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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report A-002/2020

Accident involving a DIAMOND DA20-A1 aircraft, registration EC-JLN, in front of El Altillo beach on the island of Gran Canaria (Las Palmas de Gran Canaria), on 19 January 2020

GOBIERNO DE ESPAÑA

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

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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

° ' "	Degree(s), minute(s) and second(s)
ºC	Degree(s) Celsius
ºF	Degree(s) Fahrenheit
%	Percent
AD GCLP	Gran Canaria Airport
AESA	Spain's National Aviation Safety Agency
AGL	Above ground level
AMSL	Above mean sea level
ARC	Airworthiness review certificate
ATO	Approved training organisation
ATPL	Airline Transport Pilot License
CAVOK	Visibility, cloud and present weather better than prescribed values or conditions
cm	Centimetre(s)
CPL	Commercial Pilot License
CTR	Control zone
FL	Flight level
ft	Feet
GCLP APP	Gran Canaria airport approach control
h	Hour(s)
hp	Horsepower
hPa	Hectopascal(s)
kg	Kilogramme(s)
KIAS	Knots indicated airspeed
km	Kilometre(s)
km/h	Kilometres per hour
kt	Knot(s)
kW	Kilowatt(s)
L	Litre(s)
l/h	Litres per hour
LDG	Landing
m	Metre(s)
m^2	Square metre(s)
METAR	Aviation routine weather report (in aeronautical meteorological code)

min	Minute(s)
mph	Miles per hour
Nº	Number
PPL	Private Pilot License
psi	Pounds per square inch
rpm	Revolutions per minute
S	South
s/n	Serial number
SEP	Single Engine Rating
SLU	Limited single-member company
T/O	Take-off
TBO	Time between overhauls
TLB	Technical logbook
UTC	Coordinated universal time
V_A	Manoeuvring speed
V_{FE}	Maximum flap extended Speed
VFR	Visual Flight Rules
VLA	Very light aircraft
V_{NE}	Never exceed speed
V_{NO}	Maximum structural cruising speed
W	West

Synopsis

Owner:	Rosique Aicraft, S.L.
Operator:	Private
Aircraft:	DIAMOND A20-A1, registration EC-JLN
Date and time of incident:	Sunday, 19 January 2020: 09:23 h[1]
Site of accident:	In front of El Atillo beach (island of Gran Canaria)
Persons on board:	Two, one crew member and one passenger, unharmed
Type of flight:	General aviation - Private
Phase of flight:	On route
Flight rules:	VFR
Date of approval:	24 March 2021

Summary of incident

The aircraft was on route between El Berriel Aerodrome (Gran Canaria) and La Gomera Airport during a private flight intended to increase the pilot's flight experience. The flight plan also included a landing and take-off manoeuvre at Tenerife North Airport.

The aircraft was flying over the sea, a few miles north of the Gran Canaria coastline, when its engine failed. The crew contacted the control centre by radio and declared an emergency due to engine failure.

Shortly afterwards, the aircraft landed in front of El Altillo beach.

The two crew members were able to leave the aircraft and swam to shore, where they were assisted by passers-by who happened to be in the area.

It is considered believes the accident occurred due to insufficient lubrication of the connecting rod in cylinder no.1, which led to an in-flight engine failure and forced the crew to make an emergency landing on water.

The investigation has determined that the following factor contributed to the accident:

- The deficient oil-level verification procedure used by the ATO personnel operating the aircraft.

[1] All times used in this report are local time, which coincides with UTC

The following operational safety recommendations are issued:

REC.28/21. It is recommended that Canavia Lineas Aereas SLU review and, where appropriate, amend its operational procedures to ensure that all oil-level checks in aircraft equipped with Rotax 912 engines meet the standards of uniformity and reliability required to guarantee correct readings.

REC 29/21. It is recommended that the aircraft manufacturer, Diamond Aircraft, review the aircraft flight manual to ensure that the engine oil-level check procedure details all of the steps recommended by the manufacturer BRP-Rotax Gmbh. & Co KG.

1. FACTUAL INFORMATION

1.1. History of the flight

The aircraft took off from El Berriel Aerodrome on the southeast coast of the island of Gran Canaria (see figure 2) to carry out a flight under visual flight rules (VFR) to La Gomera Airport. The flight plan also included a landing and take-off manoeuvre at Tenerife North Airport and the subsequent return to El Berriel Aerodrome.

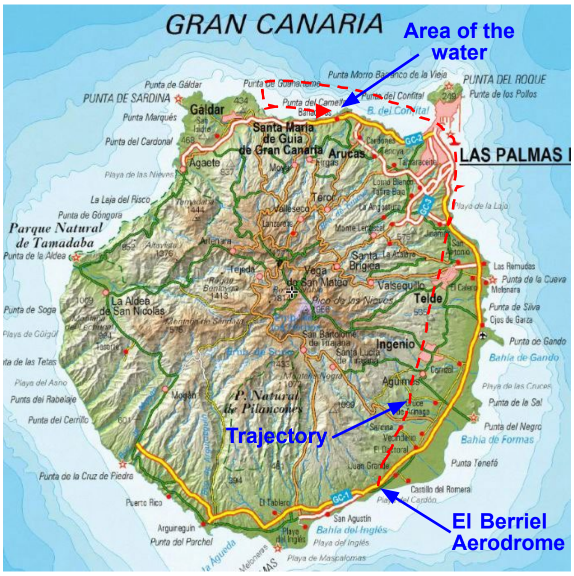


Figure 1. Map of Gran Canaria (left) showing the aircraft's trajectory, the position of El Berriel Aerodrome and the location of the landing. A photograph of the aircraft involved (right).

The two occupants on board both had private pilot licenses and were following a modular ATPL course at the school that operated the aircraft.

They had leased the aircraft to increase their flight hours and gain the experience necessary to obtain a commercial pilot license (CPL) and the theoretical part of the airline transport license (ATPL). They had agreed that one of them would act as pilot-in-command during the outbound flight, and the other would take on the role for the return flight.

After take-off, they headed north until reaching the coast and then turned west towards Tenerife.

At around 09:18 h, when the aircraft was at an altitude of 3100 ft and approaching Punta Guanarteme, the pilot called the control centre and declared an emergency due to low oil pressure and smoke in the cabin, expressing his intention to head to Gran Canaria Airport.

A short time later, he called again, this time reporting a complete engine failure and announcing his intention to attempt to land.

In the end, he was forced to make an emergency sea landing in front of El Altillo beach.

The two occupants were able to evacuate the aircraft and swam to shore, where they were assisted by passers-by who happened to be in the area.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				N/A
None	1	1	2	N/A
TOTAL	1	1	2	

1.3. Damage to the aircraft

The aircraft did not sustain any significant damage as a result of having to ditch in sea.

However, it was partially submerged, and the waves and currents pushed it towards the shoreline and caused it to crash into some rocks, damaging both of its wings.

Added to these localised breakages was the widespread damage caused by the corrosive effect of seawater on the aircraft's electronic equipment and metal parts, particularly those made from aluminium.

1.4. Other damage

No other damage sustained.

1.5. Personnel information

1.5.1. Pilot

The 25-year-old Spanish pilot had a private pilot license (PPL) for aircraft, issued by Spain's National Aviation Safety Agency (AESA) on 19 June 2019. He had a SEP rating (land) for single-engine piston aircraft valid until 30 April 2021. His level of linguistic competence in Spanish was 6.

His class 2 medical certificate was also valid until 12 September 2023.

According to the information provided, his total flight experience was 98 h, of which 6 h 30 min were in the type of aircraft involved in the incident.

1.6. Aircraft information

1.6.1. General information

The DIAMOND DA20-A1 aircraft is a single-engine, low-wing, single-pilot aircraft equipped with fixed, tricycle-type landing gear. It was manufactured in 1995 with serial number 10046.

Its general characteristics are as follows:

- Wingspan: 10.84 m
- Length: 7.17 m
- Height: 2.11 m
- Wing area: 11.60 m^2
- Empty weight: 522 kg
- Maximum take-off weight: 750 kg
- Fuel capacity: 76 L
- Engine ROTAX 912S3, s/n: 4924443
- Propeller: Two-blade, Hoffman, HO-V352F/170FQ
- Never exceed speed (V_{NE}): 161 KIAS
- Manoeuvring speed (V_A): 104 KIAS
- Maximum structural cruising speed (V_{NO}): 118 KIAS
- Maximum speed with flaps extended (V_{FE}): 81 KIAS

Engine limitations:

- Maximum take-off power (5 min.): 73.5 kW (100 hp)
- Maximum allowable thrust on take-off: 2385 rpm
- Maximum continuous power: 69 kW (93 hp)
- Maximum allowable continuous thrust: 2260 rpm
- Oil pressure:
  - Minimum 0.8 bar (12 psi)
  - Normal 2.0-5.0 bar (29-73 psi)
  - Maximum 7.0 bar (102 psi)
- Oil temperature:
  - Minimum: 50ºC (122ºF)
  - Maximum: 130ºC (266ºF)

1.6.2. Airworthiness and maintenance information

The aircraft had an Airworthiness Certificate issued by Spain's National Aviation Safety Agency on 14 February 2012, categorising the aircraft as a Very Light Aircraft (VLA).

Its airworthiness review certificate (ARC) was valid until 6/04/2020.

The organisation responsible for maintaining the aircraft was Rosique Aircraft, an AESA-approved maintenance organisation with reference ES.145.207 according to Annexe II (Part 145) of EU Regulation No.1321/2014.

On 15/03/2019, the airframe and engine underwent their 200 h inspection and the propeller underwent its 100 h inspection. The airframe had 5605 h and the engine 1812 h. The next scheduled overhaul was the 50 h overhaul due at 5650 h (airframe).

The most recent maintenance inspection carried out on the aircraft was a 50 h inspection completed on 15 October 2019. Both the oil and the filter are replaced every 50 hours; therefore, they had both been changed during this inspection. At that time, the airframe had 5649 hours and the engine 1856 hours.

The oil used was Aeroshell Oil Sport Plus 4.

The next overhaul due was the 100 h inspection which would have had to be carried out when the airframe accrued 5700 h or on 30/08/2020, whichever came first.

At the time of the accident, the airframe had accrued 5694 h and 40 min. The engine had been installed in March 2014 and had 1900 h and 20 minutes of operation. The next overhaul was due after an additional 5 h and 20 min of operation.

The time between general overhauls (TBO) for the engine fitted in the incident aircraft is 2000 h or 15 years, whichever comes first. Therefore, the engine was scheduled to undergo its next general overhaul after a further 126 h and 40 min or in March 2029.

1.6.3. The Rotax 912S engine lubrication system

The ROTAX 912S engine is fitted with a dry-sump forced lubrication system with an oil pump that has an integrated pressure regulator. The oil pump is driven by the camshaft.

Figure 2 contains a diagram of the lubrication system extracted from the maintenance manual (heavy maintenance) of the 912 and 914 series engines. The part located after the filter that lubricates the camshaft, crankshaft and connecting rod bearings has been highlighted to facilitate their visualisation.

As indicated in said manual and shown in the diagram, the oil pump sucks the oil from the oil tank (1) through the line (2), which channels it to the oil radiator (3). The oil leaves the radiator through the pipe (4) and reaches the oil pump (5), then exits towards the filter (7).

After passing through the filter, the oil is driven through the duct (11) inside the left semi-crankcase.

The first branch of this duct (11) lubricates the four hydraulic tappets of cylinders 2 and 4. From the tappets, the oil flows through the pushrods to lubricate the valve mechanism of these two cylinders, then returns to the crankcase through the return line.

The camshaft bearing (18) and the main crankshaft bearing (19) are lubricated by the next branch of the duct (11). From the latter, the oil flows through a duct inside the crankshaft to lubricate the connecting rod bearing (20) of cylinder 4 and the bronze bushing (21) of the IH01 support bearing in the ignition housing.

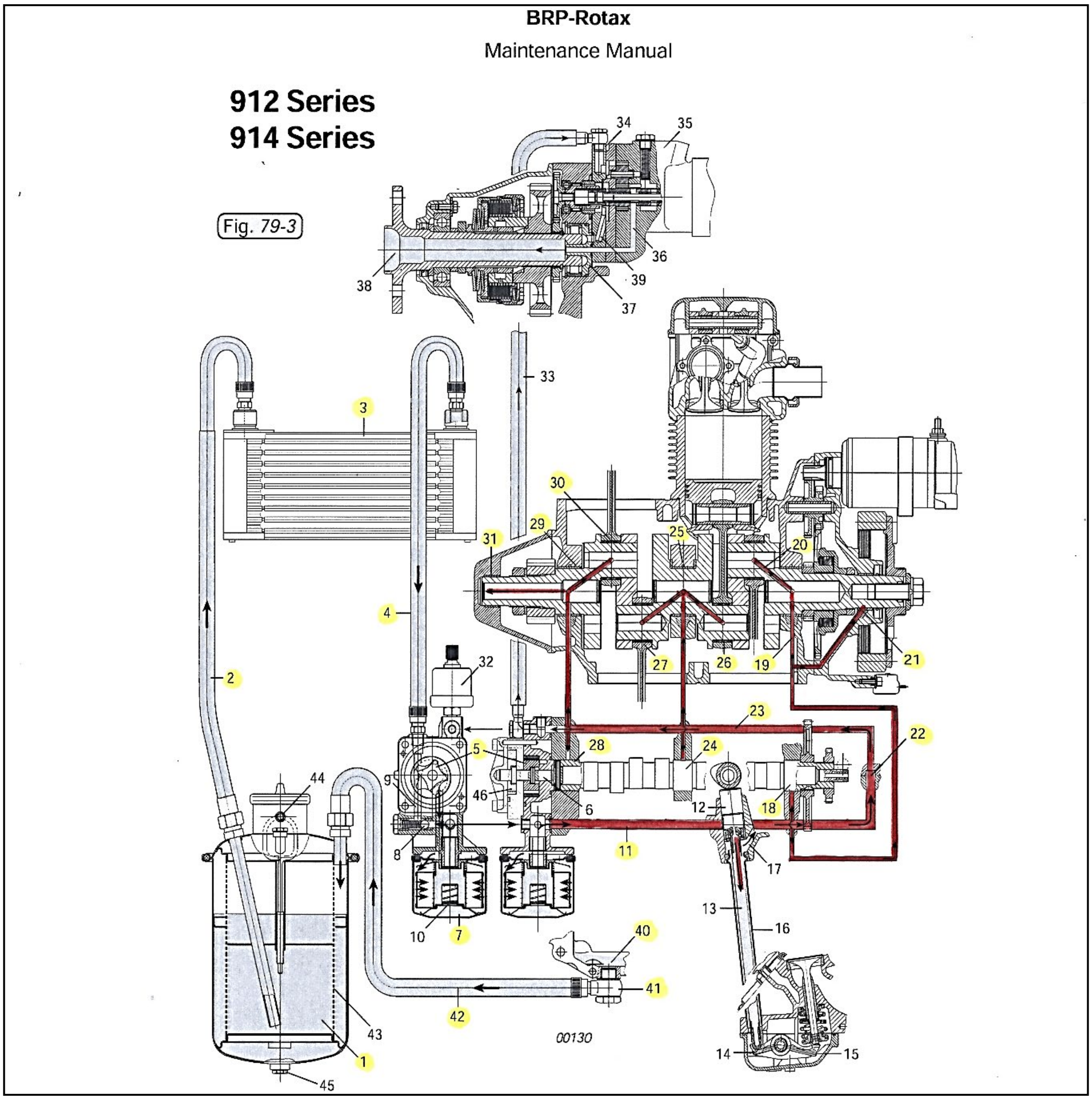


Figure 2. Diagram of the Rotax 912 and 914 series engine lubrication circuit

The oil flows from the duct (11) through the sealing surface of the semi-crankcases (22) and into the right semi-crankcase, then continues flowing through another duct (23). This duct is divided into three branches: one of them channels the oil to the camshaft bearing (24) and another channels it to the main crankshaft centre bearing (25). From there, the oil travels through two internal conduits in the crankshaft to the connecting rod bearings (26) and (27) of cylinders 2 and 3; the third branch continues towards the front of the engine.

This last duct branches off again at the front support of the crankshaft. One of these branches lubricates the camshaft bearing (28). Another channels the lubricant to the main crankshaft bearing (29). From there, the oil is pushed to the front to lubricate the bearing (31) and towards the crankpin to lubricate the connecting rod bearing in cylinder no.1 (30) through an internal duct in the crankshaft. The third branch of the duct (33) feeds the hydraulic governor.

The oil that emerges from all the lubrication points flows towards the lower part of the crankcase (40). The pressure generated in the crankcase by the exhaust gases pushes the oil out through the nozzle (41), and it returns it to the tank through the return pipe (42).

1.6.4. Aircraft Technical Log (TLB)

The technical flight log was reviewed from 17/10/2019 to the day of the event (21 sheets).

In that period, the aircraft made 45 flights with a total duration of 43 h and 40 min.

The oil level is noted on all the sheets, except for the one corresponding to 02/01/20, which is blank. In 15 of them, it's noted as "full", in 4 it's "¾", and in 1 it's "½". There were no notes to indicate that the oil level had been topped up.

Specifically, the notes show the following:

Date	Oil level
17/10/2019	¾
18/10/2019	¾
19/10/2019	¾
21/10/2019	full
23/10/2019	full
24/10/2019	full
25/10/2019	full
26/10/2019	¾
02/11/2019	full
03/11/2019	full
04/11/2019	full
04/11/2019	½

05/11/2019	full
05/11/2019	full
06/11/2019	full
07/11/2019	full
08/11/2019	full
01/12/2019	full
02/01/2020	nothing recorded
18/01/2020	full
19/01/2020	full

The last TLB sheet was completed by the pilot before commencing the flight of the accident.

There are no noted anomalies, breakdowns or indications that anything out of the ordinary occurred during that period.

1.6.5. Flight manual.

1.6.5.1 Pre-flight inspection

As specified in chapter 4 of the aircraft flight manual, which deals with standard procedures, checking the engine oil level is a crew responsibility and should be done during the pre-flight inspection. The following figure shows the instructions for checking the oil level provided in the flight manual.

7. Nose	
a) - Oil	check level by using dip-stick. min / max range is indicated by flat area of stick

1.6.5.2 Emergency procedures

Chapter 3 of the flight manual deals with emergency procedures. The procedures corresponding to the emergencies experienced during the incident are transcribed below.

<u>Procedure for low oil pressure</u>

1. Oil temperature	Check
2. If the oil pressure drops below green arc but the oil temperature is normal	Land at nearest airfield
3. If the oil pressure drops below green arc and the oil temperature is rising	Reduce throttle to minimum required power; land as soon as possible. Be prepared for engine failure and emergency landing

<u>Procedure for emergency landing approach with engine inoperative</u>

1.	Airspeed (flaps in T/O and LDG position)	57 kts / 66 mph / 106 km/h
	Airspeed (flaps UP)	65 kts / 75 mph / 120 km/h
2.	Fuel shut-off valve	Closed
3.	Ignition switch	Off
4.	Safety belts	Secured
5.	Radio	Transmit, giving location and intentions
6.	Master switch	Off

1.6.6. Weight and balance

The crew calculated the weight and balance as part of their flight preparation, according to the following data:

- Empty weight: 522.0 kg
- Occupants: 145.0 kg
- Luggage: 5.0 kg
- Fuel 53.2 kg

Total weight 725.2 kg

The take-off weight of 725.2 kg was below the maximum of 750 kg.

The aircraft's centre of gravity was 32.7 cm at take-off and 33.0 cm on landing, both of which are within the limits established by the manufacturer.

1.6.7. Rotax912S operating manual

The oil level check procedure outlined in the engine manufacturer's operating manual consists of the following steps:

- Remove the oil tank bayonet cap. Turn the propeller slowly by hand in the direction of the engine rotation, several times, to pump oil from the engine into the oil tank.
- It is essential to build up compression in the combustion chamber. Maintain the pressure for a few seconds to let the gas flow via the piston rings into the crankcase. The speed of rotation is not important but the pressure and the amount of gas which is transferred into the crankcase.
- This process is finished when air is returning back to the oil tank and can be noticed by a gurgle from the open oil tank.
- Check oil level and add oil if necessary.

The manual includes a note that says the oil level should always be in the upper half of the dipstick (between 50% and "max" mark) and never fall below the "min" mark.

The quantity of oil in the engine lubrication system can vary between about 2.5 litres (minimum level) and three litres (maximum level).

The manual indicates that the maximum oil consumption value is 0.06 l/h.

1.7. Meteorological information

The low-level hazardous weather map (see figure 3) did not show any significant meteorological phenomena. The sea temperature in the area where the aircraft landed was 19ºC and the wave height was one metre.

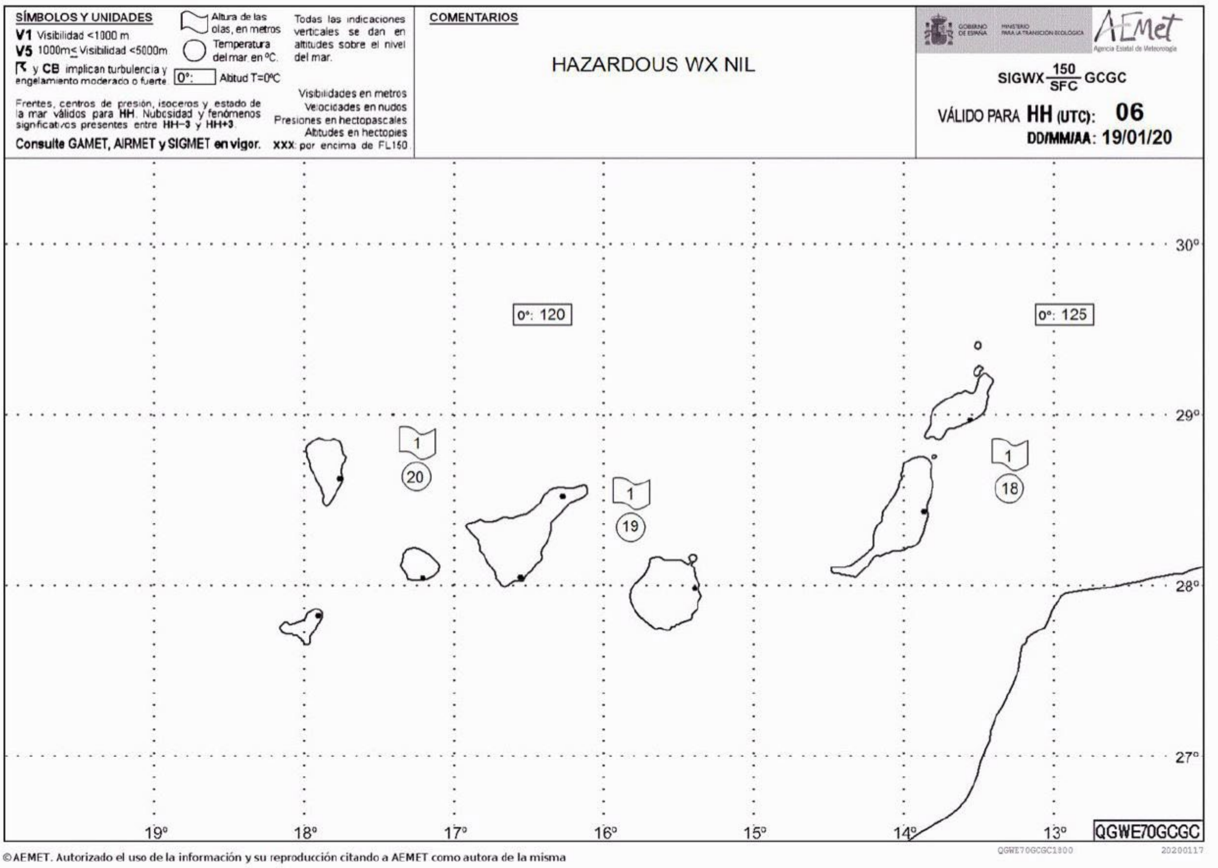


Figure 3. Low-level hazardous weather map

The 2000 ft wind and temperature map showed a northeast wind with a speed of about 10 kt in the area of Gran Canaria. The temperature was approximately 15ºC to 16ºC.

The forecasts for the Tenerife North and La Gomera airports, valid from 21:00 h on 18/01 to 21:00 h. on 19/01, were as follows:

La Gomera: wind direction 330° and 5 kt speed, CAVOK, maximum temperature 22°C at 15 h on the 19th, minimum temperature of 16°C at 06:00 h. on the 19th, evolution between 11:00 h and 13:00 h, wind direction 230° and 10 kt speed.

Tenerife North: wind direction 140° and 11 kt speed, visibility greater than 10 km, scant cloud cover at 800 ft, maximum temperature 18°C at 15:00 h, minimum temperature 11°C at 06:00h, 30% chance of thick cloud at 600 ft temporarily between 03:00 h and 09:00 h; evolution between 19:00 h and 21:00 h on 19/01, wind direction 320° and 9 kt speed; 40% chance of reduced visibility at 1,500 m temporarily between 19:00 h and 21:00 h due to fog banks, thick cloud cover at 100 ft.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The communications between the aircraft and Gran Canaria control centre have been made available to us, the most significant being the following:

At 8:49:23 h, the aircraft's crew called the GCCCIGC sector on departure from El Berriel Aerodrome, but the communication was cut off.

About a minute later, the aircraft called the GCCCIGC sector again. The communication was received, but the connection was poor. The controller replied that he had not received them clearly, that they should respond on 7064 and asked them to wait a moment.

The controller called them back shortly afterwards. The crew requested a direct flight path to point W in order to proceed to Tenerife North and perform a landing and take-off manoeuvre.

The controller informed them that there was no notified traffic and asked them what altitude they intended to fly at. The crew replied 3000 ft.

At 09:13:05, the aircraft called to report that they were above point N and climbing to 3000 ft.

At 09:17:53, the crew called GCCCIGC to inform them that they had low oil pressure and a strong burning smell, and were proceeding to turn towards Gando, if possible. In that same communication, they reported that smoke was entering the cabin and declared an emergency.

The controller confirmed he had copied their information and that they could proceed as they wished. They replied that they would try to reach the airfield.

Less than two minutes later, they called to say they had a complete engine failure.

At 09:22:35 h, the crew notified them that they would try to land in the sea next to La Playita.

That was the last radio communication the crew had with the control centre.

1.10. Aerodrome information

The visual approach chart LE_AD_2_GCLP_VAC_2 contains the specific operating procedures for El Berriel Aerodrome.

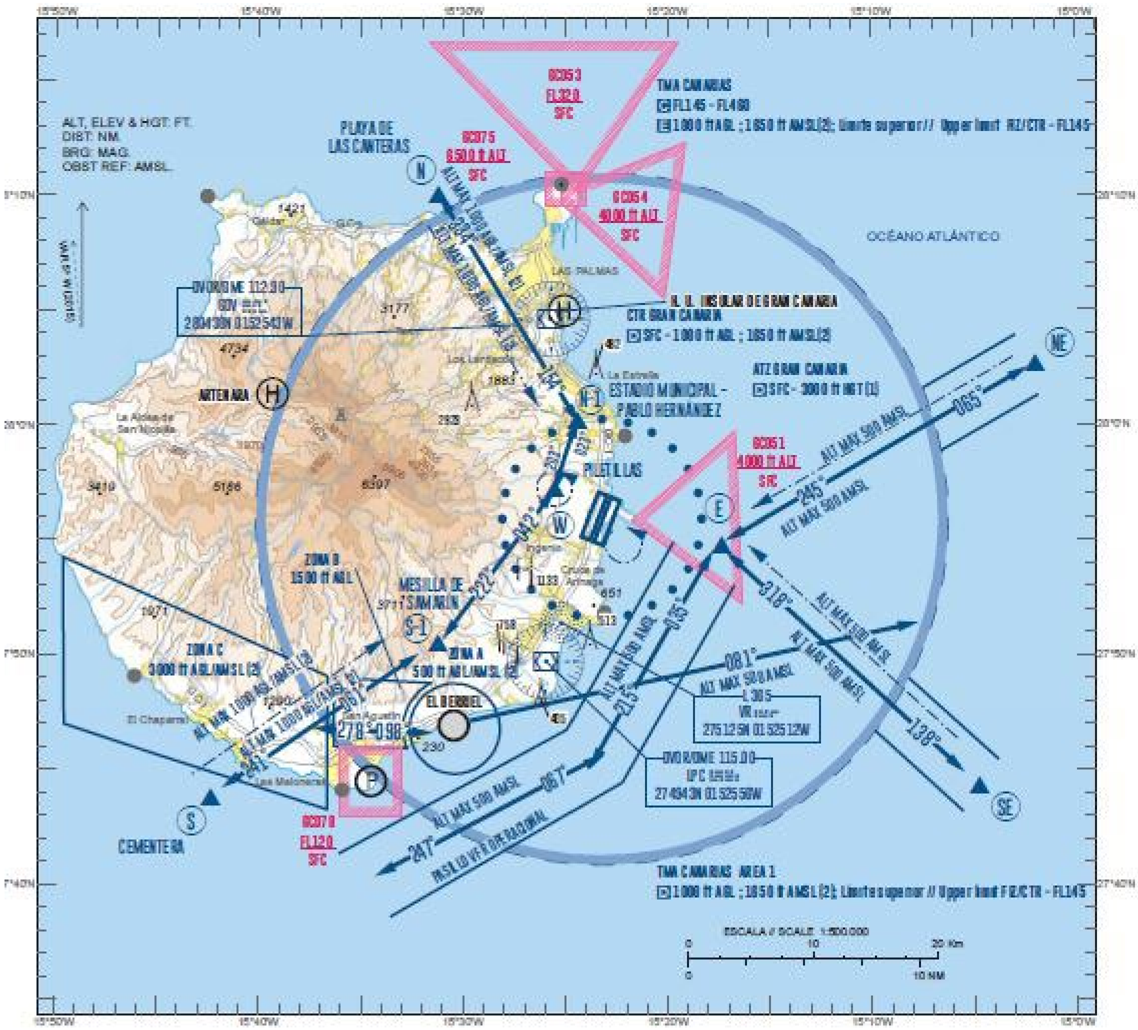


Figure 4. Extract of visual approach chart LE_AD_2_GCLP_VAC_2

Flights destined for one of the western islands have two departure alternatives, one over the west of Gran Canaria and another over the north.

VFR WEST: Aircraft carrying out local flights in zone "C" and the west of Gran Canaria, as well as flights to other western islands: After take-off, proceed on magnetic heading 278° to leave the CTR zone at point S (Cementera), then continue the flight in zone "C" or following the necessary heading towards the flight destination. Before leaving zone "C", pilots must request traffic information and permission from GCLP APP.

VFR NORTH: Aircraft carrying out local flights in the north of Gran Canaria, as well as flights destined for AD GCLP or other western islands via the north: After take-off, turn left to join the S-N route. Before leaving zones "A" or "B", pilots must request permission from Gran Canaria APP. Outside zones "A" and "B" altitude must be below 1000 ft AGL/AMSL (2). Pilots wishing to fly at higher altitudes must first request permission from Gran Canaria APP.

The flight involved in the incident was following the northerly VFR departure route.

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.

1.11.1. Radar trace

A radar trace was available for most of the flight.

At 08:53:00 h, the aircraft was located to the north of El Berriel Aerodrome, at an altitude of 800 ft and flying in a northerly direction.

About two minutes later, the aircraft made a slight turn NNE to head towards Gran Canaria Airport's point W. It flew over point W at an altitude of 1800 ft at 09:02:00 h. Soon afterwards, it began to descend. It reached the coast at Jinámar at 09:06:30 h, flying at 1000 ft.

It continued flying at 1000 ft parallel to the coastline in a northerly direction until it reached the La Luz port in Las Palmas at 09:10:30 h. It then turned west and crossed the La Isleta isthmus.

At approximately 09:11:30 h, it began to ascend. The aircraft flew westbound a few hundred metres out to sea.

When it reached Punta del Camello at 09:14:40 h, it was flying at 1800 ft.

Just as it was approaching Punta de Guanarteme at 09:18:00 h and 3100 ft, it initiated a left turn and headed south (towards the coast).

It then turned to the left to continue flying parallel to the coastline. During this part of the flight, the aircraft was descending gradually. At 09:20:00 h, it was flying at 2200 ft.

It continued to descend as it flew east. At 9:21:30 h and at an altitude of 1300 ft, it turned north.

It made a left-hand circle, during which it continued to lose altitude. The aircraft's speed[2] was between 70 and 60 kt. At 09:23:00 h and 200 ft, the aircraft began to fly parallel to the coast.

During the last part of the flight, the aircraft's speed was 50-60 kt.

The last recorded radar target was at 09:23:32 h.

1.12. Aircraft wreckage and impact information

The aircraft ended up partially submerged in the sea in front of El Altillo beach.

The waves and currents gradually shifted it towards land until it was just a few metres from the shoreline (see figure 5). As a result, the aircraft was recovered with a crane.

After being extracted from the sea, it was cleaned with fresh water to remove the salt. The tail assembly and wing were then dismantled to transport it by road to El Berriel Aerodrome.

Figure 5. Aerial photograph of the aircraft in the sea, close to the point where it landed

[2] The speed registered by the radar is ground speed.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Survival aspects

According to the two occupants of the aircraft, both were wearing self-inflating life jackets. This is standard practice at the school because almost all their flights are operated over the sea.

They also indicated that the pilot-in-command's vest automatically inflated before he left the aircraft but the passenger's vest failed to inflate both automatically and manually after he pulled the toggle.

This was confirmed by watching a video available on the internet, which shows the two crew members shortly after landing.

1.16. Tests and research

1.16.1. Aircraft inspection

The aircraft was inspected at El Berriel Aerodrome, where the aircraft were carried, with the inspection focusing mainly on the engine.

Firstly, the inspectors carried out a visual review of the exterior of the aircraft.

They found no evidence of any impact, breakage or damage on the aircraft's skin (see figure 6). Nor did they find traces of oil or any other fluid on the skin or the windshield.

All the cowlings were removed from the engine compartment. The engine and its systems appeared to be in a satisfactory condition.

Figure 6. Photographs of the front part of the aircraft

There were no traces of oil. The lubrication system was checked: tank, pipes, radiator, filter, etc., with everything appearing to be in satisfactory condition. There were no breakages or potential leakage points. The inspectors used the dipstick to check the oil level in the tank, noting that it didn't show any oil at all.

They attempted to rotate the propeller, but it was only possible to turn it around 30º.

The magnetic plug, which contained a considerable amount of metal filings, was removed.

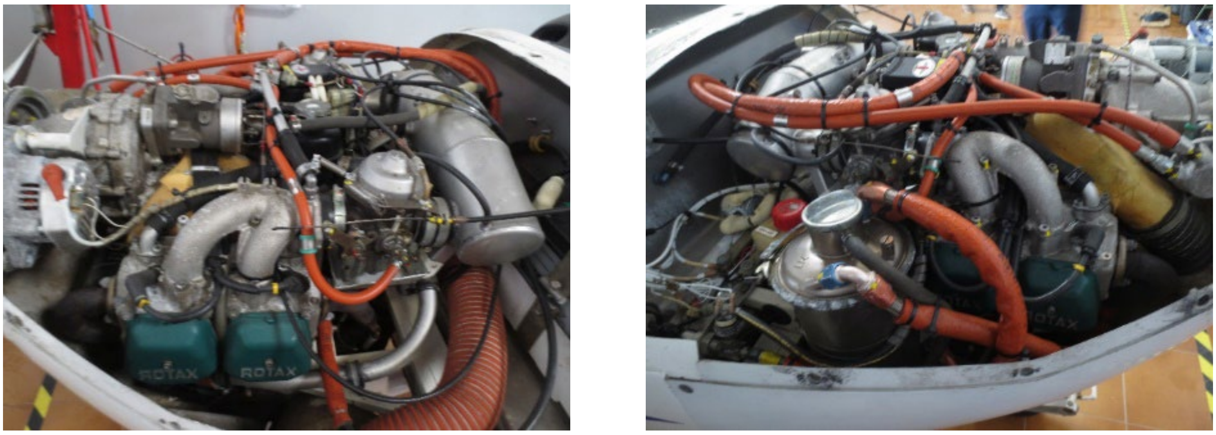


Figure 7. Photos of the engine compartment: left side (left photo) and right side (right photo)

The spark plugs were removed. All contained metallic particles mixed with salt. Other than that, they appeared to be in good condition.

The rocker covers of all four cylinders were removed, releasing a considerable amount of oily water. Nothing abnormal was observed in any of these mechanisms, which seemed to be well lubricated.

<u>Lubrication system</u>

- All the pipes were checked and found to be in satisfactory condition.
- The radiator was also checked and found to be in good condition with no leaks.
- Magnetic particles were found inside the oil filter.
- The oil tank was opened to drain the liquid inside (a mixture of oil and seawater). Once it had been allowed to settle and separate, the inspectors were able to confirm that it had contained approximately one litre of oil.
- The oil pump was disassembled and found to be in satisfactory condition.

<u>Cooling system</u>

The level of coolant was within operating ranges and looked normal.

There were no leaks, and all its main components: radiator, expansion tank, overflow bottle, water pump and pipes were in satisfactory condition.

<u>Gearbox</u>

The propeller and then the gearbox were removed. Its interior was in satisfactory condition and adequately lubricated. It was checked that it worked properly.

<u>Cylinders</u>

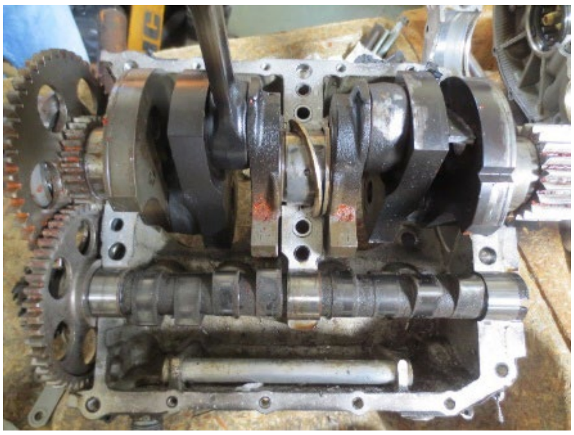
Both the heads and cylinders were in satisfactory condition, except for the presence of salt residue.

The piston of cylinder No. 2 was removed, allowing the inspectors to see inside the crankcase. They observed that the connecting rod of piston no. 1 was broken where it attaches to the crankshaft.

<u>Crankcas</u>e

All the pistons were disassembled to separate the two semi-crankcases and gain access to their interior.

Abundant salt deposits had been left by the seawater that had penetrated the engine.



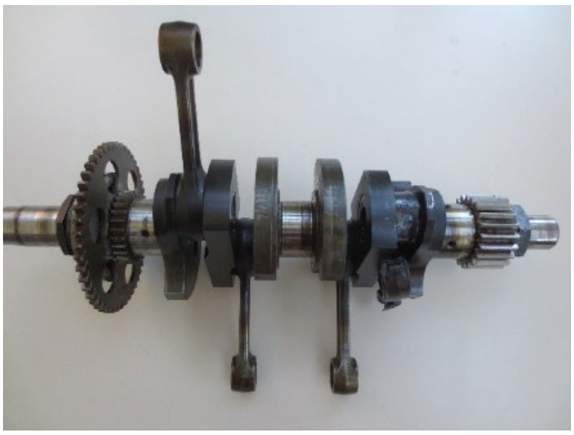


Figure 8. Photograph of the inside of the crankcase (left) and the crankshaft (right)

The crankshaft and camshaft appeared to be complete and correctly supported on their bearings (see figure 8 - left).

The condition of the camshaft was as expected for the engine's hours of operation. No signs of abnormal wear or insufficient lubrication were observed.

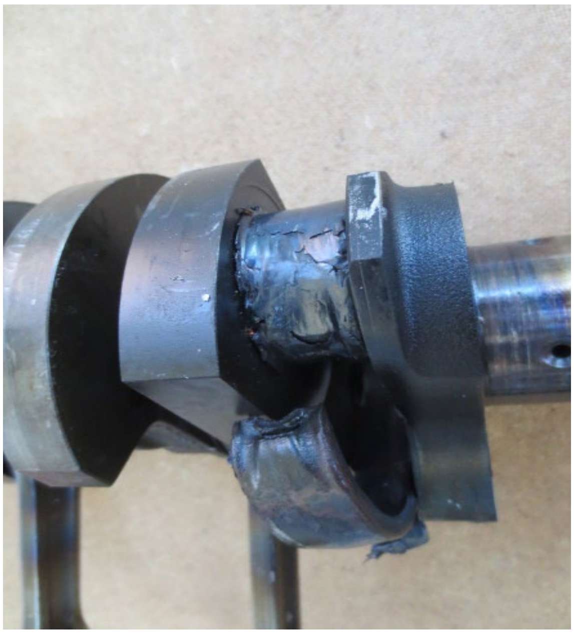


Figure 9. Photograph of cylinder no.1's crankpin, with one part of the connecting rod (left) and piston no.1 with the other part of the connecting rod (right

The connecting rod of piston no. 1 was in two pieces: one remained bolted to the piston, and the other was housed in the crankshaft's crankpin. It's useful to note that the connecting rods in this type of engine are made in one piece and mounted on the crankshaft during its assembly, which is compound by a series of components.

The connecting rod fragment that remained attached to the crankpin displayed evident signs of stretching and deformation. In fact, a part of this fragment had come out of the crankpin and ended up between the crankshaft and the crankcase, blocking the crankshaft.

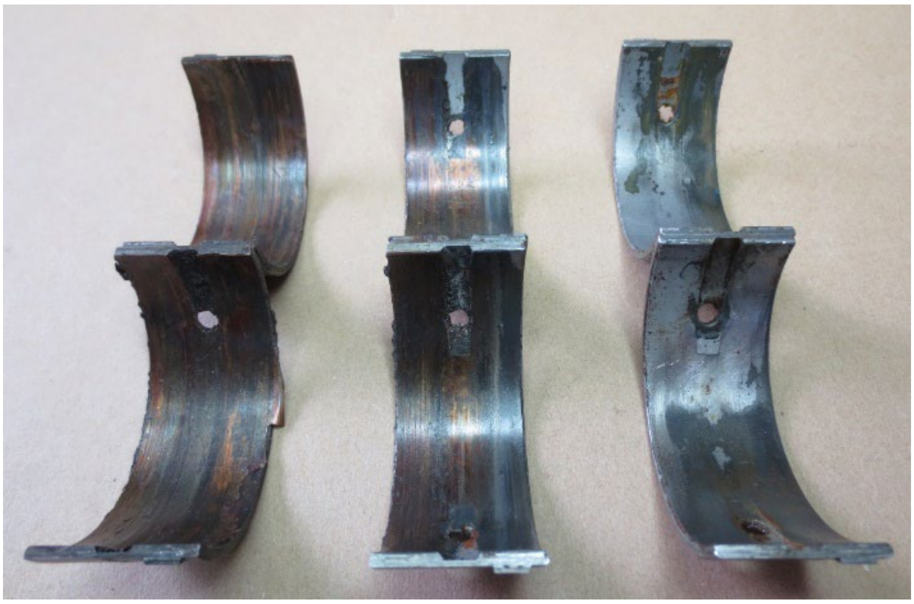


Figure 10. Photograph of the crankshaft bearings (left front support, central centre support and right rear support)

Evidence of molten material was also observed on the crankpin.

The other three connecting rods had no obvious damage and moved freely around their crankpins, although they did offer significant resistance when turned. No high-temperature colouration was observed on any of them. The findings suggest the onset of insufficient lubrication in the crankpins.

The front crankshaft support bearing showed signs of severe wear. Some of the material had melted and got into the lubrication holes, where it had solidified, blocking three of the four holes.

The centre support bearing also showed signs of heavy wear, but less so than the front bearing. Like the front bearing, some of the material had melted and seeped into one of the lubrication holes, solidifying inside.

The rear support bearing showed only minor friction damage. However, it had been noticeably corroded by the seawater. All four lubrication holes were completely clear.

A visual comparison of the bearings revealed a considerable colour difference between the front and centre bearings and the rear bearing.

None of the lubrication channels inside the crankshaft were obstructed.

1.16.2. Inspection of the life jacket

The pilot-in-command was wearing an Alpha 170 life jacket, which had been manufactured in 11/2016 and had a useful life of ten years.

The passenger was wearing an Imnasa 150N Auto life jacket, which requires maintenance every two years. The next inspection was due in May 2021. This was the life jacket that did not inflate.

Both the life jackets met the ISO 12402-3 standard (life jacket with performance level N150), according to EU Regulation 2016/425, on personal protective equipment.

The Imnasa jacket is equipped with an MK5 model inflater device manufactured by United Moulders LTD, which has two activation modes: automatic and manual.

It has an indicator for each activation mode, visually indicating that the device is either operational (green) or no longer functional due to having been triggered (red).

Before starting any flight, the crew have to check that both indicators are green.

After the event, the life jackets were recovered. The inspectors found that, on the one worn by the passenger, which is the one that didn't inflate, the two activation indicators were red. This indicates that it had been previously activated in both automatic and manual modes.

The inflater device was checked, and it was confirmed that the salt tablet, which produces its automatic activation, had dissolved.

The inspectors also checked the connection between the inflater device and the jacket itself, finding no anomalies.

On disassembling the device, the CO_2 cylinder that activates the inflation was found to be perforated.

Figure 11. Photograph of the Imnasa 150N Auto life

The inflater device was replaced with a new one of the same make and model, and it was activated manually. The life jacket inflated normally and remained inflated without losing pressure.

1.16.3. Pilot's statement

The pilot arrived at El Berriel Aerodrome at around 08:30 h, as per his agreement with the passenger.

Once at the airfield, they went to the plane. They drained the fuel tanks and carried out the pre-flight inspection. They checked both the fuel level and the oil level, the latter being above the minimum. He noted that the oil was quite dark. He looked at the TLB and saw the aircraft had five hours to go before its next inspection, which would explain the dark colour of the oil.

The flight plan consisted of departing from El Berriel and proceeding to Tenerife North, where they would practice a landing and take-off and then continue to La Gomera before returning to El Berriel.

As it took a while for the flight plan to be activated, they had to make a circuit of El Berriel. After that, control cleared them to depart via S1 and follow the visual corridor to the north, leaving by point W, N1 and N. They heading in a westerly direction, intending to stay at 3000 or 3500 feet.

He explained that the first part of the flight proceeded normally until they reached the north of the island, where they began to notice the smell of burning oil. They checked the engine parameters and saw that the oil pressure was at minimum, although he couldn't recall the oil temperature. He eased off the throttle slightly and notified control that they had a burning smell in the cabin. As he was notifying control, smoke began to come out of the dashboard, and without cutting the communication, he declared mayday, saying that there were two people on board. The other occupant, who knew the area better, took over communications and reported their exact position. Approximately ten seconds later, the engine stopped. He couldn't remember what power setting they were on at the time. Initially, they said they intended to land in a field near the coast, but in the end, they decided to ditch in the sea because they were too far away to reach the field.

He concentrated on flying the plane while his companion took care of the radio and trying to start the engine.

He set glide speed (70 kt). As they got closer to the water, he gradually extended the flaps until they were fully extended (full flap). He managed to steer clear of a few surfers in the area and began to lift the aircraft's nose to slow down as much as possible. He estimated they would be travelling at about 40 kt when they hit the water. Contact with the sea's surface was smooth and parallel to the waves.

During the descent, they shut off the fuel tank and tightened their seat belts.

After they landed, they opened the cabin, and his companion jumped into the water. He remained in the cabin, thinking that it was safer. On noticing that his companion's life jacket hadn't inflated, he called to him and told him to hold onto the aircraft until help arrived. By contrast, his life jacket inflated inside the cabin as soon as it came into contact with the water.

He added that they had checked the life jackets and confirmed that they were both operational before beginning the flight.

Gradually the current carried the aircraft to the shore, where the surfers helped them out.

1.16.4. Passenger testimony

The information provided by the passenger has not been included because it was almost identical to the information provided by the pilot.

With regard to the life jacket, he confirmed they had checked both the vests before leaving without finding any anomalies. After landing, he realised it hadn't automatically inflated when it came into contact with the water, so he tried to activate it manually, but that didn't work either.

As they were about 50 m from the shore and could reach it easily, they decided to swim towards the beach.

1.17. Organisational and management information

Several instructors from the training organisation that operated the aircraft (Canavia) were asked how they carried out the oil-level check on the aircraft involved in the incident.

All confirmed that before checking the level, they rotated the propeller several times to move the oil. After that, they checked the oil level by inserting the dipstick into the oil tank.

If the level was low, they added oil and noted it in the TLB.

1.18. Additional information

1.18.1. Similar cases

On 16 September 2020, the DIAMOND DA-20-A1 aircraft, registration EC-IIS (the same type of aircraft as the one that is the subject of this report), experienced an engine failure on approach to runway 25 at Reus Airport. (CIAIAC reference A-039/2020). This aircraft was equipped with a Rotax 912S3 engine (the same as the engine under analysis in this report), which had 1169 operating hours.

As in this case, the aircraft was operated by a flight school.

Unable to reach the airport runway, the aircraft was forced to land in an area near it and sustained significant damage.

During the field investigation, the investigators found it was only possible to rotate the propeller within a range of about 60º. When they checked the oil level with the dipstick, they found no traces of oil at all.

On draining the engine lubrication circuit, they collected approximately one litre of oil.

The engine was dismantled resulting in the following findings:

- The connecting rod of piston no.1 was snapped at the head, with signs of elastic deformation due to overheating.

- The connecting rod for piston no. 2 was in one piece, with signs of overheating on its foot.
- The connecting rod for piston no. 3 had no apparent damage and no signs of overheating.
- The connecting rod of piston no. 4 was broken at the head end.

The records in the aircraft's TLB show that, during the last 41 hours of flight, the engine lubrication circuit had been filled several times. In total, 2.15 l of oil had been added.

The average oil consumption during this period was therefore calculated to be 0.053 l/h.

1.18.2. Tides

On the day of the event, there were four tides: two low tides and two high tides, at the times and with the heights shown in the following table:

	Time	Height (m)
Low tide	02:08	-0.6
High tide	08:45	0.6
Low tide	15:06	-0.7
High tide	21:25	0.5

Sunrise was at 07:54 h.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Operational analysis

Both occupants had a PPL and were trying to increase their flight hours to gain the experience necessary to obtain a commercial pilot license (CPL) and the theoretical part of the airline transport license (ATPL).

They had planned a triangular route between El Berriel, Tenerife North and La Gomera. The radar trace confirms they followed the plan during the initial part of the flight, up to the point when they decided to return due to the smell of burning. We have been able to establish that neither the meteorological conditions at the time of the accident nor the forecasted conditions were limiting for the type of flight planned.

When they had flown over the island of Gran Canaria and were on a heading towards Tenerife, they noticed a strong smell of burning oil. They immediately decided to return to their departure point but, shortly afterwards, the engine stopped completely. They decided to divide the tasks. The pilot stayed at the controls, focusing on flying the aircraft safely, while the passenger took charge of communications and attempting to deal with the emergency by starting the engine again. Their decision to do this seems to be appropriate because it allowed the pilot to concentrate solely and exclusively on flying the aircraft safely, while the other occupant communicated the emergency, gave their position and tried to carry out the procedures indicated by the pilot.

At first, the pilot aimed for a field near the coast but on realising they wouldn't make it purely by gliding, he decided the best option was to ditch in the sea. Again, it is believed he made the correct decision.

In preparation for the sea landing, the pilot reduced the speed, extended the flaps to maximum and angled the aircraft to be parallel to the waves, thus complying with the flight manual's instructions for a landing on water. Meanwhile, the passenger secured the cabin, subsequently opening it to ensure they could exit immediately if required.

During the approach to the water, the pilot modified the aircraft's speed to the speed recommended in the manual for the manoeuvre they were attempting to perform.

They landed approximately 38 minutes after high tide. The timing meant the rocks in the area were covered with water, preventing the underside of the aircraft from hitting them.

It is concluded that the emergency was handled correctly at all times.

2.2. Analysis of the engine failure

The engine inspection revealed that the connecting rod of piston no.1 had broken into two pieces at the point where the head joins to the body. One piece was attached to the crankshaft, and the other to the piston (see figure 9).

Except for the fracture zone where plastic deformation was observed, there were no appreciable deformities on the piece attached to the piston, which included the foot and the body of the rod.

The head end of the connecting rod attached to the crankshaft displayed signs of excessive stretching and plastic deformation, which are characteristic of a creep failure due to elevated temperature conditions.

The connecting rod must have heated up gradually because if it had occurred rapidly, it would have seized up, and the break would have been brittle rather than ductile, as in this case. For this phenomenon to have occurred, the connecting rod must have been lubricated, although to a limited extent. The amount of oil that lubricated the connecting rod was sufficient enough to prevent it from seizing up but not enough to stop it from gradually heating up.

Accordingly, the temperature of the connecting rod increased until it reached a particular temperature and load (yield point), after which the plastic deformation began. This situation affected the head end of the connecting rod, but not, at least in any appreciable way, its foot.

There were no signs of deformation in the other connecting rods, although they were all stiff at the head end, which is indicative of a lack of lubrication.

These conditions, therefore, point to a lubrication deficit in the crankshaft crankpins.

This theory is further supported by the examination of the condition of the crankshaft support bearings. All of them showed signs of damage and evidence of having reached high temperatures, which is consistent with a lack of lubrication.

The rest of the engine showed no obvious damage as a result of insufficient lubrication. Therefore, it can be concluded that the reduction in oil flow was only noticeable in the area around the crankshaft.

Given that the engine inspection did not identify any obstructions in the lubrication system ducts that carry the lubricant to the damaged areas, a potential blockage can be ruled out as the cause of lubricant deficit.

Furthermore, the examination of the bearings revealed a certain level of gradation in damage severity, the rear bearing being the least damaged and the front one being the most affected.

In this engine's lubrication system, the oil travels from the rear, first being channelled towards the cylinder head, then the camshaft, and finally the crankshaft. In other words, the oil first reaches the rear support and the head area of connecting rod no. 4, then the central support and connecting rod heads no. 2 and 3, and lastly, the front support and connecting rod head no. 1.

In light of the above, it seems there is some correlation between the location of the damaged areas and the flow of the lubricant; the further downstream the area, the more severe the damage.

This suggests a decrease in the oil flow throughout the lubrication circuit. The further away from a lubrication point a component is, the less oil will reach it.

This may have been caused by a low oil level in the system. In this situation, the areas most affected by the shortage of lubricant would be those furthest away in the circuit, which happens to coincide with the components that exhibited the most damage.

The quantity of oil contained in the engine's lubrication system was approximately 1 litre, albeit mixed with a greater volume of seawater. This volume of oil is much less than the amount held in the system when the level is at minimum.

The event described in point 1.18.1 has many points in common with the incident under analysis in this report. The damages are similar and affect the same areas. In that case, there were no doubts about the amount of oil in the system, which was confirmed as just over 1 litre.

It seems reasonable to assume that the conditions that caused the engine failure being evaluated in this report would be quite similar to those in the incident discussed in 1.18.1, in short, a low oil level.

Therefore, it is believed that the engine failure was probably caused by a lack of lubrication in the crankshaft, which primarily affected the head end of the connecting rod of cylinder no.1 and the front and central bearings of the crankshaft.

2.3. Analysis of the annotations in the TLB

According to the annotations in the TLB, the engine lubrication system had not been refilled since the oil change carried out on 15/10/2019.

Although these engines are characterised by their low operational oil consumption, which the manufacturer quantifies at a maximum of 0.06 l/h, it is generally expected that an engine at the end of its useful life, as was this one was, would consume a little more due to operational wear and tear.

The following table shows the amount of oil that the engine would have consumed during these flights, based on different hourly consumptions, ranging from the maximum claimed by the manufacturer, which is 0.06 l/h, to 0.01 l/h.

Hourly consumption (l/h)	0.06	0.03	0.02	0.01
Total consumption (l)	2.70	1.35	0.90	0.45

In the worst-case scenario (maximum consumption), 2.70 l would have been consumed, which is practically equivalent to the capacity of the circuit.

In the best-case scenario, 0.45 l would have been consumed, which is equivalent to the volume of oil between the maximum and minimum level.

Therefore, unless the engine consumed almost no oil, it would need to be replenished.

Another issue is that an examination of the TLB sheets reveals inconsistencies, with the annotations describing illogical variations in the oil level.

For example, the first three sheets note the oil level as ¾. Yet, without any indications that the oil was replenished, the fourth sheet notes the oil level as maximum. That level is maintained in the subsequent three sheets; then, in the eighth, it goes back down to ¾ only to go back up to full, and so on.

There is even a record of a ½ reading between two full readings.

It's impossible for the oil level to fluctuate the way the annotations in the TLB suggest it did. This disparity could be due to various reasons. For example, it could be the oil level was checked using different techniques or simply that there were errors in the readings.

Although all the ATO instructors questioned claimed they checked the oil according to Rotax's instructions and imparted that procedure to the students, it's possible that it didn't always happen or was performed partially or incorrectly.

It's also possible that errors were made when reading the oil level on the dipstick. It wouldn't be out of the question for any oil trace on the dipstick to be identified as the oil level when, in reality, it was made by oil splashes or rubbing against the tank walls on removal.

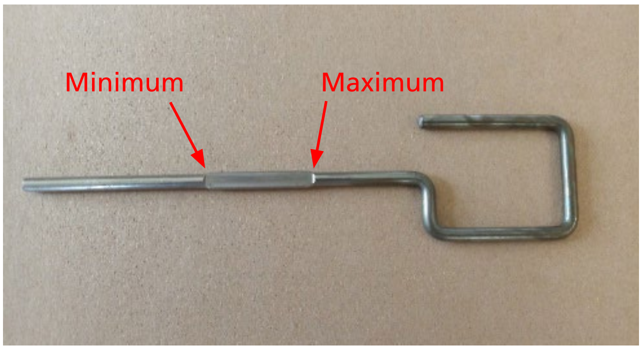


Figure 12. Oil level dipstick

Whatever the cause, there seems no doubt that the oil level checks performed on this aircraft, at least since the last oil change, were incorrect. The consequence of this was that the falling oil level went unnoticed, allowing the oil volume to drop to a point where there wasn't enough to lubricate all areas of the engine.

Situations such as the one described above pose a threat to the operational safety of aircraft. Therefore, to prevent this situation from reoccurring in the future, a safety recommendation is issued to the ATO that operated the aircraft, which should review and, where appropriate, amend its operational procedures to ensure the oil-level checks in aircraft equipped with this type of engine meet the standards of uniformity and reliability required to guarantee correct readings.

2.4. The engine's oil consumption

The maintenance documents show the engine had been maintained according to the instructions and intervals established by the manufacturer.

The oil was changed in the overhaul carried out on 15/10/2019. Since then, the aircraft had made several flights, totalling just under 45 h.

According to the annotations in the TLB, the engine lubrication system had not been refilled since the oil change carried out on 15/10/2019.

Considering that the amount of oil extracted from the engine (approximately one litre) was the amount in the system at the time of the engine failure; and also that when the lubricant was changed, the system was filled with three litres (maximum level), it would appear that the volume of oil consumed during the aircraft's next 45 hours of flight was two litres. This translates to an hourly consumption of 0.044 l/h.

Point 1.18.1 describes an event involving the same type of aircraft with the same type of engine as the one currently under investigation. It was also used for the same types of operations (pilot school). Given the similarities between the two aircraft, it is expected that there would not be significant differences in oil consumption between the two engines.

The hourly oil consumption, in that case, turned out to be 0.053 l/h.

Given the data above, it is concluded that the most plausible explanation for the engine failure was a lubrication deficit which mainly affected the area around the head of the connecting rod of cylinder no. 1, as a result of the reduced amount of oil present in the lubrication system.

2.5. Analysis of the oil-level check procedure

As reflected in point 1.6, the instructions on checking the oil level in the aircraft flight manual differ from those indicated by the engine manufacturer in the engine operating manual.

The aircraft manual simply says that the level should be checked by looking at the mark on the dipstick and does not provide any additional information on how to do it. By contrast, the engine's operating manual describes a procedure that involves several pre-check actions, such as turning the propeller by hand.

It's possible that neglecting to follow the instructions provided by Rotax could result in a misleading level on the dipstick because the measurement has not been taken under the right conditions.

Pilots are required to know and apply the procedures outlined in the aircraft flight manual. However, the same does not apply to the procedures outlined by the manufacturers of the aircraft's components, such as the engine, whose existence may even be unknown to a pilot. Under these conditions, it's perfectly feasible for a pilot to simply check the oil level solely by looking at the mark on the dipstick.

Considering the importance of checking the oil level correctly, it seems logical that the procedure described in the aircraft flight manual should not differ from that recommended by the engine manufacturer.

For this reason, a safety recommendation is issued to Diamond Aircraft, which should review the aircraft flight manual to ensure that the engine oil-level check procedure details all of the steps recommended by the manufacturer Rotax.

2.6. Operation of the life jackets

According to the aircraft's occupants, before starting the flight, they checked the condition of the life jackets and found nothing abnormal.

They confirmed that both the automatic inflater indicators on the jacket that failed to inflate (an Imnasa 150N Auto) were green, indicating that the inflater device had not been triggered.

The post-accident inspection, however, found both indicators were red, proving that both the automatic and manual modes had been activated and contradicting, therefore, the statements provided by the occupants.

After a thorough review of both the jacket and the inflater device, no deficiencies that may have prevented it from inflating were found.

The inflater device was replaced with a new one of the same make and model, and it was activated manually. The jacket inflated normally and remained inflated, with no apparent loss of pressure.

This proves there was nothing wrong with the jacket itself, so it is ruled it out as a contributing element.

Only the inflater device and its connection to the jacket remain as possible causal factors.

When the inflater device is activated in automatic or manual mode, it triggers a mechanism that involves piercing a cylinder containing pressurised CO_2. The perforation allows the gas to leave the cylinder and enter the jacket through the connection between the two, inflating the jacket.

In this case, the cylinder was perforated, which is fully consistent with the red colour of the activation mode indicators.

The other possibility is that the connection between the inflater device and the jacket failed. Although the connection was checked without finding anything abnormal, it's possible a problem went undetected during the inspection.

If the connection did fail, the gas would have leaked out of the cylinder at some point in the connection. It seems logical to think that, had this situation occurred, the person wearing the jacket would have noticed the gas escaping. That said, taking into account the tension created by the situation, the waves, the noise of the sea and the fact that the wearer was partially submerged, it's also entirely possible it went unperceived.

In addition, and although quite unlikely, there a chance the CO_2 cylinder was already perforated. The possibility that the cylinder seal was punctured at an earlier time can't be ruled out, for example, during its assembly in the device.

A tiny pore hole could have gone unnoticed as the gas would have released slowly but steadily, completely emptying the cylinder over time. If that had happened, as the trigger mechanism had not been activated, the indicators would still be green.

The evidence obtained during the investigation has not provided enough information to reliably determine which of the two hypotheses caused the jacket to fail.

3. CONCLUSIONS

3.1. Findings

A. <u>In relation to the operation</u>

- The passenger's life jacket did not inflate.

B. <u>In relation to the aircraft</u>

- No engine oil refill was noted in the TLB.
- Oil levels of between ½ and full were recorded.
- The oil-level check procedure in the aircraft manual differs from that recommended by the engine manufacturer.
- No traces of oil or any other fluid were found on the aircraft's skin or windshield.
- No breakages or possible leakage point was found in the engine lubrication system.
- The connecting rod of piston no. 1 was broken at the point close to where it's attached to the crankshaft and displayed signs of excessive stretching and plastic deformation.
- The engine's lubrication system contained approximately 1 litre of oil mixed with seawater.
- Both the manual and automatic activation indicators on the Imnasa 150N Auto life jacket were red.
- The CO_2 cylinder of the Imnasa 150N Auto BCD inflater had been punctured by the trigger mechanism.
- A new inflater device was installed in the Imnasa 150N Auto life jacket and it inflated correctly.
- The connecting rod heads of pistons 2, 3 and 4 offered significant resistance when turned.
- The front and centre crankshaft bearings exhibited considerable wear and evidence of having been subjected to high temperatures.
- The rear crankshaft bearing exhibited only minor friction damage and discolouration.
- The lubrication channels inside the crankshaft were checked and found to be unobstructed.
- No abnormality was detected in the lubrication system.
- With the exception of the crankshaft area, the rest of the engine appeared to be well lubricated.

3.2. Causes/contributing factors

It is considered that the accident occurred due to insufficient lubrication of the connecting rod in cylinder no.1, which led to an in-flight engine failure and forced the crew to make an emergency landing on water.

The investigation has determined that the following factor contributed to the accident:

- The deficient oil-level verification procedure used by the ATO personnel operating the aircraft.

4. OPERATIONAL SAFETY RECOMMENDATIONS

In this accident, the engine failed in-flight because the engine lubrication system contained less than the minimum quantity of oil. This issue was not detected during the pre-flight oil-level checks because the procedure was performed inconsistently.

For this reason, the following security recommendation is issued.

REC. 28/21. It is recommended that Canavia Lineas Aereas SLU review and, where appropriate, amend its operational procedures to ensure that all oil-level checks in aircraft equipped with Rotax 912 engines meet the standards of uniformity and reliability required to guarantee correct readings.

The investigation into this incident found that the oil-level check procedure outlined in the aircraft manual does not provide any instructions on how to carry out the procedure correctly, while the one recommended by the engine manufacturer describes a procedure involving several actions prior to checking.

Considering the importance of checking the oil level correctly, it seems logical that the procedure described in the aircraft flight manual should not differ from that recommended by the engine manufacturer.

For this reason, the following security recommendation is issued.

REC 29/21. It is recommended that the aircraft manufacturer, Diamond Aircraft, review the aircraft flight manual to ensure that the engine oil-level check procedure details all of the steps recommended by the manufacturer BRP-Rotax Gmbh. & Co KG.