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# Report A-016/2020

Accident involving a Piper PA-28R-200 aircraft, registration EC-HLV, at Casarrubios del Monte Aerodrome (Toledo) on 9 June 2020

GOBIERNO DE ESPAÑA

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63 | E-mail: ciaiac@mitma.es | C/ Fruela, 6
Fax: +34 91 463 55 35 | http://www.ciaiac.es | 28011 Madrid (España)

## Notice

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission regarding the circumstances of the accident object of the investigation, its probable causes and its consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with Articles 5.5 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010; Article 15 of Law 21/2003 on Air Safety; and Articles 1, 4 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence. The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws detailed above, the investigation was carried out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

Consequently, the use of this report for any purpose other than the prevention of future accidents may lead to erroneous conclusions or interpretations.

# Contents

# Abbreviations

| | |
|---|---|
| ° ′ ″ | Sexagesimal degree(s), minute(s) and second(s) |
| ºC | Degree(s) Celsius |
| ºF | Degree(s) Fahrenheit |
| AEMET | Spain’s State Meteorological Agency |
| AENA | Spanish Airports and Air Navigation |
| AESA | Spain’s National Aviation Safety Agency |
| AMM | Aircraft maintenance manual |
| tdca | Top dead centre angle |
| ATPL | Airline Transport Pilot License |
| ATO | Approved Training Organisation |
| CAMO | Continuing Airworthiness Management Organisations |
| CPL | Commercial Pilot License |
| CPL(A) | Commercial Aircraft Pilot License |
| CR | Class rating |
| CRI | Class Rating Instructor |
| EASA | European Union Aviation Safety Agency |
| FI | Flight Instructor |
| FI NIGHT | Flight Instructor Night |
| ft | Feet(s) |
| h | Hour(s) |
| HP | Horsepower |
| IFR | Instrumental Flight Rules |
| IPC | Illustrated parts catalogue |
| IR (A) | Instrument Rating |
| kg | Kilogramme(s) |
| KIAS | Knots-indicated airspeed |
| km | Kilometre(s) |
| km/h | Kilometre(s)/hour |
| kt(s) | Knot(s) |
| l, l/h | Litre(s), litre(s)/hour |
| LAPL | Light Aircraft Pilot License |
| LECU/LEVS | ICAO code for Cuatro Vientos Airport (Madrid) |
| LEGT | ICAO code for Getafe Airport (Madrid) |
| LEMT | ICAO code for Casarrubios del Monte Aerodrome (Toledo) |
| LT | Local time |
| m | Metre(s) |
| mm | Millimetre(s) |
| m/s | Metre(s)/second |
| $m^2$ | Metre(s) squared |
| mbar | Millibar(s) |

| | |
|---|---|
| MEP | Multi-engine piston rating |
| METAR | Aviation routine weather report |
| MHz | Megahertz |
| mph | Mile(s) per hour |
| N | North |
| NDT | Non-destructive testing |
| p/n | Part number |
| s/n | Series number |
| NTSB | National Transportation Safety Board |
| W | West |
| OM | Operating Manuals |
| PF | Pilot flying |
| PIC | Pilot-in-command |
| POH | Pilot Operating Handbook |
| PPL | Private Pilot License |
| rpm | Revolutions per minute |
| SEM-EDS | Scanning Electron Microscopy-Energy Dispersive Spectroscopy |
| SEP | Single-engine piston rating |
| Sq ft | Square feet(s) |
| TAF | Terminal aerodrome forecast |
| TSN | Time since new |
| TSO | Time since overhaul |
| US gal | American gallon |
| US quarts | American quarter gallon |
| UTC | Universal time coordinated |
| VFR | Visual Flight Rules |
| W | West |

# Synopsis

| | |
|---|---|
| Operator: | AEROFAN ATO |
| Aircraft: | Piper PA-28R-200, registration EC-HLV, s/n: 28R-7435019 |
| Date and time of accident: | Tuesday 9/June/2020, 17:35 local time |
| Site of accident: | Casarrubios Aerodrome - LEMT (Casarrubios del Monte -Toledo) |
| Persons on board: | Two pilot instructors |
| Type of flight: | General Aviation |
| Phase of flight: | Landing |
| Flight rules: | VFR |
| Date of approval: | 25/FEB/2021 |


## Summary of incident

On Tuesday, 9 June 2020, the Piper PA-28R-200 aircraft, registration EC-HLV, suffered a loss of power and landed at an alternative aerodrome during a flight carried out by two instructors from the pilot school that operated the aircraft.

The crew was unharmed, but the aircraft suffered damage to its propeller, flaps and the underside of its fuselage.

The investigation has found the accident was caused by a lack of adherence to operational procedures, which led to the aircraft landing with its landing gear retracted.

The following factors are thought to have contributed to the accident:

- the override of the automatic landing gear extension system, and
- the loss of engine power that resulted from the failure of cylinder no. 4 due to improper engine maintenance.

The report contains an operational recommendation for AESA to monitor SINMA AVIACIÓN, S.L., regarding its approval as Maintenance Organization ES.145.113; a recommendation to SINMA AVIACIÓN, S.L. to ensure the correct performance of maintenance overhauls and update its best practices; and a recommendation to AEROFAN ATO to ensure its instructor retraining flights are adequately prepared during briefing meetings.

# 1. FACTUAL INFORMATION

## 1.1. History of the flight

According to the statements made by the occupants of the aircraft, on 9 June 2020 the pilot-school-operated Piper PA-28R-200 aircraft with registration EC-HLV commenced a flight with two of the school's instructors on board to practise landings and take-offs and test the aircraft after an extended period of inactivity. It was a local round-trip flight arriving and departing from Madrid - Cuatro Vientos airport (LECU).

After landing and taking off three times without incident, they decided to leave the airport to make a short flight in the local area. When they were above Valmojado, they simulated an engine failure by pulling the throttle back to idle. As they did so, the engine began to function erratically, so they decided to return to LECU. They increased power, all the engine gauges showed normal values, and the engine reacted as expected. When they were approximately 3000 ft above Navalcarnero and flying at a speed of 120 kts with maximum engine power, the engine once again started to make small but regular explosive noises and began to vibrate violently.

Finding it difficult to maintain level flight even with the power levers at maximum, they decided to head towards the nearby Casarrubios del Monte Aerodrome (LEMT) to make an emergency landing.

As they attempted to communicate their decision to divert to LEMT due to an engine failure, the aircraft's power supply was interrupted, making communications difficult.

The PF started to turn to the right to join the downwind leg for LEMT runway 08, but the PIC thought it would be more direct to proceed directly to the base leg for runway 26 and made his opinion known by trying to take the controls. The PF turned towards the base of runway 26 and, with the electricity restored, the PIC told him to take the controls.


Photograph 1. Damaged aircraft at the accident site

They configured the aircraft for landing but were unable to check whether the landing gear had deployed due to the power failure. They eventually landed at 17:35 local time with the landing gear retracted. After securing the aircraft, the crew were able to exit the aircraft unharmed and without assistance.

### 1.2. Injuries to persons

| Injuries | Crew | Passengers | Total in the aircraft | Others |
|---|---|---|---|---|
| Fatal | | | | |
| Serious | | | | |
| Minor | | | | |
| None | 2 | | 2 | |
| **TOTAL** | **2** | | **2** | |

### 1.3. Damage to the aircraft

During the accident, the aircraft incurred significant damage to its propeller, the underside of its fuselage and its flaps.

### 1.4. Other damage

The emergency landing at the aerodrome did not cause any third-party damage.

### 1.5. Personnel information

The licenses held by the crew involved in the incident were subject to the Resolution issued by the Directorate of Spain's National Aviation Safety Agency on 5 May 2020, which, under the provisions of Article 71 of Regulation (EU) 2018/1139, extended the validity of licenses, ratings, attributions, endorsements and pilot, instructor, examiner and cabin crew certifications to mitigate the impact of the COVID-19 pandemic on commercial and general aviation.

#### 1.5.1. Pilot-in-command (PIC)

The 27-year-old Spanish pilot acting as PIC had a commercial aircraft pilot license, CPL(A), issued by Spain's National Aviation Safety Agency (AESA) on 26/07/2016, with the following ratings:

- SEP rating (land) for single-engine piston aircraft valid until 31/05/2020.
- MEP rating (land) for multi-engine piston aircraft valid until 31/07/2020.
- IR(A) instrument flight rating, valid until 31/07/2020.
- Flight instructor rating FI(A), for PPL, CPL, SEP, MEP and FI NIGHT valid until 28/02/2021.
- English language proficiency level 5 valid until 30/06/2022.

He had a class 1 medical certificate valid until 03/10/2020, and his class 2 and LAPL medical certificates were valid until 03/10/2024.

He had 951.2 hours of flight experience, of which 3.2 were in the Piper PA28 Arrow involved in the incident, and 93.3 were in the fixed-landing-gear PA28 Warrior. He also had experience in Cessna C152, C172, DA40 and DA42 aircraft.

Of his total flying time, 832.7 hours were as PIC and 706.6 were as an instructor.

He had a total of eight hours of flying time with the PIC involved on the accident.

He had been a flight instructor for the school that operated the aircraft for one year and ten months.

He made his last flight prior to the accident in a different type of aircraft, on 12/03/2020, in a flight that lasted 1.3 hours. His last flight in the aircraft involved in the incident took place on 18/02/2020 and lasted one hour.

### 1.5.2. Pilot flying (PF)

The 35-year-old Spanish pilot as PF had a commercial aircraft pilot license, CPL(A), issued by Spain's National Aviation Safety Agency (AESA) on 06/09/2017, with the following ratings:

- SEP rating (land) for single-engine piston aircraft valid until 31/05/2020
- MEP rating (land) for multi-engine piston aircraft valid until 31/12/2019
- IR(A) instrument flight rating, valid until 31/12/2019
- Flight instructor rating FI(A) for PPL, CPL, SEP, MEP and FI NIGHT valid until 31/08/2021
- English language proficiency level 4 valid until 14/09/2021

He had a class 1 medical certificate valid until 10/12/2020, and his class 2 and LAPL medical certificates were valid until 10/12/2024.

He had 920 hours of flight experience, of which 47 were in similar Piper PA28 models to the one involved in the incident and between fifteen and twenty hours were in the exact Arrow model involved in the incident (accrued during his pilot training approximately three years previously).

He also had experience in Cessna C152, C172, C310, DA40 and DA42 aircraft.

Of his total flying time, 688 h were as PIC and 624 h were as an instructor.

He had been a flight instructor for the school that operated the aircraft for one year and nine months.

He made his last flight prior to the accident in a different type of aircraft, on 23/03/2020, in a flight that lasted three hours and 25 minutes. He had no flights logged in the aircraft involved in the incident.

## 1.6. Aircraft information

### 1.6.1. General information

The Piper PA-28R-200 Arrow II is a single-engine, all-metal, four-seater, low-wing aircraft with a tricycle-type retractable landing gear designed for both VFR and IFR flights.

**Structure:**

- Wingspan: 32.22 ft
- Length: 24.6 ft
- Wing area: 170 sq ft
- Maximum height: 8.0 ft
- Empty weight: 783 kg
- Maximum take-off weight: 1202 kg (according to the weight and balance sheet for the aircraft dated 10/10/2006)

**Performances:**

- Optimum cruise speed: 165 mph
- Stall speed with landing gear retracted: 71 mph
- Stall speed with landing gear extended: 64 mph

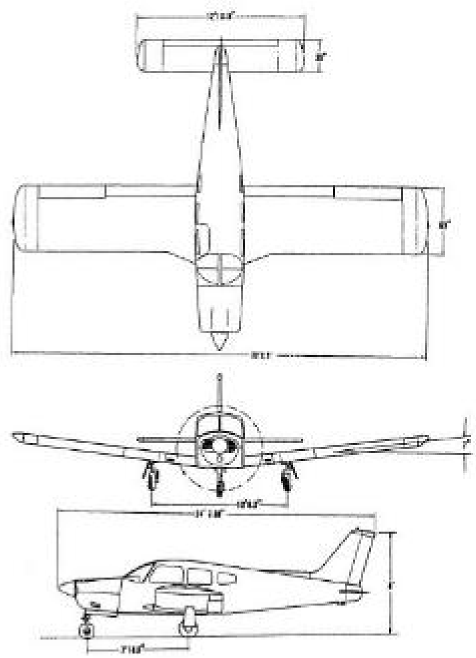


Figure 1. Incident aircraft

**Power plant:**

TEXTRON LYCOMING IO-360-A2B 4-cylinder injection piston engine. s/n: L-2411-51A.

Characteristics:

- Four-stroke, four horizontally opposite cylinders, and double ignition system (magnetos)
- Air-cooled through the two front inlets
- Maximum power: 200 HP
- Top speed: 2700 rpm
- Recommended limit for take-off power: five minutes

**Propeller:**

Hartzell p/n: HC-C2YK-1B s/n: CH3229, in aluminium.

Characteristics:

- Two-blade, constant speed, variable pitch, tractor configuration
- Maximum power: 200 HP
- Rpm range: 2000-2250 rpm
- Diameter: 1.93 m

**Fuel:**

- Type of fuel authorised and used: AVGAS 100LL
- Total fuel capacity 181.44 l (48 US gal).

**Oil:**

- Type of mineral oil authorised: MIL-L-6082B
- The oil tank holds a maximum of 7.57 l (8 US quarts).

**Instrument panel:**

Photograph 2. Cabin interior of the incident aircraft

**Landing gear:**

The incident aircraft's landing gear is a retractable, tricycle-type gear, hydraulically actuated by an electrically operated reversible pump. The pump is controlled by a selector switch on the instrument panel to the left of the control quadrant. The landing gear extends and retracts in approximately seven seconds.

Also incorporated in the system is a pressure sensing device which lowers the gear regardless of gear selector position, depending upon airspeed and engine power. Gear extension is designed to occur, even if the selector is in the up position, at airspeeds below 105 mph with power off *(Backup Gear Extender).* The device also prevents the gear from retracting at airspeeds below approximately 85 mph with full power, even if the selector switch is in the UP position.

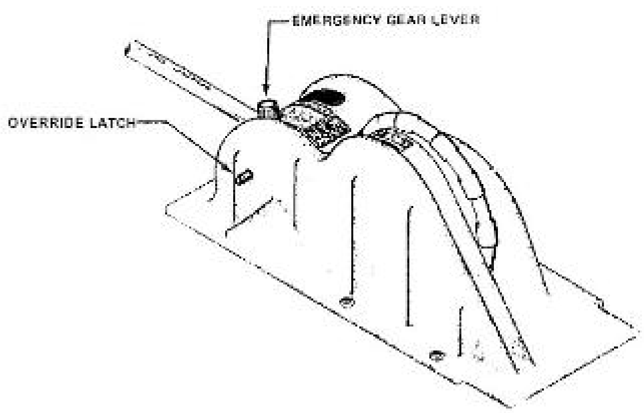



Figure 2. Emergency landing gear lever

Manual override of the device is provided by an emergency landing gear selector lever located to the left of the flap handle, which must be put in the OVERRIDE position with the landing gear lever in the UP position, regardless of the speed/ power combination.

A yellow light on the instrument panel, located below the landing gear position selector lever, alerts the pilot if the automatic back up gear extender is deactivated.

Photograph 3. Landing gear position lights

The landing gear position is indicated by three green lights below the landing gear lever, which illuminate when the gear is lowered and locked. If all the indicator lights are off, the landing gear is up. The landing gear must not be retracted at speeds above 109 mph or extended at speeds above 130 mph.

In addition, the system has an audible warning that sounds if:

- the landing gear is in the UP position, and the power is reduced,
- the aircraft is on the ground, and the selector is in the UP position,
- the landing gear is extended by the emergency system with the landing gear lever in the UP position (unless power is at maximum).

### 1.6.2. Maintenance information

The aircraft was built in 1974 with serial number: 28R-7435019. Its maintenance was carried out by SINMA AVIACION, S.L., an AESA-approved CAMO and EASA Part-45 maintenance organisation, most recently approved in inspection 17 on 12/07/2019. The latest approved maintenance programme was the PM-PA28R-200-EC-HLV edition 1, revision 2, on the 29/04/2020. The organisation was authorised to carry out general overhauls on Lycoming Series 360 engines.


Photograph 4. Engine ID plate

According to the most engine logbook issued on 23/07/2007 (second book), the engine installed was a Lycoming with p/n: IO-360-A2B s/n: L-2411-51AC, which matches the inscription on the engine plate (photo 4). However, the current AESA license plate registration has the aircraft logged with p/n: O-360-C1C, which is not an injection engine like the one in the accident aircraft.

The engine was reconditioned prior to the event in an overhaul carried out by SINMA AVIACIÓN, S.L., in accordance with EASA Form 1[1] on 06/02/2019, when the aircraft had a TSN of: 8836:10 hours. It was certified by an aircraft maintenance mechanic licensed to certify components, whose authorisation, as the person responsible for the certification, did not specify the type of components used.

The engine overhaul was carried out as per the instructions in the Textron Lycoming Overhaul Manual, p/n: 60294-7 rev. 60294-7-14 July 2011. The following components were also replaced with reconditioned parts (overhauled):

- Magneto LH p/n: 10-349365-9, s/n: A169698
- Magneto RH p/n: 10-349305-1, s/n: 4052377
- Injector p/n: 2524054-11-H s/n:72H59604
- Starter motor p/n: 149NL s/n:H-S101010
- Alternator p/n: 10-1051, s/n: H-S072904
- Vacuum pump p/n: 215CC s/n: A616P
- Fuel pump p/n: 154732400

According to the manual, mechanics must perform the following tasks during the engine overhaul:

- Disassemble and inspect all components (cylinders, accessories, internal components)

[1] EASA Form 1: EASA Form 1, ARS (authorised release certificate).

- Clean (degrease and decarbonise)
- Check the dimensions of all components
- Replace any damaged parts and those due for mandatory replacement as specified by the manufacturer
- Apply anti-corrosion treatment
- Re-assemble engine
- Run engines and perform final test
- Any rotating components, such as the starter motor, alternator, carburettor injectors, fuel pump and magnetos, must be installed after being fully overhauled by a centre approved to do so or purchased new. In both cases, they should be documented with an EASA Form 1 or equivalent.

They also overhauled the Hartzell propeller with p/n: HC-C2YK-1B s/n: CH3229, which was reconditioned on 19/09/2019 and the HARTZELL governor with p/n: F-2-7AZ D182WJ, which was reconditioned according to EASA Form 1 on 17/04/2019 (Germany).

At the time of the accident, the aircraft had 8845:15 hours of flight, and the engine had accrued nine hours since its last overhaul.

On the day of the accident, in addition to the incident flight that began at 17:00 LT, lasted 35 minutes and included four take-offs and landings, the aircraft made two other flights: one at 15:45 LT, which lasted for 40’ and involved two take-offs and landings, and another at 12:45 LT, which also lasted for 40’ and involved two take-offs and landings. No incidents were reported during either of these two flights.

The flight before those on the day of the incident took place on 27/02/2020 and lasted for 50’. The aircraft was, therefore, inactive for approximately 3.5 months. There is no evidence of the engine having been preserved according to Lycoming service letter no. L180B of 13/11/2001. However, the operator has informed us that the engine was occasionally run on the ground.

The last three maintenance overhauls performed on the aircraft prior to the incident were as follows:

- The 50 and 100 flight hour overhauls (as per the manufacturer’s SM-753-586, dated 31/01/2008) were carried out jointly on 26/09/2019. During these overhauls, in addition to the scheduled tasks, the following work was also carried out:
    - assembly of the engine, propeller and governor after their overhauls,
    - replacement of both magnetos, the alternator, the starter motor, the vacuum and fuel pumps, and the injector with reconditioned parts,
    - replacement of the engine hoses,

  - calibration of the pitot-static system, transponder, encoder and compass,
  - an extinguisher was fitted,
  - the aircraft's weight and balance was checked,
  - directives were complied with, and ground tests were performed with satisfactory results.

  The maintenance organisation certified the aircraft on 26/09/2019, authorising it to return to service.

- Review of special points dated 10/01/2020 when the aircraft had a TSN of: 8836:30 hours of flight and the engine's TSO was: 00:20 hours:
  - Application of special points 500.1, 500.12, 500.13, 2000.7, 2000.8, 3M.1, 3M.2, 3M.3, 4M according to SM 753-586 rev. PR191130 dated 30/11/2019. Satisfactory ground test.
- Review of special points dated 20/05/2020 when the aircraft had a TSN of: 8843:55 hours of flight and the engine's TSO was: 07:45 hours:
  - Application of special points 3M.1, 3M.2, 3M.3, 4M, 6M according to SM 753-586 rev. PR191130 dated 30/11/2019. Satisfactory ground test.

### 1.6.3. Airworthiness status

The aircraft with s/n: 28R-7435019 and registration EC-HLV was registered on 03/07/2000 with entry number 4840, according to AESA's record of active registrations. The last registration certificate, issued on 15/02/2019 and valid until 02/07/2020, states the aircraft's regular base as Cuatro Vientos Airport (Madrid), where the lessor is named as AEROFAN, the training school operating the aircraft at the time of the accident.

The aircraft had an airworthiness certificate No. 4673 as a "Normal Category Aircraft", issued by AESA on 14/03/2013, and an airworthiness review certificate issued when the aircraft had 8836 flight hours by an approved CAMO organisation, dated 06/11/2019 and valid until 05/11/2020.

The aircraft also had the following available authorisations:

- Aircraft station license issued by AESA including various pieces of equipment, among them two communications and navigation units, and transponder.

The last confirmed weight and balance report was dated 10/10/2006.

The aircraft had a valid insurance policy in force until 14/11/2020.

## 1.7. Meteorological information

### 1.7.1. General situation

At medium and high levels, there was a northerly component flow over the Peninsula and Balearic Islands, associated with a powerful and extensive anticyclone at all levels over the Atlantic. At low levels, there were low relative pressures, and daytime warming favoured storm development.

### 1.7.2. Conditions in the area of the accident

There is no AEMET station at Casarrubios del Monte (Toledo). The nearest stations are located at the Cuatro Vientos-LEVS and Getafe-LEGT Air Bases (about 27 km to the northeast and east-northeast, respectively). The aerodrome reports (METAR) from these bases were as follows:

METAR LEVS 091600Z 32008KT 270V020 CAVOK 24/03 Q1017
METAR LEVS 091630Z 29005KT CAVOK 24/02 Q1017
METAR LEVS 091700Z 34007KT 260V050 CAVOK 24/01 Q1017
METAR LEGT 091600Z 32010G21KT CAVOK 24/02 Q1017
METAR LEGT 091700Z 32009KT 280V360 CAVOK 24/02 Q1016

The aerodrome forecasts (TAF) applicable at the time were:

TAF LEVS 091400Z 0915/0924 30008KT CAVOK
TAF LEGT 091400Z 0915/0924 29007KT CAVOK

The remote sensing images showed medium cloudiness with bases above 5000 ft and no convective activity or reduced visibility.

According to this information, the most significant phenomenon was the wind, which was weak in Cuatro Vientos but at Getafe, which is more exposed to northerly winds, it occasionally exceeded 20 kt. Casarrubios del Monte's configuration is more similar to that of Cuatro Vientos, where the winds ranged between 5 and 8 kt.

The last METAR consulted by the crew was:

LEVS 091300Z 31006KT 240V020 9999 FEW058 22/03 Q1018.
*(Decoding: Cuatro Vientos Airport, conditions described by the METAR for day 9 at 13:00 h UTC were wind NW 310° and 6 kt, variation of wind direction between 240° and 20°, visibility more than 10 km, light cloud cover with a 5,800 ft base, temperature 22 °C, dew point 3 °C and QNH 1,018 hPa.)*

Therefore, no adverse meteorological conditions affected the flight.

## 1.8. Aids to navigation

The flight was operated under visual flight rules (VFR), and the aircraft was equipped with approved navigation aids.

### 1.9. Communications

The aircraft was equipped with certified communications devices and a transponder. There is no evidence that any of the equipment was inoperative at the time of the accident.

The crew declared the in-flight communications interruption when the engine failure occurred as an interruption in the power supply. Subsequent inspections showed that the equipment was operational and functioning correctly.

Cuatro Vientos Airport confirmed they had not registered any reported accidents on the day of the incident.

### 1.10. Aerodrome information

The aircraft made an emergency landing on runway 26 at the Casarrubios del Monte Aerodrome in the province of Toledo, which has ICAO callsign LEMT and whose geographical coordinates are: 40° 14´ 06” N; 04° 01´ 35” O.

The Casarrubios del Monte Aerodrome is a privately owned restricted aerodrome. It has an asphalt runway with a 08/26 orientation measuring 950 x 26 m at an elevation of 625 m. Air-to-air communications are made on the 123,500 MHz frequency.

The threshold of runway 08 is displaced 400 m.

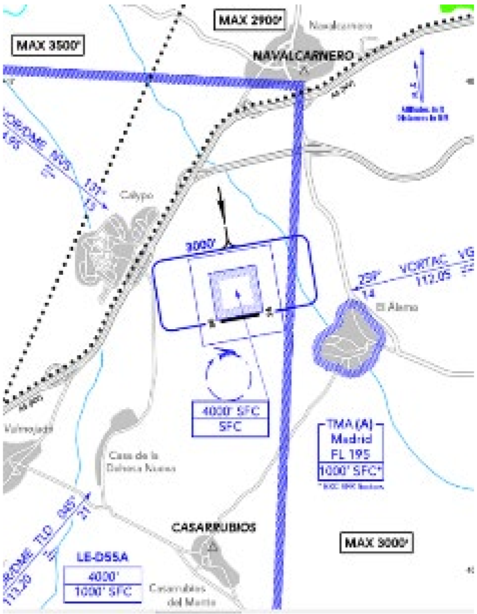



Figure 3. Approach Chart

Photograph 5. Casarrubios del Monte Aerodrome

The traffic pattern for general aviation and ultralights is to the north of the airfield at 2800 ft. The entrance point is 4 Nm to the southeast of Navalcarnero. There is another pattern for gyroplanes to the south of the airfield.

The aerodrome is surrounded by a track road approximately 10 m below the runway level, which gives rise to a significant drop off at the end extension of runway 26.

### 1.11. Flight recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, as the aeronautical regulations in force do not require any recorders on such aircraft.

### 1.12.Wreckage and impact information

The aircraft suffered significant damage as a result of making an emergency landing without extending the gear. A backhoe was used to lift the aircraft while the landing gear was extended and unfolded without issue. The main and nose landing gear legs were then locked into position to support the weight of the aircraft.


Photograph 6. Removal of the aircraft involved in the incident


Photograph 7. Incident aircraft supported on its landing gear

Photograph 8. Underside of the right flap

The aircraft was transferred to a hangar in the aerodrome for inspection. The flaps were retracted, and the compensator was in the forward position.

The following damage was observed:

- Right wing: flap undeployed, underside damaged with missing material and scratches. The remaining surfaces, wingtip and aileron, were undamaged. The fuel tank on the right wing was three-quarters full.

- Left wing: flap undeployed, scratches and missing material on the tip and the underside of its surface along one-third of its extension from the wing attachment point. The fuel tank on the left wing was half full.


Left Photograph 9. Starboard - Right Photograph 10. Position of the right flap at the accident site

- Main landing gear: both legs and their tyres were in good condition, there were no scuff marks on the doors despite having landed gear-up, but the cockpit access step on the right side of the fuselage was severely damaged.
- Nose landing gear: The gear doors were scuffed, but no scuff marks were found on the leg or tyre.

Photograph 11. Damage to the left flap

Photograph 12. Nose landing gear door

- Tail empennage: the tie-down ring under the tail displayed scuff marks to its underside.

Photograph 13. Damaged tie-down ring

- Propeller: both blades were bent backwards.
- Cabin: The fuel selector was positioned for the right-hand fuel tank. The inspection confirmed that all the navigation, landing and anti-collision lights were working correctly, and the stall warning device was operational. The landing gear lever was in the “down” position.
- The anemometer read zero, as did the variometer.
- The altimeter was set to 1017 mbar marking an elevation of 1950 ft.

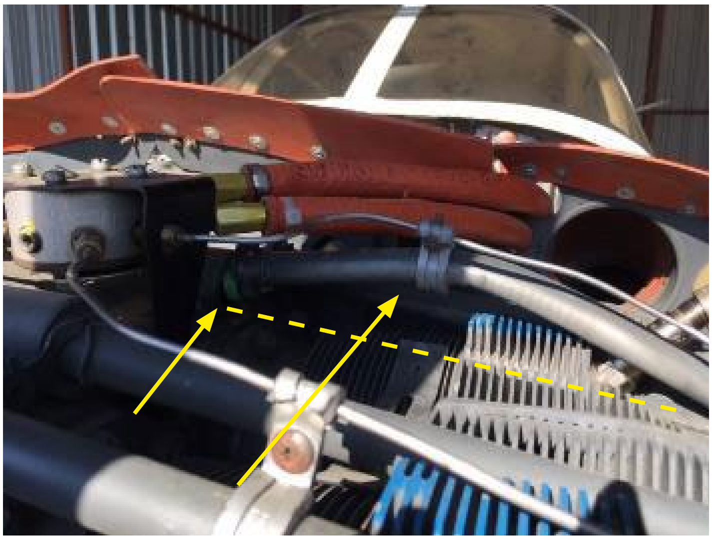
Photograph 14. Damaged propeller

- Both the communications systems were connected, and it was confirmed they were working correctly. The first system was programmed to the Casarrubios Aerodrome frequency of 123.500 MHz. Its standby frequency was set at 131.97 MHz. The second system was programmed to the Cuatro Vientos tower frequency of 118.700 MHz, with the Cuatro Vientos taxiing frequency of 121.800 MHz set on standby. Device 1 was selected in the audio control box.

- When the master was switched on, the three green landing gear indicator lights and the amber light for the automatic landing gear extension system came on. After landing, it was confirmed that the automatic landing gear extension system was overridden, with the selector between the seats in the UP "OVERRIDE" position. After the incident, the system was activated to deploy the landing gear and remove the aircraft from the runway.

Photograph 15. Automatic landing gear extension system, flap and compensator

- The alternator was correctly fitted with its belt well tensioned and the correct electrical connections. The battery had enough power to perform the necessary operational checks, even though several days had elapsed after the accident. The electrical system appeared to be in good condition.



Photograph 16. Intake-valve guide tube damage

On opening the engine cowling, the guide tube for the actuator of one of the intake valves was found deformed and bent upwards, and it had almost worked its way out of its socket. However, there was no evidence of oil spillage in the area. A detailed inspection of the engine was subsequently carried out, disassembling its components to identify any internal damage.

## 1.13. Medical and pathological information

N/A.

## 1.14. Fire

N/A.

## 1.15. Survival aspects

Both instructors had their seat belts fastened during the emergency landing, and they worked effectively.

The cabin maintained its structure after the accident. The crew was unharmed and able to exit the aircraft without assistance.

## 1.16.Tests and research

### 1.16.1. Interviews with the crew

#### 1.16.1.1. Information provided by the PF

According to the testimony of the instructor, who was acting as PF at the time of the incident before the emergency management, he had carried out three retraining flights that day with other instructors, following several months without flying due to the Covid-19 lockdown.

He made his first flight in a Cessna 152 and the second in a Cessna 172, with a total flight time of approximately two hours between them.

The accident occurred during his third flight that day. The other instructor-pilot carried out the preflight inspection of the aircraft, checking the fuel and oil, performing all the manufacturer's checklists with satisfactory results for the flight to proceed. The flight was to be an hour long.

The flight began without incident and they practised several take-off and landing manoeuvres at LECU. As PF, he carried out the first landing, the other pilot carried out the second, and he again performed the third landing.

They left the traffic pattern at point W, where they changed the fuel selector to the right tank. They headed west for maneuvering practice, and the aircraft was operating as expected at all times.

In the vicinity of Aldea del Fresno (about 40 km southwest of LECU), he informed the PIC that he would throttle back to see how the aircraft glided. On doing so, before he reached idle, the engine began to run erratically. He immediately increased power, and the engine returned to normal operation.

Arriving in Navalcarnero (about 25 km southwest of LECU), with an altitude of about 3000 ft, 22 inches of power trim intake pressure and 2400 RPM, the engine started to make unusual noises. They decided to land as soon as possible, but the fields in the area were covered with tall grass, and the LEMT airfield was close to their position, so the PIC indicated that he would inform them of the engine failure.

They began to lose altitude, so he pushed the throttle and propeller pitch lever to full forward.

As he approached LEMT, he saw that all the aircraft in the traffic pattern were heading to the head of runway 08, so he prepared to turn towards it as well. He saw the PIC gesturing to him but could not hear him because neither the intercom nor the radio were working due to intermittent power cuts.

At one point, the communications began working again. The PIC said "aircraft mine", and from that moment, the former PIC took charge of the communications.

The PF reported the engine failure on final approach to runway 26. Another aircraft on approach to runway 08 aborted its landing to make a go-around.

During the circuit, the engine supplied power but did not sound right, and they were unable to maintain altitude.

According to his statement, the aircraft was "floating" over the runway when they heard a noise. It then slid along the runway, stopping after travelling a short distance. They secured the aircraft and exited without assistance.

From the time the engine began to malfunction until the moment they landed, between eight to ten minutes elapsed.

He said he couldn't recall seeing the PIC lowering the landing gear lever because he was concentrating on communications and the other traffic. According to his testimony, he did not hear any warning to indicate that the landing gear was either not extended or not locked. He did not recall carrying out a final approach check to see whether the three green gear-down and locked lights were illuminated. Neither could he recall checking the engine parameters during its in-flight failure.

When asked if the crew had conducted the pre-flight briefing[2], he said they had but without determining what role each member would fulfil in the event of a real emergency.

#### 1.16.1.2. Information provided by the PIC

According to the testimony of the instructor who was acting as PIC at the time of the event, the incident flight was the third flight he had made that day. They were carrying out retraining for the school's instructors after several months without flying due to the Covid-19 lockdown.

[2] Briefing: preflight meeting between the crew to prepare for the flight.

He made his first flight at around 10 in the morning in the same aircraft that subsequently suffered the accident. On the first flight, he performed the preflight check and drained the fuel tanks. There was nothing of note to report from either the preflight check or the flight, which lasted about an hour and involved practising landings and take-offs at LECU.

The aircraft's second flight that day was carried out by another crew. According to his statement, the third flight took place after lunch. It was a retraining flight to validate another instructor who was to start teaching on the Piper PA-28R-200. They had flown together four or five times before. They carried out the preflight check and found everything in order.

They performed three landings and take-offs without incident. They left the traffic pattern at point W, changed the fuel selector to the right tank, and headed west.

When they reached Valmojado (about 38 km southwest of LECU), they decided to simulate an engine failure. According to his statement, when throttling back to idle the engine started to produce loud, intermittent and increasingly frequent explosive sounds, so they decided to return to LECU. They gradually increased power in the cruise configuration, and everything seemed to be going well. The engine parameters were adequate, and the engine sounded normal again.

When they were 3000 ft above Navalcarnero (about 25 km southwest of LECU), without them touching any of the controls and with the engine readings within normal parameters, the engine again started to make irregular noises similar to before, but this time with intense vibrations as well. The aircraft was trimmed at 22 inches of intake pressure and 2400 RPM. It lost power and was unable to maintain flight level. The PF reacted by pushing the controls to achieve maximum possible power (throttle and propeller levers full forward in take-off power). The aircraft stopped losing altitude, but the vibrations continued, and the engine still sounded terrible, so they decided to head to LEMT (about 12 km south of Navalcarnero) due to its proximity to their position.

The PIC announced on the air-to-air frequency that they had an engine failure and were heading to LEMT. Again, they found they were unable to maintain level flight despite having the power at maximum. He changed the communications frequency to LEMT, but instead of 123.5, he entered 122.5 by mistake. He tried to communicate and received no response. According to his statement, he thought he had forgotten the frequency and started looking for the frequency on the card. He corrected the frequency, but then the aircraft's electricity supply failed.

The PF started to turn right into the downwind leg for runway 08, but, according to the PIC, from the position they were in, it was easier to go straight to the base of runway 26, so he tried to communicate this to the PF. Unfortunately, the PF couldn't understand him because the intercom wasn't working, and, therefore, he tried to take the controls. The PF, realising his intention, began to turn to the base of runway 26.

Just at that moment, the electricity returned. He told the PIC they were better off going straight to final and took control of the aircraft. The PF communicated their intention to land immediately due to engine failure to LEMT by radio, and responded to the traffic on short final for runway 08. Once again, they lost communications, and the PIC saw the traffic in front of them make a "go-around". He already had the plane configured with flaps at 2 points. On short final, he went on to deploy the third point and lower the landing gear, but they were unable to verify if it had descended or not due to the electrical failure. The aircraft was vibrating a lot.

According to his testimony, he was intent on landing as soon as possible, and although he noticed the plane was floating too much, he didn't recall checking to see if the three green gear-down and locked lights were illuminated or hearing the stall or insecure landing gear warning sound after pulling the throttle back to idle. Their speed was about 85 kts. He was concerned about the possibility of an engine fire, so when the aircraft made contact with the runway, he cut the mixture (they had kept the mixture rich throughout the flight), throttle and master switch, and by the time they realised what had happened they had already landed on the underside of the aircraft fuselage with the landing gear undeployed.

In a subsequent interview, the PIC 'confirmed that during the preflight briefing, they had not agreed which pilot would fly the plane and which would manage the emergency and handle the radio in case of engine failure. He confirmed that they did not do anything to the engine after it started vibrating, nor did they touch the automatic landing gear extension system during the flight.

### 1.16.2. Related reports/communications

Not applicable.

### 1.16.3. Tests/Inspections

#### 1.16.3.1.Engine inspection

The owner moved the aircraft from the accident site to a hangar at Casarrubios del Monte Aerodrome, where it was inspected. The aircraft was supported on its landing gear which extended and locked into position correctly once the aircraft had been lifted and the landing gear selector switch had been activated.

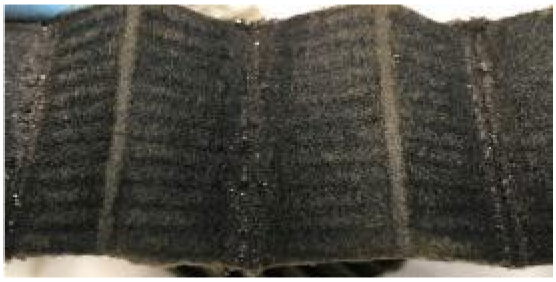
The actions carried out during the inspection, and its eventual findings, were as follows:

In a first visual inspection of the aircraft's engine, the maintenance appeared to be generally acceptable.

The cowlings, air inlets, intake tubes, air filters, exhaust pipes, heater, alternator cables, starter motor and magnetos appeared to be in good condition. The engine was clean and there was no sign of any oil or fuel leaks.

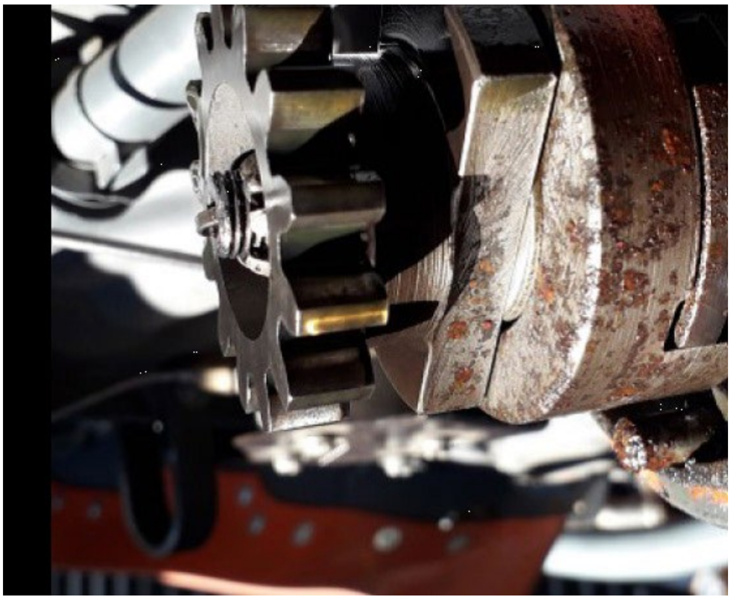
The operation and movement of the engine, throttle, mixture and propeller controls were checked and found to be in order.

- Lubricating oil system: The oil level was above 6 US quarts. It was drained for subsequent analysis. It was almost black in colour, which is unusual after nine hours of operation. The oil filters were disassembled, revealing a large quantity of metallic and non-metallic particles inside.



Photograph 17. Presence of particles in the interior of the oil filters

- Fuel system: The electric fuel pump was put into operation to check the condition of the different components: the tanks, pipes, filter, electric and mechanical pumps, fuel control unit, distributor and injectors. All were well secured and not leaking.
- Cylinders: cylinder compression was checked and found to be correct in all cylinders. The interior of the combustion chambers showed no evidence of lead or carbon deposits. No defects were found in the cylinders. The piston heads were clean, and the bolts were sliding adequately in their housings.



Photograph 18. Presence of corrosion in the left magneto

- Ignition system: all its components (magnetos, ignition ramps, terminals and spark plugs) were in their correct position.

The spark advance was timed at 19º tdca on the left and 25º tdca on the right. However, the engine plate indicates that it should be 25º tdca.

The "impulse coupling" spark in the left magneto was checked and found to be marginally energetic. There was no coupling in the right magneto, which is normal in this type of engine.

On checking the opening of the magneto contacts ("contact points") they were found to be 0.006" on the left and 0.016" on the right. The AMM specifies 0.016".

Photograph 19. Left and right magnetos

Both magnetos were disassembled. On closer inspection, it was revealed that the left magneto was unable to rotate freely due to the presence of severe corrosion around the flange, "impulse coupling", and the shaft-bearing, making it difficult to move by hand.

The spark plugs installed in the upper part of the cylinders were manufactured by TEMPEST (thermal degree 40), and those in the lower positions were manufactured by CHAMPION (thermal degree 38). Both the magnetos were working with two different types of spark plugs (different heat ranges and internal resistances).

The magnetos' ignition ramps were dismantled and found to be fastened with ineffective self-locking nuts. The insulation was correct and displayed no mechanical damage.


Photograph 20. Cylinder no. 4 intake valve guide

- In cylinder no. 4, the inspection found that the protective tube and pushrod of the intake valve were bent upwards about 10 cm above their normal position in the central area of the tube, and it had disconnected from its socket on the side of the oil sump, releasing the oil seal. Therefore, the decision was taken to remove cylinder 4.

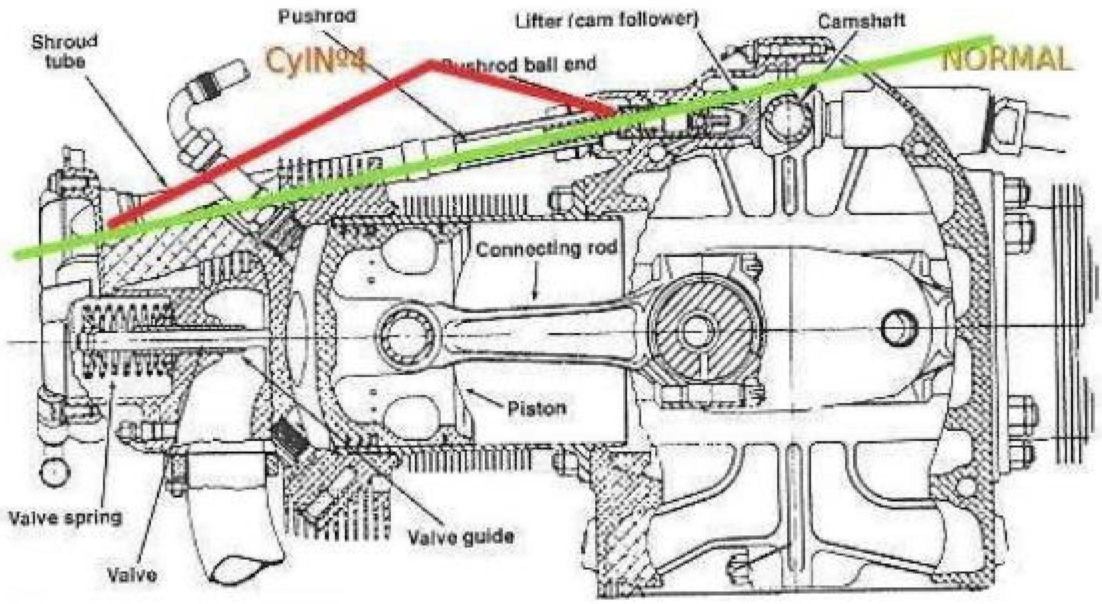



Figure 4. Diagram showing the deformation of the intake valve guide with respect to its normal position

There were no oil leaks in the engine, so the investigators checked cylinder no. 4 for a possible failure in the hydraulic tappet's lubrication pattern. The cylinder was disassembled, exposing damage to the ball-end of the exhaust valve's pushrod.

Although the intake valve was moving and not stuck in its guide, it did not come out. Additional force had to be applied to remove it, dragging a solidified, greyish material out of the guide.

There was no corrosion on the rod or the guide.

The exhaust valve had adequate movement and came out of its guide without difficulty, although there was evidence of surface corrosion and deposits on the rod and guide.

Photograph 21. Cylinder no. 4 inlet - inner rod and guide

Photograph 22. End of the pushrod

Photograph 23. Cylinder no. 4 intake valve

Photograph 24. Cylinder no. 4 exhaust valve

- The camshaft, rocker arms, axles and axle brackets were removed, revealing no appreciable damage.
- The engine was then disassembled according to the overhaul manual, with the following observations being made.

Photograph 25. Presence of oxidation in the valve rod

- In cylinders no 1, 2 and 3, the valves were moving correctly and the rods were straight, but there was evidence of deposits and superficial oxidation.

Photograph 26. Particles in the oil in the sump

- On disassembling the oil sump and accessory case, the oil was found to be predominantly black in colour, and contained a large number of particles of different materials. A large quantity of sludge had also accumulated in the bottom and corners of the sump.
- The holes through which the oil passes from the accessory case to the semi-sump had traces of silicone

Photograph 27. Oil in the oil sump

inside. The inspectors noticed that, on several surfaces, white silicone or sealant had been used to seal the joints, when in ge neral, it's only used on surfaces without joints.

Furthermore, sealant and silk thread had been used in some places. While this is correct practice if done well, it is currently in disuse due to difficulties in using it correctly; extreme care must be taken with both its placement and subsequent cleaning. In fact, the engine manufacturer advises against it and suggests the use of alternative sealants.

Photograph 28. Holes in the accessory case

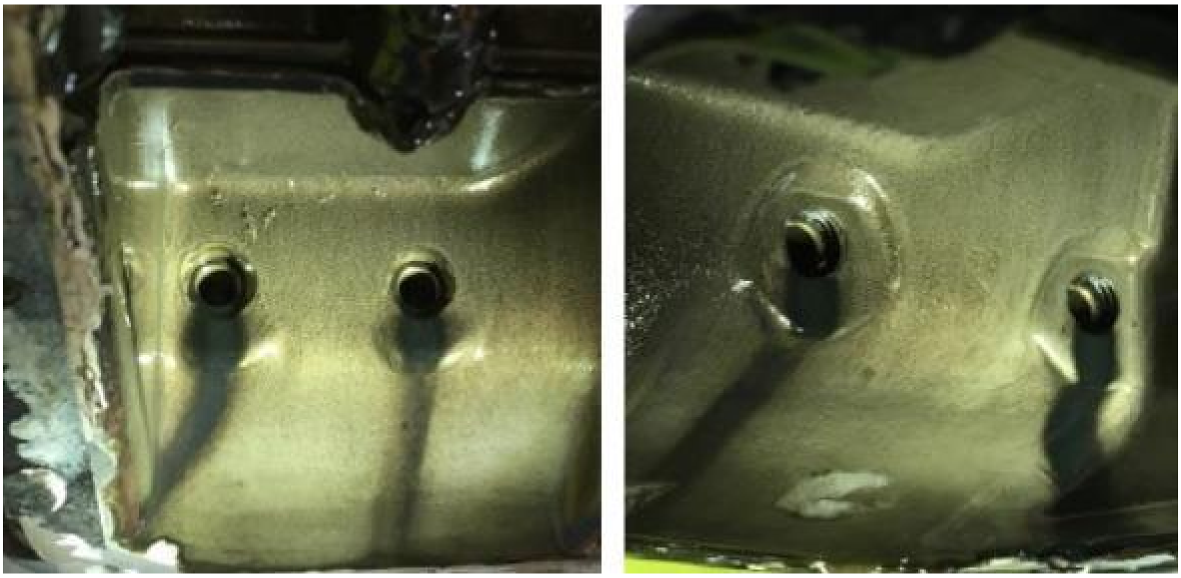
Photograph 29. Sealant on the surfaces of the sump

Photograph 30. Sludge and dirt in the sump

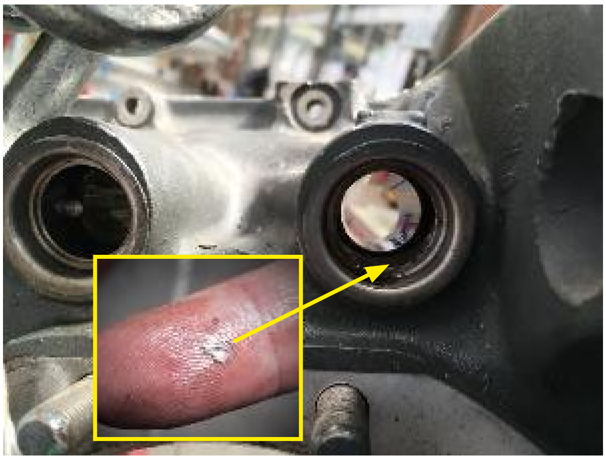
Photograph 31. Oil valve

- The seal and various sealants on the oil pressure regulating valve had deteriorated.
- The oil pump, which was in good condition, was also removed.
- The hydraulic tappets were removed with no significant observations.

The oil returning from the cylinders to the sump had a charred appearance.

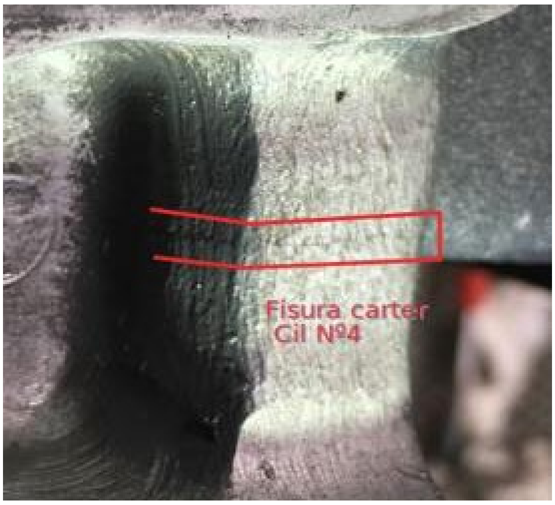


Photograph 32. Oil returning to the sump



Photograph 33. Piece of silicone found in cam follower housing of cylinder 4

- Chunks of white silicone came out of the lubricating oil conduits in the cam follower housings of cylinder no. 4, as did other contaminating particles that were blocking the holes and dislodged when air was blown through them.
- Excess white silicone used as a sealant was observed in the joints of the semi-sumps.




Photograph 35. Crack in cylinder no.4's oil sump

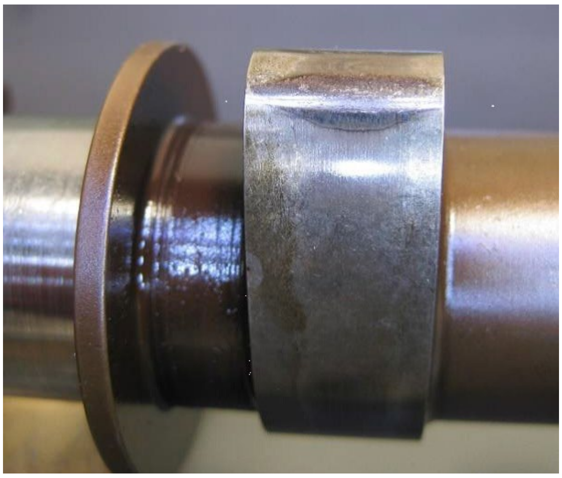
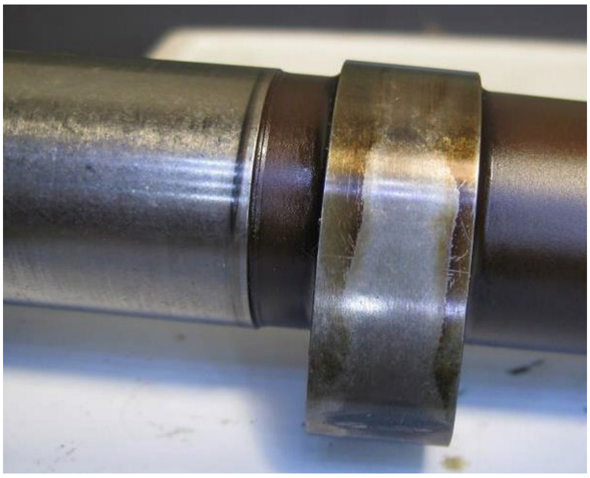
Photograph 34. Silicone in the joint of the semi-sump

- A crack was also found in the oil sump in the lower part of cylinder no. 4.

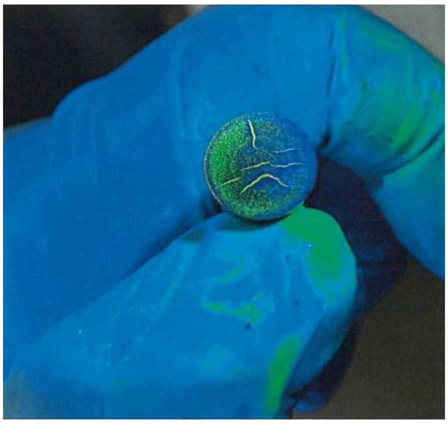
- The front and rear main bearing bushings were oversized, given that the crankshaft was marked "M010", indicating that it had been rectified removing 10-thousandths of an inch in diameter.

  Radial play was detected between the connecting rods and the crankpins, and the bushings were of standard size, not oversized for a 10-thousandth of an inch-rectified crankshaft.

- The crankshaft gear was removed, exposing screw damage which may indicate it wasn't replaced during the last overhaul.

Photograph 36. Cam wear and tear



Photograph 37. Defects found on the piston with p/n 61544 following NDT

- The camshaft showed wear on the camshaft tips, rendering it unfit for service.
- Of the eight distribution pushrods and their eight tubes, three of the tubes had a different p/n to the number specified in the engine manufacturer's IPC for that model.
- The owner requested a pre-engine repair report from an EASA Part 145 approved facility. Following an NDT inspection, the report confirmed that the fuel pump piston p/n: 61544 was not in an acceptable condition.

### 1.16.3.2. Analysis of the engine's lubricating oil

After the engine inspection revealed the poor condition of the lubricating oil, samples were taken to determine its operational condition and identify the possible source of the numerous metallic and non-metallic particles found in the oil filters and sump. A specialist body carried out the analysis and reported the following results:

1. Analysis of the engine's lubricating oil: The lubricating oil used should be W 100 Shell Aeroshell Oil. The IR spectrum differed from the indicated reference. The appearance of the oil was dark, very cloudy and contained a large number of particles.

   The analysis found the oil's siliceous content was significantly high (47%), possibly due to the presence of dirt and dust in the lubrication system, contamination from another type of oil and anti-foaming additives.

   The viscosity was slightly high, possibly caused by the presence of oxidation, contamination from other types of oil, varnishes, sludge, carbon deposits, water contamination, and excessive usage of the oil.

   The body that carried out the analysis classifies the results as either "normal condition, to be monitored or dangerous". In this case, the classification assigned was "dangerous".

2. Analysis of the particles via SEM-EDS[3] (Scanning Electron Microscope-Energy Dispersive Spectroscopy): the sample consisted of numerous particles of different sizes, colours, and morphologies, which had come from the sump oil and been deposited on the various cavities in the semi-sumps. The particles found included large, white, soft and flexible particles and others with a polymeric/organic appearance in different colours: grey-brown, black, dark grey, white, orange and green. The sample also included some type of fibre or yarn, a black-stained felt paper, and large, shiny, metallic-looking particles.


Photograph 38. Particle sample

The results showed that the white, green, orange, dark grey and black coloured particles and the thread or fibre particles were primarily polymeric/organic particles (whose main element was C, with titanium particles, probably from some type of colourant, also present in some cases). The black particles, some of which were porous, were particles of burned organic material, while the white elastic particles were identified as some type of silicone.

The most abundant particles were grey-brown in colour and composed mainly of lead, bromine and aluminium, in that order. Three types of shiny metallic particles were identified: the most abundant large particles were unalloyed iron particles. Large particles of aluminium and smaller copper particles were also found.

[3] SEM-EDS analysis: analysis carried out with the help of a scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS) X-ray emission spectrometry, which identifies all chemical elements with an atomic number greater than 4. This technique only provides the semi-quantitative chemical composition.

The result was classified as "to be monitored".

3. Analysis of the particles in the lubricating oil filter: the sample analysed showed evidence of wear that may have been caused by insufficient lubrication, the presence of abrasive particles, corrosion or other causes. As a result, the analysis revealed an elevated content of particles linked to slippage and material fatigue. A small number of non-magnetic particles were also found.

The result was classified as "to be monitored".

### 1.17. Organisational and management information

The operator of the incident aircraft was the pilot training school "CENTRO DE FORMACION AERONAUTICO AEROFAN, S.A.". The school was an Approved Training Organization (ATO) with a certificate issued by AESA on 09/09/2019 and valid for the delivery of ATPL (A), CPL (A), PPL (A) pilot training courses for single and multi-engine aircraft, CR (A), CRI (A), and some type ratings. The school used *Operations Manual* (OM) ed.0 rev.14 dated 11/12/2019 and *Training Manual* ed.2 rev.5 dated 09/09/2019.

The crew piloting the incident aircraft were part of the ATO's team of authorised instructors.

According to its OM, the school can carry out the following types of flights:

1. Recognised courses: flights for any recognised AESA Course.

2. Training/ hourly rental: flights that use the school's aircraft but are neither part of an approved AESA course nor a test flight.

3. Test flights: flights following the required overhauls, document modifications, breakdowns, etc.

In addition, to keep the flight instructors' skills up to date, the ATO schedules refresher courses when deemed necessary. In these flights, single-pilot aircraft can be operated by two instructor pilots.

The instructors involved in the incident said the accident occurred during a retraining flight to brush up on skills following more than three months of inactivity for both instructors and aircraft due to the Covid-19 lockdown. Therefore, it cannot really be classed as a refresher course for the instructors, nor as a test flight, since the aircraft had not just come out of a maintenance overhaul.

According to that same manual, the functions for which the school's aircraft can be used are as follows:

a) basic aircraft: can be used for the basic training of private pilots, student pilots on integrated courses, the in-flight training phase of instructor courses and training flights.

b) advanced single-engine aircraft can be used for the in-flight training of students in the advanced stages of training, the IFR training phase, the in-flight training phase of instructor courses and training flights in general.

c) multi-engine aircraft can be used for training students in the class rating (ME) phase, in-flight teaching for the IFR rating and training flights in general.

Although not explicitly indicated in the OM, all the school's aircraft could be used to carry out training and refresher flights for the instructor team.

### 1.18. Additional information

Not applicable.

### 1.19. Useful or effective investigation techniques

Not applicable.

# 2. ANALYSIS

## 2.1. Analysis of the meteorological conditions

Our analysis of the data collected found the only relevant meteorological factor was the variability of the wind direction between 260° and 50°, with speeds of 7 kts.

Consequently, the meteorological conditions at the scene of the accident were non-limiting for the flight, and no unforeseen adverse conditions were found to have influenced the event.

## 2.2. Operational analysis

According to the crew statements, the aircraft was operating normally until they decided to practise an engine failure by throttling back (without reaching idle), at which point the engine began to run erratically. The PF immediately increased power, and they decided to return to LECU. Previous studies have found that in Lycoming engines with opposing cylinders, a sudden throttling back can induce a rapid cooling of the engine with consequences for its performance, such as erratic behaviour, backfiring and intense vibrations. These findings are consistent with the effects perceived by the pilots, as per their statements.

When they increased power in cruise configuration, they were at about 3000 ft, and the situation seemed to recover with normal engine parameters. However, after a while, the engine started to make abnormal sounds again and, this time, the vibrations were stronger, there was a power outage, and they were unable to maintain level flight.

The PF pushed the throttle and propeller levers to maximum, and the aircraft stopped losing altitude, but the engine still sounded odd and continued to vibrate. The circumstances would have allowed them to try other configurations and checks in order to recover the engine; they had enough altitude and the engine had not stopped supplying power at any time. The decision was made to land as soon as possible, communicating their intention to make an emergency landing due to engine failure.

According to the crew, the power outage meant that both the radio communications to transmit the emergency and the intercom communications between the pilots in the cabin were inadequate. They had originally intended to return to LECU. However, after again experiencing difficulties in maintaining level flight despite having the power at maximum, they decided to land as soon as possible at the closest aerodrome to their position (LEMT). We find this decision to be appropriate and it was adopted calmly and efficiently. The PIC changed the frequency to LEMT to communicate their intentions, but they experienced further power outages that made communications challenging.

As he approached LEMT, the PF saw that all the aircraft in the traffic pattern were heading to the head of runway 08, so he turned towards it as well. He saw the PIC gesturing to him but could not hear him because neither the intercom nor the radio were working due to the intermittent power cuts.

The PF started to turn right into the downwind leg for runway 08, which is actually the stipulated procedure for landing without power. However, given their position, the PIC thought it would be easier to go straight to the base of runway 26. He tried to communicate this to the PF. Unfortunately, the PF was unable to understand him because the intercom was out of service, and, therefore, he tried to take the controls. On realising his intentions, the PF began to turn towards the base for runway 26, at which point they recovered communications. The PIC stated, "Aircraft mine", and assumed control of the landing. This lack of coordination in the cockpit was influenced by the lack of effective technical communications due to the electrical failure that made communication between the two pilots difficult and to the crew's failure to predefine their functions in the event of an emergency, which should have been part of the preflight briefing.

On short final, the PF contacted LEMT by radio to notify them of their intention to land immediately on runway 26 due to engine failure and responded to the traffic on short final for runway 08, which had to perform a "go-around". He could not recall the PIC lowering the landing gear lever because he was focused on communications and the other traffic. Nor did he remember hearing any stall or landing gear warning, and he did not check if the three green gear-down and locked lights were illuminated. Moreover, he did not recall having looked at the engine parameters during its failure, which leads us to conclude that his piloting was inadequate.

When the PIC took the controls, the aircraft was already configured with two flap points, so he deployed the third point and lowered the landing gear in short final. However, according to his testimony, the electrical failure meant he was unable to verify if the gear was down or not. The aircraft was vibrating violently and, according to his statement, he was focused on landing as soon as possible. Although he noticed the aircraft was floating "too much", he can't recall checking to see if the three green gear-down and locked lights were illuminated or hearing the stall or unsecured landing gear warning sound after pulling the throttle back to idle. The landing speed was about 85 kts and, therefore, adequate for the landing, but his main concern was the possibility of a fire in the engine (although there was no objective indication that this would happen). That said, securing the aircraft immediately after landing was an appropriate decision, and as soon as they made contact with the runway, he cut the mixture (they had kept the mixture rich throughout the flight), throttle and master switch. By the time they realised what had happened, they had already landed on the underside of the aircraft fuselage with the landing gear up.

The PIC confirmed that they did not attempt to do anything to the engine after the vibrations began, nor did they touch the automatic landing gear extension system during the flight. From the time the engine began to malfunction until the moment they landed, between eight to ten minutes elapsed; enough time to carry out the applicable emergency procedures. These should have been the procedures for "an in-flight power loss" and subsequently for a "landing without power".

According to their statements, they did not follow any of the steps from the "in-flight power loss" procedure, other than checking the engine parameters, which, according to the PIC, seemed normal; they neglected to connect the electric fuel pump and the alternative air, and they did not carry out a magneto test or try alternative power settings to see if power recovered.

In terms of the "landing without power" procedure, they decided to land as soon as possible and, given that the circumstances allowed for it, consulted the nearby aerodromes, identifying LEMT as the most suitable due to its proximity to their position. This was an appropriate decision. However, the procedure also specifically notes the conditions in which the automatic landing gear extension system operates (speed 105 KIAS and power at idle). If the system that was deactivated had been activated, as was found after landing, the gear-up landing would probably have been prevented. Having analysed the crew's statements, we believe they probably overlooked the existence of this device because of the chaotic and tense atmosphere in the cabin, which, while initially controlled, was later affected by the communication issues and continuous loss of altitude.

It is likely the crew's lack of experience in this type of aircraft also contributed to them not realising the automatic landing gear extension system was on override. A separate issue, but also most likely the result of tension in an emergency situation, was the fact that the crew appeared unaware that the engine had a five-minute take-off power limitation according to the manufacturer's recommendation. This limitation was exceeded and probably contributed to the engine failure.

Given the information outlined above, we conclude that the actions of the crew during the emergency landing, with the improvised change of PF and PIC functions, taking over the controls alternately, a lack of effective communications and scant experience or knowledge of the aircraft and its devices, contributed to the aircraft landing with its gear up and confirms a failure to adhere to operating procedures.

### 2.3. Analysis of the aircraft's maintenance

The inspection of the aircraft and the engine, in particular, found that the power loss identified by the crew was caused by the failure of cylinder no. 4, which was inoperative because its intake valve pushrod and protective sleeve had bent upwards and separated from its connection.

According to the crew, the engine initially began to malfunction when they simulated an engine failure, rapidly reducing power but not quite reaching the idle position.

It should be noted that the engine continued to supply power at all times during the incident, although the amount of power gradually decreased, causing the engine to run erratically and vibrate violently when maximum power was applied, which is consistent with the fact that only one of its cylinders had failed.

The engine's condition was not consistent with that of one that had only accrued nine hours of flight since its last overhaul.

Of particular note is the condition of the two magnetos, which had been reconditioned and installed at the same time as the engine. At first glance, they appeared to be in good condition. However, on disassembling them, the inspectors found the left magneto had deteriorated to such an extent it had become inoperative. The insulation of both magnetos' ignition ramps was in an acceptable condition with no mechanical damage, but they were secured with self-locking nuts that had become ineffective, suggesting careless and insufficient maintenance.

Both magnetos were incorrectly timed according to the engine plate' specifications, the contacts on the left magneto were too closed, the "impulse coupling" was barely performing its function, and severe corrosion around the flange area and shaft-bearing hindered its movement, which could have rendered it non-operational during the flight. While the left magneto was probably inoperative, we do not believe it caused the power loss reported by the pilots. The engine would have functioned normally with the right-hand magneto alone, which was in good condition despite being a more conventional model (no impulse coupling). Nonetheless, what has become apparent when considering all of the above is the poor standard of maintenance applied to the aircraft.

The spark plugs installed in the upper part of the cylinders were a different brand to those used in the lower positions and had different heat ranges and internal resistances, which is not recommended for the correct functioning of the magnetos.

The lubricating oil drained from the engine displayed neither the density nor the colour of oil that had only been in use for nine hours since it was last changed. On disassembling the engine and oil filters, inspectors found several different types of contaminating particles and sludge in the bottom of the oil sump, suggesting the engine was poorly cleaned during the last general overhaul, or even, perhaps, that it wasn't cleaned at all.

The oil returning from the cylinders to the sump had a charred appearance, which suggests the areas which should have been cooled and lubricated had overheated, probably due to obstructions caused by an accumulation of contaminants in the ducts and narrow passages of the lubrication pattern. If the obstruction were to progress from partial to total, it would only take a few seconds for the components in these areas (cylinders, rocker arms, valves etc.) to fail. Furthermore, the increased temperature in these areas could degrade the oil, causing it to gradually lose its ability to lubricate and cool properly.

Given that the oil only had a few hours of use, its level of degradation and contamination suggests that the lubrication problem had probably existed from the beginning. It is likely the engine was neither cleaned during the overhaul nor adequately preserved during the aircraft's period of inactivity, and that the presence of corrosion and contaminants in the engine further compounded the poor condition of the oil.

The presence of metallic particles in the oil filters is consistent with the wear and tear on the head of the valve cams and should have been spotted during the engine overhaul.

The deformed protective tube of the intake valve pushrod in cylinder no. 4 was caused by insufficient lubrication and an accumulation of contaminating deposits in the tube-rod space.

In particular note is the fact that the lubrication hole in the valve housing was blocked by a large silicone particle, preventing oil flow. This explains why there were no oil spills even though the protective tube had disconnected from the side of the oil sump and the oil seal was loose. The failure caused a noticeable power loss consistent with the pilots' statements, but no pressure loss or leakage of lubricating oil.

The valve itself was not inoperative; it was moving. However, the inspectors struggled to remove it from the protective tube because of the solidified greyish material inside.

Furthermore, according to the engine manufacturer, in engines that have recently been overhauled or have few operating hours (as was the case in this incident), the protective tube and pushrod can also become deformed if the tube-rod tolerance is incorrectly adjusted or misaligned. The damage to the part meant we were unable to confirm whether faulty adjustment or alignment was a factor in its malfunction. However, given the overall evidence of lax maintenance, we cannot rule it out. What the investigation can confirm is a lack of lubrication and an accumulation of contaminants in the tube-rod space.

On opening the engine cowling, the maintenance at first appeared to be adequate with everything correctly fitted and no spillages, but a more detailed inspection of the disassembled engine parts revealed this to be deceptive.

Large amounts of silicone were identified in the joint between the semi-sumps and the lid of the accessory case, with the excess silicone having not been removed. In addition, the following observations all led us to the conclusion that the engine's maintenance had been sloppy and insufficient: the dirtiness of the components, the presence of corrosion, the sludge at the bottom of the oil sump, the crack in the oil sump in the lower rectified part of cylinder n°4, the abundance of contaminating particles (some of them extremely large) throughout the entire lubrication pattern, and the dark colour of the interior of the semi-sumps, which is characteristic of prolonged contact with used oil and did not appear to have been cleaned recently.

Other findings to have come out of the investigation, such as the fact the main bearing bushings were M10 oversized while the connecting rod bushings were standard size and therefore unsuitable for the rectified crankshaft, or that, three of the eight protective tubes for the valve pushrods had a different p/n from the one indicated in the IPC, point to a poor standard of engine maintenance, which could have compromised the operational safety of the aircraft. The inspection even revealed practices that are now redundant, such as using silk thread sealants on the joints. The manufacturer no longer recommends this particular procedure due to the meticulous and careful execution required for its correct application, a trait not evidenced in this particular case.

### 2.4. Analysis of the aircraft wreckage

During the general inspection of the aircraft, the damage identified was consistent with an emergency gear-up landing.

The flaps were scuffed on their outside edges and undersides, indicating that they were deployed during the landing as per the pilots' statements.

The main gear doors were not scuffed despite the aircraft having landed on the underside of the fuselage. This is possibly because the aircraft rested on the cockpit access step on the right side of the fuselage, which, given the extent of wear it incurred, was the side that supported the aircraft as it slid along the runway. The fact that no damage was identified on the left underside of the fuselage could be because the aircraft was level when it landed and remained so until it came to a complete stop. This would explain the damage to the nose gear hatch, which was scratched, and the aircraft's 'tie-down' anchor point on the tail, which was also marked underneath. These support points kept the aircraft slightly elevated until the nose dropped at the last moment.

The propeller blade tips were bent backwards, suggesting the engine had power at all times. This is consistent with the crew's statements and the findings of the investigation.

In relation to the intermittent power supply that affected the crew's internal and external communications, after checking the system, the investigation found that the alternator was well attached with the correct electrical connections and its belt adequately tensioned. Furthermore, even several days after the accident, the battery still had enough power to maintain communications. As a result, we have been unable to verify the loss of the electricity supply.

According to the crew, the power outage prevented them from checking if the landing gear was extended or not because they were unable to confirm if the green landing-gear down and locked lights were illuminated. However, the inspection found that the lights worked correctly when the landing gear was down and locked, as did the other visual and acoustic warnings. Similarly, the inspection found that both the emergency landing gear extension mechanism and the automatic landing gear extension device were operational. While everything worked correctly, the latter did not activate because it was in the OVERRIDE position. This fact seemed to go unnoticed by the crew, probably due to their lack of experience in that type of aircraft, given that the device is not common in other aircraft.

### 2.5. Analysis of the organisation and management

With regard to the operating training organisation, the performance of refresher or retraining flights for its instructor team was within its training scope.

The PIC's experience was between fifteen and twenty flight hours (he could not specify exactly) accrued during his training as a pilot approximately three years ago. The PM's experience was 3.2 flight hours.

Flight hours accrued in other Piper PA28 models cannot be taken into account because, unlike the retractable landing gear on the accident aircraft, the other models were all equipped with fixed landing gear.

Consequently, we believe the organisation should ensure that when an aircraft needs to be tested after a prolonged period of inactivity[4], as was the case in this event, the flight should be carried out by a crew with more experience in that aircraft type to reduce the potential for improper management during an emergency.

Similarly, considering the analysis of the crew's emergency management, the organisation should guarantee that all flights, even if both crew members are instructors, are correctly prepared for during the pertinent briefing. The briefing should include a definition of the functions of each of the crew members, the flight plan, alternative aerodromes and their traffic patterns, and at least a basic study of the area to be flown.

Regarding the management of the maintenance organisation responsible for the aircraft, the investigation findings lead us to believe that it was inadequate. The maintenance carried out on the incident aircraft, particularly its engine components, which had accrued just nine flight hours since its last overhaul sixteen months previously and had been inspected nineteen days before the accident when the engine had 07.45 flight hours, did not safeguard its performance. The times and dates of the inspections are not consistent with the poor condition of the engine and some of its components or with correct preservation procedures during periods of inactivity, if they were applied.

At the time of the event, the EASA Part 145 certified maintenance organisation was being monitored by the aeronautical authority, within the continuous supervision process through its Continuous Surveillance Plans. Given that the findings of the investigation into the maintenance carried out on the incident aircraft are not consistent with the documentary records provided by the organisation, we have concluded that the management of the organisation was deficient. As a consequence, we believe the maintenance tasks performed threatened the operational safety of the aircraft.

[4] In its Service Letter No. L180B dated 13/11/2001, the engine manufacturer recommends the engine should be preserved during prolonged periods of inactivity, considered to anything more than thirty days. Furthermore, in Service Instruction No. 1425A of 19/01/1988, it recommends the lubricating oil be replaced more often than during the scheduled overhauls (50 h) if the aircraft does not fly at least 25 h in four months. In this case, the recommendation establishes an oil change every 25 hours of flight. As a minimum.

## 3. CONCLUSIONS

### 3.1. Findings

- The crew had valid pilot and instructor licenses under the 05/05/2020 AESA Resolution to extend license validity periods due to the global COVID-19 crisis.
- The crew's medical certificates were valid and in force.
- The PIC had between fifteen and twenty hours of experience in the type of aircraft involved in the incident, accrued during his pilot training three years previously.
- The PM had 3.2 flight hours in the type of aircraft involved in the incident.
- The aircraft's last registration certificate was issued on 15/02/2019 and states the aircraft's regular base as Cuatro Vientos Airport (Madrid), with the lessor being the training school operating the aircraft at the time of the accident.
- The accident occurred during an instructor retraining flight following a three and a half-month period of inactivity for both the instructor personnel and the aircraft.
- A maintenance centre with a valid EASA Part-45 certificate maintained the aircraft.
- The aircraft had a valid airworthiness certificate.
- The maintenance organisation cleared the aircraft to return to service with a certificate dated 26/09/2019, after an overhaul of the engine, propeller, governor, magnetos, injector, starter motor, alternator, and fuel and vacuum pumps.
- The aircraft was built in 1974 and had 8845:15 hours of flight. The engine had accrued nine hours since its last overhaul.
- The last scheduled maintenance overhaul performed was a 50 and 100 flight hour service on 26/09/2019, and the last special points check prior to the incident flight was conducted on 20/05/2020, when the aircraft had a TSN of: 8843:55 hours of flight and the engine's TSO was: 07:45 hours.
- Cylinder no.4's intake valve pushrod and its protective tube were deformed and dislodged from their connection to the oil sump due to insufficient lubrication caused by a build-up of contaminants in the tube-rod space and the obstruction of the lubrication holes in the cam follower housings by silicone particles, rendering the cylinder inoperative as a result.
- The exhaust valve pushrod was also deformed but not blocked, with abundant accumulations of contaminants.
- The malfunction of cylinder no. 4 caused a loss of engine power in flight.
- The left side magneto is inoperative and severely corroded.
- A crack was found in the oil sump in the lower zone of cylinder no. 4.
- The crankshaft was M10 rectified, the main bearing bushings were M10 oversize, and the connecting rod bushings were standard size and, therefore, unsuitable for the crankshaft.

- Of the eight valve pushrod protective tubes, three had a different p/n to the number specified in the engine manufacturer's IPC for that model.
- On disassembling the engine, the inspection confirmed the presence of dirt in most components and a large quantity of sludge in the bottom of the oil sump.
- The camshaft showed wear on the camshaft tips, rendering it unfit for service.
- The analysis of the engine's lubricating oil revealed degradation and contamination with various types of particles. Its use was deemed dangerous for the engine's operation and at odds, therefore, with the nine recorded flight hours since it was last changed.
- An analysis of samples of the particles found in the engine's lubricating oil and oil filters identified contaminating particles of polymeric/organic and metallic origin. The oil filter contained metallic particles resulting from slippage and material fatigue, abrasives and corrosion.
- There were no limiting meteorological conditions for visual flight.
- The aircraft sustained damage to its flaps, lower fuselage and propeller, which is compatible with the type of damage typically produced during an emergency gear-up landing.
- The landing gear, including its cabin indication system, was working correctly at the time of the accident.
- The automatic landing gear extension system was overridden with the lever in the OVERRIDE position at the time of the accident.
- The crew were unharmed and exited the aircraft without assistance.

### 3.2. Causes/contributing factors

The investigation has found the accident was caused by a lack of adherence to operational procedures, which led to the aircraft landing with its landing gear retracted.

The following factors are thought to have contributed to the accident:

- the override of the automatic landing gear extension system, and
- the loss of engine power as a result of the failure of cylinder no. 4 due to improper engine maintenance and exceeding the manufacturer's recommended take-off power limit.

## 4. OPERATIONAL SAFETY RECOMMENDATIONS

REC 17/21: It is recommended that AESA should carry out an inspection of SINMA AVIACION, S.L., regarding its approval as Maintenance Organization ES.145.113, to ensure it still has the capacity to operate in compliance with the standards required by its approval.

REC 18/21: It is recommended that SINMA AVIACION, S.L. should draft an action plan to ensure its work complies with the EASA PART 145 approval granted by the authority.

REC 19/21: It is recommended that AEROFAN ATO should take the necessary steps to define and include its instructor retraining flights in its training programme and ensure that these flights are adequately prepared during the preflight crew meetings.