HELLENIC REPUBLIC
MINISTRY OF INFRASTRUCTURE AND TRANSPORT

AIR ACCIDENT INVESTIGATION AND AVIATION SAFETY BOARD (AAIASB)

ACCIDENT INVESTIGATION REPORT
AIRCRAFT SX-SEX
ON APRIL 21st, 2018
AT SKALOMA FOKIDAS

01 / 2021

ACCIDENT INVESTIGATION REPORT
01 / 2021
Aircraft Piper PA-28-140 with registration SX-SEX
on April 21st, 2018 at Skaloma Fokidas

This accident investigation was carried out by the Air Accident Investigation and Aviation Safety Board according to:

- **Annex 13 of the Chicago Convention**
- **EU regulation (EU) 996/2010**
- **Law 2912/2001**

According to Annex 13 of the Chicago Convention of the International Civil Aviation, EU Regulation 996/2010 and Law 2912/2001 Accidents and Incidents Investigation is not intended to attribute blame or liability. The sole purpose of this investigation and the findings is to prevent accidents and incidents.

Therefore, the use of this report for any purpose other than to prevent future accidents and incidents could lead to misinterpretations."

Members of the Air Accident Investigation and Aviation Safety Board

Chairman
Ioannis Kondylis
Airline Captain, Investigator

Members

Vice Chairman Akrivos Tsolakis
Airline Captain, Investigator

Grigorios Flessas
Airline Captain

Christos Valaris
Ret. A. F. Brigadier General

Charalampos Tzonos-Komilis
Airline Captain, Investigator

Secretary: Kyriakos Katsoulakis

Table of Contents

List of Abbreviations

AD	Airworthiness Directive
AGL	Above Ground Level
AIP	Aeronautical Information Publications
v/v	By volume
CAMO	Continuing Airworthiness Management Organisation
Cm	Centimetre
CPL	Commercial Pilot License
CRS	Certificate of Release to Service
deg	Degrees
ELT	Emergency Locator Transmitter
FIC	Flight Information Centre
fpm	Feet per Minute
ft	Feet
GPS	Global Position System
h	Hour
hPa	Hecto Pascal
IPC	Illustrated Parts Catalogue
kg	Kilogram
km/h	Kilometers per Hour
kt	Nautical Miles per Hour
LAPL	Light Aircraft Pilot Licence
LF	Landing Field
LT	Local Time
lt	Litter
min	Minute
N	North
NM	Nautical Miles
°C	Celsius
PIC	Pilot In Command
POM	Pilot Operating Manual
PPL	Private Pilot License
RON	Research Octane Number
S	Second
SM	Statute Miles
SEP	Single-Engine Piston
STC	Supplemental Type Certificate
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VHF	Very High Frequency
W/V	Wind Velocity

Title

OPERATOR	**:**	ARAXOS AIR CLUB
OWNER	**:**	ARAXOS AIR CLUB
MANUFACTURER	**:**	PIPER AIRCRAFT CORPORATION
A/C TYPE	**:**	PA-28-140
NATIONALITY	**:**	HELLENIC
A/C REGISTRATION	**:**	SX-SEX
LOCATION OF ACCIDENT	**:**	NAFPAKTOS - ITEA NATIONAL ROAD IN THE AREA SKALOMA IN FOKIDA COUNTY
DATE and TIME	**:**	21/4/2018 at 15:58 LT
Note	**:**	All Local Time LT = UTC + 3 h

Synopsis

On 21/4/2018, at 12:00 h, the Aircraft Piper PA-28-140 with registration SX-SEX took off from Messolonghi LF with four Pilots onboard with destination Kopaida "Dimitra" LF. All on board were Pilot members of the Araxos Air Club. Two Pilots would disembark at Kopaida LF in order to pick up another ultralight Aircraft with registration SX-UBX.

At 15:20LT SX-SEX Aircraft took off from Kopaida LF with two Pilots on board to return to Messolonghi LF. At 12:57:52LT at an altitude of 2500 ft and while the Aircraft had passed the IXONI point, the pilot reported to the FIC an emergency due to a problem with the fuel pump and his intention to land on the old highway. During the approach for the forced landing, the Aircraft collided with the horizontal support cable between two electricity pillars, resulting in its impact on the road of the old highway where it stopped after traveling a distance of 64.5 m.

The forced landing was monitored by the two Pilots of the other Aircraft who informed the FIC and NHERC. The rescue teams that arrived rescued one fatally injured and one injured.

AAIASB was informed about the accident and the investigation team was appointed on the same day, while on 23/4/2018 the AAIASB informed the State of design and manufacture of the Aircraft, the European Commission, the European Aviation Safety Agency, the Civil Aviation Authority and the Safety Incidents Reporting Committee.

1 FACTUAL INFORMATION

1.1 History of Flight

On 21/04/2018 at12:00 LT the Aircraft Piper PA-28-140 with registration SX-SEX took off from Messolonghi LF, performing its first flight of the day after 09/04/2018, with destination Kopaida LF "Dimitra". Two pilots and two additional pilots were on board the Aircraft in order to return to Messolonghi LF with the ultra-light Aircraft with registration SX-UBX which was located in Kopaida LF. According to the flight plan, the Aircraft after its departure from Messolonghi would pass through the points RIO and PUNTA, the flight would be with VFR and its duration 01:45 h with a cruising speed of 80 kts.

According to information from the interviews, the flight from Messolonghi LF to Kopaida LF was completed without any problems with the left fuel tank used to feed the engine. Despite the fact that fuel had been requested and was available to fill the tanks at the Kopaida LF, the crew finally decided not to up lift fuel from departure.

At 15:15 h SX-SEX started the engine and took off at 15:20 h with destination back to Messolonghi LF. Shortly before, SX-UBX took off from Kopaida Airport with same destination. With two pilots on board the Aircraft SX-SEX would go through BAGIA and IXONI point, the flight would be VFR with a scheduled duration of 01:15 h and with a cruising speed of 70 kts.

According to the available data, but also according to interviews that were taken, the flight of SX-SEX developed as follows:

- At 15:35:04 LT SX-SEX reported to FIC normal flight over PUNDA point at 3000 ft[1].
- At 15:50:39 LT SX-SEX reported to FIC normal flight over IXONI point at 3000 ft.
- After IXONI point the Aircraft executed a right turn flying towards the island of Trizonia.
- The pilots of the SX-UBX Aircraft, observing the presiding Aircraft SX-SEX turning right and descending, contacted its crew, who stated that there was a problem with the fuel supply to the engine.
- SX-SEX Aircraft going through Marathia area and up to Skaloma area, located between Marathia and the point of crash, had its engine in intermittent operation while after the

[1] Where altitude is indicated it is from Mean Sea Level (MSL)

area of Skaloma, 500 m before the point of crash, its engine had ceased operating and an attempt was made to restart it.

- At 15:57:52LT, the flight crew reported to FIC: "*[….] "the SEX emergency from fuel pump we are going to land on the old national road".*
- At 15:58:58 LT, Aircraft SX-UBX reported to FIC*: "SX-SEX on the ground over the old national road between Trizonia and Nafpaktos".*

SX-SEX Aircraft, during its forced landing on the old National Road Nafpaktos - Itea, 14.4 Km east of Nafpaktos, crashed onto the road at a point with coordinates 38º24'09.7''N, 021º59'17.8''E and stopped with coordinates 38º 24'10.8''N, 021º 59'15.7''E.

Fig. 1: Flight tracs according to flight plans from and to Kopaida and Messolonghi LF. The red line is the track from Messolonghi LF to Kopaida LF and the green from Kopaida LF back to Messolonghi LF.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	2	0	0
Serious	0	0	0
Minor / None	0 / 0	0	0

1.3 Damage to Aircraft

The Aircraft was completely destroyed by the impact.

1.4 Other damage

The pillars supporting cable was broken by the collision of the Aircraft. Also, a metal fuse from the pillars support line was fired at an adjacent House, located at a distance of approximately 87 m from the point of contact with the cable, causing damage to the house's stairway (Photo 1).

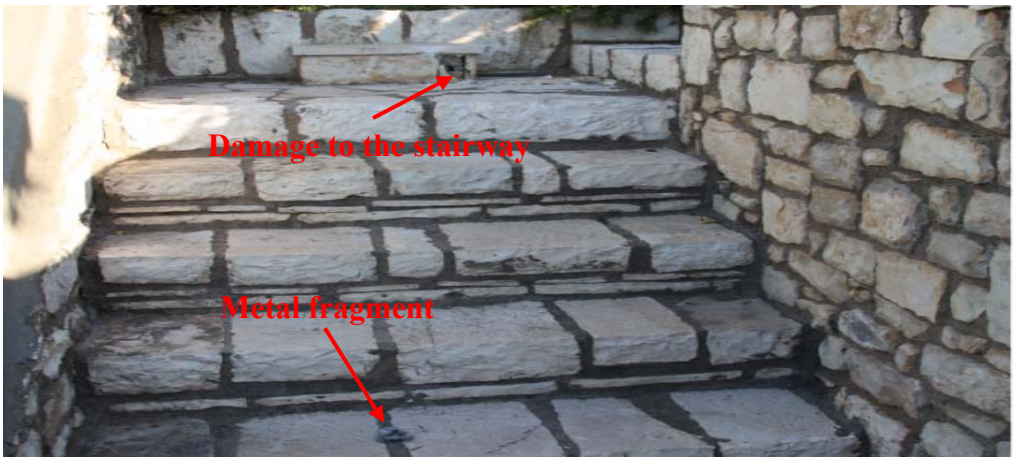


Photo 1: View of the metal fragment and damage caused.

1.5 Personnel information

1.5.1 Pilots

1.5.1.1 Pilot A

Pilot A, according to the flight plan, was the Commander of SX-SEX, he was a retired Air Force Officer. He occupied the right-hand seat of the Aircraft and that was the first time he flew with this particular Aircraft.

He was a CPL(A) license holder with initial issue date on 10/02/1994, last issue date on 30/05/2016, expiration date on 26/05/2021. He had the SEP class without restriction with re-evaluation date on 31/05/2018, An English language proficiency certificate level 5 and expiration date on 16/06/2017, he had received the renewal of the level 4 proficiency certificate on 21/02/2018.

He was holding a medical certificate of all classes with date of issue on 16/05/2017 and expiration date of class 2 on 16/05/2018 and with the restriction to wear corrective lenses for near vision.

According to his register at the CAA, on 17/05/2016, during the application for the renewal of his Licence, he had a total of 4150 h flight hours, of which 3600 h was as PIC. After 17/05/2016, the history of flight hours, although searched, could not be retrieved.

1.5.1.2 Pilot B

Pilot B was a PPL(A) license holder with an initial issue date on 22/07/2014, a last issue date of 19/08/2015 and an expiration date on 17/08/2020. He had the SEP class without restrictions, with a re-evaluation date on 31/08/2019, an English language proficiency certificate level 4 with an expiration date on14/05/2018.

He had a medical certificate of class 2 and LAPL with date of issue on 26/07/2017 and expiration of class 2 on 26/08/2018, with the restriction to wear corrective lenses for near vision and the performance of specific regular medical examinations.

He had a total of 219: 25 h Flight hours while with that specific A/C type he had accumulated 21:30 h Flight hours from 12/08/2017 to 05/04/2018.

Last	Had Accumulated
24 h	00:00 h
7 days	00:00 h
90 days	01:35 h

1.6 Aircraft information

The accident Aircraft is a single-engine, low-wing with all-metal construction and has two main and one nose landing gear which are non-retractable. In its basic configuration it is a two-seater with the optional configuration of two additional seats.

1.6.1 General information

Aircraft Manufacturer	:	Piper Aircraft Corporation
Model	:	PA-28-140
Serial number	:	28-7425044
Construction year	:	1973
Registration	:	SX-SEX
Total flight hours	:	4795:45 h[2]
Flight Hours from the last Inspection	:	04:42 h
Technical certificate	:	Date of issue 10/08/2017, expiration date 10/08/2018

[2] The total hours refer to the hours of the Aircraft's engine and propeller before the departure of the Aircraft from Kopaida LF.

Insurance certificate	:	Validity period: 20/07/2017 έως 19/07/2018
Radio Stations license	:	Validity period: 10/08/2017 until 31/12/2019

1.6.1.1 Engine

Manufacturer	:	Lycoming
Type	:	O-320-E3D
Serial number	:	L-31830-27A
Total Flight Hours since its last overhaul	:	493:45 h
Flight Hours since last inspection	:	04:42 h

1.6.1.2 Propeller

Manufacturer	:	Sensenich 74DM6-058
Serial number	:	K38116
Total Flight Hours from its Construction	:	493:45 h
Flight Hours since last inspection	:	04:42 h

1.6.2 Maintenance

The Aircraft was maintained, according to a maintenance program approved by the CAA, by a certified maintenance organization EL.145.0078, which had the capability on the specific type of Aircraft. The airworthiness of the Aircraft was managed by a Certified Airworthiness Management Organization EL.MG.0037, which also had an airworthiness review capability. The Aircraft, in accordance with the latest certificates of release to service and the instructions of the maintenance program, had carried out the following scheduled inspections:

Date	Flight Hours	Type of inspection
19/07/2017	4763:18	50 h, 100 h, 500 h ,1000 h, annual inspection for the issuance of an airworthiness certificate.
10/02/2018	4790:10	Implementation of a mandatory directive US-2018-02-05.
12/03/2018	4791:03	50 h

Among other tasks, foreseen in the 100 h inspection, is the inspection of tanks and fuel lines for leaks, water and contamination.

Also, on 19/07/2017 at the 461: 15 h of engine operation from the last overhaul inspection, the 400 h inspection of the engine was accomplished.

On 28/07/2017, the airworthiness review of the Aircraft was completed by the Organization for the continuous airworthiness, where, among other things, was the Aircraft manuals.

Among the tasks, included in the last 50-h maintenance inspection accomplished on 12/03/2018, are the followings:

- Cleaning the filter inside the electric fuel pump,
- Removing and cleaning the fuel filter and the fuel filter bowl. In particular, the work in question, according to the manufacturer's maintenance manual and maintenance schedule, must be carried out at least every 50 h of flight or every 90 days,
- Cleaning the carburettor filter,
- Check for the proper flight manual.

Additionally, during the last inspection on 12/03/2018, the spark plugs cables with product number (Part Number) M2989 and M2990 were replaced with serviceable of the same product number, while both magnetos with product number 4371 and 4270 were also replaced by serviceable with same product numbers.

For the above replacements, the manufacturer's Illustrated Parts catalog (IPC) specifies the following product numbers:

- Spark plug cables: M1795 and M2992,
- Magneto 4370 and 4371.

In the Service Bulletin with number 240W of the engine manufacturer dated 23/02/2012, it is stated that during overhaul[3] of the engine all the rubber piping should be replaced.

Also, based on the Service Bulletin 251D of the Aircraft manufacturer, repeated inspection instructions are given to the fuel tanks that have been repaired due to leakage with the sealing material "Randolph Products Company 802 Sloshing Sealer". According to the above maintenance instruction, it was observed that this material, over time, detaches from the inner surface of the tank and restricts the flow of fuel to the supply lines and the fuel filter, thus causing a loss of engine power.

[3]Every 2000 h flight or 12 calendar years

1.6.3 Maintenance Program

The maintenance program, issued by the organization EL.MG.0037 on 12/07/2017, was approved by the CAA on 04/08/2017 and was the first edition with a revision number of zero. The maintenance program was based on the manufacturer's service manual with number 753-586, revision number IR950215 and revision date 15/02/1995.

1.6.4 Manufacturer's Service Manual

From the review of the revisions of the maintenance manual, after the revision IR950215 on 15/02/1995, four more revisions emerged, the last one being PR191130 on 19/11/2019. The current revision of the manufacturer's service manual when issuing and approving the maintenance program was PR080131 with a revision date of 31/01/2008.

1.6.5 Aircraft Records

From the examination of the Aircraft records, that were delivered to AAIASB, it was found that the first entry, in the original maintenance book, was on 10/11/1973 and the last on 19/12/1992 with 3460 h flight hours. From 19/12/1992 onwards, the existence of a newer maintenance book was not established.

The next maintenance recording of the of the Aircraft was on 28/04/2010 and then:

In January 2013, on 30/01/2015, 23/06/2015, 25/06/2015, 10/05/2017. When the management of the Aircraft was taken over by the Organization EL.MG.0037 the recordings of the maintenance were continuous.

1.6.6 Aircraft fuel system

1.6.6.1 General description of the system

According to the Pilot Operating Manual, the fuel of the Aircraft is stored in two wing tanks with a capacity of 25 US gal (94.64 lt) each while total unusable fuel is 2.2 US gal (8.32 lt). For each tank the unusable fuel is 1.1 US gal (4.16 lt).

The standard capacity of 36 US gal, corresponds to approximately 3/4 of its total capacity and is achieved by filling it to the bottom of the indicator of the tank. The full filling of the tanks, with 50 US gal, is achieved by refueling them up to the top of the fuel filling port of the tank. For the indications of the quantity and pressure of the fuel there are corresponding indicators in the cockpit.

The fuel system also has an auxiliary electric fuel pump that is used in case of failure of the mechanical pump. The electric pump must also be switched on during take-off, landing and when changing the engine fuel tank.

The fuel system has a fuel filter located in the front, left, lower part of the engine compartment. It has a drainage device which should be carried out during the pre-departure inspection.

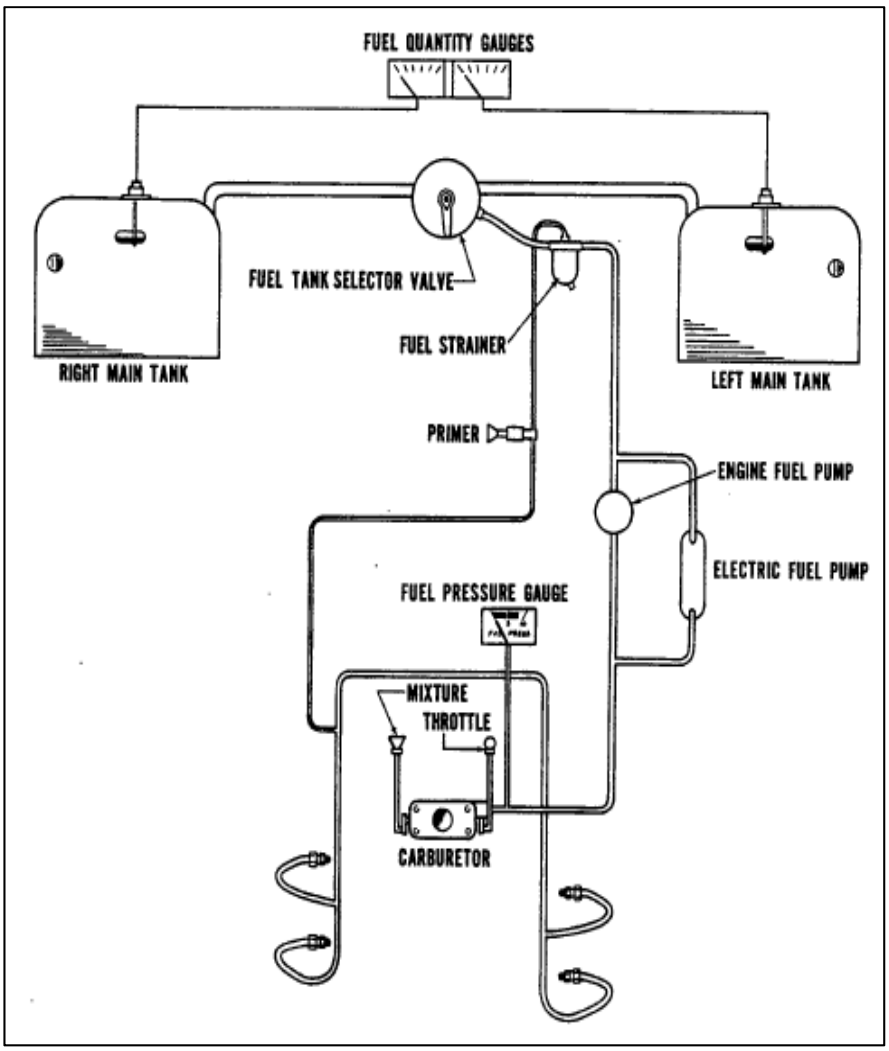


Fig. 2: General layout of the Aircraft fuel system.

1.6.6.2 Engine fuel management

To manage the fuel supply to the engine, there is a fuel tank selection valve in the lower left side wall of the cockpit with three positions in a row: "FUEL OFF", "L TANK", "R TANK". According to the current POM it is recommended, for reasons of lateral balance of the Aircraft in flight:

- The use of one tank for one hour after take-off,
- Switch to the other tank until the fuel is almost exhausted,
- Re-selection of the first tank.

1.6.6.3 Aircraft Fuel

According to the current POM only aviation gasoline (AVGAS) must be used with a minimum octane number of 80/87.

The Aircraft carried a supplemental type certificate (STC) with number SA1963CE while the engine number SE1931CE, based on which it could use unleaded automotive gasoline fuel.

These two supplementary certificates were adopted by the German Civil Aviation Authority in 2001 for the A/C and in 2000 for the engine, while in 2017 the Araxos Aeroclub had received permission to use those supplementary type certificate for the A/C and the engine.

According to the supplementary type certificate, the A/C could use unleaded automotive gasoline according to the standard EN 228 with a minimum grade of RON 98 or alternatively meet the specification ASTM D-439 or D-4814 with a minimum degree of Anti-knock Index (AKI) 91[4] or a mixture unleaded Automotive gasoline with aircraft gasoline (AVGAS) and be ethanol free. For this purpose the STC states that an alcohol test must be performed on the fuel to be used.

Based on the supplementary type certificate (STC) of the Aircraft with number SA1963CE, an additional page (STC Supplement) is given which should be integrated in the POM and indicates the type of Aircraft PA-28-140, the SX-SEX registration details, the serial number of the Aircraft 28-7425004 and the date of issue 23/03/1984.

Given the non-entry of the fuel amount in the logbook of the Aircraft, from the interviews conducted to the two passengers Pilots, it emerged that during the departure of the Aircraft from Messolonghi LF the left tank of the Aircraft, according to its visual observation, contained fuel 3/4 of its total capacity (68.13 lt), while for the right tank the indication of the fuel level instrument was between 1/4 and 1/2 (23lt - 47lt)[5] of its total capacity. During the flight of the Aircraft to Kopaida LF, the left fuel tank was used.

Upon arrival of the Aircraft at "Dimitra" of Kopaida LF, the indication of the fuel quantity instrument of the left tank was at 1/4 of its capacity (23 lt), while for the right tank the indication was between 1/2 and 1/4 (23 lt - 47 lt) of its total capacity.

---

[4] AKI is determined by the ratio (RON + MON) / 2

[5] From the collected data it was not possible to certify more accurately the amount of fuel in the right tank

1.6.6.4 Refuelling process in the Messolonghi LF

The refuelling of the Aircraft is carried out under the responsibility of the Captain who supplies fuel from a gas station of his choice and carries out the refuelling himself. The Messolonghi LF, according to the AIP data, does not provide fuel to the Aircraft.

1.6.7 Aircraft Weight

According to the last weighing of the Aircraft on 19/07/2017, the Empty Weight was 637 kg. The useful weight (Crew plus Pax plus fuel) is 338.22 kg. That makes a Maximum Take-off Weight of 975.22 kg.

The take-off weight of the Aircraft upon its departure from Messolonghi LF was calculated[6] to be between 1045 kg and 1063 Kg, while respectively the take-off weight of the Aircraft upon its departure from Kopaida LF, was calculated to be between 841 Kg and 859.5 Kg.

1.6.8 Fuel Consumption

According to the POM at 75% of the engine power, which is the normal cruising power, the hourly best economy fuel consumption with zero wind and mixture management as described by the manufacturer is 31.7 lt / h (8.4 US gal / h).

1.6.9 Aircraft Technical Logbook

The Technical Logbook, during the aircraft examination, was found inside the Aircraft. On its pages there were fields for recording data where, among other things, was the field of uplifted amount of fuel. On the day of the accident, the specific field was empty before departure from Messolonghi LF but also before departure from Kopaida LF. The last completion in the specific field was on 17/03/2018 where a zero (0) liters quantity was indicated.

Of the total 28 completed pages of the Logbook, only seven (7) were filled in the field of uplifted amount of fuel while in none of its pages was a recording of technical remark entries.

As can be seen from pages 27 and 28 of the Aircraft logbook, on the day of the accident:

- Before departure from Messolonghi the indication of operating hours of the Aircraft was 4794.19 h while on arrival in Kopaida it was 4795.45 h.
- Before the departure from Kopaida, the indication of the operating hours of the Aircraft recorded in the diary was 4795.45 h.

---

[6] The Aircraft weight was calculated between the values 1045 kg and 1063 Kg due to the fuel quantity in the right tank which was between 23 lt and 47 lt**.**

Also according to the Technical Logbook entries the last three flights conducted by the Aircraft, before the day of the accident, were on 17/03/2018, 05/04/2018 and 09/04/2018 where the departure and destination flight was Messolonghi LF.

1.6.10 Pilot Operating Manual

1.6.10.1 Pilot Operating Manual Description

During the examination of the Aircraft, at the accident site, the POM was found and retrieved as shown in Photo.2. This manual corresponds to:

- A Piper Cherokee Warrior PA-28-151 with serial number 28-7615411 and Lycoming O-320-E3D engine.

For the Aircraft, mentioned in the manual, the maximum take-off weight is 1054 Kg while the useful weight is 450 Kg.

As part of the investigation, the following POM were retained by AAIASB:

1. The approved POM by the CAA, with approval date 25/08/2017, as shown in Photo 3 which corresponds to:

- The Piper Cherokee Aircraft, Model PA-28-140 with serial numbers from 28-7425001 to 28-7625275.
- Lycoming O-320-E3D engine.
- The listed maximum take-off weight is 975 kg while the maximum useful weight is 396 Kg.

2. The POM from the Araxos Aeroclub, as shown in Photo 4 which corresponds to:

- The Piper Cherokee PA-28-150-160-180 Aircraft with O-320-E3A, O-320-D2A and O-360-A3A engines respectively.

The maximum allowed take-off weights are respectively: 975 Kg, 997 Kg, and 1088 Kg while the maximum useful weights are respectively: 426 Kg, 446 Kg and 530 Kg.

Photo 2: That POM was found inside the A/C at the accident sight

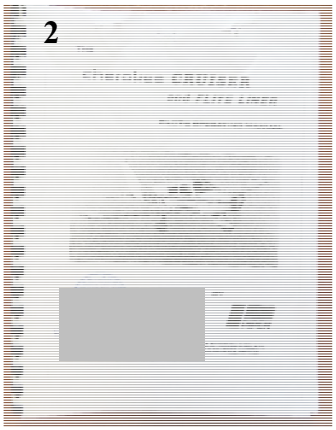


Photo 3: The POM that corresponds to the accident A/C

Photo 4: The POM delivered by Araxos Aeroclub

1.6.10.2 Check Lists

Three different checklists were retrieved from the cockpit of the accident Aircraft (Photo 5). Out of the three lists, from the review of the engine failure procedure, No2 and No3 include with small differences, the same actions, while those of list No1 differ.

Of the three lists, only No.2 refers to the type of accident Aircraft and the mentioned registration TC-VBV is the previous registration of that Aircraft.

Photo 5: The three different check lists retrieved from cockpit of the accident Aircraft

According to the Check list 2, the emergency procedures for inflight engine failure are:

Airspeed	*80 MPH*
Carburetor Heat	*ON*
Fuel Selector Valve	*SWITCH TANKS*
Mixture	*RICH*
Master Switch	*ON*
Auxiliary Fuel Pump	*ON*
Ignition Switch	*BOTH*
Primer	*IN & LOCKED*

Also in the POM it is mentioned that, in case of time permitting, the position of the power lever and the mixture lever to be selected placed in different positions depending whether the problem is very rich or very lean mixture but also when there is partial limitation of the fuel system.

1.6.10.3 Fuel management procedure

From the review of POM 1 and 3, of the above paragraph, the proposed fuel management procedure is as follows:

- Use of the first fuel tank for one hour after take-off,
- Change to the second tank for a period of two hours,
- Change to the first fuel tank. The second tank will contain fuel for about half an hour.

From the review of POM 2, of the above paragraph, the proposed fuel management procedure is as follows:

- Use of the first fuel tank for one hour after take-off,
- Switch to the other tank until the fuel is almost exhausted,
- Re-selection of the first tank.

1.6.10.4 Gliding Performance

The POM 2 includes a gliding diagram of the Aircraft (Appendix 5.3, Diagram 1)

1.7 Meteorological information

From the available wind data of the flight areas of the Aircraft, the following emerges:

A. Flight from Messolonghi to Kopaida at 12:00 h LT

- Wider area of Messolonghi and Rio at about 800 ft: W/V of 100^0/10 kts,

- Corinthian gulf at 5000 ft: W/V 020^0- 040^0 / 10 -15 kts,
- Kopaida area at about 800 ft: W/V 020^0/10 kts.

B. Flight from Kopaida to Messolonghi at 15:00 h LT

- Kopaida area at 800 ft approximately: W/V 020º/10 kts,
- Corinthian gulf at 5000 ft: from W/V 020º - 030º / 10 -15 kts,
- Accident sight: W /V 020º - 030º / 15kts.

1.8 Aids to Navigation

Not applicable

1.9 Communications

The Aircraft was equipped with a VHF Trans /Receiver of type NARCO MK12D, TERRA TX720 and ICOM IC-A15. Communication, of both Pilots, with FIC was conducted without any problem.

The transcripts of the conversations of the Aircraft with the FIC were handed over to AAIASB in the concept of accident investigation.

1.10 Aerodrome Information

Not applicable

1.11 Flight Recorders

A portable electronic device with a memory card was found and collected at the scene of the accident, which was sent to the Directorate of Criminological Investigations of the Greek Police for laboratory examination for possible data recording. The results of the examination did not reveal any data to be investigated due to non-functionality of the electronic device, while the memory card did not reveal any material related to the accident.

1.11.1 Flight track reproduction by the PALLAS system

1.11.1.1 Flight leg Messolonghi LF to Kopaida LF

From the reproduction of SX-SEX flight by the PALLAS system, the followings emerged:

- The Aircraft after departure from Messolonghi LF at 12:02 h had an altitude of 1900 ft and a ground speed of 60 kt (Photo 6),
- The maximum altitude of the Aircraft was 4500 ft with a ground speed of 92 kt,
- The last recording of the A/C track was at 13:08 h, with a recorded altitude of 1000 ft and a ground speed of 76 kt, having a course to the north (Photo 7).

Photo 6: A/C track at 12:02 h

Photo 7: A/C track at 13:08 h

1.11.1.2 Flight leg Kopaida LF to Messolonghi LF

From the recording of the PALLAS system and the reproduction of the flights of the two Aircrafts from Kopaida LF to Messolonghi LF the followings emerged:

- The trace of both Aircrafts were visible almost all the way except at the time between 15:24:58 LT to 15:29:38 LT where their trace was not visible due to the topography of the area.
- Of the two Aircraft, SX-UBX was identified by the code 7000 throughout by ground station recording, in contrary to the SX-SEX whose code 7000 did not exist for most of the recording.
- At 15:50 LT, the accident Aircraft at the IXONI point had an altitude of 2500 ft and a ground speed of 101 kt, while SX-UBX Aircraft was at the same altitude with a speed of 97 kt (Photo 8),
- After the IXONI point SX-SEX made a right turn (Photo 9).
- From 15:51LT until the last recording at 15:56 LT the following values of altitudes and ground speed were recorded:

TIME	ALTITUDE (ft)	GROUND SPEED (kt)
15:51	2500	102
15:52	2000	111
15:54	2000	106
15:56	1400	105

Table 1: Characteristic values of height and ground speed of the Aircraft according to the reproduction of the trail path.

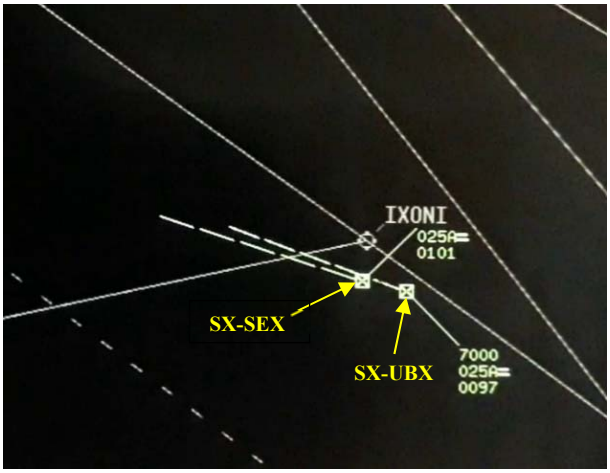


Photo 8: Accident A/C at IXONI

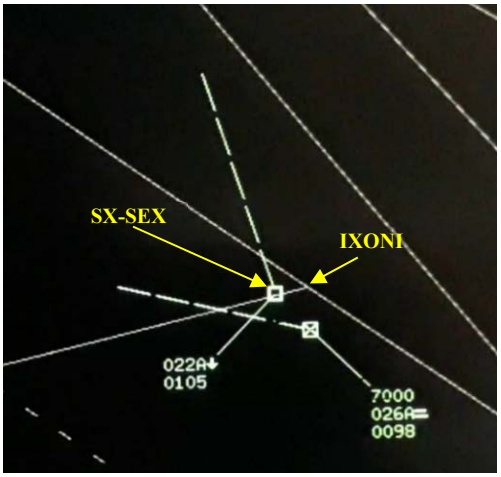


Photo. 9: SX-SEX during turn after IXONI

- After 15:56 h, the trace of the Aircraft was marked "INV"[7] (Photo 11) and then disappeared from the screen of the PALLAS system.

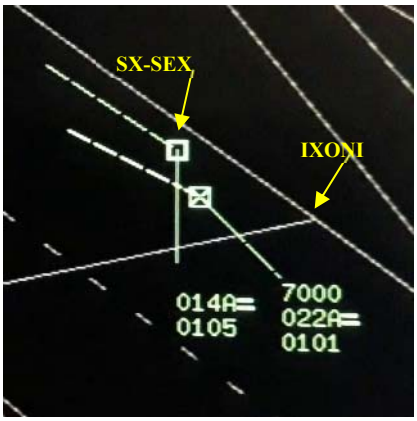


Photo 10: Last recorded position of the A/C at 15:56.

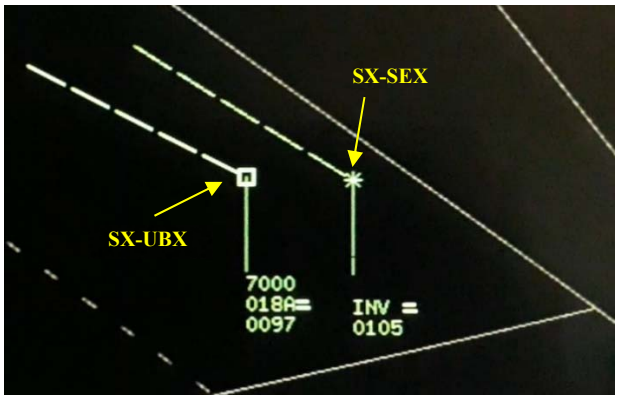


Photo. 11: The trace of the Aircraft with the indication "INV

1.11.2 Flight Trace Capture by PALLAS system

The PALAS system recorded the trace of the two A/C after their take-off from the Kopaida, where the relevant imprint is shown in Fig.3 and Fig.4. Capture starts at 15:15:00 h and ends at 16:00:00 h. The first trace is captured at 15:19:58 h and the last at 15:59:58 h.

From 15:24:58 h to 15:29:38 h there is no recording by the system due to the existing mountain topography at the area. In the imprinting of the traces, from 12:19:58 h to 12:24:58 h and from 12:37:59 h to 12:38:59 h there is the appearance of a second recorded trace.

[7] INV: This indication appears when the ground station is not able to identify the target. The ground station predicts the next position of the target according to the previous positions and if the target is not recognized then it disappears from the ground station screen.

Fig. 3: Capture of the flight path by the PALAS system for the leg Kopaida to Messolonghi

Fig. 4: Detail A, the trac of SX-UBX after IXONI up to the accident site of SX-SEX

1.12 Wreckage and Impact information

1.12.1 Accident Site Description

The scene of the accident is located on the old National Road Nafpaktos - Itea in the area Skaloma of the Fokida County. The Aircraft, during its forced landing on the National Road, collided with a horizontal cable between two pillars that support electricity lines. The southernmost of the two pillars has a height of 12.7m from the ground and the northernmost 9.30 m from the ground and 14.30 m from the road while the cable between the two pillars has a length of 33m.

Fig. 5: General view of the accident site.

1.12.2 Aircraft impact

The point where the Aircraft collided with the cable is 7m away from the north pillar, it has coordinates 38^0 24'08.7"N, 021^0 59'19.8"E while its height from the road is 13.9 m (45.6 ft). During the collision of the Aircraft with the cable, the left side Landing Gear and the nose Landing Gear were cut off from the Aircraft and ended up in an adjacent house at a distance of 80 m and 64 m respectively from the point of collision with the cable (Fig. 5).

After the collision with the cable, the Aircraft followed a downward trajectory at an angle of 13^0 and collided with the road at a point with an altitude of 212 ft, coordinates 38^0 24 '09.7' 'N, 021^0 59'17.8' 'E at a horizontal distance of 59.4 m from the point of impact with the cable. At the time of the impact on the road, the course of the Aircraft was 322^0, while on the road, footprints were created from the engine shaft and the right wing of the propeller as well as from the tire of the right main Landing Gear (Photos 12,13)

Photo12: Impact point on the road

Photo 13: Imprint of the starboard tire on the road.

After the impact with the road, the Aircraft travelled a course of 299^0 for a distance of 64.5 m and was immobilized at a point with coordinates 38^0 24'10.8"N, 021^0 59'15.7"E and altitude 227 ft (69.18 m) from sea Level (Photo 14).

Photo14: The Aircraft at the point of immobilization

1.12.3 Examination of Aircraft

From the initial examination of the Aircraft at the of accident site, it was ascertained that except for the two Landing Gear that were detached from the Aircraft during its collision with the cable and had ended up in an adjacent house, the rest of the Aircraft was intact.

In both wings, the fuel tanks were closed and locked, the trailing edges were present, the wing and tail component were intact. In the left wing there was a curved deformation upwards at a length of 85 cm from the end of the wing.

The engine propeller, Photo 15, was found next to the Aircraft with distortion and abrasions to an increased degree in one wing and to a lesser degree in the other.

Photo 15: The engine propeller at the accident site.

Photo 16 : The deformation of the engine shaft at the point of connection with the propeller.

1.12.3.1 Cockpit Examination

The cockpit and engine had rotated about 90 degrees to the left.

The examination of the cockpit revealed:

- The fuel tank selection valve was located between the “O” position and the “L” position,
- The battery power switches were in the ON position,
- The switch of the electric fuel pump was in the ON position,
- The landing lights switch in OFF position as well as and pitot heat switch,
- The power lever of the engine was distorted to the right, while the axis of its front limit was distorted to the front,
- The RPM indicator was at 600 rpm and the aircraft hours meter indicated 4796.12 h,
- The flap lever was one detent before the full down (Flaps 25 position).
- The ignition switch of the engine was in the “BOTH” position,
- The fuel mixing lever was close to the lean position,
- The carburettor heat was near to the open position,
- The air speed indicator was at 110 kts.
- The Fuel priming lever was in full in position.

Photo 17: Fuel selection valve position

1.12.3.2 Fuel tank selection valve

As mentioned in paragraph 1.12.3.1, the tank selection valve was between the “O” position and the “L” position. During the examination of the Aircraft and the removal of the tank selector, deformations were observed on the surface of the display disc in the holes of its support screws, as well as abrasions on the surface of the disc and the selector.

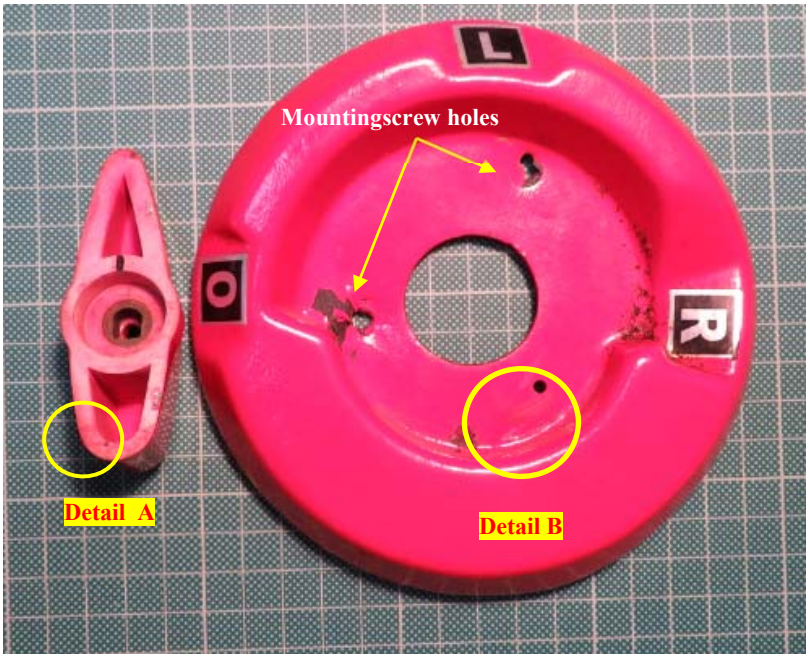


Photo 18: Fuel selector (Left) and the display tray (Right)

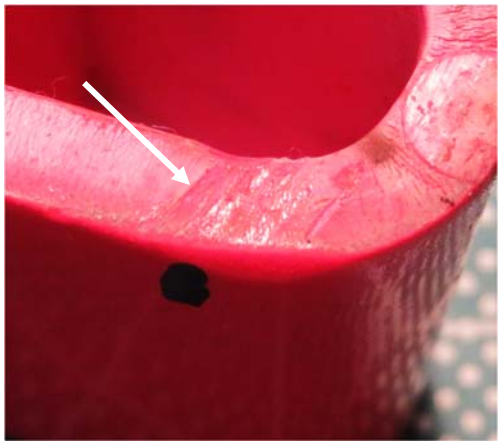


Photo 19: Detail A, abrasions in valve selector.

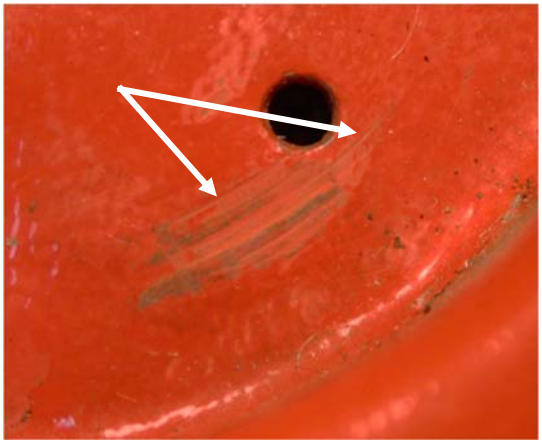


Photo 20: Detail B, the abrasions on the disc indications.

1.12.3.3 Fuel tanks

From the initial examination of the two fuel tanks, it was found out that they were closed and intact without the smell of fuel at the accident site. Examination of the abdomen of the left tank showed no signs of leakage while the drain valve was operating normally without a trace of leakage. Of the two tanks, the left one was empty (Photo 21), without the existence of the unusable amount of 1.1 US gal (4.16 lt) being detected, while the right tank contained a quantity of fuel (Photo 22), where after the its drainage was found to be 20 lt.

Photo 21: **Left tank at the original examination**

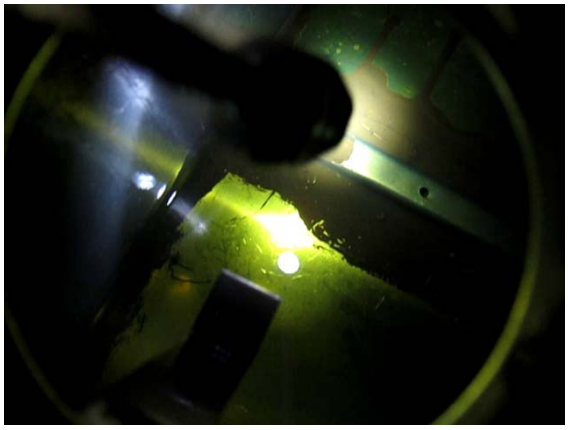


Photo 22: Right tank at the original examination

Also, from their further examination it was found that the right tank contained deposits which, after being removed from the wing of the Aircraft and its opening, are shown in Photo 23. These deposits were in the form of a sticky material and a sample was collected for laboratory examination. At the same time, after the removal of the tank, the fuel level sensor of the tank was removed for laboratory examination, while its vent lines were found to have free flow inside them.

The left tank was opened from its back, without being removed from the wing of the Aircraft From the macroscopic examination, a piece of rivet and deposits (Appx. 5.4, Photo 37) were observed in the area of the level sensor but also of the fuel outlet, while the existence of the sticky material of the right tank was not found.

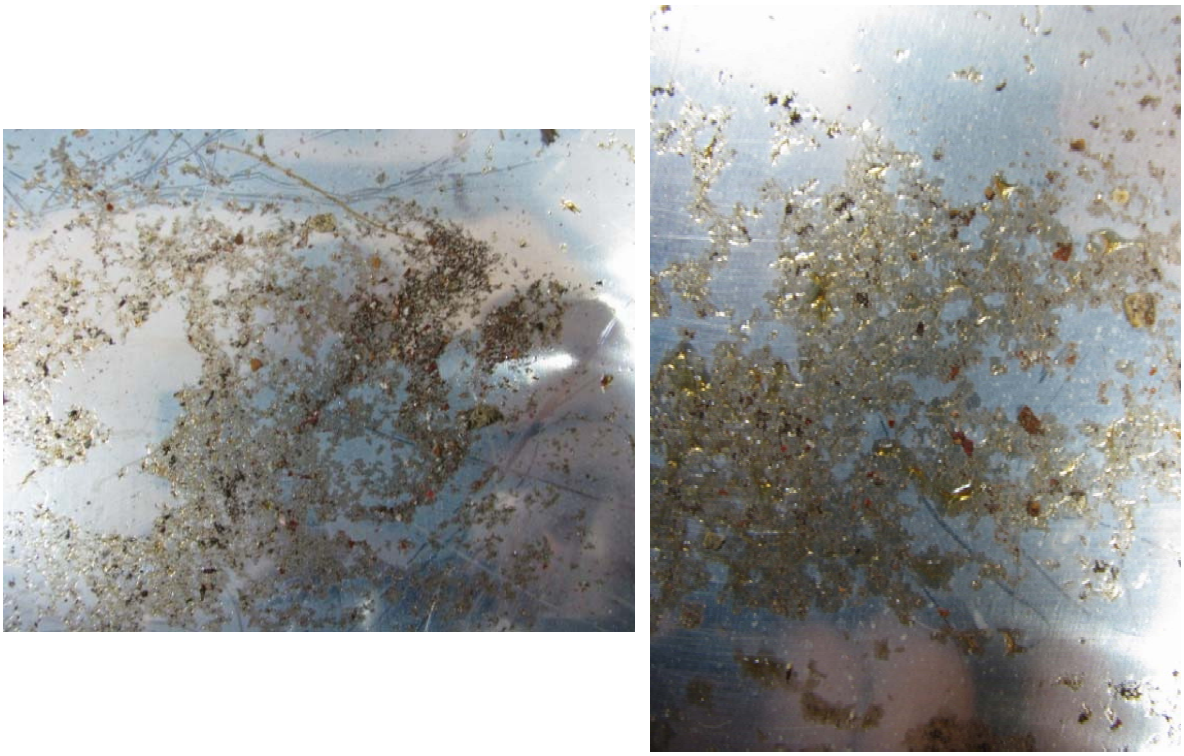


Photo23: Findings of the right tank after its opening.

1.12.3.4 Engine Examination

During the examination of the engine, even though bending of the left engine mounts was observed, no internal damage was found as its crankshaft was rotated. Also, during the test of one magneto it was found that it was working normally, while it was not possible to test the other one due to the necessity to develop an increased rotation speed on it.

The carburettor had suffered extensive damage due to the sliding of the Aircraft on the road.

The spark plugs were removed, examined and found in good condition. The Part Number of the spark plugs was also checked and found to be in accordance with that specified in the (IPC).

The fuel filter was found as shown in Photo 24(a), with the filter bowl partially open, while after removing the bowl, it was found that on the filter and more specifically on the side of the unfiltered fuel, earthy deposits were found as shown in Photo24(b) and 38, 39 of Appx. 5.5, while its inner side was deformed and torn. Also, at the exit of the fuel from the body of the fuel filter there were deposits as in the filter. The fuel filter and the filter body were subjected to laboratory testing.

The electric fuel pump was also removed from the engine from which the fuel filter inside it was removed for macroscopic examination. From this, light deposits were found on its surface (Photo 33, Appx. 5.2), while the pump was subjected to laboratory testing.

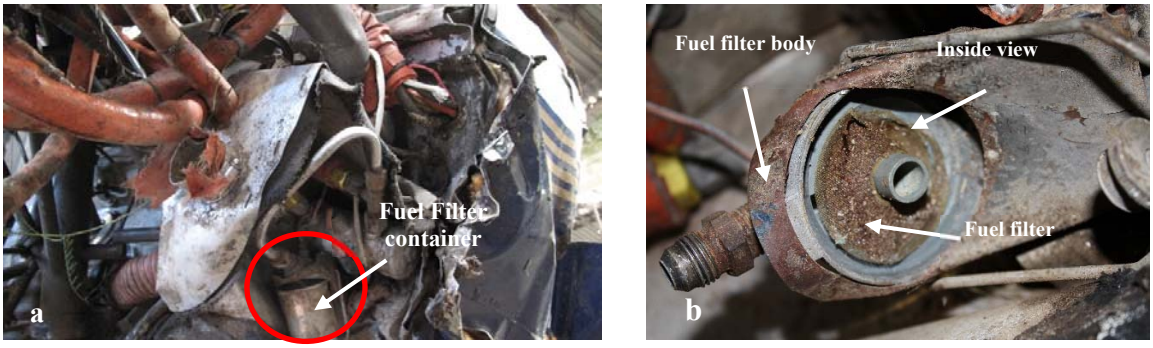


Photo 24: The engine fuel filter with the partially open filter tank (Photo a) but also the filter after removing the tank (Photo b).

1.12.3.5 Operational test of the fuel tank selection valve

In the fuel tank selection valve, an operational test was performed in all three positions ("FUEL OFF", "L TANK", "R TANK"). The operational test revealed that the valve was operating normally.

1.12.3.6 Operational test of the electric fuel pump switch

In this particular switch, an operational test was performed, from which it was ascertained its good operation in the two positions, open (ON) and closed (OFF).

1.12.3.7 Continuity check of the spark plugs cables

During the investigation, the continuity of the spark plugs cables was checked. From this inspection continuity was confirmed in all the cables, except for the lower cable of the 2nd cylinder which was cut off to a large extent due to the impact and the subsequent sliding of the Aircraft

1.12.4 Laboratory tests

During the investigation process, the following were subjected to laboratory tests:

- Engine RPM indicator and the airspeed indicator
- Electric fuel pump,
- Right fuel tank level sensor,
- Cockpit fuel level indicators,
- Engine fuel filter and filter body,
- Deposit inside the right fuel tank
- The right tank sealing material.

1.12.4.1 Laboratory test engine RPM indicator

Test was performed under a stereomicroscope in order to search for possible traces of the pointer of the instruments on its calibrated plate. Examination of the airspeed indicator showed no trace of the pointer on the calibrated plate.

The engine speed pointer showed an imprint on its back on the calibrated plate as shown in the Photos. 25 and 26. Photo 27 shows that the extension of the imprint through the needle shaft corresponds to an indication of 890 rpm.

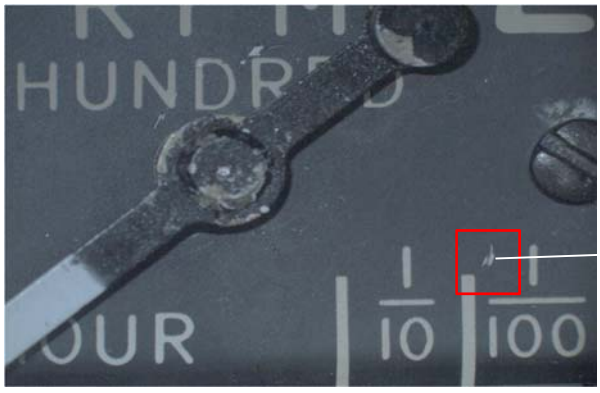


Photo 25: Imprint on the calibrated plate of the engine RPM indicator

Photo 26: Detail of the footprint on Photo25.

.

Photo 27: Correspondence of the imprint extension on the calibrated scale

1.12.4.2 Laboratory test of electric fuel pump

During the laboratory test, the resistance of the pump was measured according to the instructions of the manufacturer's service manual. From the results of the test it was found that

the value of the resistance is 5.54 Ω while the limits set by the service manual of the manufacturer were from 4.87 Ω - 6.4 Ω.

Also, a functional test of the pump was carried out in a suitable laboratory in order to measure its outlet pressure according to the procedure defined in the service manual of the manufacturer (Photo 28). The test revealed that the value of the outlet pressure was 4.84 psi, with manufacturer-defined limits of 4.0 psi - 4.75 psi.

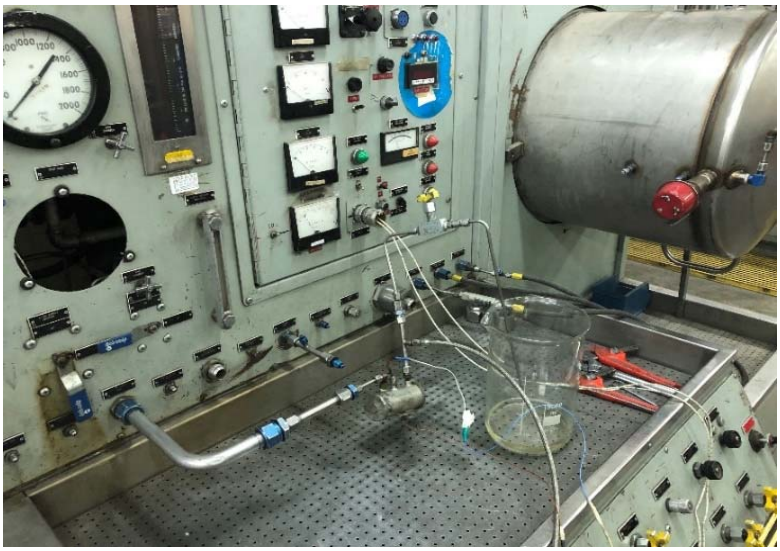


Photo 28: The electric fuel pump during its functional test.

1.12.4.3 Checking the right fuel tank level sensor

This inspection was performed in accordance with the procedure specified in the manufacturer's maintenance manual. The test was performed in a suitable support laboratory and for the test a proprietary device ("jig") was made (Photo 32 Appx. 5.1), to which the level sensor was adapted. The purpose of the test was to measure its ohmic resistance at the two extreme positions of the arm.

The following results were obtained from the measurements:

Ohm Resistance in position:	**Measurement results**	**Service manual figures**
Full Tank	34 Ω	33.5 +0, -4.5 Ω
Empty Tank	239 Ω	240 +20, -0 Ω

A check was also made for 'dead spots' in the path of the arm from the lower extreme position to the upper extreme position, from where the existence of 'dead spots' during the specific path of the arm was not found.

1.12.4.4 Cockpit fuel level indicators check

Furthermore to the above check, a functional check of the fuel level indicators of the cockpit was performed. This specific inspection did not conclude about the functionality of the indicators, due to the damage they had suffered from the impact of the Aircraft

1.12.4.5 Laboratory test of fuel filter, right fuel tank deposits, fuel filter body and right-hand tank seal.

Laboratory tests on the fuel filter, right fuel tank deposits and filter body deposits were performed on a scanning electron microscope equipped with an energy scattering spectrophotometer (SEM-EDS) which showed the following results:

- The material of all the samples was a mixture of more or less similar composition, mainly agglomerates of earthy origin, dust and rust,
- Material derived from dyes (paint) and organic residues was detected in all samples,
- Metal material, rivet head, was found in the sample of the fuel tank. Examination of the XRF device showed stainless steel,
- A particle of fibrous morphology and texture similar to that of asbestos was found in the fuel filter.

In addition, during the examination of the fuel filter in the stereomicroscope, a glassy material was observed that almost completely covered its cells, as seen in Photos 29, 30, 31 of high magnification.

In addition to the above laboratory results, from Photos. 38 and 39 of Appx. 5.5, it is observed that the deposits of the glassy material in the fuel filter have a symmetrical distribution around its inner and outer diameter and cover almost the entire area of the fuel flow through the filter.

1.12.4.6 Analysis of glass material

In order to qualitatively determine the composition of the above glassy material but also the sticky material of the fuel tank deposits, as shown in Photo. 23, a more extensive laboratory test was performed. The test was performed by the method of FT-IR spectrometry and by FT-IR microscope.

In the fuel tank:

- The sticky deposits were made of acrylic resin

Particles consisting of the following materials were detected in the fuel filter:

- Quartz particles (SiO2),
- Calcium carbonate particules (CaCO3),
- Acrylic resin particles which had a slimy / sticky texture,
- Polyethylene fibers.

Also, from the above examination no spectrum was identified which corresponds to the presence of nitrocellulose (key component of the sealing material Sloshing Sealer 802 of the tanks).

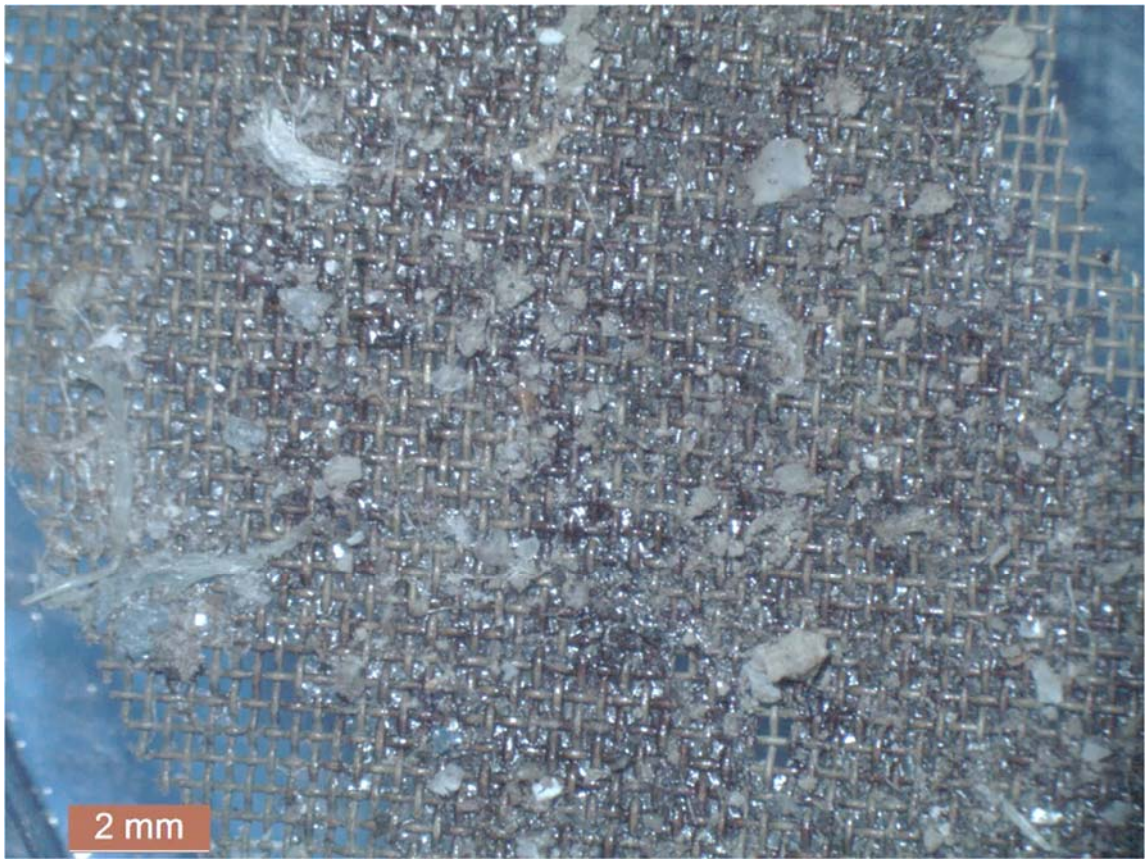


Photo 29: Field view of the fuel filter.

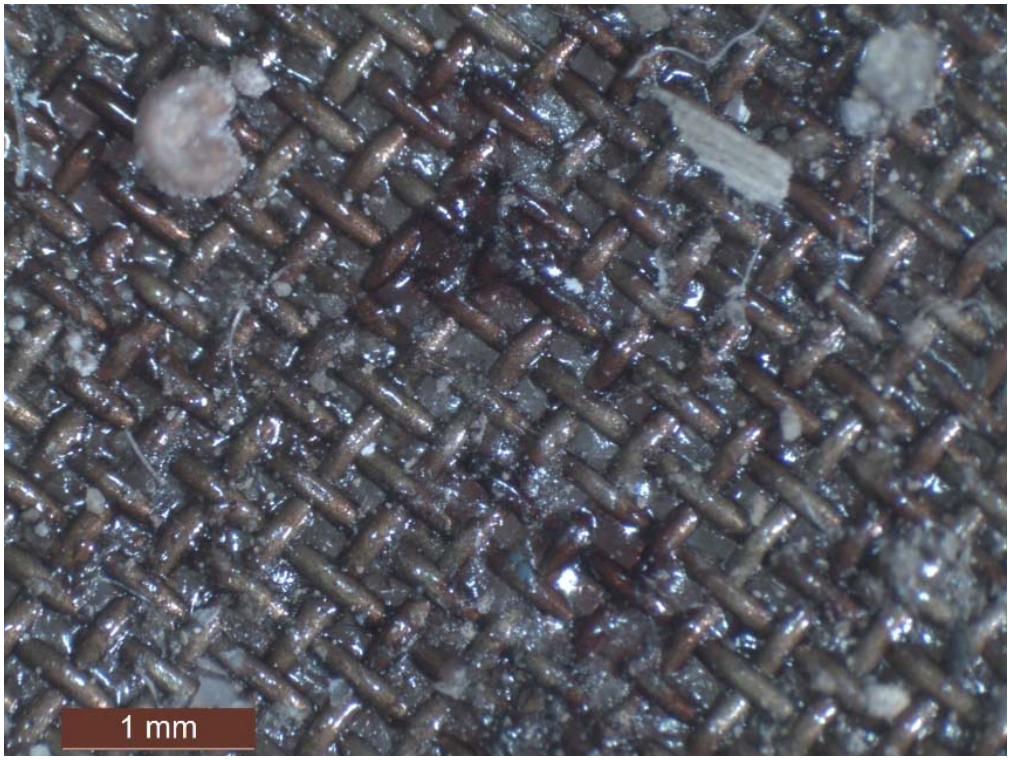
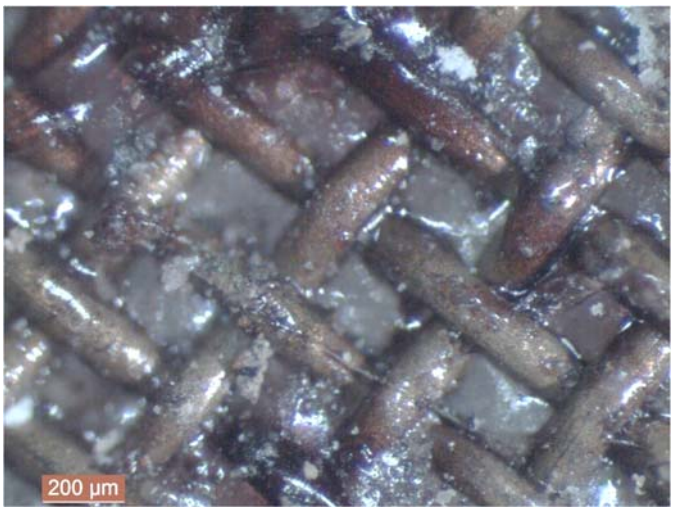


Photo 30: View of fuel filter with glassy material



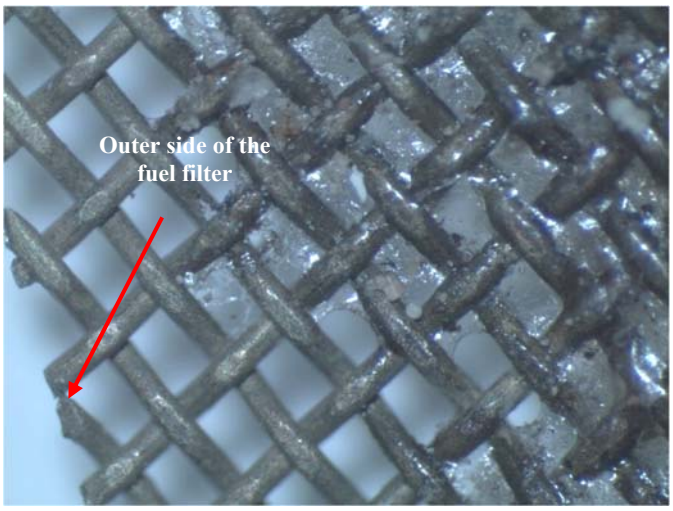


Photo 31: View of the glass material at a larger magnification.

1.12.4.7 Analysis of tank sealant material

In addition, during the above examination, a qualitative determination of the composition of the sealing material, brown colour, was performed on the structural connections of the tank on its inner surface, by FT-IR spectrometry. The test results showed that the sealing material was made of calcium carbonate and polysulfide resin (Polysulfide Rubber).

1.13 Medical and pathological information

Both occupants of the Aircraft underwent forensic and toxicological examination. According to the results of the toxicological examination, the use of substances and alcohol was not found in any of the occupants.

Also, from the results of the forensic examination, no pathological findings were found, which would be likely to be factors or to create conditions that would affect the ability to operate the aircraft.

The injuries of the pilot A who held the right position are indicative of the operation of the Aircraft until the last moment. Fractures were especially found during the forensic examination - metatarsal dislocations in both legs (from the impact on the legs on the footrests - aviator fracture) and fracture left thumb dislocation compatible with the position of the hand on the engine power control. Both pilots had multiple other fatal injuries compatible with the deformity of the cockpit and the severity of the impact.

1.14 Fire

Not applicable.

1.15 Survival Aspects

From the transcription of the conversations between the pilots of the SX-UBX Aircraft with the FIC, it is reported that at 13:04:27 h the pilots of the SX-UBX had called the National Health Emergency Response Center.

The data of the investigation show that:

- At 13:15 h the center of National Health Emergency Response received a call for an emergency,
- At 13:16 h, the call was forwarded to the mobile unit of National Health Emergency Response in Patras.
- At 13:20 h, the ambulance of the Nafpaktos sector was informed,
- At 13:27 h a fire truck arrived at the scene of the accident together with a police vehicle.
- At 13:28 h the ambulance arrived at the scene of the accident,
- At 13:38 h, Pilot A, who was inside the Aircraft in on the right seat, was picked up by an ambulance,
- At 13:48 h, a mobile unit of National Health Emergency Response arrived at the scene of the accident where at 14:01 h pick up Pilot B, who was out of the Aircraft.

1.16 Tests and Research

1.16.1 Laboratory examination of gasoline

A quantity of fuel was taken from the right tank of the Aircraft for laboratory analysis. The results of the analysis revealed the following:

- vapor pressure 40.9 kPa (limit[8]7 50.0 kPa to 80.0 kPa),
- octane number RON 99.5 (minimum value 95),
- MON 88.7 (minimum price 85),
- Ethanol 0.2% v/v (maximum 5% v/v),
- 0.0% v/v methanol (maximum 3% v/v),
- there was a slightly positive kinizarin quality assay,
- aromatic hydrocarbons 33.9% v/v (maximum 35% v/v),
- olefins 5.6% v/v (maximum 18% v/v),
- MTBE[9] 8.5% v/v, TAME[10] 2.7% v/v, ETBE[11] 0.9% v/v and sum of oxygen[12] compounds 12.3% v/v.

1.16.2 Liquid acrylic resin mixture with unleaded gasoline 100 RON

During the investigation, two samples of 100 RON gasoline were taken from a gas station to which a quantity of 20 ml of liquid acrylic resin was added. More specifically, from the first sample of 200 ml gasoline, a 10% acrylic resin solution was obtained (Appx.5.6, Photo 40), while from the second sample of 300 ml gasoline, a 6.6% acrylic resin solution was obtained. Twenty minutes after the preparation of the 10% acrylic resin solution (Appx.5.6, Photo 41), it was observed that a layer of resin had settled on the wall of the glass container (whether wet or not) which remained after a period of one month (Appx.5.6, Photo 42), while at the bottom of the container was left insoluble acrylic resin in the form of sediment as shown typically in Photos. 40, 41, 42 of Appx. 5.6.

---

[8] The reported limits are in accordance with Government Gazette 293 B '12/02/2016 and the standard of ELOT EN 228: 2014 for unleaded petrol with a maximum oxygen content of 2.7% by mass.

[9] Methyl Tertiary Butyl Ether

[10] Tertiary Amyl Methyl Ether

[11] Ethyl Tertiary Butyl Ether

[12] Sum: Ethanol, Methanol, MTBE, TAME, ETBE.

Respectively in the other solution with a concentration of 6.6%, its behaviour was more or less similar to the 10% solution. Within nine minutes of its preparation (Appx.6.6, Photo 44), a layer of acrylic resin had settled on the non-wetting wall of the container, while after a period of one month, the deposition of the non-wetting wall had weakened and the insoluble acrylic resin had accumulated in the form of a precipitate at the bottom of the container (Appx.5.6, Photo 45).

1.16.3 Applying liquid acrylic resin to a fuel filter

During the investigation, a fuel filter was obtained the same as that brought by the accident Aircraft, which was applied locally with liquid acrylic resin (Appx.5.7, Photo 46b). The filter was then left at room temperature to dry the liquid acrylic resin and then examined under a stereomicroscope from which the photos were taken. 47 and 48 of Appx. 5.7.

The above mentioned photos of the stereomicroscope show the formation of a layer of acrylic resin on the fuel filter in correspondence with the layer formed on the fuel filter of the accident Aircraft.

1.17 Organizational and Management Information

Not applicable

1.18 Additional Information

1.18.1 Refueling Regulations at Airports

In the no. D3 / C / 12041/2861 regulation of the CAA entitled "Regulation of Refueling of Aircraft with Fuels at Airports", are described in paragraph 19.5 "Supply of Aircraft " and in paragraph 19.10 "Special Provisions" of article 19 "Supply of Light and Ultra-Light Air", the fuel refueling procedure and the possibility of supplying fuel for the aforementioned touches referred to in Article 19. The relevant paragraphs are set out below.

- *19.5 Aircraft Supply*

19.5.3. Aircraft can be refueled with special fuel tanks (ADR certified canisters) via a special tube and nozzle arrangement and not by gravity. The supply in this case will be done in accordance with the provisions of this regulation. It is necessary to use special filters to retain water and microparticles that may be contained in the transfused fuel.

- *19.10. Special provisions*

19.10.1. Owners of ultralight Aircraft, whose possible engine failure may result in partial or total loss of power, an event which is an acceptable risk, can also be refuelled at gasoline *stations outside the airport. However, the supply will be done in accordance with the*

*provisions of par. 19.5.3. and the movement of fuel inside the airport will be done with special fuel tanks (ADR certified canisters) of maximum volume per transport of thirty (30) litt*ers.

1.18.2 Acrylic resin

Acrylic resin is an organic compound, a derivative of polyacrylic acid. It is soluble[13] in aromatic hydrocarbons, esters, halogenated hydrocarbons, ketones and tetrahydrofuran and is insoluble in gasoline. Its applications are in paints, coating materials, varnishes, adhesives, drying materials and in the industry of fabric, paper, leather

1.18.3 Specifications of unleaded gasoline

1.18.3.1 Government Gazette 293 / 12.02.2016 entitled " vehicle fuel - unleaded gasoline - requirements and test methods"

According to the Government Gazette 293 / 12.02.2016 entitled " vehicle fuel - unleaded gasoline - requirements and test methods" it is stated that:

"Unleaded gasoline with a maximum authorized oxygen content of 3.7% (m / m) may contain ethanol - which satisfies the requirements of Decision 314/2010 of the Supreme Chemical Council - vehicle *Fuels - Ethanol of biological origin (bioethanol) as a constituent gasoline - Requirements and Test Methods≫, Government Gazette 69 / B / 2012, as in force, - in a content of up to 10% b. vol.*

"To meet the needs of some old vehicles:

The suppliers ensure the availability in the Greek market of gasoline with a maximum oxygen content of 2.7% (m / m) and a maximum ethanol content of 5% (v / v) by 2016 at least".

In both cases of fuel in the above Government Gazette is given an upper limit of Methanol 3% v/v.

1.18.3.2 EN 228:2014[14] Specification

For fuels with a maximum oxygen content of 3.7% the ethanol and methanol limits have been set at 10% v/v and 3.0% v/v respectively.

For fuels with a maximum oxygen content of 2.7%, the corresponding limits are 5.0% v/v and 3.0% v/v.

---

[13] Source: Plastics Analysis Guide, A. Krause, A. Lange, M. Ezrin, Introduction to the Chemical Analysis of Plastics, A. Krause, A Lange

[14] Government Gazette 293 / 12.02 / 2016 refers to the standard EN 228: 2014 and not to the latest version of the standard

1.18.4 Effect of alcohol in automotive gasoline on the Aircraft's fuel system

The use of fuel with alcohol content in Aircraft is not allowed for the following reasons:[15],[16]

- Affects the volatility of the fuel with the possible creation of the vapor blocking effect (Vapor Lock).
- Creates Phase Separation in the fuel when the fuel is cooled as a result of the Aircraft being at high altitudes.
- Increases the amount of water that can be dissolved in gasoline. The amount of water that can be dissolved varies with the concentration of alcohol, the temperature of the fuel and the content of aromatic compounds. It dissolves the sticky deposits of the fuel system which can settle in the fuel filter but also in small measuring holes[17].
- Reduces the energy efficiency of the fuel. Ethanol has 75% of the energy content of gasoline and methanol has respectively 55%.
- Alcohol is corrosive and is not compatible with sealing rings and other fuel system materials resulting in deterioration of the fuel system and the presence of damage.
- The volumetric efficiency of the fuel decreases with increasing alcohol concentration.
- Corrosion of engine components and exhaust system.

1.18.5 Effect of fuel / water mixture on polymer dryers

Especially for polymer sealants, when they are immersed in a liquid, diffusion of the liquid molecules is created in them.

In Aircraft tanks, sealants are used in an environment where the presence of fuel hydrocarbons together with the possible presence of water can affect the volume and bonds of the sealant[18], while temperature changes in the operation of the tanks affect the strength of the dryer.

1.18.6 Fuel use approval ASTM D4814 or EN 228 specifications

In January 2003, a decision was issued by the Governor of the CAA approving the use of fuel of ASTM D4814 or EN 228 specifications for use by light Aircraft (maximum take-off weight below 5700 kg).

Among the mentioned conditions for the use of the above fuel, special mention is made:

---

[15] FAA Special Airworthiness Information Bulletin

[16] Ethanol content concerns in motor gasoline (mogas) in aviation in comparison to aviation gasoline (avgas).

[17] Alternate Fuels for general Aviation Aircraft with Spark Ignition Engines DOT/FAA/CT88/05, June 1988.

[18] Investigation of the Water and Fuel Exposure Characteristics of Aircraft Fuel Tank Sealants and the Effect on their Glass Transition Temperature.

- The ban on the supply of fuel for aviation use by gas stations and their transfer to unauthorized containers.
- In fuel control for possible water detection, alcohol detection as well as in fuel volatility control.
- The use of particulate and water retention filters when refuelling the Aircraft.

1.18.7 Chemical composition of the sealing material Sloshing Sealer, 802

According to the specification and response of the State chemist, the sealing material Sloshing Sealer 802, consists of nitrocellulose, chromic zinc as a dye, isopropanol and ethyl acetate. The last two elements are solvents which are removed after the application and hardening of the resin.

1.19 Useful or Effective Investigation Techniques

Not applicable.

2. ANALYSIS

During the investigation of the accident, a series of laboratory tests were performed which were necessary to determine the cause of the loss of engine power.

Due to the non-entry of the amount of fuel in the Aircraft logbook before the realization of the two flights on the day of the accident, the reported quantities of fuel are based on the data collected and have the maximum possible accuracy.

2.1 Aircraft Flights

2.1.1 First leg - Flight from Messolonghi to Kopaida

On 21/4/2018, the Aircraft departed from Messolonghi to Kopaida and the flight was performed without reporting any technical problem. From the collected data, the distance of this particular leg was about 92 NM and the actual operating time of the engine was 01:16 h. Both pilots had all Valid necessary Certificates to perform the flight, while the Aircraft held valid all the necessary Certificates.

The take-off weight of the Aircraft at its departure from the Messolonghi FP was calculated[19] to be between 1045 kg and 1063 Kg, which exceeded the corresponding maximum value of 975.22 Kg of that specific Aircraft It is estimated that the captain considered the take-off safe, possibly in consultation with the POM 1 par.1.6.10.1 which was found in the Aircraft but did not correspond to the Aircraft of the accident.

From the above it is concluded that the Aircraft took off from Messolonghi with a weight greater than its maximum take-off weight.

With the addition of fuel, the take-off weight would exceed the maximum allowed set by POM 1, found in the Aircraft, so the Captain probably chose not to refuel the Aircraft in Messolonghi.

During this flight leg the left fuel tank was used. In the eastern course of the Aircraft to Kopaida the prevailing northeast wind created a head wind component of 11 to 14 kt and a cross wind component of 5 to 10 kt while in its northeaster course to Kopaida it created a head wind of 10 to 15 kt.

If the Aircraft flew, in the conditions defined in POM 2, for maximum economy achieving a consumption of 31.7 lt / h (8.4 US gal / h) then its consumption for the corresponding leg

[19] The weight of the Aircraft calculated between the values 1045 kg and 1063 Kg due to the amount of fuel in the right tank was calculated between 23 lt and 47 lt.

would be 40 lt of fuel. It is concluded from the above that real fuel consumption on this leg was 17% higher than that of maximum fuel economy.

Based on the amount of fuel at the departure from Messolonghi LF and the arrival at Kopaida LF it was estimated that the fuel consumption was 47 lt (12.41 US gal). It follows from the above that real fuel consumption in this area was 17% higher than that of maximum fuel economy.

2.1.2 Second - Flight from Kopaida to Messolonghi

On the same day at 15:20 h the Aircraft departed from Kopaida LF for Messolonghi LF with 23 lt of fuel in the left tank and between 23 lt - 47 lt of fuel in the right tank.

The take-off weight of the Aircraft at its departure from Kopaida LF, was estimated[20] to be between 841 Kg and 859.5 Kg. These values did not exceed the corresponding maximum value of 975.22 Kg.

After it's take-off the Aircraft followed a course as shown in Fig. 3 and after passing through the points VAGIA and POUNDA headed to the IXONI point.

During the duration of the engine operation of 00:35 h from Kopaida LF until the report to the FIC at the point IXONI, if the hourly best economy consumption of 31.7 lt / h (8.4 US gal / h) was achieved, the fuel consumption would be 18.7 lt.

As the Aircraft left the Kopaida LF with 23 lt of fuel (18.9 lt usable quantity) in the left tank and the left tank was found empty of fuel after the accident, it appears that at the departure from the Kopaida LF the Aircraft consumed the 23 lt fuel (18.9 lt usable quantity) of the left fuel tank and before the IXONI point, due to low fuel level, they changed the fuel supply tank by selecting the right fuel tank.

Because the exact amount of fuel in the right tank was not known upon departure from Kopaida LF, it was not possible to document the duration during which the right tank was feeding the engine.

However, due to the fact that 20 lt of fuel were drained from the right tank, it is possible that the level of the right tank at the time of the change from the left tank, approached it at 1/4 (23 lt).

Due to the fact that the units related to the change of the supply tank, i.e. the electric fuel pump, its activation switch and the tank selection valve as it emerged from the relevant

[20] The weight of the Aircraft was calculated between the values 841 kg and 859 Kg due to the quantity fuel, in the right tank, was estimated between 23 lt and 47 lt.

controls, were operating normally, there are no indications that the change of the supply tank was not successful.

At 15:50:39 h, when the pilots of the Aircraft reported IXONI point at an altitude of 2500 ft, as recorded by the PALLAS system, they did not report any technical anomaly.

Given, as reported to the pilots of the other Aircraft, that the reason for the right turn was a fuel supply problem, it appears that this occurred after the report to the IXONI point and before the start of the right turn.

From the review of the data of Table 1, lasting 00:05 h, but also the reproduction of the trace, it seems that after the appearance of the power supply problem, the Aircraft performed a smooth descent, maintaining a ground speed at levels close to that during the report at IXONI, while after the completion of the right turn, it followed a north-westerly direction of about 300^0, where based on the available wind data the Aircraft had a head wind of 3 kt and right cross wind of 15 kt.

In the time duration of 00:05 h the Aircraft with an average speed of 106 kt travelled a distance of about 8.5 NM. Considering the gliding diagram of the Aircraft (Appx. 5.3, Fig.1), it appears that for a gliding from a height of 2500 ft according to the conditions mentioned, a distance of 5.0 SM (4.3 NM) is required.

From the examination of the engine, no signs of mechanical or ignition system failure can be concluded. From the examination of the fuel system, as mentioned in paragraphs 1.12.3.3 and 1.12.4.5, a qualitative similarity of an adhesive material in the right tank and in the fuel filter, which was almost completely covered, a qualitative similarity of the other common findings. in the filter but also in the right tank and the absence of sticky material in the left tank.

Despite the almost complete coverage of the fuel filter with the sticky material of acrylic resin and other deposits that may have come from the right tank, it appears from the descent trail, that the ground speed and the distance travelled, by the Aircraft during its descent from 15:51 h to 15:56 h the engine was running, possibly intermittent, as it emerged and from the interviews taken.

From the results of mixing the gasoline with liquid acrylic resin as mentioned in par. 1.16.2, it appears that the deposition of the acrylic resin layer on the tank wall of the experiment is consistent, in time and quality, with the deposition of the acrylic resin on the fuel filter at the time the engine was powered by the right tank.

From the above it appears that during the supply of the engine from the right tank, whose level as mentioned above was probably about 1/4 of its total capacity, resin agglomerates as well as other deposits from the bottom of the tank were sucked and settled on the filter.

The coverage of the fuel filter, caused a reduction in the fuel flow ~~of~~ to the engine, resulting in a reduction in the power produced and was the cause of the accident.

From the examination of the cockpit (par. 1.12.3.1) it was found that its configuration was consistent with the execution of the emergency procedures in case of loss of engine power (par. 1.6.10.2), while the observed abrasions in the indication disc of the tank selection valve and in the selector are consistent with movement, due to the impact of the Aircraft , of the valve selector from the position "L" (left tank) to the position "OFF" closed.

From the above it looks that after the right tank supply problem occurred, the pilots changed the supply tank by restoring the engine supply from the left tank. However, due to pre-existing deposits in the fuel filter, the flow of fuel to the engine continued to be reduced resulting in the non-return of full engine power.

During the initial examination of the Aircraft at the accident site it was found that the left tank did not have even the unusable amount of fuel of 1.1 US gal (4.16 lt). As the left tank was closed and intact and no fuel odour was observed at the accident site, there is no evidence that the unusable amount of fuel leaked from the tank during the collision of the Aircraft.

After the appearance of the engine power supply problem, the Aircraft followed a north-westerly direction of about 300^0 in the direction of the national road, where based on the available wind data the Aircraft had a head wind of 3 kt and a cross wind of 15 kt from the right.

It is possible that the pilots set the Aircraft on a sideslip with a right ruder and left aileron to balance the deviation of the course due to the right cross wind of 15 kt but also to accumulate the remaining fuel at the root of the left wing where the fuel outlet from the tank to the engine was located, resulting in the suction of fuel from the engine until the fuel is completely depleted.

After 15:56 h, probably due to the low altitude and the mountains in area, the trace of the Aircraft had not been recorded by the PALLAS system, with the result that there is no accurate picture of the course and descent of the Aircraft. The point of the last recording of the Aircraft trail is determined according to the reproduction of the flight trail, above the islet of Trizonia and at a distance of 4.5 NM from the point of impact where the Aircraft was at an altitude of 1400 ft with a ground speed of 105 kt. From the gliding[21] diagram of the Aircraft (Appx. 5.3,

[21] The results obtained from the diagram are according to the gliding conditions referred to it. Due to the flap extension but also the prevailing head wind of 3 kt and 15 kt cross wind, the gliding distance would be shorter due to the reduced ground speed.

Diagram 1), it appears that in order to perform the sideslip from this point to the point of crash, at least 2800 ft of height are required, i.e. twice the height of the Aircraft at the specific point. From the above it can be concluded that after 15:56 h, which was the last recording point by the PALLAS system, the Aircraft engine, powered by the left tank, continued to operate probably in a manner similar to that from 15:51 h until 15:56 h, until the complete depletion of the fuel of the left tank possibly over the area Skaloma. The lack of fuel in the left tank was a contributing factor to the accident.

Despite the application of the emergency procedure, the non-restoration of the full power of the engine and given the available time of about 00:07 h from the appearance of the power problem until the crash of the Aircraft, the Pilots are likely to try to recover engine power by repositioning the mixture lever in different positions according to the POM. This fact justifies that the lever of the mixture was found near the position 'poor', as mentioned in par. 1.12.3.1. The emergency procedure performed by the Pilot was in accordance with the instructions in Checklist 2 of paragraph 1.6.10.2 and POM 2, but due to the pre-existing condition of the fuel filter it is not considered that recovery of engine power was possible.

Considering that initially the Aircraft collided with a cable supporting two electricity pillars, where it lost part of its kinetic energy and two of its three landing gear were detached, the distance from the cable with the road and the subsequent slip on the road, it is concluded that the Aircraft before the collision with the cable had a speed which was consistent with the indication of 110 kt of the speedometer, but this value is not substantiated by the laboratory examination of the speedometer.

Given the detachment from the Aircraft of the nose and the left main landing gear and considering the inclination of the supporting cable it is possible that the Aircraft during its collision with the cable had a left inclination and a small pitch angle. The specific position of the Aircraft is compatible with the attempt to align it with the national road during the attempted of forced landing.

The collision of the Aircraft with the cable may be due to its untimely recognition by the Pilot due to at that time the application of emergency procedure as otherwise, due to the speed of the Aircraft, it would be possible to manoeuvre to avoid it. Due to the attitude and the speed of the Aircraft before the collision with the cable it is considered that if the Aircraft had not collided with it, it would probably have made the forced landing on the national road.

The contact of the Aircraft with the cable, is considered a contributing factor in causing the accident.

After the collision with the cable the Aircraft followed a downward trajectory with an angle of 13^0 down and collided with the asphalt. Examination of the Aircraft after the accident revealed that the deformation of the junction of the engine crank with the propeller is consistent with the trajectory of the Aircraft following the impact.

2.1.3 Rotation of the engine when the Aircraft collided with the road

From data collected during the investigation, it appears that approximately 500 m before the collision of the Aircraft with the cable, an attempt was made to restart the engine, which is compatible with the pre-existing shutdown of the engine due to fuel depletion in the left tank. The absence of internal damage to the engine in combination with the observed high velocity of the Aircraft were conditions for the rotation of the engine propeller due to the air flow (Wind Milling) before the collision with the cable event which is documented by the laboratory examination. of the engine tachometer recorded at 890 rpm but also from the deformation of the propeller blades during the impact on the road.

The type of deformation of the propeller blades in combination with the absence of the same deformation in its two propeller blades, is compatible with the rotation of the propeller during the impact of the Aircraft on the road, with a rotational speed less than the relevant velocity of the Aircraft at the time of impact.

2.1.4 Fuel required for the flight

After the accident, 20 lt of fuel were drained from the right wing tank, from which, minus the unusable amount of 1.1 US gal (4.16 lt), it appears that 15.84 lt were available to power the engine.

From the point where the supply problem occurred to the Messolonghi LF, it was estimated that with an hourly best economy fuel consumption of 31.7 lt / h (8.4 US gal / h), approximately 12 lt of fuel was required.

During the above mentioned part of the flight, it is not known whether there would be a difference in flight conditions from those set for hourly best economy fuel consumption, so it is not documented if the available quantity of 15.84 lt was sufficient to reach Messolonghi LF.

2.1.5 Laboratory tests

2.1.5.1 Examination of Filter and right fuel tank

During the initial examination of the Aircraft the filter bowl was found to be partially open (Photo 24), so it is possible that when the Aircraft skidded on the road, but mainly outside it

on the dirt surface at the side of the road materials of earthy origin entered the filter. Due to this fact, although their concentration was relatively homogeneous and symmetrical in terms of the inner and outer diameters of the filter in the fuel flow area, it cannot be substantiated whether the geodetic materials came exclusively from the right fuel tank.

From the other deposits found in the filter and in the right fuel tank such as dust, rust and paint materials it is very likely that they came from the right tank when it was feeding the engine while the asbestos residue found in the fuel filter cannot be documented with certainty that it comes from the fuel tank or from the skidding of the Aircraft after its impact with the road.

The acrylic resin found in the filter and in the right fuel tank is not a component of gasoline.

During the investigation, the opinion of the Aircraft manufacturer was asked about the possible cause of the origin of the acrylic resin in the right tank and in the fuel filter.

The manufacturer in its answer was not able to know the cause of the origin of the acrylic resin.

The investigation could not document the origin and the way in which the acrylic resin was found in the right tank and in the fuel filter of the Aircraft.

The following cases were examined, during the investigation, of the origin of the acrylic resin:

1. It has entered the tank during the refuelling of the Aircraft

- Given the way of refuelling the Aircraft in the Messolonghi LF (par. 1.6.5.4), it is possible that a container was used for the refuelling of the Aircraft, which was not used exclusively for this purpose. Although it was not known when the Aircraft was refuelled to look for the refuelling tank, this case is possible.

2. The polymeric insulation material of the tanks (Sealant) has undergone depolymerization due to its multi-year interaction with the combination of fuel and possibly alcohol, water. The monomer material, which was produced, due to the continuous temperature changes and with the catalytic action of the oxidation[22], underwent re-polymerization.

- According to the answer of the State Chemist, at the request of AAIASB, the procedure described above is not documented due to the fact that:

a) Polysulfide elastomeric resins are sulphur-containing polymers as opposed to sulphur-free acrylic polymers.

b) From a chemical point of view, the degradation products of polysulfide elastomers cannot be repolymerized and lead to the formation of acrylic polymer.

[22] As mentioned in Par. 1.12.4.5 the finding of rust during the laboratory test.

2.1.5.2 Controls of electric fuel pump and Right tank level sensor

From the results of the laboratory tests as presented in paragraphs 1.12.4.2 and 1.12.4.3, there was no evidence that the components of the fuel system in question contributed to the cause of the accident. The marginal deviations of the measured quantities from the values specified in the manufacturer's service manual are not considered to have affected the functionality of the units tested.

2.1.5.3 Examination of Aircraft fuel

According to the results of the fuel analysis, the RON grade of the tested fuel is higher than the minimum specified by the Supplementary Type Certificate (STC). The amount of ethanol detected by the laboratory test is within the permissible limits for the use of gasoline in cars, but outside the limits for use in aircrafts according to the applicable STC.

The detected amount of kinizarin, is a tracer that separates unleaded gasoline 95 RON from unleaded gasoline 100 RON and does not affect the quality of gasoline. The presence of kinizarin in combination with the high-octane number (RON 99.5) indicates that the gasoline was probably a mixture of 95 RON unleaded gasoline and the 100 RON unleaded gasoline.

The examination of the fuel showed that the value of the vapor pressure was 9.1 kPa lower than the minimum value of the vapor pressure specified for unleaded gasoline in April[23]. According to data from the engine manufacturer, the above values of vapor pressure and RON number are not considered insufficient.

The rust findings found during the laboratory examination are an indication of corrosion of metal parts into the fuel system, possibly due to the presence of oxygen compounds in the fuel but also the insufficient and non-regular drainage of water from the fuel tanks.

According to Government Gazette 293 / 12.02.2016 and the standard EN 228: 2014 as they are mentioned in par. 1.18.3.1 and 1.18.3.2, in the Hellenic Territory the unleaded automotive gasoline that is available legally contain a percentage of alcoholic compounds (ethanol and methanol). According to paragraph 1.18.4, the use of unleaded automotive gasoline with an alcohol content for aviation purposes may have a direct effect on the performance and operation of the engine and is a latent cause of an accident.

---

[23] The value of the vapor pressure in April is between the values 50.0 kPa and 80.0 kPa according to Government Gazette 293,12/02/2016 and the model of ELOT EN 228: 2014.

From the fuel test, the amount of 0.2% ethanol detected, although small, is within the limits set for use in vehicles but prohibited for use in an Aircraft engine according to the applicable supplementary type certificate.

The use in the engine of the accident Aircraft fuel with the above amount of ethanol, is an indication that the fuel was not checked if it complies with the zero alcohol limit of the supplementary type certificate before refuelling the Aircraft.

Due to the fact that the aircraft Tech. Log does not contain any information regarding the refuelling and the lack of fuel in the left tank, it is not documented when the aircraft was refuelled, but also it is not known whether they contained the same fuel quality.

The presence of the low vapor pressure of the gasoline in the right tank is an indication that the Aircraft probably was not refuelled before leaving Messolonghi, resulting in the remaining amount of gasoline in the right tank, due to the twelve-day stay of the Aircraft on the ground, to have lost part of the volatile components thereby reducing the vapor pressure.

Also, the low value of the vapor pressure does not create conditions for the occurrence of the phenomenon of Vapor Lock in the fuel supply line to the engine, resulting in the interruption of the flow of fuel to the engine.

2.2 Supplementary Type Certificate

From the review of the Supplementary Type Certificate it was found that the serial number of the Aircraft listed did not correspond to the serial number of the Aircraft while the serial number of the engine was identical to that indicated on the Supplementary Type Certificate.

At the same time, the Supplement of the Supplementary Type Certificate had not been incorporated in the current POM.

From the above, although they did not contribute in the cause of the accident, it is ascertained that the correctness of the data of the supplementary type certificate was not checked by the Araxos Aeroclub but also by the Organization EL.MG.0037 which was responsible for the management of the Aircraft

2.3 Mixing liquid acrylic resin with unleaded gasoline 100 RON

In addition to the findings referred to in paragraph 1.16.2, it was observed that the acrylic resin remained insoluble on both the walls and the bottom of the container.

This behaviour is consistent with what is stated in the relevant correspondence[24], which states the insolubility of acrylic resin in gasoline.

Because the acrylic resin is soluble in the aromatic hydrocarbons contained in a maximum of 35% in gasoline, part of the blended resin dissolved in the gasoline while the remainder remained insoluble in the other hydrocarbons that make up the gasoline.

2.4 Refueling of the Aircraft

In addition to the presence of acrylic resin in the right fuel tank, as mentioned in paragraphs 1.12.3.3 and 1.12.4.5 in the two fuel tanks and more strongly in the right fuel tank, deposits were detected whose presence is not compatible with an aircraft fuel tank. Since the fuel tanks were found to be closed and intact, it appears that the deposits did not enter the tank during the crash of the Aircraft but probably entered when refuelling the tanks of the Aircraft with fuel that had not passed through a particle retention filter.

Also, the presence in the fuel filter of polyethylene fibers as well as the detection of material derived from paints are consistent with the possible use of a plastic container with paint residues during the refueling of the Aircraft.

From the above findings but also from the fact that in the examined fuel sample a quantity of alcohol was found, it is possible that the Aircraft was refueled without having complied with the provisions of the current legislation, par. 1.18.1 but also of the decision of par. 1.18.6. From the data of the investigation, it was not possible to conclude when the Aircraft was last refueled.

2.5 Aircraft maintenance

The Aircraft was maintained according to the maintenance program which was not based on the current revision of the Aircraft service manual at the time of its issuance and approval. At the same time, the existing maintenance program contained inaccurate references between chapters, and it was not clear whether the replacement limit for the fuel hoses complied with the instructions in the manufacturer's service manual.

[24] Source: Plastics Analysis Guide, A. Krause, A. Lange, M. Ezrin, Introduction to the Chemical Analysis of Plastics, A. Krause, A Lange.

From the Service Bulletin referred to in par. 1.6.2 with number 240 W of the engine manufacturer and the review of the maintenance records it emerged that the engine had performed 493.45 h since its last overhaul[25] on 26/01/2010.

It is concluded from the above that the calendar or in-flight hours of the fuel line of the fuel line had not been exceeded.

From the review of the work card of the last inspection of 50 h that took place on 12/03/2018, 04:42 h before the accident, it emerged that the inspection was carried out according to a work card that did not correspond to the valid manufacturer's service manual of that period.

Although the work card performed did not come from the current revision of the manufacturer's service manual, the task of removing and cleaning the fuel filter tank and filter was included in the work card performed during the last inspection, but also in the one that came from the valid service manual of the manufacturer. Respectively the cleaning work of the filter of the electric fuel pump was also included in the above mentioned work cards.

From the Certificate of Release to Service (CRS) of the Aircraft in use but also from the work card it is ascertained that the above two works were carried out in the last inspection of 50 h.

The review of the technical records of the Aircraft shows that between the last inspection of 50 h on 12/03/2018 and the previous inspection of 50 h on 19/07/2017, a 27:45 h flight had taken place and the task to remove and clean the fuel filter and the bowl every 90 days, as provided by the manufacturer's service manual and the maintenance program, had not been performed.

The non-performance of the above inspection in the intervals of 90 days, does not create an indication that it contributed to the restriction of fuel flow from the filter, since it was carried out in the last inspection of 50 h on 12/03/2018.

The inspection of the 400 h of the engine, instead of being carried out on 20/01/2014, 400: 00 h of engine operation was carried out with a delay of 61:18 h. Despite the delayed execution of this inspection, no findings were made when it was carried out.

Also, the review of the list of the remaining hours for the inspections showed that the inspection of the battery and cables was not carried out in the scheduled calendar period, but without contributing to the cause of the accident while it was observed that there were incorrect entries in the execution date of tasks as well as in the number of flight hours of the Aircraft in tasks performed during the last inspection.

[25] Every 2000 flight hours or 12 calendar years

A review of the (AD's-Airworthiness Directives) revealed that there was a mandatory engine instruction that had not been evaluated by the Maintenance Management Organization EL.MG.0037 as to whether it should be applied to the engine. The investigation did not reveal any data linking the implementation of the mandatory directive to the specific engine.

From the data mentioned in par. 1.6.2 regarding the replacement of the cables of the sparking plugs well as the magnetos, it appears that components were used which had all the legal certificates of suitability for use, but their Part Number was not provided by the manufacturer's IPC, while the same manual did not provide an interchangeability between the product number of the components used and those provided.

After contacting the engine manufacturer, it emerged that for the sparking plugs cables, the differences between the cables provided by the manufacturer's IPC and those installed did not affect the operation of the engine.

Regarding the magnetos, also after contacting the engine manufacturer, it emerged that the product number 4270 used during the replacement of the magnetos, is a product number that had ceased to be used and was replaced by the product number 4370, but without the use of 4270 not being allowed.

It follows from the above that the use of a part number of the parts other than those provided for in the manufacturer's component list did not contribute to the accident.

Despite the non-contribution of the above to the cause of the accident, the Organization EL.145.0078 which performed the maintenance work of the Aircraft, should have replaced the cables of the sparking plugs and the magnetos with those provided by the manufacturer's IPC and not with those with which the engine was equipped before been replaced.

From the review of the available Aircraft records, it was found that there are gaps in the maintenance records, as a result of which the complete maintenance history of the Aircraft is not known, while no legible record was found which shows that the right tank was repaired due to a leak. using the Sloshing Sealer 802 sealant.

Despite the incomplete maintenance history of the Aircraft, according to the answer of the state chemist to a question of AAIASB, the absence of use of the above sealing material is also documented by the absence of the nitrocellulose spectrum in the sample which was examined in the laboratory during the investigation.

2.6 Pilots Operating Handbook (POM)

Between the POM 1 and 2 of paragraph 1.6.8.1, it was found that in addition to the different Aircrafts that these are mentioned and the other possible differences, there are differences in

the Aircraft weights, in the recommended tank change procedure, in the gliding diagram while the POM 1 found in the Aircraft there is no diagram of the autonomy of the Aircraft in relation to the density height for a quantity of fuel in 3/4 of each tank, as it exists in the POM 2.
At the same time, it was found that the emergency procedure in case of engine failure during the flight, as mentioned in par. 1.6.8.2, is identical in both manuals.
Regarding the POM 3, apart from the other differences it had with the POM 2, it did not contain emergency procedures, a gliding diagram and a diagram of the autonomy of the Aircraft in relation to the density level for the amount of fuel in 3/4 of each tank, as it exists in POM 2.
The absence of the autonomy diagram as mentioned above, does not enable the pilots during the flight preparation process to calculate the autonomy of the Aircraft in case the tanks contain 3/4 of their total level.
From the data collected during the investigation, it was not known whether the two pilots used any of the POM 1 or 3 for the planning of the flight, since the POM 2 was not in the possession of the aeroclub nor inside the Aircraft and came into the possession of AAIASB from CAA.
The reason that the POM found inside the Aircraft which corresponded to the type PA-28-151 and not to the type of the accident Aircraft PA-28-140, could not be substantiated as the presence of the correct POM was certified during the airworthiness review on 28/07/2017 but also in the last inspection of 50 h of the Aircraft on 12/03/2018, 04:42 h before the accident.

2.6.1 Fuel Tank Selector Change Procedure

From those mentioned in par. 2.1.1 and 2.1.2, during the flight to Kopaida LF and from Kopaida LF until shortly before the report to the point IXONI, the left fuel tank was selected to supply the engine. The total flight time for the above two flight legs was 01:51 h and was longer than the time of one hour referred to in the first step of the recommended fuel management procedure of the applicable POM.
Nevertheless, if, in the context of the proposed tank change procedure, a change was made from the left to right fuel tank according to the first step of the recommended procedure or after taking off from Kopaida LF, there would be more fuel available in left tank during the application of the emergency procedure that probably enabled the Aircraft to land at Kopaida LF.
Although the tank change procedure as described in the current POM, is considered recommended, taking into account the above, its non-application was a contributing factor in causing the accident.

From the review of the findings in the fuel filter, it is considered that even if the pilots implemented the proposed tank change procedure of the current POM, the power supply problem and the loss of engine power would not have been avoided.

3 CONCLUSIONS

3.1 Findings

3.1.1 Aircraft – Maintenance

- The Aircraft held valid all the necessary certificates.
- A POM found in the Aircraft did not correspond to the accident Aircraft.
- In the context of the investigation, AAIASB received three different POMs for this Aircraft, of which only one corresponded to the Aircraft.
- Three different checklists were found on the Aircraft.
- In the Technical Logbook of the Aircraft there are no records concerning the refueling of the Aircraft
- The Aircraft was maintained based on a maintenance program approved by CAA, which however, did not correspond to the current revision of the maintenance manual during its issuance and approval.
- The Aircraft had undergone its last maintenance of 50 h, 04:42 h before the accident.
- In the last maintenance the planned inspection of the fuel filter, the filter tank and the filter of the electric pump was carried out.
- In the last maintenance, the spark plugs cables and the magnetos were replaced by other serviceable ones, but the Part Number was not provided in the IPC, nor was interchangeable to the product number from the same manual.
- In the last maintenance, the planned inspection of the fuel filter, the filter tank and the filter of the electric pump was carried out.
- The fuel filter and the filter tank were not inspected every 90 days in accordance with the provisions of the maintenance program and the service manual.
- There was no time exceedance in the replacement limit of the fuel hoses.
- From the available records of the Aircraft, it was found that there are gaps in the maintenance records, as a result of which the complete maintenance history of the Aircraft is not known.
- The available Aircraft records do not show that the right tank of the Aircraft had been repaired due to a leak.
- Laboratory tests did not reveal the use of the Sloshing Sealer 802 sealant.

3.1.2 Aircraft Flight

3.1.2.1 Flight from Messolonghi LF to Kopaida LF

- The Aircraft during its flight from Messolonghi to Kopaida was overweight according to the current POM, while the left fuel tank was used to power the engine
- No technical anomaly was recorded for this flight.
- It is not documented whether the Aircraft was refueled before departure.
- The fuel level in the left tank was at 3/4 while on the right between 1/4 and 1/2 of the total capacity.
- Fuel consumption was 17% higher than that of best fuel economy.

3.1.2.2 Flight from Kopaida LF to Messolonghi LF

- The weight of the Aircraft was within the prescribed limits.
- The fuel level in the left tank was at 1/4 of its total capacity while on the right between 1/4 and 1/2 of its total capacity.
- The exact amount of fuel in the right tank could not be documented but probably approached 1/4 of the total capacity of the tank.
- On departure from Kopaida the Pilot used the left fuel hand tank to power the engine, while before the IXONI point he changed the fuel tank and used the right hand.
- Up to the IXONI point, the Pilots did not report any technical abnormalities.
- There is no indication that the supply tank change was not successful.
- The Aircraft after the supply problem performed a smooth descent while flying at a distance of about twice that provided for gliding maintaining a ground speed close to that before the supply problem.
- From the descent trail and the ground speed it appears that during the descent of the Aircraft from 15:51 h to 15:56 h, the engine was running, possibly intermittently.
- The Pilots after the onset of the feed problem, seem to have reset the engine supply to the left tank until all the fuel contained was completely depleted.
- The cockpit configuration was consistent with performing the engine power loss procedures.
- The emergency procedures performed by the Pilot complied with the Check List instructions.
- Despite the application of emergency procedures, the recovery of engine power was not considered possible.

- The Aircraft before the collision with the cable had a speed value close to110 kt, but this value is not documented by the examination of the airspeed indicator.
- If the Aircraft had not collided with the cable, it is possible that it would have made the forced landing on the national road.
- The investigation could not document whether the remaining amount of fuel in the right tank was sufficient for the flight of the Aircraft from the point of occurrence of the power problem to Messolonghi LF.

3.1.3 Examination of the Aircraft

- The fuel tanks of the Aircraft were closed and intact while there was no smell of fuel at the accident site.
- At the Aircraft apart from the two landing Gears that had been debouched during the collision with the cable, no major part of it was missing.
- The trailing edge flaps of the wings was present while the control surfaces on the wings and the tail section were intact.
- In the left wing there was a curved deformation upwards at a length of 85 cm from the end of the wing.
- The fuel tank selection valve was operating normally.
- Deposits were found on the filter and in the right fuel tank.
- The fuel filter was almost completely covered with a layer of acrylic resin.
- A layer of acrylic resin, among other deposits. was found at the bottom of the right fuel tank.
- Deposits were detected in the left fuel tank while the presence of sticky material was not detected.
- The deposits found in the two fuel tanks were not compatible with the Aircraft fuel tank and may have entered during the Aircraft refueling with fuel that had not passed through a particulate filter.
- The abrasions, on the indication disc, of the tank selector valve and the selector are consistent with the movement of the valve selector from the “L” position (left tank) to the “OFF” position due to the impact of the Aircraft
- The left fuel tank was found empty of fuel without containing the unusable amount of fuel.

- 20 lt of fuel were drained from the right tank, of which 15.84 lt were available to power the engine.

3.1.4 Laboratory tests

- The examination of the engine RPM indicator showed a trace of the pointer which corresponded to 890 rpm while the examination of the airspeed indicator did not show an imprint from the instrument pointer.
- The examination of the electric fuel pump and the level sensor of the right tank did not reveal contribution to the accident.
- From the test of the fuel level indicators of the cockpit, no conclusions were drawn due to the damage they had suffered from the collision of the Aircraft.
- Examination of the samples taken from the fuel filter, the deposits of the right fuel tank and the deposits on the body of the fuel filter showed that there was a mixture of more or less similar composition, mainly agglomerates of earth origin, dust and rust.
- In the right fuel tank of the Aircraft but also in the fuel filter the layer of localized material was found made of acrylic resin origin.
- The acrylic resin layer covered almost the entire surface of the fuel filter.
- The investigation could not document exactly how the acrylic resin was found in the right tank and fuel filter of the Aircraft.
- It is possible that the acrylic resin entered the fuel tank during the refueling of the Aircraft
- In the examined fuel the presence of ethanol was found in a percentage of 0.2%.
- The value of the fuel vapor pressure was lower than the minimum predicted.
- The RON octane number of the fuel was greater than the minimum value specified in the Supplementary Type Certificate.
- Unleaded automotive gasoline available in Greece can legally contain a percentage of alcoholic compounds (ethanol and methanol). Unleaded gasoline with an amount of alcohol for aviation use is a latent cause of an accident.

3.1.5 Aircraft impact

- The Aircraft upon impact with the cable had speed compatible with the indicator of the speedometer (110 kt).
- After impact with the cable the Aircraft followed a downward trajectory with an angle of 13^0 and impacted on the asphalt.

- The engine propeller rotated when the Aircraft collided with the road surface.

3.2 Route Cause

Loss of engine power due to fuel flow restriction to the engine because of the almost complete coverage of the fuel filter with an acrylic resin layer.

3.3 Contributing Factors

- The collision of the Aircraft with the cable.
- Fuel depletion in the left tank.
- The non-application of the recommended tank change procedure according to the Pilots Operating Manual.

4 SAFETY RECOMMENDATION

4.1 To the Civil Aviation Authority

In the No. D3/C/12041/2861 regulation of the CAA entitled "Regulation of Refueling Aircrafts at Airports", article 19 describes, among others, the process of refueling and the possibility of supplying fuel for light and ultra-light Aircraft, while in effect is the from January 2003 decision of the CAA Director approving the use of fuel of specifications ASTM D4814 or EN 228.

The investigation revealed that in the Hellenic Territory the unleaded automotive gasoline that is available, has quality characteristics as they are mentioned in the Government Gazette 293/12.02.2016 and in the standard EN 228: 2014. Among other characteristics, the vapor pressure and the possible legal percentage of ethanol and methanol, the maximum value of which is mentioned in the above Government Gazette and in the standard EN:228, can have a direct effect on the operation of the Aircraft engines and are a latent cause of accident. For this reason it is necessary to check if the fuel meets the characteristics mentioned in the above texts and especially if it complies with the limit of zero alcohol.

Also, in the two fuel tanks the existence of a quantity of foreign bodies was observed, whose presence is not compatible with an Aircraft fuel tank. Since the fuel tanks were found closed and intact after the crash of the Aircraft, it appears that there was probably a refueling with fuel that had not previously been filtered.

2021-01: It is recommended that the Civil Aviation Authority review and possibly revise the implementation of the applied procedure so that the supply and transportation of

unleaded gasoline and the refueling of Aircrafts with unleaded gasoline is in accordance with applicable regulations.

4.2 **To the Civil Aviation Authority, the Airworthiness Management Organization EL.MG.0037 and the Maintenance Organization EL.145.0078.**

The investigation revealed that the Aircraft was maintained based on a maintenance program prepared by the organization EL.MG.0037, was approved by the CAA but was not based on the current revision of the Aircraft service manual at the time of its issuance and approval.

Also, during inspection of the maintenance works of the Aircraft, it was found that:

1. Engine components were replaced in the Maintenance Organization EL.145.0078 by others with part number which were not specified in the manufacturer's IPC.
2. The calendar restriction for carrying out the inspection of the fuel filter was not observed.
3. There was a mandatory directive which was not assessed as to whether it was applicable.
4. The inspection of the battery and cables was not carried out within the stipulated calendar deadline.
5. In the list of the remaining hours for the inspections, it appeared that there were incorrect entries in the date of execution of works but also in the number of flight hours of the Aircraft in tasks performed during the last maintenance.

2021-02: It is recommended that the CAA review and possibly revise the implementation of internal procedures for the control of:

- The Airworthiness Management Organization EL.MG.0037,
- The Maintenance Organization EL.145.0078 and
- The manuals to be approved.

2021-03: It is recommended that the Airworthiness Management Organization EL.MG.0037 and the Maintenance Organization EL.145.0078 to review and possibly revise their operating procedures. of those Organizations.

5 APPENDICES

5.1 Checking the level sensor

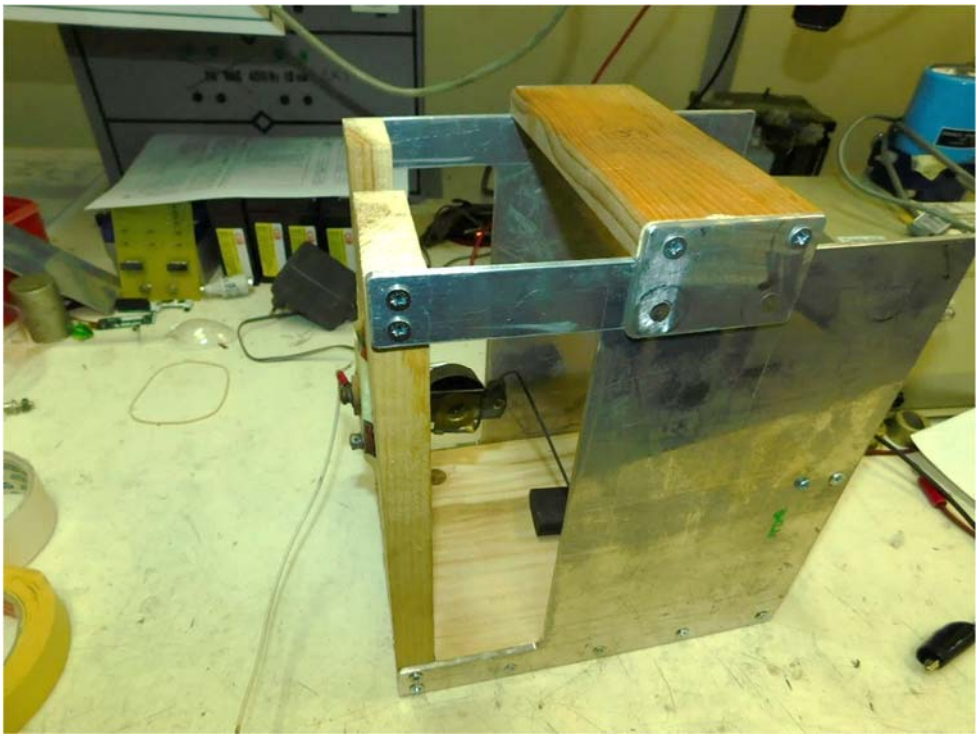


Photo 32: The proprietary control of the fuel tank level sensor with the sensor mounted.

5.2 Macroscopic inspection of electric fuel pump filter

Photo 33: The filter of the electric fuel pump in the macroscopic examining it with its slight deposits.

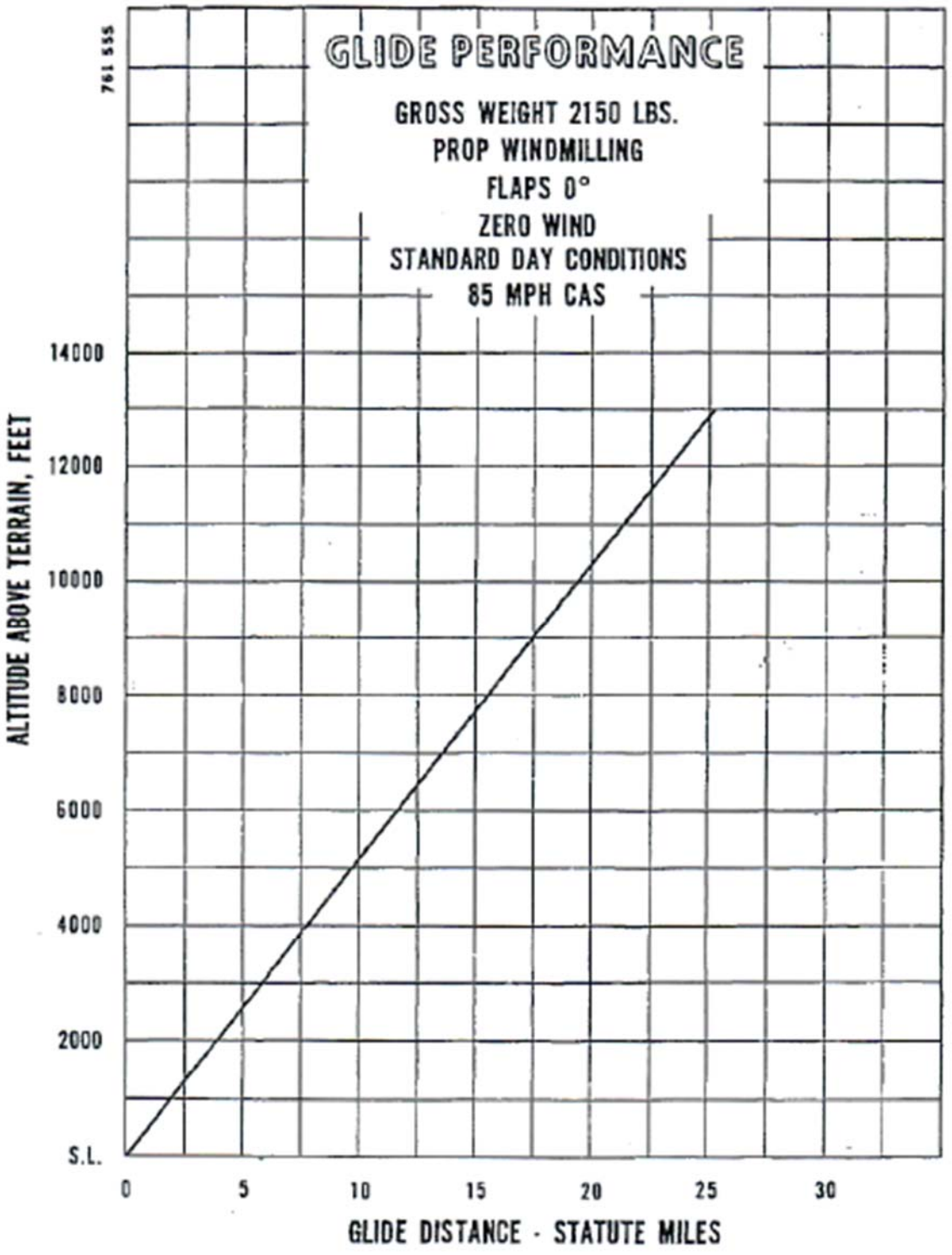


Chart 1: Aircraft gliding diagram

5.3 Aircraft Fuel tanks

Photo 34: Right hand fuel tank after being opened

Photo 35: Same as photo 34.

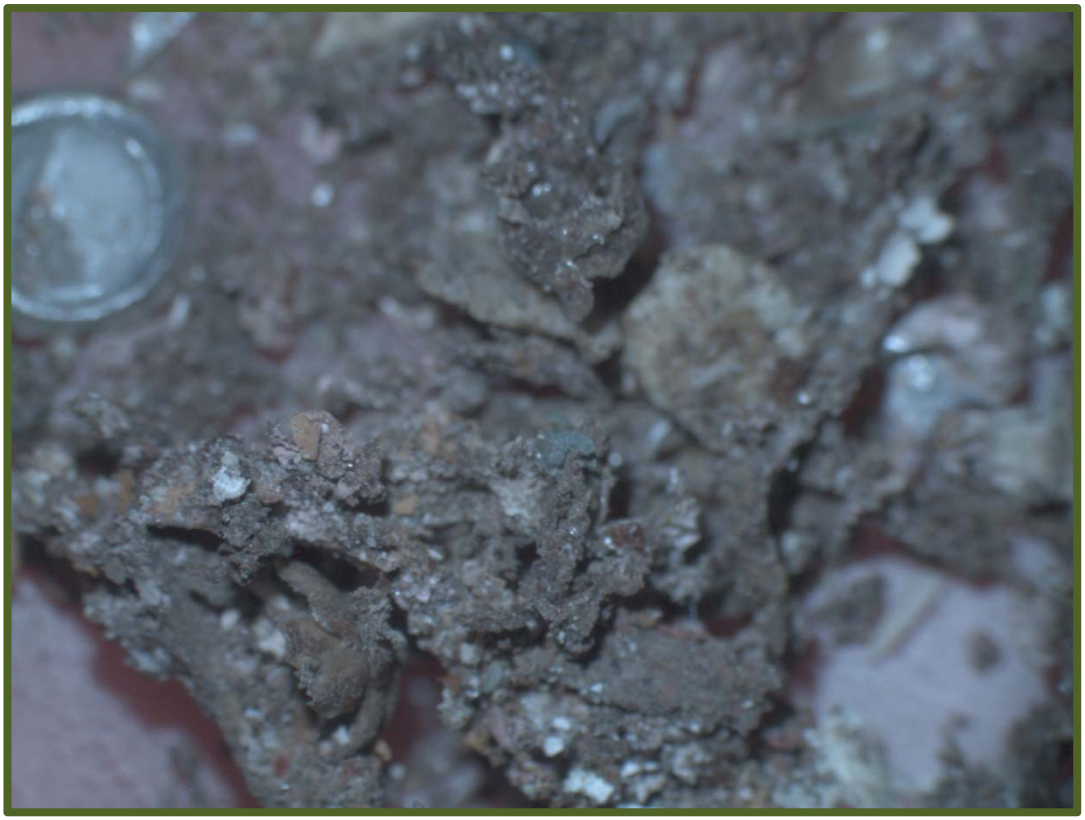


Photo 36: Detail A, Stereomicroscopy of the deposits in the right fuel tank during the laboratory test.

Photo 37: Sample of deposits in the left fuel tank

5.4 Fuel Filter

Photo 38: The inside view of the fuel filter

Photo 39: The outside view of the fuel filter .

5.5 Acrylic resin solutions

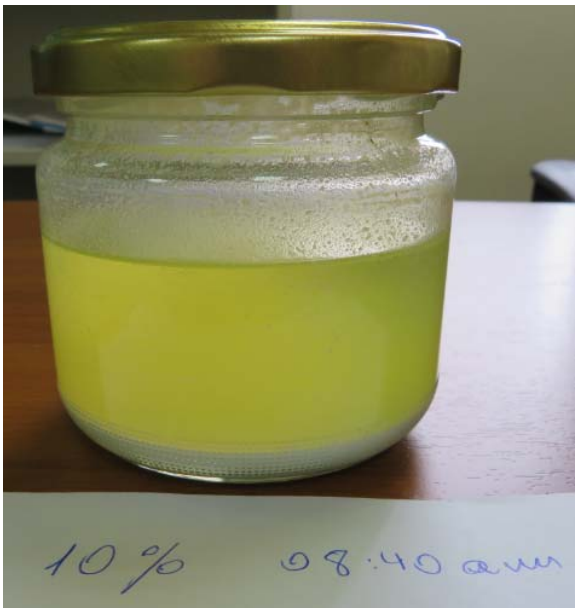


Photo 40: The 10% acrylic resin solution immediately after its preparation.

Photo 41: The same solution after a period of time of 20 minutes.

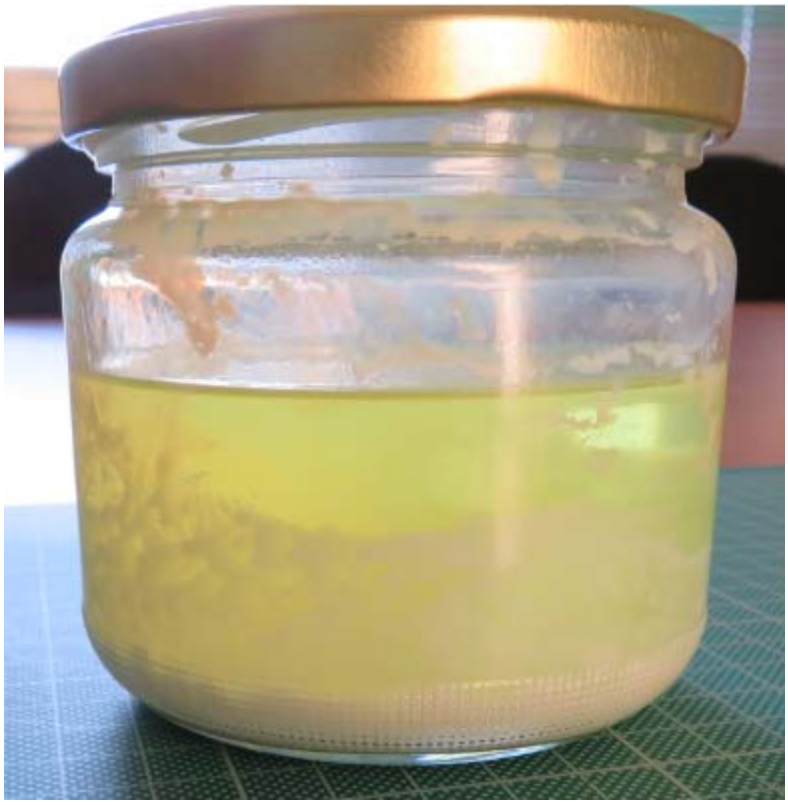


Photo 42: The above solution after a period of one month.

Photo 43: The 6.6% acrylic resin solution immediately after its preparation.

Photo 44: The same solution after time interval 9 minutes

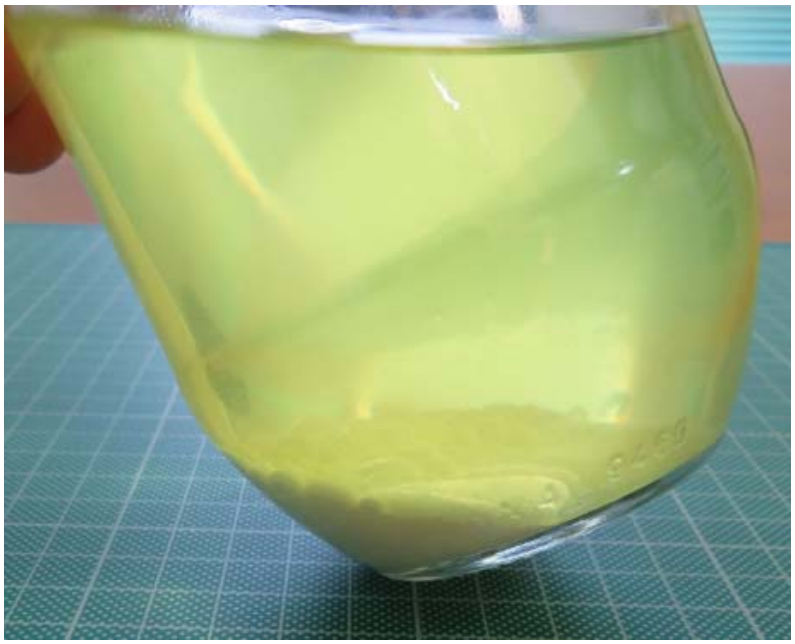


Photo 45: The above solution after a period of one month.

5.6 Applying liquid acrylic resin to a fuel filter

Photo 46: (a) the fuel filter before applying the liquid acrylic resin and (b) after smearing it as shown by the bows.

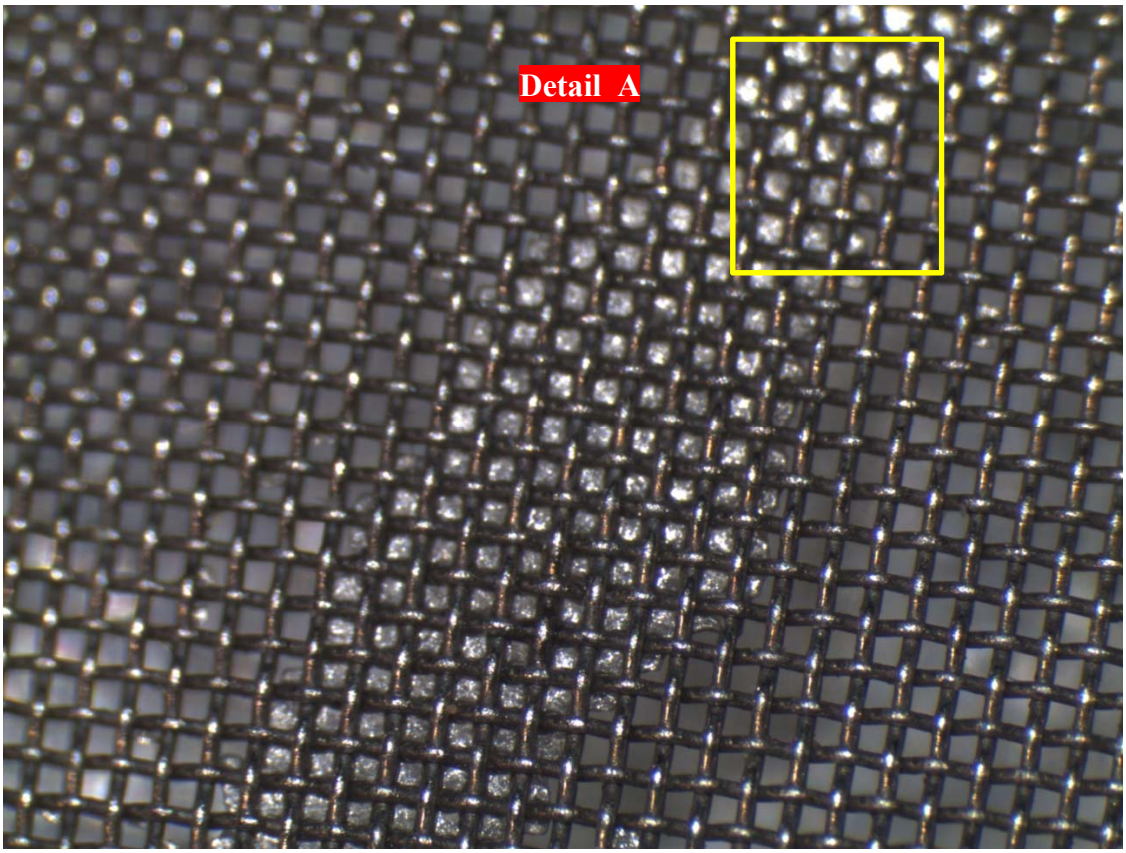


Photo 47: The fuel filter in the stereo macroscope showing its local formation layer of acrylic resin.

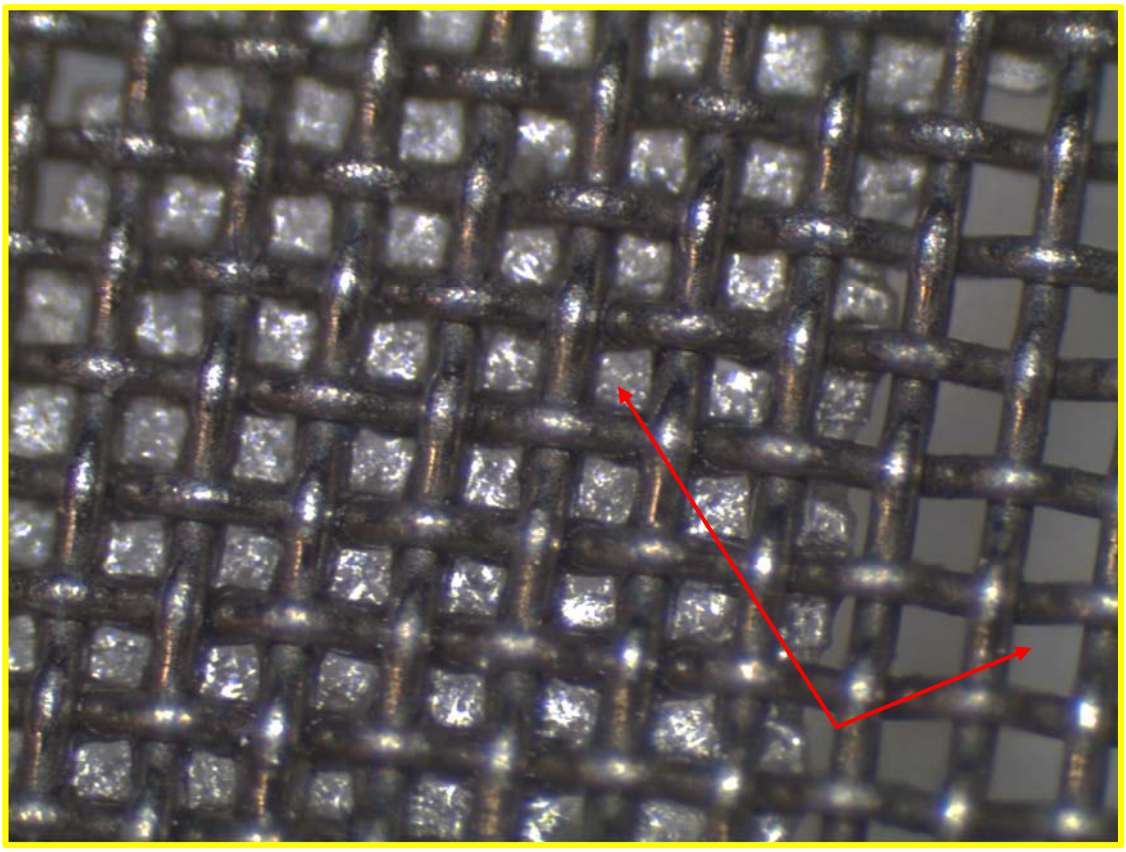


Photo 48: Detail A of the stereomicroscope, showing the area with a layer of acrylic resin and without a layer of acrylic resin.

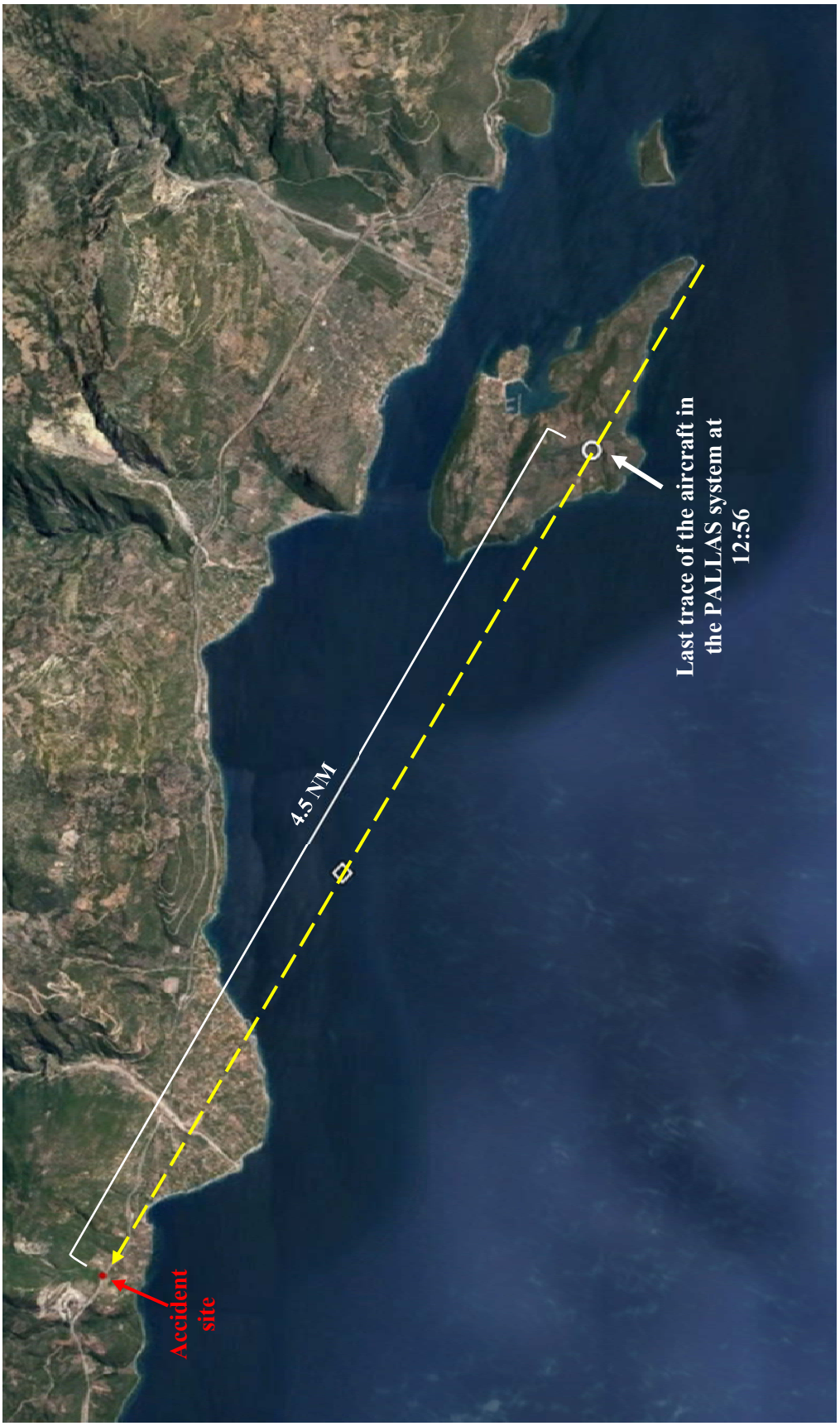


Fig. 6: The estimated course of the Aircraft after the loss of engine power.

N**ea Philadelphia, 26 November 2020**

THE CHAIRMAN

Ioannis Kondylis

THE MEMBERS

Akrivos Tsolakis

Grigorios Flessas

Christos Valaris

Charalampos Tzonos-Komilis

Exact Copy

THE SECRETARY

Kyriakos Katsoulakis