Technical report
A–029/2022

Accident on 04 June 2022 involving a TECNAM P2008 JC aircraft, registration EC-NKE, at Madrid-Cuatro Vientos Airport (Madrid, Spain)

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GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES Y MOVILIDAD SOSTENIBLE
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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 that is the object of the investigation, its probable causes, and its consequences.

In accordance with the provisions in Article 5.4.1 of Annexe 13 of the International Civil Aviation Convention; and with Articles 5.6 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 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 specified 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.

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

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ABBREVIATIONS

AENA..... Spanish Airports and Air Navigation

AESA..... Spain's National Aviation Safety Agency

ANSV..... Italian National Flight Safety Agency

ATO..... Approved training organisation

AVGAS..... Aviation fuel

CPL(A)..... Commercial pilot license (aircraft)

CR(A) MEP(ground). . Multi-engine piston rating land

CR(A) SEP(land) ..... Single-engine piston rating land

CS VLA..... Certification specifications for light aircraft

EASA..... European Union Aviation Safety Agency

FI(A) ..... Instructor rating (aircraft)

ft ..... Feet

h ..... Hour

LT ..... Local time

HP ..... Horsepower

IR(A) ..... Instrument Rating (aircraft)

kg..... Kilogrammes

KIAS. ..... Knots of indicated airspeed

kt..... Knots

l..... Litre

m. ..... Metre

TR(A)..... Aircraft type rating

VFR ..... Visual flight rules

Technical report

A-029/2022

Owner and Operator:	QUALITY FLY, S.A.
Aircraft:	TECNAM P2008 JC, registration EC-NKE
Date and time of the accident:	04 June 2022; 11:10 HL[1]
Site of the accident:	Madrid Cuatro Vientos Airport
Persons on board:	1 instructor, 1 student, unharmed
Type of flight:	General Aviation - instruction flight - dual
Phase of flight:	Landing – emergency landing
Flight Rules	VFR
Date of approval:	29 November 2023

SYNOPSIS

Summary of the accident

On 04 June 2022, the TECNAM P2008 JC aircraft, registration EC-NKE, was involved in an accident near Madrid - Cuatro Vientos Airport.

During an instruction flight with an instructor and student on board and after performing a landing and take-off manoeuvre, the aircraft's engine stalled. The crew made an emergency landing to the south of the airport, during which the aircraft overturned. There were no injuries. The aircraft sustained significant damage.

The investigation has determined that the cause of the accident was a loss of control of the aircraft due to uneven terrain while performing an emergency off-field landing after the engine shut down for unidentified reasons.

[1] All times used in this report are local time.

1.- FACTUAL INFORMATION

1.1.- History of the flight

On Saturday, 04 June 2022, at 11:10 h, the TECNAM P2008 JC aircraft, registration EC-NKE, experienced an accident while performing an emergency landing due to an engine shutdown in a field adjacent to Madrid - Cuatro Vientos Airport.

The aircraft had taken off at 09:17 h from runway 27 of the same airport for a 2-hour training flight, with an instructor and student on board. After a navigation flight over the southeast of Madrid, it returned to Cuatro Vientos to practise landing and take-off manoeuvres. According to the instructor, he had switched on the electric fuel pump when entering the circuit. Subsequently, during the first authorised manoeuvre on runway 27, while climbing and before turning left to enter the crosswind leg at about 600 ft of altitude and a speed of 75 kt, they received a low fuel pressure alert, and then the engine sputtered and stalled. The instructor also reported that at the same time, there was a complete electrical failure; the cockpit displays switched off, and communications with the tower were lost. After declaring an emergency and taking over the controls, he attempted to start the engine. The student did not participate in the emergency management. When this failed, the instructor decided to make an emergency landing on the adjacent fields to the south of the airport. After the landing, the uneven terrain caused the aircraft to overturn.

Neither of the occupants sustained injuries, and they evacuated the aircraft unaided. The emergency services arrived shortly afterwards and emptied the fuel from the tanks. The accident caused significant damage to the aircraft.

1.2.- Injuries to persons

Injuries	*Crew*	*Passengers*	*Total in the aircraft*	*Others*
Fatalities				
Serious				
Minor				
Unharmed	2		2	
TOTAL	2		2	

1.3.- Damage to aircraft

The aircraft sustained damage during the landing, mainly to its fuselage, propeller and landing gear.

Figure 1. Damage to the landing gear and vertical stabiliser

The image in Figure 1 shows the broken nose leg and the damage to the end of the vertical stabiliser sustained during the rollover.

1.4.- Other damage

There was no other damage.

1.5.- Personnel information

The 44-year-old pilot-in-command had a CPL(A) license issued on 11 December 2017, with the following ratings: CR(A) MEP (land) valid until 28 February 2023, CR(A) SEP (land) valid until 28 February 2024, IR(A) valid until 30 April 2025, FI(A) valid until 31 May 2025, and TR(A) ATR42/72 valid until 21 December 2022.

The pilot also had a Class 1 medical certificate valid until 17 April 2023.

According to his statement, he had 1,741 h of experience at the time of the accident, of which 128 h were as an instructor.

The 18-year-old student pilot on board had 37 h of experience.

The student's Class 1 medical certificate was valid until 26 January 2023.

1.6.- Aircraft information

The TECNAM P2008 JC, registration EC-NKE, is a single-engine aircraft with a fixed, tricycle-type landing gear. It was manufactured in 2020 with serial number 1150. Its empty weight is 418 kg, and its maximum take-off weight is 650 kg. It has a 100 HP ROTAX 912S2-01 4-cylinder horizontally arranged engine, with serial number 9139246. It was registered in Spain's Civil Aircraft Registry on 02 March 2021. Its airworthiness review certificate was valid until 20 May 2023. At the time of the accident, both the aircraft and engine had 666 flight hours. The aircraft has a type certificate issued by EASA Nº EASA.A.583.

The most recent maintenance work on the aircraft was a 50h revision performed on 18 May 2022, at which time it had 650 flight hours.

According to the information obtained, it was last refuelled on 29/05/22, filling the tanks with 51 litres of AVGAS 100LL. After this, no flights were made until the day of the accident. This fuel is the one available at airports in the AENA network.

The engine manufacturer indicates in the engine maintenance manual that if leaded fuel is used, such as AVGAS 100LL, oil and filter changes should be carried out every 50 h. If unleaded fuel is used, oil and filter changes should be carried out every 100 h.

In the case of the EC-NKE aircraft, the operator indicated that both automotive fuel and AVGAS 100LL had been used in the past, with oil and filter changes according to the records provided every 50 h, as indicated by the manufacturer.

In the engine overhaul manual, the manufacturer refers to the removal of carbon deposits in the cylinders, stating that they are to be expected when using AVGAS 100LL fuel. The online maintenance manual makes no reference within the relevant periodic inspections to the detection or removal of deposits of this type.

The image in Figure 2 includes the electrical diagram of the aircraft provided in the maintenance manual. The primary source of electrical energy is a belt-driven alternator, shown in the diagram, to power the electrical loads.

The mixture is ignited in the cylinders by two electronic ignition boxes, which are powered by the alternator once the engine is running.

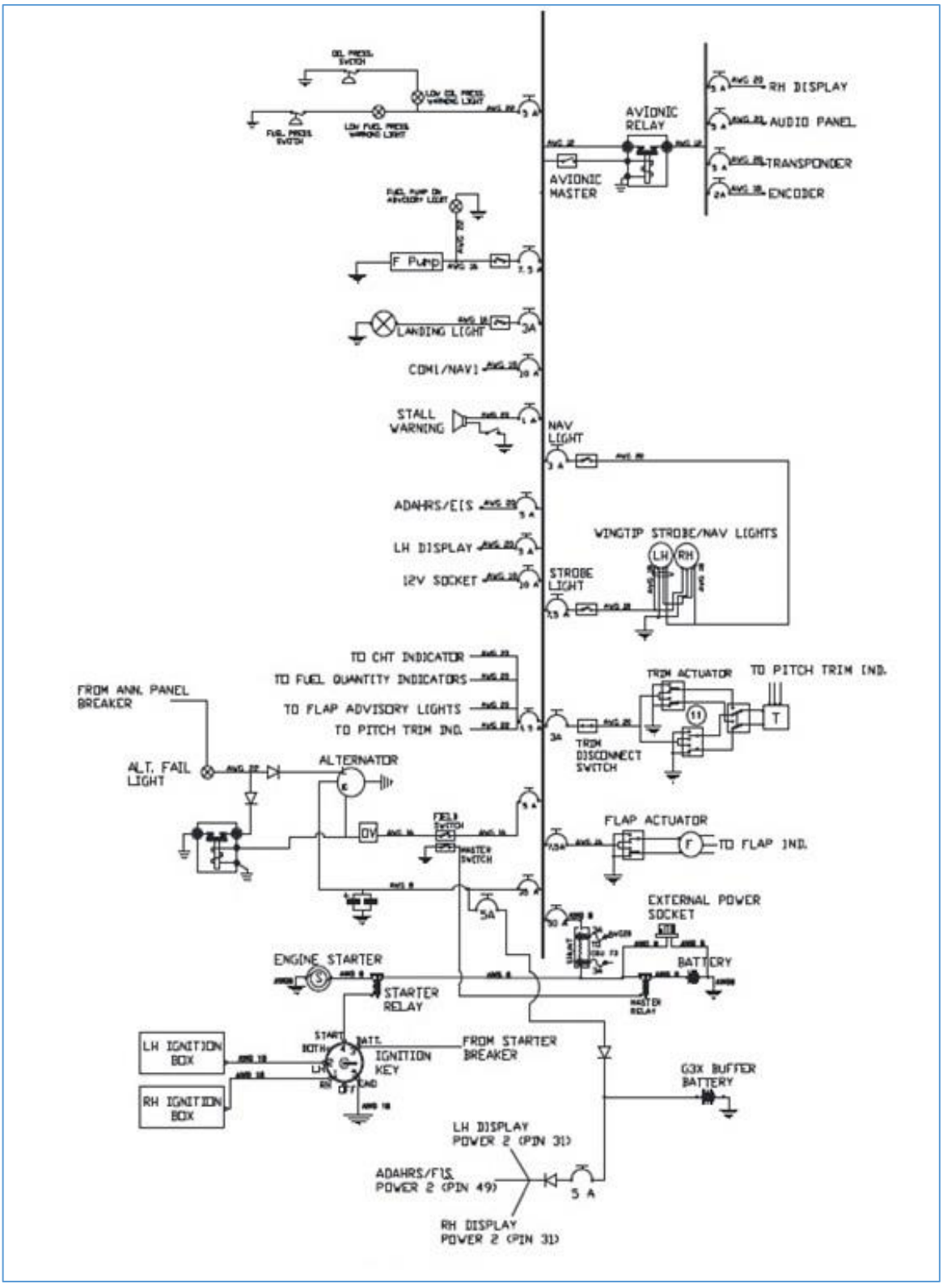


Figure 2. Electrical system of the TECNAM P2008JC

According to the aircraft's Flight Manual, the procedure for starting the engine after an in-flight engine failure is as follows:

1. Carburettor heat: ON (if required)
2. Electric fuel pump: ON
3. Fuel quantity indicator: check
4. Fuel selector: select opposite tank if not empty
5. Ignition key: BOTH
6. Ignition key: START
7. Throttle lever: set as required

In case of unsuccessful engine restart:

1. Secure engine (throttle at idle, ignition key OFF, fuel selector OFF, fuel pump OFF, alternator OFF).

2. Perform emergency landing:

    a. Flaps: up
    b. Indicated airspeed: 71 KIAS
    c. Find a suitable place to land safely.
    d. Fuel selector valve: OFF
    e. Fuel pump: OFF
    f. Ignition key: OFF
    g. Safety belts: tighten

3. On landing:

    a. Flaps: as necessary
    b. Alternator and master switch: OFF

The aircraft has 2 cockpit displays, all instruments being digital and integrated into the cockpit, in accordance with CS VLA requirements. According to the manufacturer, this is the approved configuration and cannot be modified or customised. The main battery provides the necessary power for start-up and supplies the essential loads in the event of alternator failure. According to the Flight Manual, it can supply electrical power for 30 minutes. The aircraft also has a transponder.

Figure 3 shows an image of the aircraft's instrument panel extracted from the Flight Manual.

It can be appreciated the unavailability of basic analog flight instruments (airspeed indicator, altimeter and variometer).

Figure 3. Control panel on the TECNAM P2008JC

1.7.- Meteorological information

There were no limiting meteorological conditions for the flight.

1.8.- Aids to navigation

The radar information provided by ENAIRE shows that the aircraft's trace disappears from the screen at 11:09:29 h, with the last recorded indication showing it climbing at 2,600 ft.

1.9.- Communications

According to the information provided, at 11:09:03 h, while climbing after a landing and take-off manoeuvre, the pilot informed Madrid-Cuatro Vientos Airport tower that he needed to land due to a low fuel pressure warning. This communication was cut off before it could be completed.

After observing the traffic losing altitude, the alarm was activated.

Communications are included below.

Instant	*Station*	*Communication*
09:02:47	QFY22A	"Tower this is QFY22A with information N, reaching S point"
09:02:52	LECU TWR	"QFY22A hello, join left downwind runway 27, QNH 1017 information O"
09:02:57	QFY22A	"Ah... Join left downwind runway 27 information O copied eh... QNH 1017, QFY22A"
09:03:16	QFY22A	"Tower, please could we perform touch and goes?"
09:03:21	LECU TWR	"Approved"
09:03:22	QFY22A	"Thank you"
		Comunicaciones con otras aeronaves
09:05:48	QFY22A	"Tower QFY22A downwind runway 27"
09:05:51	LECU TWR	"QFY22A wind 240 degrees 5 knots maximum 12 knots runway 27 clear for touch and go"
09:05:56	QFY22A	"Runway 27 clear for touch and go, QFY22A"
		Comunicaciones con otras aeronaves
09:07:51	LECU TWR	"ECASJ entrar y mantener pista 27"
09:07:54	ECASJ	"Entrar y mantener pista 27"
		Comunicaciones con otras aeronaves
09:08:40	LECU TWR	"QFY22A if possible early turn to crosswind please"
		Comunicación de otra aeronave
09:08:52	LECU TWR	"QFY22A when able turn crosswind"
		Comunicación con otra aeronave
09:09:01	LECU TWR	"QFY22A"
09:09:03	QFY22A	"QFY22A eh... we need to...land as soon as possible because we have an indication of fuel pressure so I am going to land in the..."
09:09:13	LECU TWR	"ECASJ viento 270 grados 5 nudos 27 autorizado a despegar"
09:09:16	ECASJ	"En carrera SJ"
09:09:18	LECU TWR	"QFY22... QFY28A maintain S point"
09:09:25	QFY28A	"Maintain S, QFY28A"
09:09:29	LECU TWR	"ASJ mantenga posición, mantenga posición"
		[LECU TWR PULSA ALARMA MIENTRAS QFY22A REALIZA ATERRIZAJE DE EMERGENCIA IMPACTANDO CON EL SUELO Y VOLCANDO AERONAVE]

The images in Figures 4 and 5 include the radar trace of the aircraft, with call sign QFY22A. It can be seen that at 11:09:29 HL it disappears from the screen.

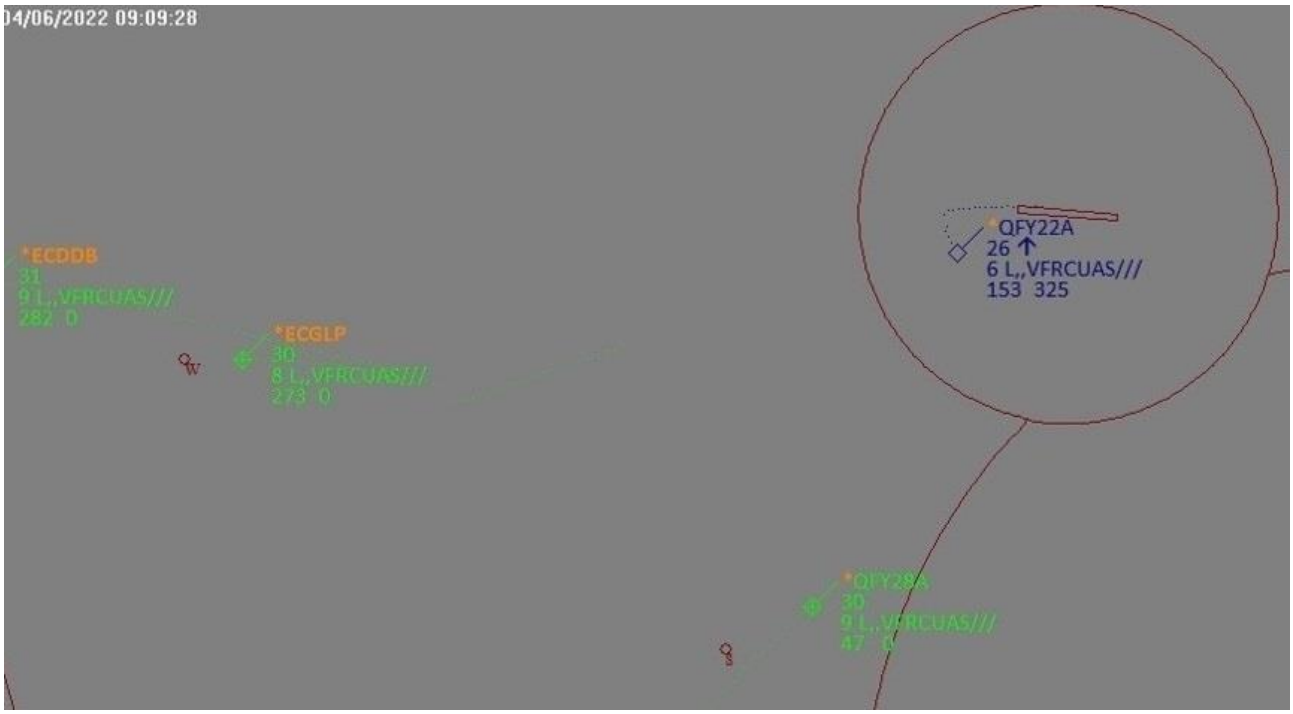


Figure 4. Radar trace at 11:09:28 h

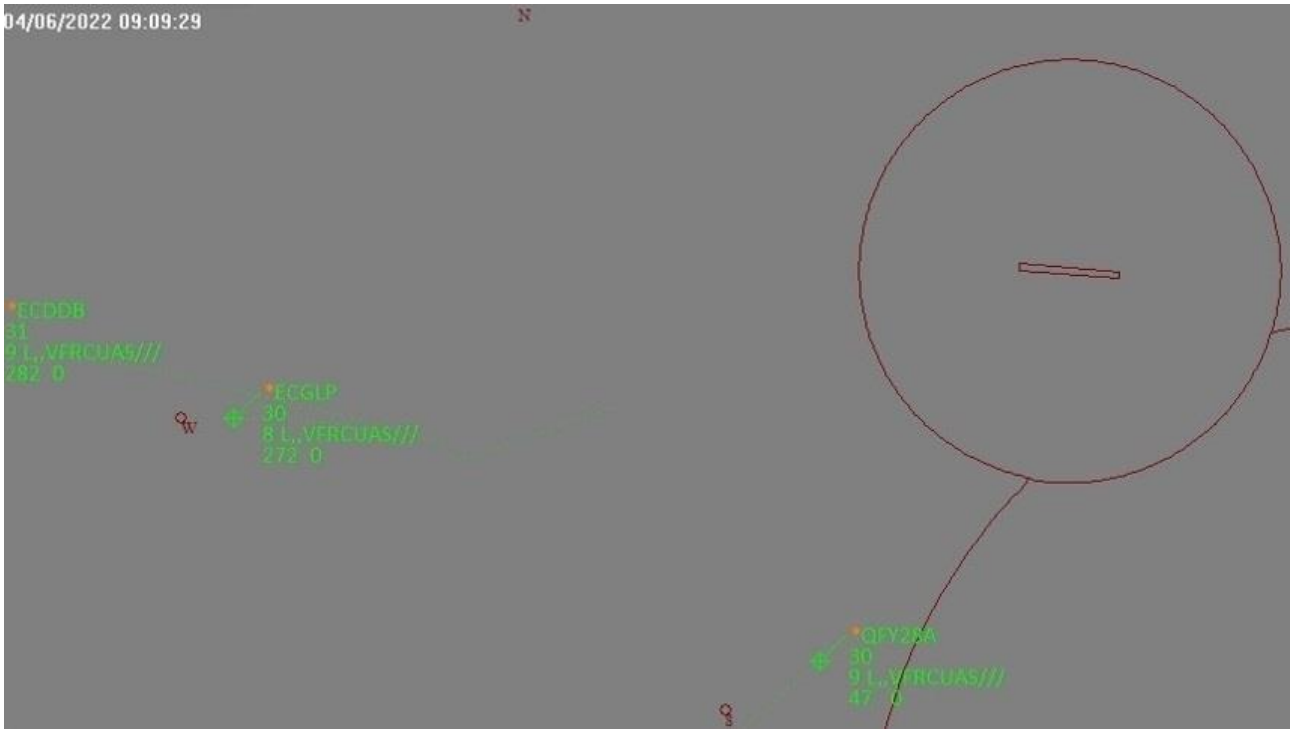


Figure 5. Trace disappears at 11:09:29 h

1.10.- Aerodrome information

Madrid - Cuatro Vientos Airport (ICAO code, LECU) is located 8.5 km southwest of the city of Madrid. Its elevation is 2,270 ft. It has a paved 1,500 m-long by 30 m-wide runway with a 09/27 orientation.

1.11.- Flight recorders

The aircraft was not equipped with a flight data recorder (FDR) or cockpit voice recorder (CVR) because they are not a regulatory requirement for this type of aircraft. It had a Garmin G3X which records some flight parameters.

1.12.- Wreckage and impact information

The pilot performed the emergency landing on a field located to the south of the airport, about 350 m from the runway. Due to the unevenness of the terrain, the aircraft flipped over a few seconds after touching down.

Figure 6. Final position of aircraft EC-NKE

The image in Figure 6 shows the aircraft in its final position.

1.13.- Medical and pathological information

Both occupants were unharmed.

1.14.- Fire

No fire broke out in the aircraft or the surroundings.

1.15.- Survival aspects

The harnesses and restraint systems performed their function adequately. The aircraft's cabin did not sustain any deformations that could have endangered the lives of the crew.

1.16.- Tests and research

1.16.1 Aircraft inspection

The aircraft was initially transported to a hangar at Cuatro Vientos Airport and then moved to Casarrubios Aerodrome. It was inspected at both locations, with the support of technical personnel and in the presence of the maintainer and the operator.

With regard to the examination of the engine carried out at Cuatro Vientos, the following should be noted:

- the oil and coolant levels were found to be correct.
- the 2 temperature sensors showed signs indicating that the engine may have overheated at some point.
- the fuel tank vents were not defective.
- the mechanical fuel pump was disassembled, and petrol was found inside it. The diaphragm was in good condition, and when the propeller was partially rotated, the pump worked pumping enough fuel.
- the electric fuel pump was disassembled and found to have petrol in it, and the filter was clean and in good condition.
- both carburettors were disassembled and found to have fuel in the float bowls, and the floats and jet nozzles were found to be in good condition, with no obstructions or dirt.
- no anomalies were detected in the fuel lines running from the wings to the engine, nor in the fuel return pipe.
- the fuel selector valve in the cockpit was found to have come loose so that when it was moved, it did not change the selection from one tank to the other; the right tank

was selected. This problem was fixed so that each tank could be selected to check the operation of its electric pump.

- the master switch was switched on, the cabin displays came on, and the battery was found to be sufficiently charged to provide electrical power.

- the electric pump was switched on, and the display showed a fuel pressure of 4.3 psi when the right tank was selected and 4.1 when the left tank was selected.

- the magnetic screw was disassembled and found to be normal in appearance, with little or no metal debris present.

- none of the breakers were out of position, which meant there was no indication of an electrical overload having occurred in any of the circuits.

The front of the aircraft was lifted onto a stand to test the engine, revealing that the crankshaft was blocked at one point and could only be partially rotated. On disassembling the cylinder heads to check whether any of the cylinders had seized, deposits of carbon residue were found inside them. The residue was worse in cylinder No. 3 than in the others.

Figure 7. Residue in cylinders 1 & 2

Figure 8. Residue in cylinders 3 & 4

The images in Figures 7 and 8 show the carbon deposits observed. In cylinders 1, 2 and 4, these deposits primarily constituted a layer covering the piston heads. In No. 3, however, the residue had also fallen to the bottom of the cylinder and been dragged along the wall by the piston as it moved towards top dead centre.

It was confirmed that, after removing the cylinder head of cylinder No. 3 and making room for the debris inside it to move outwards, the crankshaft could be rotated freely, with no blockage or resistance to its rotation.

No fuel residues suggesting poor combustion were observed on the spark plugs, camshaft or crankshaft.

The engine's online maintenance manual does not include actions to detect this type of build-up in the routine overhauls. However, based on the inspection findings, the maintainer indicated that it would include boroscopic inspections of the cylinders in the 100 h overhauls to detect potential build-ups of carbon residue.

A second engine inspection was subsequently carried out at Casarrubios Aerodrome to identify any damage to the engine that could indicate the cause of the failure. The gearbox was disassembled to check the condition and roundness of the crankshaft, and no anomaly was found. It was also confirmed that there had been no damage to the cylinders and connecting rods that would indicate a sudden engine shutdown involving some kind of internal resistance.

Figure 9. Fuel pumps, sensors and ignition boxes

A third inspection of the aircraft was carried out to test the operation of the electrical system, and the fuel pumps, fuel pressure sensors and ignition boxes were disassembled for further testing on another engine.

1.16.2 Analysis of the residues in the cylinders

A sample of the residues extracted from the cylinders was analysed by electron microscope to check whether any type of external contamination could have occurred. The elements detected are indicated in the following table, along with the weight of each expressed as a percentage.

Analysis	C	O	Na	Al	Si	P	S	K	Ca	Fe	Zn	Br	Pb	Total
1	27.11	13.68	-	-	1.36	1.38	0.82	-	1.26	-	0.60	7.41	46.36	*100*
2	24.98	45.26	4.28	6.54	16.63	-	-	0.26	0.90	-	-	-	1.14	*100*
3	52.11	21.85	-	1.14	21.16	-	-	0.52	-	0.60	-	-	2.61	*100*
4	42.63	32.23	-	3.33	9.50	-	-	1.83	3.35	-	-	-	7.12	*100*
5	28.15	17.82	-	-	2.13	2.45	2.60	-	1.16	-	5.05	4.54	36.11	*100*

Based on the results of the analysis, the following was concluded:

1. S, P and Br come from the fuel and give rise to the ash and residues deposited by the combustion gases.

2. Ca and Zn are elements that can be found in lubrication oils.

3. Pb, Al, Fe, Na, K and Si are metallic elements that may be present in the original fuel composition.

1.16.3 Information provided by the engine manufacturer

Through the accredited representative assigned by the Austrian Safety Investigation Authority, Rotax was provided with information and photographs of the inspection carried out on the engine.

In relation to the residues found in the cylinders and how they may affect the engine's performance, they indicated that they could be due to factors such as the quality of the fuel and oil used, the power demanded from the engine, oil consumption and previous operation. They also pointed out that the quantity observed was within the normal range, not excessive and, therefore, could not have caused the failure.

1.16.4 Functional test of the fuel pumps, pressure sensor and ignition boxes

The mechanical and electrical fuel pumps were mounted on an engine on a test bench to test their operation by measuring the pressures produced using an analogue pressure gauge.

After starting the engine, the following approximate fuel pressures were recorded when the engine was cold:

- with only the mechanical pump running: approx. 0.30 bar
- after switching on the electric pump: approx. 0.40 bar
- switching off the electric pump, the pressure dropped to approx. 0.35 bar

The engine was allowed to warm up for several minutes, increasing the oil temperature to 50 °C. The following pressure values were measured:

- with only the mechanical pump: approx. 0.40 bar
- after switching on the electric pump: approx. 0.43 bar
- after switching off the electric pump: approx. 0.30 bar

The engine was accelerated to full power, measuring:

- with only the mechanical pump: approx. 0.40 bar
- after switching on the electric pump: approx. 0.40 bar
- after switching off the electric pump: approx. 0.35 bar

The fuel pressure sensor and low fuel pressure warning sensor were also checked.

With regard to the pressure sensor, different pressure values were progressively applied to the sensor via a line, verifying that the electrical voltages generated corresponded to the pressure values entered: no faults were detected.

With regard to the low-pressure warning device, a multimeter was connected to its output, and different pressure values were applied to the input to check the electrical continuity and test its operation. Pressure values of up to 7 psi were applied, and it was found that the sensor did not respond to any of the pressure variations, remaining in an open circuit and triggering the low fuel pressure alarm.

According to the manufacturer, the minimum fuel pressure is 2.2 psi, so when the pressure is above this value, the internal switch should be actuated, and if it falls below this value, the alarm should be activated.

The sensor was opened to check its internal condition, revealing moisture, residue accumulation and corrosion inside.

Figure 10. Interior of the low fuel pressure warning sensor

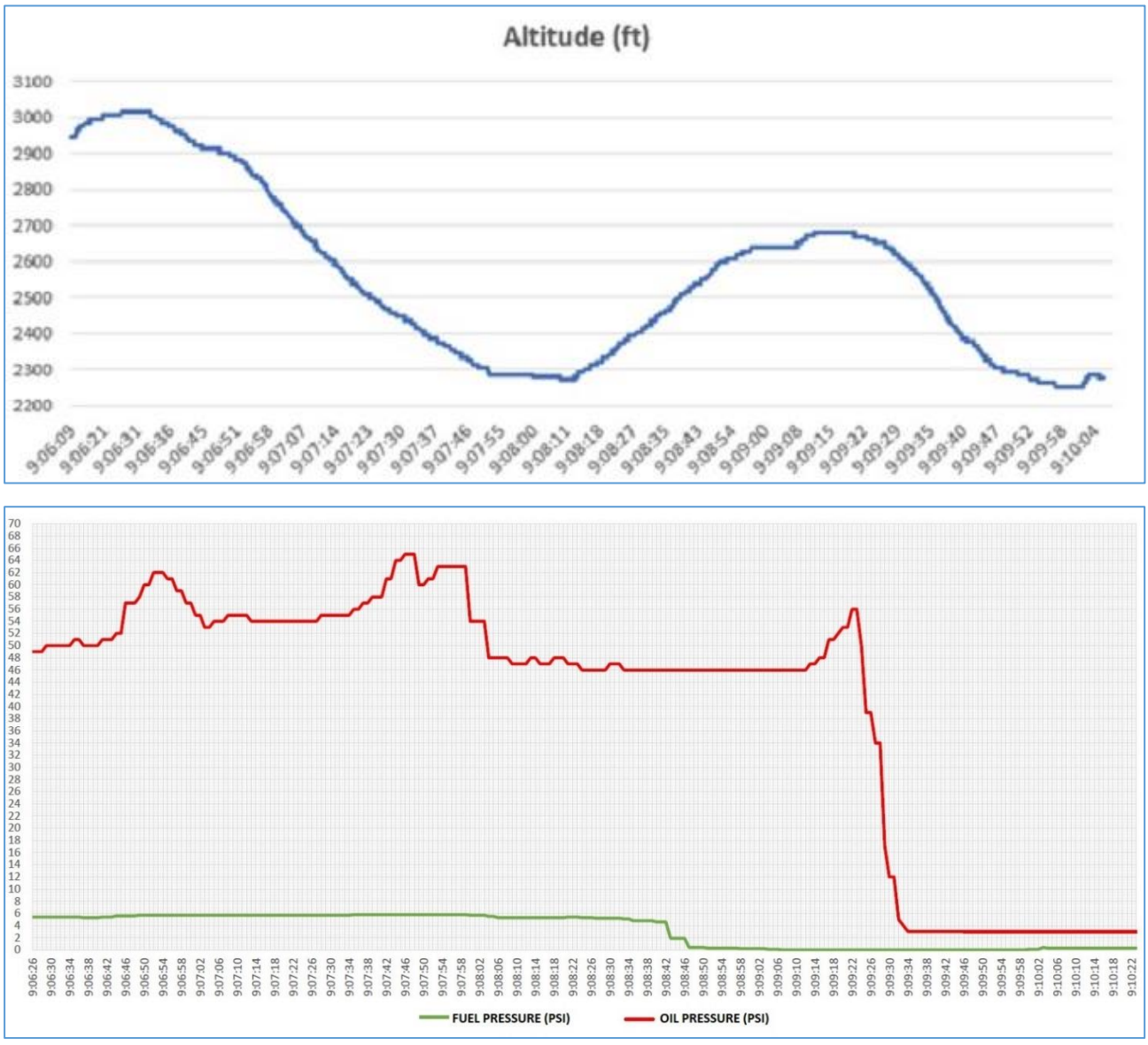
The sensor was found to have a membrane which responds to pressure variations. This membrane moves a plastic actuator, which in turn slides and pushes a metal tab that acts as a switch. This plastic actuator was found to be jammed and could not be moved, leaving the warning device in an open circuit. Consequently, it was determined that the sensor had lost its seal. Cleaning spray was applied to the area around the plastic actuator, and when some of the dirt preventing it from moving was removed, the actuator was released.

The ignition boxes were mounted and tested on another engine, confirming that the ignition was working correctly.

1.16.5 Information provided by Quality Fly

The aircraft had a Garmin G3X device which stores some flight parameters. The graphs in Figure 9, obtained from the data provided by Quality Fly, show the altitude, fuel pressure and electrical consumption values in the flight's last few minutes.

They show that at 11:08:42 h, about 20 seconds before the last communication with the tower, which was cut off, the fuel pressure began to drop to zero during the climb after take-off, and the power consumption also decreased. According to the information obtained, at 11:08:47 h, the low fuel pressure alarm was activated.



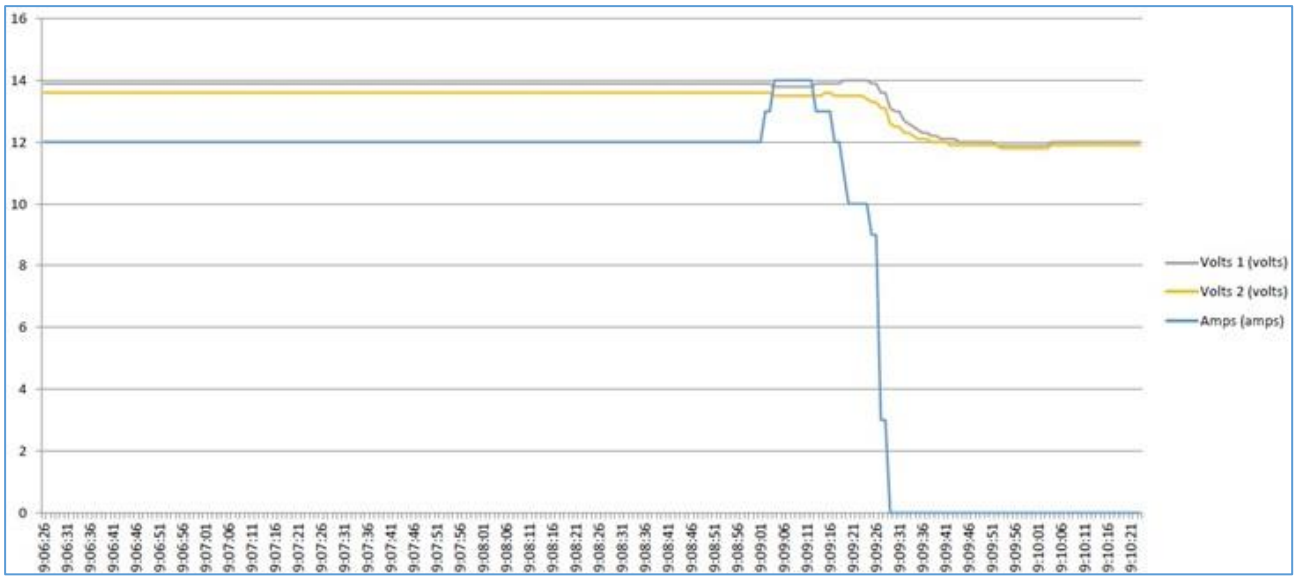


Figure 11. Altitude, fuel and oil pressure, electrical intensity and battery voltages

Quality Fly reported that tests were carried out on another TECNAM P2008 JC aircraft similar to the one involved in the accident to determine possible conditions in which the pressure drops related to an engine shutdown could occur in the fuel system. The results were forwarded to the aircraft manufacturer, but no response was received.

1.16.6 Information provided by the aircraft manufacturer

Through the corresponding accredited representative assigned by the ANSV, Tecnam was provided with the information relevant to the events. The manufacturer was unable to determine the conditions under which a failure similar to the one reported by the crew could occur.

1.16.7 Aircraft model query

The ECCAIRS (European Co-ordination Centre for Accident and Incident Reporting Systems) application was consulted in relation to the TECNAM P2008JC aircraft model, but no information was obtained on cases similar to the one under investigation.

1.17.- Organizational and management information

Quality Fly, S.A. is an approved training organisation with certificate no. E-ATO-197 issued by AESA. Its operational base is Madrid - Cuatro Vientos Airport.

1.18.- Additional information

N/A.

1.19.- Useful or effective investigation techniques

N/A.

2.- ANALYSIS

The aircraft had taken off from Cuatro Vientos Airport for an instruction flight with an instructor and student on board. It returned to Cuatro Vientos Airport 1 h later and requested authorisation to perform landing and take-off manoeuvres. During the climb in the first manoeuvre, at an altitude of 400 ft, the engine sputtered and stalled, and there was a loss of electrical power that affected the transponder and the radio, cutting off the aircraft's communications and causing its radar trace to disappear, at which point the instructor took over the controls. After unsuccessfully attempting to restart the engine, the instructor decided, for safety reasons, not to try to return to the runway and to perform an emergency landing to the south of the airport instead. Despite the landing being correctly carried out, the aircraft flipped over due to the unevenness of the terrain. It must be pointed out that the emergency management by the crew was correct.

The graphs in Figure 9, obtained from the Garmin equipment installed on board, show that while climbing after the take-off, at approximately 11:08:43 h, the fuel pressure dropped sharply to zero, and the alternator stopped providing electrical power, as reported by the instructor.

A subsequent inspection was carried out to try to determine the cause of the engine shutdown and electrical failure experienced. No deficiencies were found in the fuel and electrical systems, and no engine damage was found. The battery was found to be providing electrical power, and there were no signs of short circuits. Some carbon deposits were observed in the cylinders, which were analysed to determine their origin, and several components were disassembled for further testing on a similar engine.

2.1 Analysis of the carbon deposits in the cylinders

When the crankshaft was rotated to check for resistance, it was found that it could only be rotated to a certain degree, after which it jammed. Carbon deposits were found when the cylinder heads were disassembled to check for possible seizure of some of the cylinders. Notably, when the cylinder head of cylinder No. 3 was disassembled, allowing the accumulated residue to move from the top of the chamber to the piston, the piston started

to move normally when the crankshaft was rotated. No further anomalies were observed. It was thus established that no seizure had occurred and that the arrangement and quantity of the carbon deposits on the cylinders did not affect the movement of the crankshaft.

The residues found were analysed in order to determine whether any external contamination had occurred. The analysis showed that they had mainly been formed during the combustion process and were made up of elements that can come from both petrol and oil. No unusual substances were found.

The operator initially used both automotive petrol and leaded AVGAS 100LLL aviation fuel, following the engine manufacturer's instructions to change the oil and filter every 50 h. No combustion defects that could have influenced the formation of carbon were observed. It should be noted that the presence of carbon deposits is common in all combustion engines, but as the manufacturer indicates in the major overhaul manual, if AVGAS 100LL fuel is used, more significant deposits are to be expected.

In terms of whether these deposits could affect the movement of the pistons and, therefore, the functioning of the engine, the manufacturer dismissed this possibility, indicating that the quantity observed was within the normal limits. As a result, a second engine inspection was carried out to try to detect any damage or evidence of failure. During this inspection, the crankshaft and connecting rods were found to be undamaged, and no other deficiencies were identified. It is possible that these deposits could have broken off from the layer formed as a consequence of the accident, and subsequently interfered with the movement of the crankshaft, but they have been ruled out as the cause of the engine failure.

2.2 Check of the condition of pumps, fuel pressure sensors and ignition boxes

No deficiencies were detected in the fuel pumps, pressure sensors and ignition boxes, which all functioned correctly when installed in a test engine.

With regard to the low fuel pressure warning device, although it had lost its seal and had rust and accumulated residue inside, which prevented it from working, it should be noted that on testing the fuel system in the first inspection carried out in the days following the accident, the fuel pressures were correct and no alarm sounded in the cockpit, which indicates that it was working after the accident. It is likely that the condition of the warning device, whose actuator was jammed, was caused by the rust and deposits that accumulated in the period between the accident and the time of the test, some 11 months. It is also likely that had the aircraft continued to operate, the residue would have continued to accumulate inside, and the sensor would probably have eventually failed due to the observed loss of airtightness.

From the information obtained in the inspections and in the tests of the disassembled elements, it has not been possible to determine a cause that determines the failures of the engine and electrical system, and it has not been ruled out that a possible intervention resulted in the battery not energizing the essential systems of the aircraft.

3.- CONCLUSIONS

3.1.- Findings

- Following an engine stall during a landing and take-off manoeuvre, the crew made an emergency landing on a field to the south of the airport, causing the aircraft to overturn.
- The aircraft's tanks contained sufficient fuel for the flight.
- No deficiencies were detected in the fuel and lubrication systems.
- There was no damage to the cylinders, crankshaft or connecting rods.
- The battery was checked and found to have sufficient charge to supply electrical power, with the cockpit displays coming on when the master switch was activated.
- It was noted that the crankshaft could only be partially rotated, and on removing the cylinder head of cylinder No. 3, a build-up of carbon deposits was observed, although this was ruled out as the cause of the engine failure.
- The fuel pumps and ignition boxes were tested on another engine, and no faults were found.
- The low fuel pressure warning device was found to be inoperative at the time of testing, as residue and rust had formed inside it.

3.2.- Causes/contributing factors

The cause of the accident was a loss of control of the aircraft due to uneven terrain while performing an emergency off-field landing, after the engine shut down for unidentified reasons.

4.- SAFETY RECOMMENDATIONS

No recommendations are issued.