengers on-board a Cessna 182P with registration ZS-MZV took off from Rand Aerodrome (FAGM) to a private game reserve, located 12 nautical miles (nm) north-east of Hoedspruit Civil Aerodrome (FAHT). According to the pilot, the duration of the flight was one hour and 54 minutes (1.9 hours). On Monday morning, 28 June 2021, the pilot and the same three passengers took off from the private game reserve (gravel runway) to FAHT where they landed on Runway 35 approximately 30 minutes (0.5 hours) later. After landing, the pilot backtracked on the runway, which was 1200 metres (m) long, to the fuel bay to uplift fuel. According to the fuel service provider, the pilot instructed him to refill (add) 50 litres to the left tank and 5 litres to the right tank of the aircraft.

1.1.2 The pilot then filed a flight plan for the private flight from FAHT to Rand Aerodrome (FAGM). On the flight plan, he indicated his flight endurance to be 3 hours and 30 minutes (3.5 hours). According to a closed-circuit television (CCTV) footage obtained from FAHT, the pilot and his three passengers took off from Runway 35 at 0740Z. The pilot was allocated a squawk code (#7342) by air traffic control (ATC) and the aircraft was tracked on Secondary Surveillance Radar (SSR). The aircraft was observed flying at 8 500ft (FL085). At 0834Z, as the aircraft was abeam Loskop Dam to the north-west, the pilot commenced with a descent to 6 500ft.

1.1.3 According to the pilot (and owner of the aircraft) the fuel gauges of the aircraft were erratic throughout the flight; the gauges were fluctuating between quarter (¼) tank and full tank. The pilot further stated that the left tank drained fuel quicker than the right tank; hence, the fuel selector was switched to the right tank during the cruise flight. During descent, the fuel selector was set to “BOTH” tanks for landing. The pilot approached FAGM from the north-west and the ZS-MZV aircraft was cleared to land Runway 35 at 0921Z by ATC who provided the prevailing wind conditions as 360° at 16 knots (kts). The pilot joined on a left downwind for landing and opted for 20° wing flaps due to the strong wind conditions.

1.1.4 Approximately 100m from the threshold of Runway 35 while flying between 70 and 75 miles per hour (mph), a gust of wind led to an unstable approach and the pilot opted for a go-around. He climbed to a circuit altitude of 6 500ft and turned left to rejoin on a left downwind for Runway 35. The pilot decided to extend his downwind leg to give himself additional space and time to set up the approach again as gusty wind conditions prevailed at the time. Midway down the left downwind for Runway 35, the aircraft lost engine power and the engine revolutions per minute (rpm) gauge started to fluctuate. The pilot commenced with fault-finding, checking the fuel gauges first, which were still giving erratic indications. He cycled the fuel selector lever between BOTH tanks and the right tank. Upon realising that the engine power could not be restored, the pilot leaned the fuel mixture for landing and, shortly thereafter, the engine stopped.

1.1.5 The pilot then sought out and identified an open field (which was 30° to his left and 30° to his right). He then decided to land on an open piece of swampland. Thereafter, he broadcasted *'Mayday'* on the FAGM tower frequency and selected full wing flaps for landing, as well as switched off the master switch. He then instructed his passengers to assume brace position. He also unlaced the doors prior to touchdown.

1.1.6 The aircraft came to rest in a left-wing low attitude facing a southerly direction in a dense reed area. The occupants on-board the aircraft were not injured; however, the aircraft was substantially damaged during the accident sequence. Following the Mayday call, ATC requested a helicopter crew that was engaged in training at FAGM to fly to the accident scene to assist the occupants. The helicopter landed near the accident site and, later, transported the passengers and the pilot to FAGM, two at a time.

1.1.7 The accident occurred during daylight at Global Positioning System (GPS) position determined to be 26˚17'18.20" South 028˚10'19.40" East, at an elevation of 5 047ft.

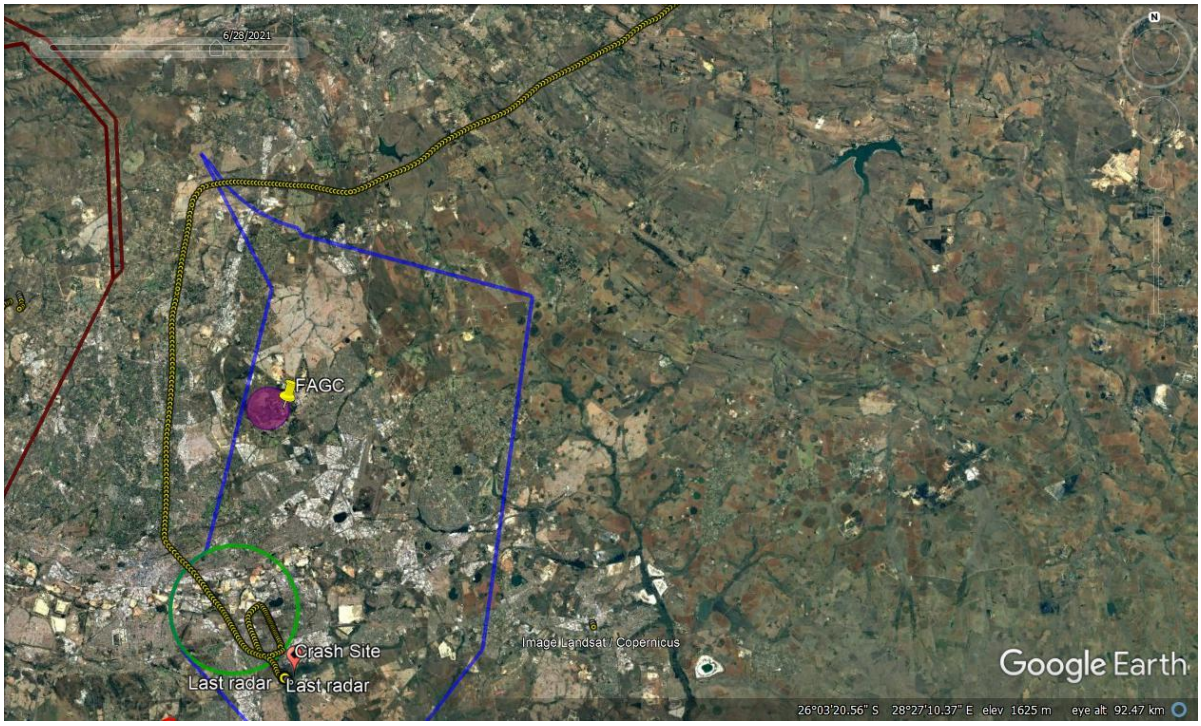


Figure 1: Overlay with the yellow dots indicating the radar track flown by ZS-MZV.
(Source: Google Earth)

Figure 2: A close-up overlay with the yellow dots indicating the radar track flown by ZS-MZV. (Google Earth)

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	1	-	3	4	-
Total	**1**	**-**	**3**	**4**	**-**

Note: Other, means people on the ground.

1.3 Damage to Aircraft

1.3.1 The aircraft was substantially damaged during the accident sequence.

Figure 3: The aircraft as it came to rest in a swampland.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command (PIC)

Nationality	South African	Gender	Male	Age	31
Licence Number	027 550 0850	Licence Type	Private Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 August 2024 (Class 2)				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	115.5
Total Past 90 Days	43.7
Total on Type Past 90 Days	42.7
Total on Type	42.7

1.5.2 Pilot's flying history

According to the pilot's logbook, the pilot started flying on 8 September 2019 as a student pilot on the Cirrus SR20 aircraft type. On 5 August 2020, he conducted his first solo flight, which consisted of circuits, with a flight time of 24 minutes. On 24 November 2020, he flew a 40-hour dual check with a flight instructor. On 22 March 2021, he undertook his private pilot licence skills test, which he passed. During his training period, he flew a total of 71.8 hours, of which 56.7 hours were dual flying hours and 15.1 hours were solo flying hours.

On 3 April 2021, the pilot commenced his conversion training to a Cessna 182 with an Approved Training Organisation (ATO). The conversion consisted of three flights with a flight instructor at a total flight time of 4.5 hours. The pilot subsequently flew 23 flights on different Cessna 182 aircraft at a total flight time of 38.2 hours. At the time of the accident, the pilot had accumulated 42.7 hours in total on the Cessna 182 aircraft type.

The pilot was issued a Private Pilot Licence (PPL) on 26 March 2021 with an expiry date of 31 March 2022.

1.6 Aircraft Information

1.6.1 Airframe:

Type	Cessna 182P	
Serial Number	182-61343	
Manufacturer	Cessna Aircraft Company	
Year of Manufacture	1991	
Total Airframe Hours (at time of the incident)	3 960.3	
Last MPI (hours & date)	3 932.1	20 August 2020
Hours Since Last MPI	28.2	
C of A (issue date)	7 June 1991	
C of A (expiry date)	30 June 2021	
C of R (issue date) (Present Owner)	28 May 2021	
Operating Categories	Standard Normal (Aeroplane)	

Engine:

Type	Continental O-470-R
Serial Number	222471-72R
Hours Since New	3 960.3
Hours Since Overhaul	979.6

Propeller:

Type	McCauley 2A34C201
Serial Number	723704
Hours Since New	3 960.3
Hours Since Overhaul	979.6

1.6.2 Weight and Balance

Item	Weight (lbs)	Arm (inches)	Moment (lbs x inches)
Aircraft empty weight	1 828	36.57	66 848
Nose wheel fairing (spat)	3.9	6.0	23
Main wheel fairings (spats)	11.4	60.2	686
Pilot and front passenger	384	37.00	14 208
Second row passengers	227	74.10	16 820
Baggage (Area A)	25	96.7	2 418
Baggage (Area B)	20	114.8	2 296
Zero fuel weight	**2 499.3**	**41.3**	**103 299**
Fuel (36 US Gallons at 6lb/Gal.)	216	48.10	10 380
Take-off weight	**2 715.3**	**41.9**	**113 679**

According to the Aircraft Flight Manual (AFM), the maximum take-off weight (MTOW) for this aircraft type is 2 950lbs (1 330kg).

According to the aircraft maintenance organisation (AMO) that conducted the last re-weighing of the aircraft on 21 August 2017, the aircraft was weighed with 10 quarts of engine oil (in the engine compartment). The fire extinguisher, first aid kit and signal strips were in the cabin. There was no fuel in the tanks and the aircraft was also not fitted with wheel spats at the time.

The passengers, baggage and fuel quantity weights that were considered for the weight and balance calculation for the aircraft prior to take-off from FAHT were provided by the pilot in the weight and balance calculation that was made available to the investigator. According to the calculation, the take-off weight was 235lbs (106kg) below the MTOW for this aircraft with 136 litres (36 US gallons) of fuel on-board.

1.7 Meteorological Information

1.7.1 The meteorological aerodrome report (METAR) for Hoedspruit Aerodrome (Air Force Base) FAHS on 28 June 2021 at 0700Z (Packtime 0709Z) was as follows: FAHS 280700Z AUTO 31005KT //// // ////// 17/13 Q1022=. FAHT is located 5.5nm north-west of FAHS.

Wind Direction	310˚	Wind Speed	5 knots	Visibility	+ 10 km
Temperature	17˚C	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	13˚C	QNH	1022hPa		

1.7.2 Density Altitude at take-off

Source: https://wahiduddin.net/calc/calc_da.htm

The density altitude at the time of take-off from FAHT was approximately 2 359ft. This information was based on the aerodrome information for FAHT and the weather (METAR) for FAHS at the time.

Density Altitude Calculator

Elevation	◉ feet	○ m	1800
Air Temperature	○ deg F	◉ deg C	17
Altimeter Setting	○ in Hg	◉ hPa	1022
Dew Point	○ deg F	◉ deg C	13

Calculate Reset

Density Altitude	2359	feet	719	m
Absolute Pressure	28.27	in Hg	957.4	hPa
Air Density	0.0713	lb/ft3	1.143	kg/m3
Relative Density	93.28	%	93.28	%
Estimated AWOS	2200	feet	671	m

1.7.3 The METAR for FAGM on 28 June 2021 at 0900Z was as follows: FAGM 280900Z 35020KT CAVOK 17/M01 Q1026=

Wind Direction	350˚	Wind Speed	20 knots	Visibility	+ 10 km
Temperature	17˚C	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	-1˚C	QNH	1026hPa		

1.7.4 The METAR for O.R. Tambo International Airport (FAOR) on 28 June 2021 at 0930Z was as follows:

FAOR 280930Z 33013KT CAVOK 17/M01 Q1025 NOSIG=

Wind Direction	330˚	Wind Speed	13 knots	Visibility	+ 10 km
Temperature	17˚C	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	-1˚C	QNH	1025hPa		

1.7.5 When the pilot was cleared to land Runway 35 by ATC, he was provided with the prevailing wind which was 360° at 16 knots.

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational equipment as approved by the Regulator (SACAA). There were no records indicating that the navigational system was unserviceable prior to or during the flight.

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment as approved by the Regulator.

1.9.2 The pilot was in contact with Flight Information Centre (FIC) North on the very high frequency (VHF) 127.40-Megahertz (MHz).

1.9.3 The aircraft was fitted with a transponder and the pilot was allocated a squawk code #7342.

1.9.4 The pilot was in contact with ATC at FAGM on the VHF 118.70MHz. The aircraft was cleared to land Runway 35 at 0921Z.

1.9.5 The pilot broadcasted *'Mayday Mayday Mayday'* on the FAGM tower frequency at 0924Z. (MAYDAY: Is an internationally recognised radio call announcing a distress condition where an aircraft or its occupants are being threatened by serious and/or imminent danger in which the flight crew requires immediate assistance.)

1.10 Aerodrome Information

1.10.1 The pilot toom off from Hoedspruit Civil Aerodrome (FAHT), which is an unlicensed aerodrome. The aerodrome has a single asphalt surface runway, which is orientated 17/35; the runway is 1 200m long and 9m wide and is located at GPS position: 24°21'10.01" South 030°56'58.38" East, at an elevation of 1 800ft.

Figure 4: Aerial view, final approach for Runway 35 at FAHT. (Source: Wynand Uys)

1.10.2 The accident occurred 2.5 nautical miles (nm) south of the threshold of Runway 35 at FAGM.

Aerodrome Location	Rand Aerodrome (FAGM)	
Aerodrome Co-ordinates	26°31'14.21" South 028°09'04.88" East	
Aerodrome Elevation	5 483 ft	
Runway Designations	11/29	17/35
Runway Dimensions	1 579 x 15m	1 197 x 15m
Runway in Use	35	
Runway Surface	Asphalt	
Approach Facilities	Runway lights, Approach lights, VOR/DME	
Aerodrome Status	Licensed	

An aerodrome chart is attached to this report as Appendix A.

1.11 Flight Recorders

1.11.1 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor were these required by regulation to be fitted on this aircraft.

1.11.2 The aircraft was equipped with a Garmin GNS 430 unit. This unit did not contain non-volatile memory and, therefore, could not be downloaded.

1.12 Wreckage and Impact Information

1.12.1 The pilot landed in a swampland on an open area between dense reed facing a north-easterly direction. The pilot was unable to maintain directional control and the aircraft veered off to the right, approximately 80 metres (m) after touchdown, and came to rest in a left-wing low attitude facing a southerly direction.

Figure 5: Aerial view of the terrain and the aircraft. (Source: AAS)

Figure 6: The open area that the pilot landed on.

Figure 7: The open area view beyond the accident site.

Figure 8: The aircraft as it came to rest.

Figure 9: The front view of the aircraft with one of the propeller blades slightly bent.

1.13 Medical and Pathological Information

1.13.1 Not applicable.

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 accident was survivable as the cockpit and cabin area remained intact and all four occupants were properly restrained as they had made use of the aircraft-equipped safety harnesses.

1.16 Tests and Research

1.16.1 Following recovery of the wreckage on 29 June 2021 and following an assessment, it was decided that an engine ground run of the airframe should be conducted.

Date: 30 June 2021, Subject: Engine Run ZS-MZV

- *An examination of this aircraft and test run of the engine was conducted on 30 June 2021 at an approved AMO.*

- *The wings were removed during recovery.*
- *The cockpit instrumentation remained in the aircraft when it was recovered.*
- *The propeller remained attached to the engine, and one of the blades exhibited signs of bending.*
- *The aircraft's (damaged) propeller was removed and replaced with an undamaged propeller for the test run.*
- *The engine started, accelerated, and ran through the full travel of the throttle control. The engine ran for approximately 5 minutes before the test was discontinued.*

Figure 10: The engine ground run following recovery of the aircraft.

1.17 Organisational and Management Information

1.17.1 This was a private flight conducted under the provisions of Part 91 of the Civil Aviation Regulations 2011. The pilot owned the aircraft.

1.17.2 The last mandatory periodic inspection (MPI) carried out on the ZS-MZV aircraft prior to the accident flight was certified on 20 August 2020 at 3 932.1 airframe hours. The AMO that certified the inspection was in possession of an AMO-approval certificate that was issued by the SACAA on 31 July 2020 with an expiry date of 30 April 2021.

1.18 Additional Information

1.18.1 Emergency Landing without Engine Power
Source: Owner's Manual, Section 3, Emergency Procedures

"If an emergency stoppage occurs, establish a flaps-up glide at 80mph. If time permits, attempt to restart the engine by checking for fuel quantity, proper fuel selector valve position,

and mixture control setting. Also check that engine primer is full in and locked and ignition is properly positioned.

If all attempts to restart the engine fail, and a forced landing is imminent, select a suitable field and prepare for landing as follow:

1. *Pull mixture control to idle cut-off position.*
2. *Turn fuel selector valve handle "OFF".*
3. *Turn all switches "OFF" except the master switch.*
4. *Approach at 80mph.*
5. *Extend wing flaps as necessary within gliding distance of the field.*
6. *Turn master switch "OFF".*
7. *Unlashed cabin doors prior to final approach.*
8. *Land in a slightly tail-low attitude.*
9. *Apply heavy braking while holding full up elevator."*

1.18.2 Aircraft Fuel System:

Source: Cessna 182 Owner's Manual (that was found on-board the aircraft).

The aircraft was fitted with long-range fuel tanks with a total fuel capacity of 79 US Gallons (USG) (299L or 474 lbs). The unusable fuel in each tank is 2.5 USG (9.5L or 15 lbs).

Section II

DESCRIPTION AND OPERATING DETAILS

The following paragraphs describe the systems and equipment whose function and operation is not obvious when sitting in the airplane. This section also covers in somewhat greater detail some of the items listed in Check List form in Section I that require further explanation.

FUEL SYSTEM.

Fuel is supplied to the engine from two tanks, one in each wing. With the fuel selector valve on "BOTH," the total usable fuel for all flight conditions is 60 gallons for the standard tanks and 79 gallons for optional long range tanks.

Fuel from each wing tank flows by gravity to a selector valve. Depending upon the setting of the selector valve, fuel from the left, right, or both tanks flows through a fuel strainer and carburetor to the engine induction system.

IMPORTANT

The fuel selector valve should be in the "BOTH" position for take-off, climb, landing, and maneuvers that involve prolonged slips or skids. Operation from either "LEFT" or "RIGHT" tank is reserved for cruising flight.

NOTE

When the fuel selector valve handle is in the "BOTH" position in cruising flight, unequal fuel flow from each tank may occur if the wings are not maintained exactly level. Resulting wing heaviness can be alleviated gradually by turning the selector valve handle to the tank in the "heavy" wing.

For fuel system servicing information, refer to Lubrication and Servicing Procedures in Section V.

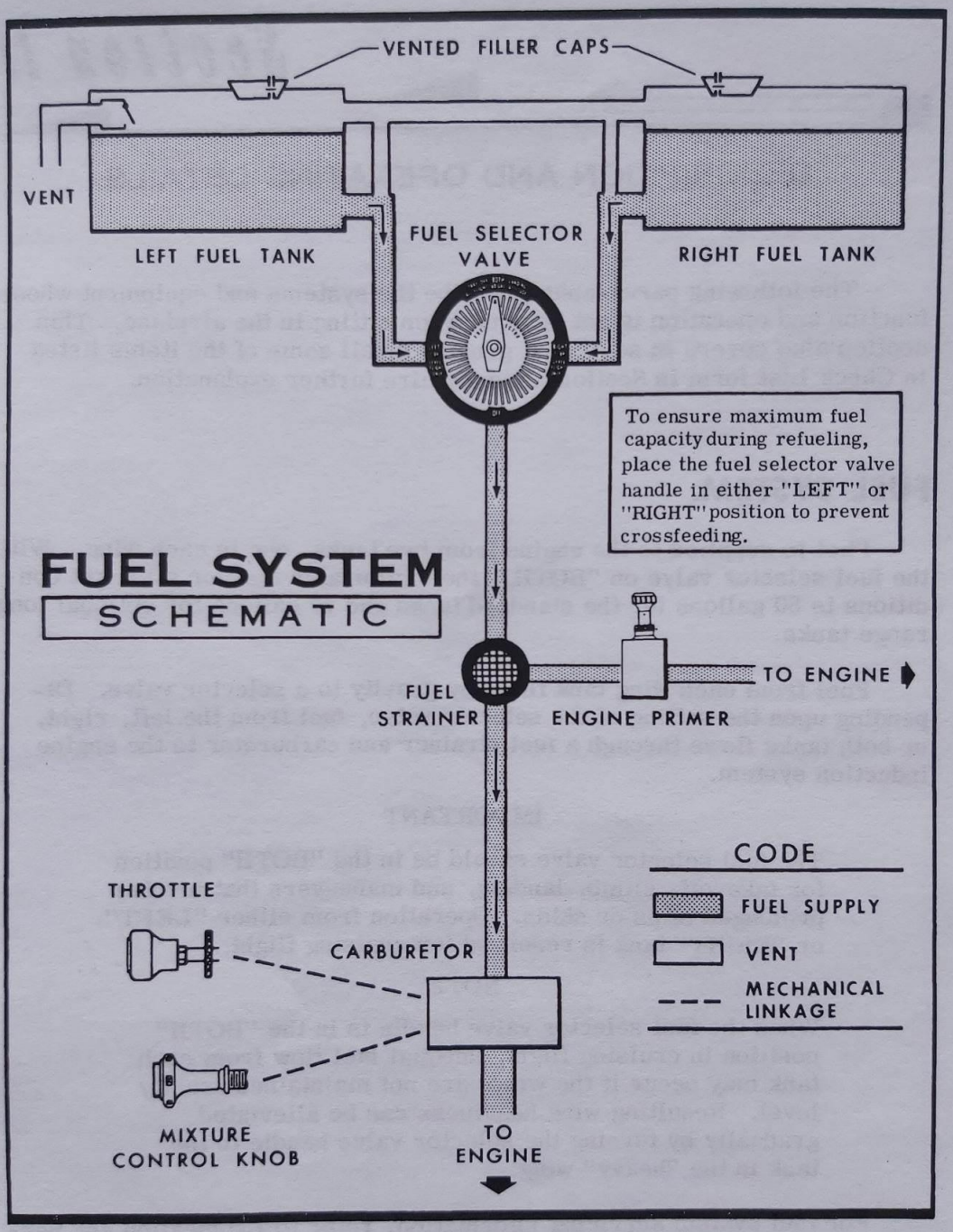


Figure 2-2.

2-2

1.18.3 Fuel Planning:

The investigator received the following fuel planning information for the flight from FAHT to FAGM from the pilot:

Fuel planning		
Origin	FAHT	
Destination	FAGM	
Distance (nm)	199.8	
Cruise speed (kts)	125	< *factoring in a 10-15kt headwind*
Flight duration (hrs)	1.6	
Assumed fuel burn	12.5	GPH
Trip fuel	20.0	
Taxi + Run-Ups	1.5	
Reserve	2.0	< *10% of trip fuel*
Contingency	6.3	< *30min*
Total required (USG)	**29.7**	**USG**

1.18.4 Dipstick for measuring fuel in the tanks:

A transparent plastic tubular dipstick (see Figure 11) was used by the pilot for measuring the aircraft's fuel levels. This device is used by: *dipping it into the tank and holding the thumb over the end part/side, and then lifting it out*. Fuel level is read on the calibrated scale on the side of the tube.

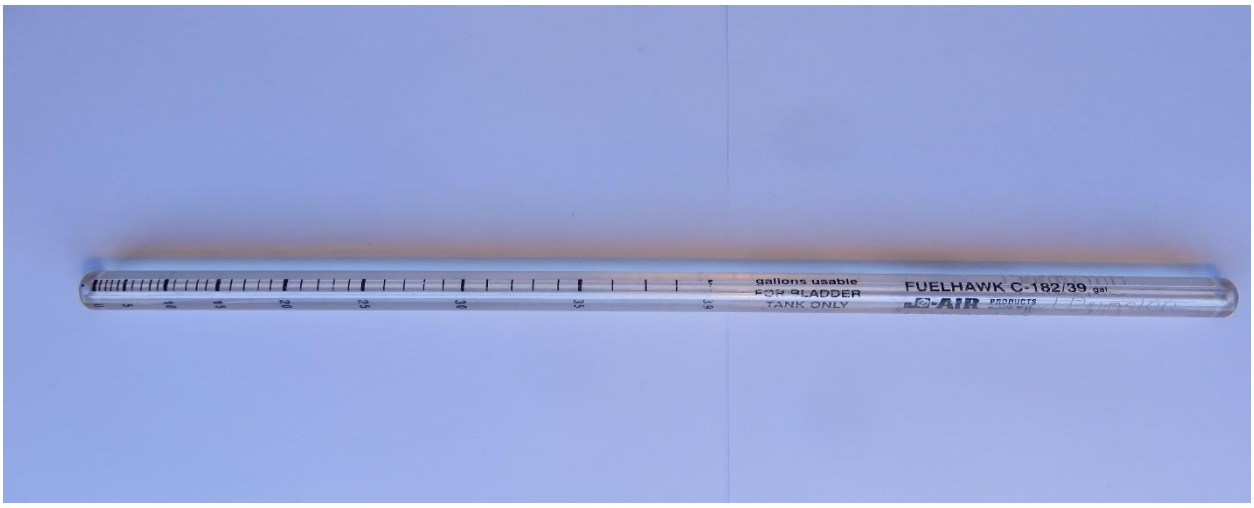


Figure 11: The dipstick that was used by the pilot.

Figure 12: The dipstick viewed from the bottom end.

1.18.5 Fuel Uplift Records

Source of information: The aircraft's flight folio, as well as several fuel service providers furnished the investigator with invoice copies of every fuel uplift (see Table 1). One of the fuel uplifts was not entered in the flight folio but was added to the table below.

It should be noted that the aircraft was flown on 30 September 2019 and was refuelled at Lanseria International Aerodrome (FALA) after landing (to full tanks); 144 litres of fuel was uplifted. The aircraft was then parked by the owner. The next time the aircraft was flown was on 13 February 2021. During the time the aircraft was parked, an unknown amount of fuel was drained or stolen from the fuel tanks.

Table 1: Flights and fuel uplifts for Cessna 182P, ZS-MZV

Date	From	To	Flight duration as per Hobbs hours	Fuel uplifts in litres (L)	Fuel status	Place of fuel uplift	Fuel consumption Litres / hr
30/09/2019	FVJN	FALA	3.1	144L	Full	FALA	47.0
Aircraft on	the ground	until 13 Feb	2021 was	parked	with	FULL	fuel tanks
13/02/2021	FALA	FALA	0.5	----------	Not available		Fuel / drained to be used / or stolen

13/03/2021	FALA	Eagle's Creek	0.3	116L	Full	Eagle's Creek	----------
13/03/2021	Eagle's Creek	FAGC	0.3	----------		----------	
14/03/2021	FAGC	Jackalberry Lodge	2.3	----------		----------	
15/03/2021	Jackalberry Lodge	FAGC	2.1	40L		FAGC	
17/03/2021	FAGC	Eagle's Creek	0.2	197L	Full	Eagle's Creek	48.4
17/03/2021	Eagle's Creek	FALA	0.3	----------		----------	
09/04/2021	FALA	FALA	1.0	33L		FALA	
20/04/2021	FALA	FALA	1.8	----------		----------	
12/05/2021	FALA	FALA	0.9	88L		FALA	
13/05/2021	FALA	FA Olifants	2.1	----------		----------	
17/05/2021	FA Olifants	FALA	2.4	236L	Full	FALA	49.2
20/05/2021	FALA	FA Olifants	2.1	----------		----------	
24/05/2021	FA Olifants	FANS	0.9	128L	Full	FANS	42.7
24/05/2021	FANS	FALA	1.7	----------		----------	
30/05/2021	FALA	FAGM	0.6	113L	Full	FAGM	49.2
06/06/2021	FAGM	FAVG	2.6	121L	Full	FAVG	46.5
13/06/2021	FAVG	FAGM	2.5	----------		----------	
25/06/2021	FAGM	FA Olifants	1.9	----------		----------	
28/06/2021	FA Olifants	FAHT	0.5	55L		FAHT	
28/06/2021	FAHT	FAGM	1.8	----------		Accident	

*NOTE: Jackalberry Lodge is located 14nm south-east of FAHT (GPS position: 24°30'36.00" South 031°08'24.01" East).

*NOTE: The abbreviation FA Olifants was used by the pilot for Olifants River Game Reserve, located 12nm north north-east of FAHT (GPS position: 24°09'22.95" South 031°01'28.43" East).

All flights from April 2021 were flown by the pilot, and add to a flight time of 22.8 hours.

Between 13 and 28 June 2021, the pilot conducted four flights on this aircraft and flew a total of 6 hours and 42 minutes (6.7 hours). During this period, only 55 litres of fuel was uplifted at FAHT when the pilot landed on Runway 35 and backtracked to the refuelling bay, which was approximately 1 200m from Runway 35. The pilot had, at the time, informed the service provider that he was concerned about their take-off weight, hence, he opted to uplift only 55L.

Considering the flight time and fuel uplift information presented in Table 1, the average fuel consumption was calculated to have been 47.3 litres per hour (12.5 USG/hr). This confirms or aligns with the fuel consumption the pilot used as referenced on page 20 (1.18.3) of this report.

1.18.6 Fuel Requirements:

The quantities of fixed fuel reserve and variable fuel reserve required for a flight are prescribed in Part 91.07.12 of the Civil Aviation Regulations of 2011. *Part 91.07.12 of the CAR was adhered to, stated under the following sub-headings; (i) taxi fuel, (ii) trip fuel, (iii) contingency fuel that equates to 5% of the planned trip but not less than 5 minutes, (iv) destination alternate - 15 minutes, (v) and final reserve fuel of 45 minutes.*

The pre-flight planning process must include a calculation of the quantity of useable fuel an aircraft must carry before the flight commences.

The quantity of useable fuel required to be on-board at the commencement of a flight must include:

1. Start, taxi and run-up fuel
2. Take-off and trip fuel
3. Contingency fuel that equates to – 5% of the planned trip but not less than 5 minutes.
4. Destination alternate fuel – 15 minutes (where a flight is operated without a destination alternate aerodrome, the amount of fuel required to enable the aircraft to fly for 15 minutes at holding speed at 1 500ft above the destination aerodrome elevation in standard conditions)
5. Final reserve – the amount of fuel required to fly for 45 minutes
6. Additional/Discretionary fuel (this is optional and at the pilot's discretion)

The commencement of a flight, for the purposes of fuel requirements, is when the aircraft first moves under its own power with the purpose of taking off.

<u>Fuel Calculation:</u>
Calculations are based on a fuel burn of 47.3 litres (12.5 US gallons) per hour.

Item	**Quantity in litres (L) and US gallons**
Start and taxi	7L (litres) (1.8 USG)
Climb	19L (5.14 USG as per POH)
Cruise to FAGM 90 minutes x 0.78L	(47.3L divided by 60) = 71L (18.8 USG)
Sub-total	**97L (25.6 USG)**
Plus 5% contingency fuel	5L (1.3 USG)
Plus Alternate 45% power 15 x 0.57L	(34L divided by 60) = 8.5L (2.25 USG)
Plus Destination Reserve 45% power 45 minutes x 0.57L	25.7L (6.8 USG)
Total fuel required for the flight	**136.2L (36 USG)**

1.18.7 Flight Plan

The information below shows the flight plan information that was filed by the pilot for the accident flight from FAHT to FAGM. *The symbol #### is used to replace personal information that was entered on the flight plan*.

"(SPL-ZSMZV/A7342-FAHT0729
-FAGM0210 FAWB FAGC
-DOF/210628 REG/ZSMZV OPR/MIKE ZULU VICTOR PTY LTD ######## RMK/SARNML REFID270600314
-E/0330 P/004 A/WHITE BLUE RED N/FAKS C/S ##########)"

1.18.8 Duties of PIC Regarding Flight Preparation

Part 91.07.2(1)(j) of the CAR 2011 as amended states the following:

1) The PIC of an aircraft shall not commence a flight unless he or she is satisfied that—

(j) the requirements in respect of fuel, oil, oxygen, weather, minimum safe altitudes, aerodrome operating minima and availability of alternate aerodromes for the route being flown and any likely alternatives, whether flown under instrument or VFR, are complied with;

1.18.9 Flight Folio and Fuel Records as per Civil Aviation Regulations 2011

Flight Folio

Part 91.03.5 (1) The owner or operator of a South African registered aircraft shall ensure that the aircraft carries a flight folio or any other similar document which meets the requirements of and contains the information as prescribed in Document SA-CATS 91, at all times.
(2) The flight folio shall be kept up-to-date and maintained in a legible manner by the PIC. (3) All entries shall be made immediately upon completion of the occurrence to which they refer.
(4) In the case of maintenance being undertaken on the aircraft, the entry shall be certified by the person taking responsibility for the maintenance performed.
(5) The owner or operator shall retain the flight folio for a period of 5 years calculated from the date of the last entry therein.

Fuel Record

Part 91.03.6 (1) The owner or operator shall maintain fuel records to enable the Director to ascertain that, for each flight under his or her control, the requirements of regulation 91.07.12 are complied with.

(2) The PIC of the aircraft shall enter the fuel and oil records referred to in sub regulation (1) in the flight folio.
(3) The owner or operator shall maintain oil records to enable the Director to ascertain that trends for oil consumption are such that an aircraft has sufficient oil to complete each flight.

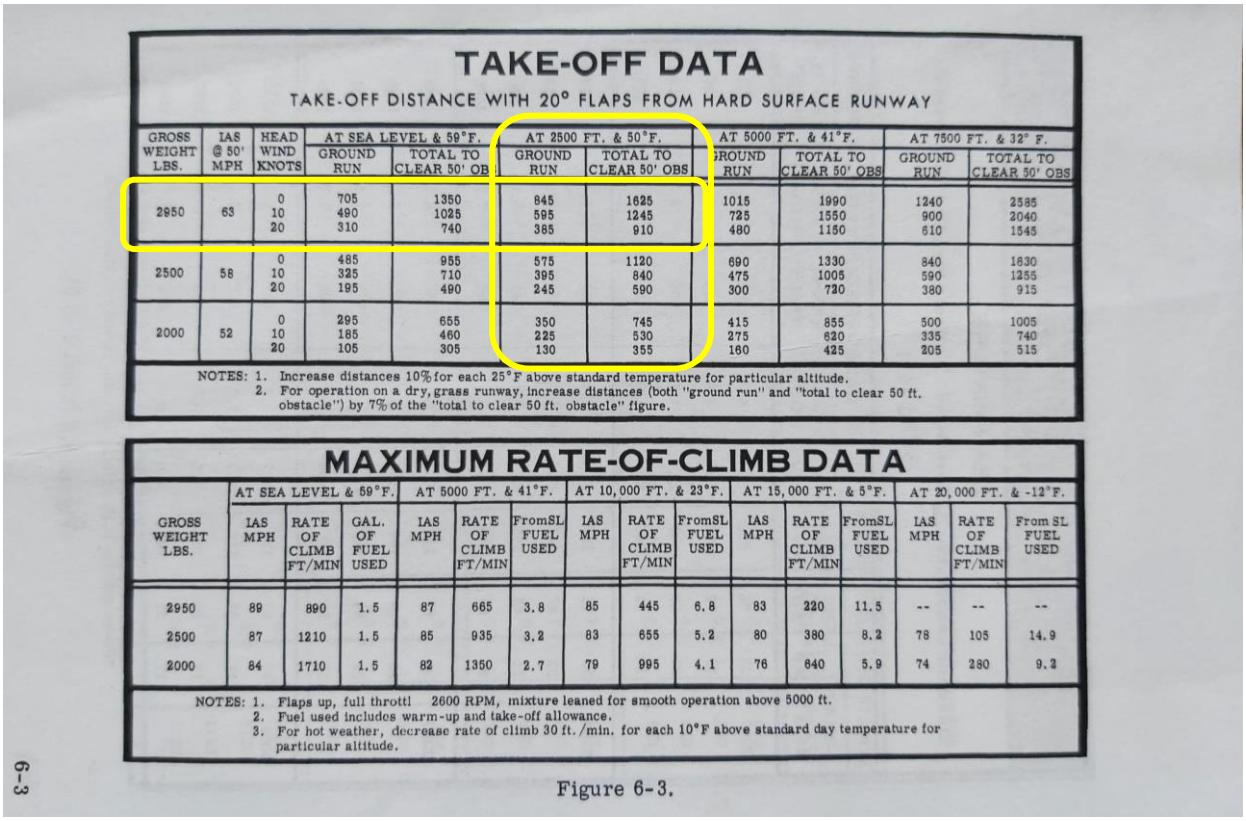
1.18.10 Operational Data

Source: Cessna 182, Owner's Manual, Section VI, Pg. 6-1 and 6-3.

"The operational data charts are presented for two purposes; first, so that you may know what to expect from your airplane under various conditions, and second, to enable you to plan your flights in detail and with reasonable accuracy.

The data in the chart had been compiled from actual flight tests with the airplane and engine in good condition and using average piloting techniques. The charts are based on standard day conditions."

From the take-off data chart (Figure 13), there is ample runway length available for take-off even if the aircraft was at its MTOW limit at an elevation of 2 500ft, which was higher than the density altitude at the time. The temperature on take-off was approximately 17°C, which was 2°C above the international standard atmospheric (ISA) temperature of 15°C at a pressure altitude of 1013.2 millibar/hpa. The 7°C and the 10°C (50°F) temperatures were used in the table (in the yellow window). The ground run required was 845ft (158m). To clear a 50ft obstacle at the end of the runway, a distance of 1 625ft (496m) was required. The runway at FAHT is 1 200m (3 936ft) long.



TAKE-OFF DATA

TAKE-OFF DISTANCE WITH 20° FLAPS FROM HARD SURFACE RUNWAY

GROSS WEIGHT LBS.	IAS @ 50' MPH	HEAD WIND KNOTS	AT SEA LEVEL & 59°F. GROUND RUN	AT SEA LEVEL & 59°F. TOTAL TO CLEAR 50' OB	AT 2500 FT. & 50°F. GROUND RUN	AT 2500 FT. & 50°F. TOTAL TO CLEAR 50' OBS	AT 5000 FT. & 41°F. GROUND RUN	AT 5000 FT. & 41°F. TOTAL TO CLEAR 50' OBS	AT 7500 FT. & 32° F. GROUND RUN	AT 7500 FT. & 32° F. TOTAL TO CLEAR 50' OBS
2950	63	0	705	1350	845	1625	1015	1990	1240	2585
		10	490	1025	595	1245	725	1550	900	2040
		20	310	740	385	910	480	1150	610	1545
2500	58	0	485	955	575	1120	690	1330	840	1630
		10	325	710	395	840	475	1005	590	1255
		20	195	490	245	590	300	720	380	915
2000	52	0	295	655	350	745	415	855	500	1005
		10	185	460	225	530	275	620	335	740
		20	105	305	130	355	160	425	205	515

NOTES: 1. Increase distances 10% for each 25°F above standard temperature for particular altitude.
2. For operation on a dry, grass runway, increase distances (both "ground run" and "total to clear 50 ft. obstacle") by 7% of the "total to clear 50 ft. obstacle" figure.

MAXIMUM RATE-OF-CLIMB DATA

GROSS WEIGHT LBS.	AT SEA LEVEL & 59°F. IAS MPH	RATE OF CLIMB FT/MIN	GAL. OF FUEL USED	AT 5000 FT. & 41°F. IAS MPH	RATE OF CLIMB FT/MIN	FromSL FUEL USED	AT 10,000 FT. & 23°F. IAS MPH	RATE OF CLIMB FT/MIN	FromSL FUEL USED	AT 15,000 FT. & 5°F. IAS MPH	RATE OF CLIMB FT/MIN	FromSL FUEL USED	AT 20,000 FT. & -12°F. IAS MPH	RATE OF CLIMB FT/MIN	From SL FUEL USED
2950	89	890	1.5	87	665	3.8	85	445	6.8	83	220	11.5	--	--	--
2500	87	1210	1.5	85	935	3.2	83	655	5.2	80	380	8.2	78	105	14.9
2000	84	1710	1.5	82	1350	2.7	79	995	4.1	76	640	5.9	74	280	9.2

NOTES: 1. Flaps up, full throttl 2600 RPM, mixture leaned for smooth operation above 5000 ft.
2. Fuel used includes warm-up and take-off allowance.
3. For hot weather, decrease rate of climb 30 ft./min. for each 10°F above standard day temperature for particular altitude.

6-3

Figure 6-3.

Table 1: Take-off data chart with data used in the yellow windows.

1.19 Useful or Effective Investigation Techniques

1.19.1 No new methods were used.

2. ANALYSIS

2.1 General

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

2.2 Analysis

2.2.1 Pilot

The pilot had a Private Pilot Licence (PPL) that was issued on 26 March 2021 with an expiry date of 31 March 2022. According to the pilot's logbook, he had flown a total of 115.5 hours, of which 42.7 hours were on the aircraft type.

The pilot is the owner of the aircraft. The pilot was the pilot-in-command on all 14 flights conducted since 9 April 2021 using the aircraft; this equated to a flight time of 22.8 hours.

Available information indicated that the pilot had conducted three flights on the aircraft where no fuel was uplifted. The duration of these three flights was 4 hours and 54 minutes (4.9 hours). The aircraft was fitted with long range fuel tanks which allowed for a fuel capacity of 299 litres (79 US gallons) of useable fuel when filled to maximum capacity.

Using the average fuel consumption of 47.3 litres (12.5 US gallons) per hour, the engine would have consumed approximately 240 litres of fuel by the time the pilot had landed at FAHT. If we presume the fuel tanks were filled to the filler necks (absolute maximum capacity) when the aircraft was last refuelled at FAVG (Durban), there should have been approximately 59 litres of fuel left in the tanks if no fuel had vapourised, leaked or stolen from the aircraft when the pilot landed at FAHT. After landing at FAHT, 55 litres of fuel was uplifted which, when added to the fuel that was already in the aircraft, equated to 114 litres of fuel. The flight from FAHT until the accident occurred was 1 hour and 48 minutes (1.8 hours); during this period the aircraft would have consumed approximately 90 litres of fuel. There should have been approximately 24 litres of fuel left in the tanks. During the recovery of the aircraft, a total of 4 litres of fuel was drained from both wing tanks. The fuel was drained prior to the removal of the wings. This leaves 20 litres of unaccounted fuel if the fuel tanks were filled to absolute maximum capacity at FAVG.

According to the requirements of Part 91.07.12, there should have been 136 litres of fuel on-board the aircraft prior to departure at FAHT. According to available information, there was most probably 114 litres on-board, which was 22 litres below the regulatory requirements.

The pilot indicated that he was concerned about his take-off weight prior to take-off from FAHT, which is the reason he opted to uplift only 55 litres. According to the weight and balance calculation, the aircraft was 106kg (234lbs) below its MTOW during take-off from FAHT, taking into consideration the data supplied by the pilot, which was not accurate. From the information contained in the Cessna 182 Owner's Manual (see Figure 13), it was determined that the runway at FAHT was long enough (1 200m / 3 936ft) to accommodate the aircraft's take-off distance even if it was near or at its MTOW. It would appear that the pilot did not conduct all the necessary calculations prior to take-off, hence, the decision to remain with the 55-litre fuel uplift limit, even though it was possible to have uplifted ample fuel for the flight.

Fuel burn rates quoted in aircraft manuals are mostly predicted on a new aircraft, engine and propeller. The pilot needs to establish a realistic fuel burn rate for his aircraft when carrying out fuel planning.

Accurate fuel management starts with knowing exactly how much fuel is being carried on-board at the commencement of a flight. This is easy to establish if the tanks are full, however, if the tanks are not filled to a known quantity, then an alternative method must be used to accurately establish fuel quantity.

Accurate fuel management also relies on establishing a method of determining how much fuel is being burned. There are many variables that can affect the fuel burn rate, such as the power setting, the effect of flying at different altitudes or levels, flying at different airspeeds, the technique used to adjust the mixture, etc. If these factors are not considered and managed by the pilot, then the awareness or knowledge of the fuel remaining on-board during flight will be reduced.

Maintaining an adequate fuel supply to the engine during flight is dependent on the pilot's knowledge of the aircraft fuel system as well as the familiarity and proficiency usage.

Establishing and using appropriate procedures such as maintaining records of fuel uplifts and the fuel quantity on-board after fuelling, carrying out a reconciliation after fuelling, monitoring your fuel usage in-flight and being prepared to carry out in-flight re-planning, where appropriate.

The pilot had several options en route where he could have diverted to another aerodrome to uplift fuel. He flew past FAGC to the west (which was 1nm away) but did not opt to divert to uplift fuel.

The pilot filed the fuel endurance as 3 hours and 30 minutes (3.5 hours) on the flight plan. In order to have complied with this fuel endurance, it was required that a minimum of 166 litres (44 US gallons) of fuel should have been on-board the aircraft prior to take-off from FAHT. This was not the case, and the information was, therefore, misleading and inaccurate.

The pilot provided the investigator with contradictory/misleading information when it came to the actual fuel state of the aircraft prior to take-off from FAHT. It should be noted that both the CA 12-03 form as well as the flight plan that were completed and filed by the pilot are official documents which are required to be populated with accurate information.

(i) On the pilot's questionnaire (SACAA form CA 12-03), the pilot stated the take-off fuel on-board as 136-140 litres (36-37 US gallons).

(ii) On the official weight and balance calculation he provided to the investigator, the pilot stated the fuel on-board as 136 litres (36 US gallons or 216lbs).

(iii) On the flight plan, the pilot entered fuel endurance of the aircraft as 3 hours and 30 minutes (3.5 hours), which added to 166 litres (44 USG) when using the average fuel consumption of 47.3 litres (12.5 USG) per hour.

(iv) In his fuel calculation information (information was provided in writing) under sub-paragraph 1.18.3 of the report, he stated that the fuel required for the flight was 112 litres (29.7 USG).

With reference to Part 91.02.7(1) (j) of the CAR of 2011 as amended, the pilot did not meet the fuel requirements to ensure the safety of the flight was not compromised. On take-off, there was neither 136 litres nor 166 litres of fuel on-board the aircraft.

2.2.2 Aircraft

During an interview with the pilot, he stated that the aircraft fuel gauges were inaccurate. No evidence could be found to show that this defect was reported to a maintenance organisation to be rectified as there was no flight folio entry found in this regard.

Fuel system instruments

Inaccurate fuel system instruments played a much greater role in fuel exhaustion than in starvation cases. The instruments were never the sole factor in any incident because standard aviation procedures specify that the pre-flight preparation should ensure sufficient fuel for the flight, including all reserve requirements.

Thus, the majority of cases of inaccurate fuel system instruments occurred in conjunction with pilots factors. The most common scenario was that the pilot unwittingly relied on inaccurate gauges (usually in conjunction with other oversights) and exhausted the fuel supply. A second distinct scenario, however, was that the pilot was aware that the fuel system instruments were inaccurate but chose to ignore their indications completely, or made an incorrect compensation.

Miscalculations of fuel consumption have also contributed to a number of unnecessary occurrences. This problem has a number of sources, including lack of pilot's knowledge and lack of inclination to apply the required knowledge. There is also what could be described as "procedural component", which is lack of consistency of fuel volume measurement units which had caused problems for some pilots despite the advent of the metric standard in aviation. Typically, miscalculations have emerged when pilots must convert between various units. For example, although fuel is sold by the litre, fuel consumption figures given in the flight manual may be in US gallons. If the instruments record the actual amount of fuel on-board the aircraft, they may also be calibrated in US gallons, or in pounds. (For weight and balance purposes, fuel is calculated in kilograms, which results in an additional conversion of units).

Unreliable fuel system instruments have also contributed to some in-flight miscalculations of fuel consumption. Those standards do not address the accuracy of measurement of partially full tanks. By means of personal account, there is widespread scepticism towards the reliability of fuel system instruments in the "pilots community". Scepticism which induces pilots to interpret the instruments cautiously is commendable; however, scepticism which induces pilots to disregard the instruments without obtaining alternative fuel measurements is an area of concern.

2.2.3 Flight Folio and Fuel Record

Part 91.03.5 (Flight folio) and 91.03.6 (Fuel record) of the CAR 2011 provide clear guidance on what is required to be entered in the document and the purpose of the document as per the SA Civil Aviation Technical Standards (CATS) 91.

After the aircraft returned to service on 13 February 2021 and having been idle for approximately 16 months, several entries in the flight folio were found to have either not been entered at all, including the last three flights of the aircraft, or be lacking information (i.e., fuel uplift information or flight time).

The aircraft was refuelled during this period on several occasions, but this does not reflect in the flight folio. There were also flights that were entered as one entry, even though the aircraft had been flown for more than one sector within the sequence. The neglect by the pilots to populate the flight folio accurately hampered this investigation as essential information was missing. The investigator had to follow up on every flight since 13 February 2021, including contacting all refuelling stations where fuel was uplifted or could have potentially been uplifted, and even contacting some of the pilots who have flown the aircraft during this period.

2.2.4 Weight and Balance

The weight and balance calculation on 1.6.2 of this report was based on the information supplied by the pilot with the aircraft having 136 litres (36 US gallons) of fuel on-board. It was determined that this fuel load was inaccurate as the actual fuel on-board was less at approximately 114 litres (30 US gallons). This would have reduced the take-off weight of the aircraft further by approximately 35lbs (16kg) with a take-off weight of 2 680.3lbs (1 215kg), which was 270lbs (122kg) below the MTOW.

2.2.5 Environment

During the flight from FAHT to FAGM, the aircraft was cleared to climb to FL085. With the elevation at FAHT being 1 800ft, the aircraft was required to climb approximately 7 000ft, which was most probably higher than what the pilot had anticipated, and this would have had a substantial effect on fuel consumption. En route to FAGM, there were upper winds on the nose from the south-west for a substantial period of the flight, which resulted in an additional flight time of approximately 15 minutes.

2.2.6 Conclusion

Apart from the inaccurate fuel gauges, which the pilot could not rely on, no other evidence could be found that the aircraft had any mechanical-related defects or any malfunction that could have contributed or have caused the accident.

Fuel requirements for the flight from FAHT to FAGM as calculated by the pilot were made available to the investigator, and he had indicated that 112 litres (29.7 US gallons) of fuel was required for the flight according to his calculations (see sub-paragraph 1.18.3 of the report). According to the calculations in this report, it was determined that there was approximately 114 litres of fuel on-board the aircraft prior to take-off from FAHT, that is, if the aircraft was refuelled to its absolute maximum capacity at FAVG. According to the provisions of Part 91.07.12 of the CAR 2011 (Fuel and Oil Requirements) there should have been a minimum of 136 litres (36 US gallons) of fuel on-board the aircraft for the intended flight, however, this requirement was not met, and the pilot commenced with the flight with approximately 22 litres less fuel than what was the regulatory requirement. It should be noted that the pilot had entered the fuel state of the aircraft prior to take-off from FAHT as 136 litres (36 US gallons) in the pilot's questionnaire, and he also used the same value in the weight and balance calculation he supplied to the investigator post-accident.

The pilot was concerned about the take-off weight of the aircraft and, therefore, instructed the fuel service provider at FAHT to only top up with 55 litres of fuel. According to the weight and balance calculation, the aircraft was actually 270lbs (122kg) below its MTOW prior to take-off. It was, therefore, possible to uplift several more litres of fuel and still remain within the safe operating envelope for the flight as the take-off distance, even at MTOW, was adequate for a safe take-off and 50ft obstacle clearance at the end of the runway, of which there was none.

The pilot had not incorporated any reserve or deviation fuel for the flight, nor had he opted to divert, land and refuel at any stage. From the radar data, the pilot flew past FAGC within 1nm from the aerodrome (see Figure 1) and continued with the flight to FAGM, stretching the fuel supply. The reason the pilot did not opt to divert to another aerodrome could have been attributed to the fact that he was obliged to adhered to Part 91.03.4 (Air traffic service flight plan and associated procedures) of the CAR 2011, as he had filed a flight plan, which was active for the flight. Part 91.03.4(11), however, does make provisions for a pilot to deviate from a flight plan when an emergency arises that necessitates immediate action, in which event, the responsible Air Traffic Service Unit (ATSU) shall, as soon as possible, be advised of the action taken.

In the pilot's fuel calculation as outlined in sub-paragraph 1.18.3 of the report, the pilot indicated that the flight time was 1 hour and 36 minutes (1.6 hours). At the time of the accident, this flight time (1.6 hours) was exceeded by approximately 15 minutes, which resulted in an additional fuel usage of approximately 12 litres.

The table below was compiled based on estimates as no actual fuel state was available prior to take-off. The only known fuel amount was the 4 litres that was drained during recovery of the aircraft.

Estimated fuel in tanks at take-off	Estimated fuel used	Estimated fuel left in tanks
114L	- 90L	24L
Fuel drained during recovery	----------	- 4L
Fuel unaccounted for	----------	20L

The 20 litres of fuel that was unaccounted for could be attributed to:

(i) The aircraft not being refuelled to its absolute maximum capacity at FAVG.
(ii) The fuel consumption could have been above average during the climb phase of the flight after take-off from FAHT to FL085 as the aircraft had to climb approximately 7000ft to reach its cruising altitude.
(iii) The aircraft had been used for three flights since the last fuel uplift; this would have required additional fuel usage for start, taxi and power checks.
(iv) An unknown amount of fuel could have vapourised, considering that the aircraft was parked outside at the game reserve with not much fuel in the tanks.
(v) An unknown amount of fuel could have been drained/stolen from the aircraft.

The engine stoppage was attributed to fuel exhaustion, which required the pilot to perform a forced landing. The post-recovery engine ground run confirmed that the engine was mechanically in working condition.

3. CONCLUSION

3.1 General

From the available evidence, 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 conclusion heading:

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

- **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 occurring, or would have mitigated the severity of the consequences of the accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

Pilot

3.2.1 The pilot had a Private Pilot Licence (PPL) that was issued on 26 March 2021 with an expiry date of 31 March 2022. According to the pilot's logbook, the pilot had flown a total of 115.5 hours, of which 42.7 hours were on the aircraft type.

3.2.2 The pilot was issued a valid Class 2 aviation medical certificate on 24 August 2019 with an expiry date of 31 August 2024.

3.2.3 The pilot flew from a private game reserve near Hoedspruit and, after being airborne for 30 minutes (0.5 hour), he landed at FAHT where 55 litres of Avgas was uplifted.

3.2.4 The pilot was concerned about the take-off weight of the aircraft and, as a result, he compromised the fuel requirements for the (accident) flight. The pilot provided a weight and balance calculation for the flight, which indicated that the aircraft was 234lbs (106kg) below the MTOW limitation of 2 950lbs (1 330kg) prior to take-off from FAHT. The information was found to be inaccurate, and the aircraft's take-off weight was actually less, at approximately 270lbs (122kg) below the MTOW.

3.2.5 The pilot filed a flight plan prior to departure from FAHT and was allocated a squawk code (#7342) by air traffic control. The pilot entered the flight endurance as 3 hours and 30 minutes (3.5 hours), which was found to be inaccurate as the minimum fuel of approximately 166 litres was required to meet this flight endurance.

3.2.6 The last three flights that the pilot conducted on this aircraft were not entered in the flight folio.

Aircraft

3.2.7 The aircraft was issued a Certificate of Airworthiness on 7 June 1991 with an expiry date of 30 June 2021.

3.2.8 The aircraft was issued a Certificate of Release to Service on 20 August 2020 with an expiry date of 19 August 2021 or at 4 032.1 airframe hours, whichever comes first.

3.2.9 The aircraft was issued a Certificate of Registration on 28 May 2021.

3.2.10 The last scheduled maintenance inspection carried out on the aircraft prior to the accident flight was certified on 20 August 2020 at 3 932.1 airframe hours. The aircraft had accumulated a further 28.8 airframe hours since the said inspection.

3.2.11 The aircraft was fitted with long range fuel tanks, which allowed for a total useable fuel capacity of 79 US gallons (299 litres or 474lbs).

3.2.12 During recovery of the aircraft, a total of 4 litres of fuel was drained from both wing tanks.

3.2.13 The pilot flew the aircraft knowing the gauges were inaccurate, yet no corrective action was taken to rectify the defect.

3.2.14 The aircraft's flight folio was lacking critical information, which hampered this investigation.

3.2.15 No evidence could be found that fuel was leaking from the tanks or fuel caps during flight.

Environment

3.2.16 The aircraft was cleared to climb to FL085 (8 500ft) by ATC after take-off from FAHT. The aircraft encountered some headwinds at this altitude from the south-west.

3.2.17 Fine weather conditions prevailed at the time of the accident. The ATC at FAGM had informed the pilot that the wind was 360° at 16 knots when she cleared the aircraft for landing.

Aerodromes

3.2.18 Hoedspruit Civil Aerodrome (FAHT) is not a licensed aerodrome. According to the CCTV footage obtained from FAHT, the aircraft took off from Runway 35 at 0740Z.

3.2.19 In consultation with the take-off data chart in the aircraft owner's manual, approximately 1 625ft (496m) of runway length was required for take-off to clear a 50ft obstacle at the end of the runway. The runway at FAHT was 1 200m (3 936ft) long.

3.2.20 The Rand Aerodrome (FAGM) is a licensed aerodrome. Runway 35 is 1 197m (3 926ft) and 15m (49ft) wide.

3.2.21 The aircraft was cleared by ATC to land at FAGM at 0921Z.

3.2.22 On short final approach for Runway 35 at FAGM, the pilot aborted landing, stating that the approach was unstable. He opted to perform a go-around (baulked landing).

3.2.23 While positioning for a second landing for Runway 35, the engine stopped in operation and the pilot broadcasted a Mayday call at 0924Z on the FAGM tower frequency.

3.2.24 A helicopter that was engaged in training in the FAGM circuit was dispatched to the scene of the accident. The pilot was able to land close to the accident site and transported the four occupants to FAGM, two at a time.

3.3 Probable Cause/s

3.3.1 The pilot's fuel management practise resulted in a complete loss of engine power due to fuel exhaustion; the pilot had no choice but to perform a forced landing in a swampland, which caused substantial damage to the aircraft.

3.4 Contributory Factors

3.4.1 The pilot opted to commence with the flight even after realising that he did not meet the minimum fuel requirements as called for in Part 91.07.12 of CAR 2011 as amended.

3.4.2 The pilot undertook the flight knowing the fuel gauges were inaccurate. No evidence could be found that the defective fuel gauges were entered as 'defective' in the flight folio.

3.4.3 The pilot flew an unstable approach after being cleared to land Runway 35 at FAGM, which resulted in a go-around (baulked landing); this required a second approach to be flown during which the engine stopped.

3.4.4 According to the flight plan, fuel endurance was entered as 3 hours and 30 minutes (3.5 hours), which was inaccurate and misleading.

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 Message

4.2.1 The fact that the flight folio lacked essential information because some of the pilots had not entered data on this document as stipulated in Part 91.03.5 of the CAR 2011 hampered this investigation.

It is recommended that the SACAA embarks on a campaign to ensure that all aircraft flight folios are correctly populated as called for in Part 91.03.5 and Part 91.03.6 of the CAR 2011, especially during ramp inspections.

5. APPENDICES

5.1 Appendix A (FAGM Aerodrome Chart)
5.2 Appendix B (Fuel and Oil Requirements as per Part 91.07.12 of CAR 2011)

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

APPENDIX A

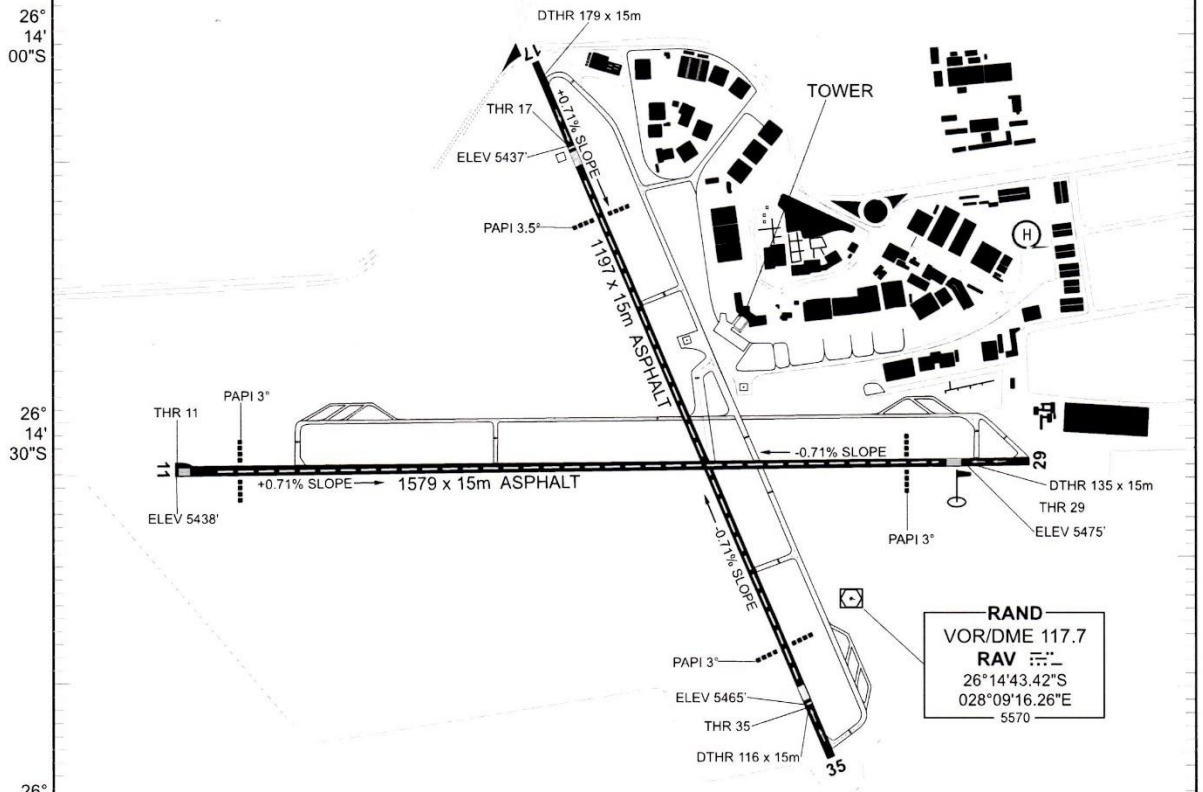
AERODROME CHART 26°14'31.12"S 028°09'04.88"E **ELEV 5483'**

RADAR APP 134.40 (N)
123.70 (W)
124.50 (S & E)
TWR 118.70

RAND (JOHANNESBURG)
FAGM

ELEV, ALT & HGT IN FEET
DIST IN METERS
BRG ARE MAG
VAR 19°W (2009)

NOTE
1. Windshear on approach RWY 35.
2. High tension power lines on approach to RWY 17 marked with red/white spheres.
3. High trees on approach RWY 17.



SCALE 1:20 000
0 180 360 720 Meters

RWY LIGHTING					
RWY	ALS	PAPI	RTHL	REDL	RENL
11	NIL	3°	GREEN	WHITE	RED
29	NIL	3°	GREEN	WHITE	RED
17	NIL	3.5°	GREEN	WHITE	RED
35	NIL	3°	GREEN	WHITE	RED

OTHER: OBST, TWY & AD BEACON

028°08'30"E 028°09'E 028°09'30"E

PHYSICAL CHARACTERISTICS

RWY	DIRECTION (T)	THR COORDINATES	THR ELEVATION	TORA (m)	TODA (m)	ASDA (m)	LDA (m)	SWY (m)	CWY (m)	SLOPE	SURFACE	BEARING STRENGTH	CIRCUIT
11	089°	26°14'33.55"S 028°08'25.99"E	5438'	1579	1579	1714	1714	135	0	0.007 U	ASPH	LCN 51	R/H
29	269°	26°14'32.87"S 028°09'22.86"E	5475'	1714	1714	1714	1579	0	0	0.007 D	ASPH	LCN 51	L/H
17	157°	26°14'12.66"S 028°08'54.55"E	5437'	1376	1376	1492	1313	116	0	0.007 U	ASPH	LCN 43	R/H
35	337°	26°14'48.44"S 028°09'11.51"E	5465'	1313	1313	1492	1376	179	0	0.007 D	ASPH	LCN 43	L/H

CHANGE: RWY Physical Characteristics

EFF: 20 JUL 17

SOUTH AFRICAN CIVIL AVIATION AUTHORITY

AD-01

APPENDIX B

Fuel and oil requirements

91.07.12 *(1) A pilot-in-command of an aircraft shall not commence a flight unless he or she is satisfied that the aircraft is carrying sufficient amount of usable fuel and sufficient oil to complete the planned flight safely and to allow for deviations from the planned operation.*

(2) The pilot-in-command shall ensure that the amount of useable fuel to be carried shall, as a minimum, be based on—

(a) the following data—

(i) current aircraft-specific data derived from a fuel consumption monitoring system, if available; or

(ii) if current aircraft-specific data is not available, data provided by the aeroplane manufacturer; and

(b) the operator conditions for the planned flight including—

(i) anticipated aeroplane mass;

(ii) notices to Airmen;

(iii) current meteorological reports or a combination of current reports and forecasts;

(iv) air traffic services procedures, restrictions and anticipated delays; and

(v) the effects of deferred maintenance items and/or configuration deviations.

(3) The pre-flight calculation of usable fuel required shall include—

(a) Taxi fuel, which shall be the amount of fuel expected to be consumed before take-off; taking into account local conditions at the departure aerodrome and auxiliary power unit (APU) fuel consumption;

(b) Trip fuel, Which shall be the amount of fuel required to enable the aeroplane to fly from take-off or the point of in-flight re-planning until landing at the destination aerodrome taking into account the operating conditions of paragraph (b) of sub-regulation 91.07.12 (2);

(c) Contingency fuel, which shall be the amount of fuel required to compensate for unforeseen factors. It shall be 5 per cent of the planned trip fuel or of the fuel required from the point of in-flight re-planning based on the consumption rate used to plan the trip fuel but in any case shall, in the case of aeroplanes, shall not be lower than the amount required to fly for 5 minutes at holding speed at 1 500 ft above the destination aerodrome in standard conditions;

Note.*—Unforeseen factors are those factors that could have an influence on the fuel consumption to the destination aerodrome, such as deviations of an individual aeroplane from the expected fuel consumption data, deviations from forecast meteorological conditions, extended delays.*

(d) Destination alternate fuel, which shall be—

(i) where a destination alternate aerodrome is required, the amount of fuel required to enable the aeroplane to—

(aa) perform a missed approach at the destination aerodrome;

(bb) climb to the expected cruising altitude;

(cc) fly the expected routing;

(dd) descend to the point where expected approach is initiated; and

(ee) conduct the approach and landing at the destination alternate aerodrome; or

(ii) where two destination alternate aerodromes are required, the amount of fuel, as calculated in sub-regulation 91.07.12 (3), required to enable the aeroplane to proceed to the destination alternate aerodrome which requires the greater amount of alternate fuel; or

(iii) where a flight is operated without a destination alternate aerodrome, the amount of fuel required to enable the aeroplane to fly for 15 minutes at holding speed at 1 500 ft above the destination aerodrome elevation in standard conditions; or

(iv) Where the aerodrome of intended landing is an isolated aerodrome—

(aa) for a reciprocating engine aeroplane, the amount of fuel required to fly for 45 minutes plus 15 per cent of the flight time planned to be spent at cruising level, including final reserve fuel, or two hours, whichever is less; or

(bb) for a turbine engine aeroplane, the amount of fuel required to fly for two hours at normal cruise consumption above the destination aerodrome, including final reserve fuel;

(e) Final reserve fuel, which shall be the amount of fuel calculated using the estimated mass on arrival at the destination alternate aerodrome or the destination aerodrome, when no destination alternate aerodrome is required—

(i) for a reciprocating engine aeroplane, the amount of fuel required to fly for 45 minutes, under speed and altitude conditions specified by the Director;

(ii) for a turbine engine aeroplane, the amount of fuel required to fly for 30 minutes at holding speed at 1 500 ft above aerodrome elevation in standard conditions;

(f) Additional fuel, which shall be the supplementary amount of fuel required if the minimum fuel calculated in accordance with sub-regulations 91.07.12 (a), (b), (c), (d) or (e) is not sufficient to—

(i) allow the aeroplane to descend as necessary and proceed to an alternate aerodrome in the event of engine failure or loss of pressurisation, whichever requires the greater amount of fuel based on the assumption that such a failure occurs at the most critical point along the route;

(aa) fly for 15 minutes at holding speed at 1 500 ft above aerodrome elevation in standard conditions; and

(bb) Make an approach and landing;

(ii) allow an aeroplane engaged in EDTO to comply with the EDTO critical fuel scenario as established by the Director.

(iii) meet additional requirements not covered above;

(g) Discretionary fuel, which shall be the extra amount of fuel to be carried at the discretion of the pilot-in-command.

(4) Operators shall determine one final reserve fuel value for each aeroplane type and variant owned or operated rounded up to an easily recalled figure.

(5) An aeroplane shall not take off or continue from the point of in-flight re-planning unless the usable fuel on board meets the requirements prescribed in paragraphs (b), (d), (e) or (f) of sub-regulation 91.07.12 (3), if applicable.

(6) The pilot-in-command shall continually ensure that the amount of usable fuel remaining on board is not less than the fuel required to proceed to an aerodrome where a safe landing can be made with the planned final reserve fuel remaining upon landing.

(6A) The use of fuel after flight commencement for purposes other than originally intended during pre-flight planning shall require a re-analysis and, if applicable, adjustment of the planned operation.

***Note**. — Guidance on procedures for in-flight fuel management including re-analysis, adjustment and/or re-planning considerations when a flight begins to consume contingency fuel before take-off is contained in the In-Flight Fuel Management TGM on the CAA website.*

(7) The pilot-in-command shall request delay information from ATC when unanticipated circumstances may result in landing at the destination aerodrome with less than the final reserve fuel plus any fuel required to proceed to an alternate aerodrome or the fuel required to operate to an isolated aerodrome.

(8) The pilot-in-command shall advise ATC of a minimum fuel state by declaring MINIMUM FUEL when, having committed to land at a specific aerodrome, the pilot calculates that any change to the existing clearance to that aerodrome may result in landing with less than planned final reserve fuel.

***Note.** — The declaration of MINIMUM FUEL informs ATC that all planned aerodrome options have been reduced to a specific aerodrome of intended landing and any change to the existing clearance may result in landing with less than the planned final reserve fuel. This is not an emergency situation but an indication that an emergency situation is possible should any additional delay occur.*

(9) The pilot-in-command shall declare a situation of fuel emergency by broadcasting MAYDAY MAYDAY MAYDAY FUEL, when the calculated usable fuel predicted to be available upon landing at the nearest aerodrome where a safe landing can be made is less than the planned final reserve fuel.

(10) Notwithstanding the provisions in paragraphs (a), (b), (c), (d), and (f) of sub-regulation 91.07.12(3), the Director may, based on the results of a specific safety risk assessment conducted by the operator which demonstrates how an equivalent level of safety will be maintained, approve variations to the pre-flight fuel calculation of taxi fuel, trip fuel, contingency fuel, destination alternate fuel, and additional fuel. The specific safety risk assessment shall include at least the—

(a) flight fuel calculations;

(b) capabilities of the operator include—

(aa) a data-driven method that includes a fuel consumption monitoring programme; and/or

(bb) The advanced use of alternate aerodromes; and

(c) specific mitigation measures.