DATA SUMMARY

LOCATION

Date and time	**Monday, 14 April 2008; 18:20 local time**
Site	**Valdemaqueda municipal limits (Madrid)**

AIRCRAFT

Registration	**EC-FHZ**
Type and model	**PIPER PA-28R-200**
Operator	**Private**

Engines

Type and model	**LYCOMING IO-360-C1C**
Number	**1**

CREW

Pilot in command

Age	**55 years old**
Licence	**Airline Transport Pilot License ATPL(A)**
Total flight hours	**25,000 h (approximately)**
Flight hours on the type	**Over 4,000 h**

INJURIES

	Fatal	Serious	Minor/None
Crew		**2**	
Passengers		**1**	
Third persons			

DAMAGE

Aircraft	**Destroyed**
Third parties	**Trees**

FLIGHT DATA

Operation	**General aviation – Instructional – Dual**
Phase of flight	**En route – Cruise level**

REPORT

Date of approval	**26 September 2011**

1. FACTUAL INFORMATION

1.1. History of the flight

On 14 April 2008, a Piper PA-28R-200 aircraft, registration EC-FHZ, took off from the Cuatro Vientos Airport at 17:44 to go on a local two-hour training flight. Onboard the aircraft were an instructor and two students, one of whom was in the LH seat in the cockpit. In the flight plan filed, however, only two persons were listed as being onboard the aircraft.

According to the pilot in command's statement, the fuel tanks had been fully refilled prior to takeoff and he had conducted the pre-flight check. During the flight, they proceeded toward El Tiemblo (Avila), after which they planned to continue on to El Escorial (Madrid). During this leg the crew noticed a sudden increase in engine speed and a drop in propeller pitch. The instructor took the controls and tried to keep the engine running, though it eventually stopped. The occupants reported a burnt smell inside the cabin.

When the instructor was unable to restart the engine, he carried out the engine failure procedure and prepared to make an emergency landing. The rough terrain in the area made it impossible to find a suitable field in which to land. Given their low altitude, he headed for a tree-covered hillside where they impacted the top of a large pine tree and fell to the ground. The emergency landing took place at around 18:20. All three occupants were seriously injured.

Emergency services were notified and found the aircraft at 20:05. The occupants were taken to various Madrid area hospitals.

1.2. Damage to aircraft

The aircraft's structure was seriously damaged by the initial impact with the tree and then with the terrain.

1.3. Personnel information

The pilot had valid ATPL(A) and PPL(A) licenses, as well as the proper ratings for the flight in question. He also had a valid Class 1 medical certificate.

The pilot in the LH seat had an expired Private Pilot License PPL(A) and Medical Certificate (Class 1). On the date of the accident he was receiving training to renew his Single Engine Piston rating. It was his first instructional flight.

1.4. Aircraft information

1.4.1. *Airframe*

Manufacturer:	Piper
Model:	PA-28R-200
Production number:	28R-7135127
Registration:	EC-FHZ
Year of manufacture:	1971
Total hours:	7,758 h
MTOW:	1,202 kg
Owner:	Centro Tecnológico Are, S.L.
Operator:	Centro Tecnológico Are, S.L.

1.4.2. *Airworthiness certificate*

Number:	3325
Issue date:	9/06/2005
Expiration date:	7/06/2008

1.4.3. *Maintenance record*

Last inspection:	Date	Hours
50-hour:	30/05/2007	7,673
100-hour	23/08/2007	7,723
500-hour	12/05/2003	7,160

1.4.4. *Engine*

Manufacturer:	Lycoming
Model:	IO-360-C1C
Power:	200 HP
Serial number:	L-7850-51A
Total hours:	7,733 h

Last inspection:	Date	Hours
50-hour:	30/05/2007	7,642
100-hour	23/08/2007	7,694
500-hour	12/05/2003	7,163
Installed:		
• Used	14/11/1991	3,868 TSO

1.4.5. *Propeller*

Manufacturer	Hartzell
Model	HC-C2YK-1B/7666[a]-2
Serial number	1054
Installed	• Aircraft hours: 7,159 h • Date: 24/04/2003

1.4.6. *Background*

The engine installed on the aircraft had been maintained by the same company that owned it under its authorization as maintenance center no. 157.

According to the documentation reviewed, the engine was overhauled on 2 December 1996 with 6,046 h time since new (TSN).

1.5. Communications

ATC services did not register by radio the aircraft emergency. It was the Air Traffic Service Reporting Office (ARO) that informed ATC of the incident, due to an instructor phone call.

However, as per instructor's statement, he communicated the emergency by frequencies 121.5 MHz (Emergency), 118.7 (Cuatro Vientos airport TWR) and 131.97 MHz (usual frequency outside ATZ).

1.6. Wreckage and impact information

Once the engine stopped, the pilot was unsuccessful in starting the engine using the start-up procedure. He then proceeded to conduct an emergency landing. In an effort

Figure 1. View of wreckage

to find a suitable landing area, he made two or three 360° turns, though he was unable to find an adequate field before the airplane lost altitude. He eventually headed for a hillside covered with large trees.

In the final moments of the flight, the aircraft "landed" on a treetop some 15 m off the ground that absorbed most its kinetic energy. The aircraft then fell to the ground on the shore of a stream.

The wreckage did not scatter. The right horizontal stabilizer was damaged, part of the right wing's lower surface was missing (it had become lodged in the tree) and the wing roots had broken.

The on-site inspection revealed that the aircraft was configured for an emergency landing. The most notable aspects noted with regard to the powerplant were as follows:

- The propeller appeared to have impacted the ground at zero rpm's
- Propeller pitch control broken
- Starting gear engaged.
- Gascolator without an internal filter
- Clean oil and filter
- No obstructions in air intake system
- Ignition system working
- The disassembly of the no. 2 cylinder revealed a broken crankshaft.

The Narco Avionics ELT10 emergency beacon, S/N 47680, was not armed and its battery had exceeded its lifetime limit (May 2001).

1.7. Survival aspects

The cockpit did not crush on impact and the safety harnesses fulfilled their design purpose. All of the occupants were, however, subjected to severe trauma. The impact with the treetop as the aircraft approached the ground had a positive effect on the occupants' ability to survive the impact.

As regards the search and rescue efforts, the aircraft was not found until 20:05. Once its occupants were stabilized, they were taken to Madrid area hospitals at around 21:00.

According to the reports from the emergency responders involved, the pilot called the emergency number 112 from the accident site and then the ARO office (Air Traffic Services Reporting Office). Once the initial information regarding the location of the crash site was received, emergency services in the Community of Castilla-Leon were notified. Given the lack of specific information on the location, the search area was expanded and the firefighting service of the Community of Madrid was notified.

The various communications and actions involved also resulted in the following services being activated, in addition to those already mentioned: SAR with a Puma helicopter; SUMMA 112 with a medical helicopter; the National Police, with a helicopter from the Cuatro Vientos base and a military Aviocar from the same base.

Despite the number of aerial resources used, locating the site was hampered by the wide search area in question and by the wooded nature of the terrain which served to conceal the aircraft. In the end, telephone and direct visual contact between the pilot and one of the helicopters aided in locating the downed aircraft.

The hardships described were exacerbated by the lack of positioning information that an ELT would have provided.

1.8. Tests and research

Engine inspection

The workshop inspection of the engine revealed the following:

- broken crankshaft between the central support and the aft part of the no. 2 cylinder crankpin,
- circular crack between the front crankshaft support and the front part of the no. 1 cylinder crankpin,

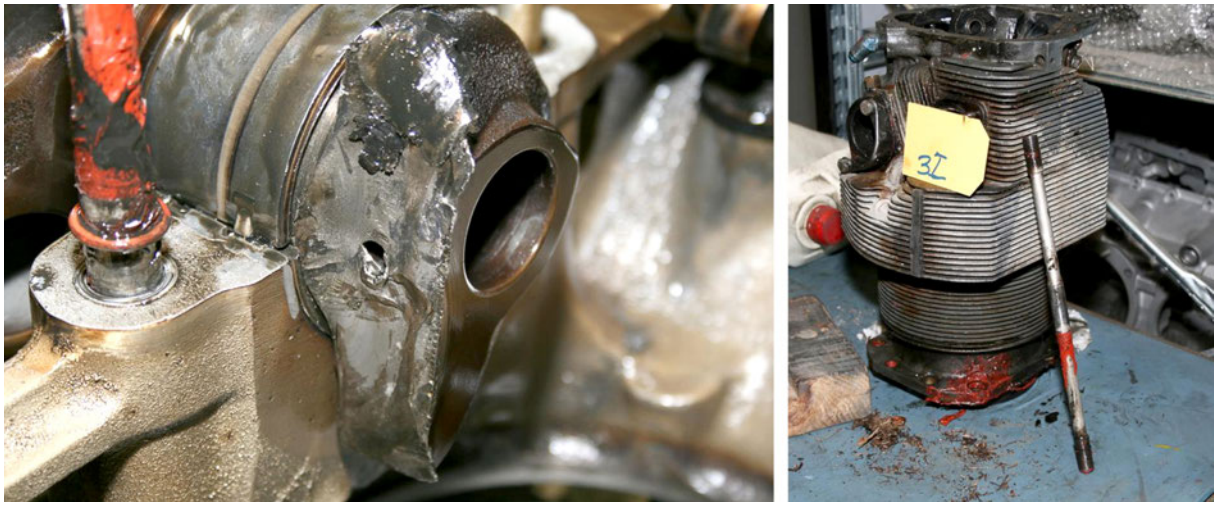

Figure 2. Engine and the no. 3 cylinder

- the central supports of the main crankcases exhibited fretting[1]
- there was an orange coating on the through-studs for the central mount (like a plastic sealant)
- the base of the no. 3 cylinder was covered in a layer similar to that found on the through-studs,
- improper lubricant residue on the crankshaft central support,
- the half bearings from the crankshaft central support were worn from overloading (they were burred),
- the crankcase central support exhibited pile-up[2] due to overloading,
- of the engine's four pistons, the one installed in the no. 3 cylinder was different from the rest and did not correspond to the one installed during the engine's overhaul.

Metallurgical analysis and fracture processof the engine

The damaged components were taken to a materials testing laboratory for a more in-depth analysis of the fractures found in the engine.

The most notable aspects of said analysis were:

- the crankshaft fractured as a result of a simultaneous fatigue process in two areas of the same fracture surface (see Figure 3),
- the presence of several developing fatigue cracks in different sections of the crankshaft,

[1] Roughness or coarseness caused by material wear due to friction.
[2] Upward deformation of a surface that alters the contact plane between two surfaces.

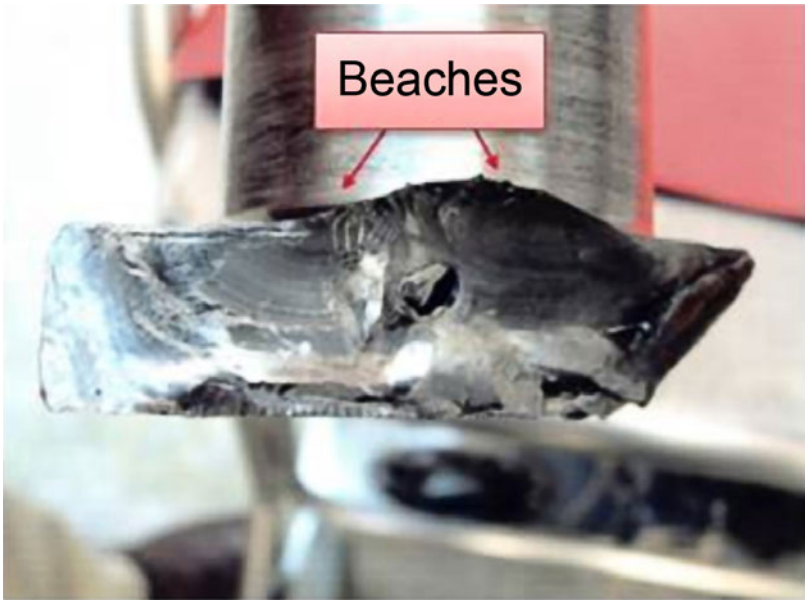

Figure 3. Crankshaft fracture area

- the high loading to which the crankshaft had been subjected was evidenced in the deformations found in the crankshaft's central support and in its half bearings, as shown by:

  – erosion and deformation in the greasing ports, see Figures 4 and 5,

Figures 4 & 5. Deformations in the central half bearing and half casing

  – fretting in the contact area between the two half casings near the central support resulting from repeated relative motion of the contact surfaces under load, see Figure 6,
  – edging on the side surface of the crankcase's central support and on one of the central half bearings.

Figure 6. Close-up of surface on central support

- fatigue cracks in both half casings,
- wear marks between the side faces on the half bearings.

Considerations on the final engine overhaul

According to the engine documentation, it had been in operation for 1,687 h since its last overhaul, which was completed at the authorized maintenance center run by the operator/owner of the airplane.

One of the overhaul documents consulted, the engine run-in deficiency log, had an entry stating that the engine was "losing oil at the base of the no. 3 cylinder" and that the corrective action taken was to "re-tighten the bolts at the base of the no. 3 cylinder".

The post-accident inspection of the engine revealed the presence of abundant sealing material (see Figure 2) in the through-studs and at the base of the no. 3 cylinder (see Figure 3). It was also noted that the new cylinder installed in this position was subsequently replaced by another.

Also of note regarding the engine documentation is the fact that the structural inspections of the critical components, as opposed to what was contained in the report, had been conducted using the liquid penetrant test, as required by Lycoming's Overhaul Manual for all of the ferromagnetic components in its engines.

There is also a contradiction in the dates on the overhaul report since the maintenance center's "Receiving Sheet" indicates the engine as being received on 22/11/1996, though the center's reports for when the pieces were subjected for structural inspections were dated 8/11/1996. It could not be confirmed whether the pieces subjected to

testing were subsequently installed on the engine with serial number L-7850-51A, since the pieces are only identified with a description and a part number, instead of a serial number, even though it is well-known that certain components, such as the crankshaft, do have a serial number.

Other pieces shown on the listing of replaced parts during the overhaul, such as the through-studs, we deemed acceptable after the structural inspection.

1.9. Organizational and management information

The information obtained from Spain's Aviation Safety Agency (AESA) shows that Centro Tecnológico Are, S.L., is authorized to provide Private Pilot License classes from 08/06/2001 until 08/04/2012.

As a maintenance organization, the company is currently authorized, since 20/08/2010, to carry out tasks pursuant to Part M Subpart F. It is currently in the process of providing the necessary documentation to obtain approval as a CAMO (Continuing Airworthiness Maintenance Organization).

2. ANALYSIS

2.1. General

The aircraft was conducting a visual flight in the foothills of the Guadarrama mountains, at the southwestern edge of the province of Madrid, bordering on Segovia.

According to the pilot's account, while in flight, the engine suddenly sped up and the propeller pitch dropped. The actions taken did not keep the engine from stopping.

The flight instructor then carried out the in-flight engine stoppage procedure and prepared for an emergency landing. The rough terrain made it difficult to find a suitable landing area. The pilot tried to reach a hillside he had spotted but was unable to reach it. The airplane impacted a treetop, which absorbed its descent momentum, before falling to the ground.

All three occupants suffered serious injuries.

2.2. Considerations on the rescue of the aircraft's occupants

The terrain where the aircraft fell, though accessible, was in a wooded area that impeded direct visual contact from the air. The availability of a cellular telephone and cellular coverage was instrumental to locating the site.

The event gives rise to two considerations: the time to locate the site and the coordination of the rescue teams.

In terms of the first, the time required to locate the site was prolonged beyond that theoretically necessary due to the following:

- The emergency beacon did not work because it had not been properly maintained (this same consideration was analyzed in report A-043/2008, which included the following Safety Recommendation[3]).
- The radio emergency issued by the pilot was not received by ATC services, due to the short range of the VHF equipment and the orographic features of the terrain the pilot was flying. It prevented him from knowing the approximate landing zone.

With regard to the second item, the facts ascertained reveal that the rescue teams belonged to different services and organizations, including a total of six aerial services, possibly due to two circumstances: a lack of coordination and an excessive desire to find the accident site.

In relation to the above, CIAIAC report A-031/2006 included a Safety Recommendation (REC 02/10)[4] that was applicable to this case.

2.3. Analysis of the metallurgical study and fracture process of the engine

The results of the study show that the crankshaft broke as the result of excessive bending loads originating in the central half bearing, which was mounted outside of its positioning tabs, specifically, toward the front of the engine. This, in turn, resulted in the greasing stub becoming lodged in the surface of the central half bearing.

As a consequence, the crankshaft journal, which is alongside the central support, shifted, leading to its misalignment with respect to the other two supports, causing increased bending loads on the crankshaft. The additional loads, then, in conjunction with the probable appearance of vibrations and increased loads on the half casing mounts, incubated the various cracks discovered during the inspection.

[3] REC 08/11: It is recommended that Spain's Aviation Safety Agency (AESA) use the Airworthiness Review (AR) process, whether conducted by AESA itself or by duly authorized Continuing Airworthiness Management Organizations (CAMOs), to ensure that a check is made of the correct operation and coding of Emergency Locator Transmitters (ELT).

[4] "So as to ensure accurate coordination between various emergency services, it is recommended that both the Interior Ministry's Civil Protection Agency and Emergencies Directorate and the Ministry of Defense's Air Force ensure that the 112 Emergency Response Service of the various Autonomous Communities and Search and Rescue Services (SAR) consider informing and communicating with the other(s) of those aircraft accidents to which they respond."

2.4. Analysis of the overhaul prior to the accident

As noted in Section 1.8, the entries in the engine run-in deficiency log already indicated that this engine was "losing oil at the base of the no. 3 cylinder" and that the corrective action taken was to "re-tighten the bolts at the base of the no. 3 cylinder". This action, while seemingly correct, contradicts Lycoming's indications in its Service Instruction no. 1290E, "Repair of Oil Leakage at Crankcase Thru-Stud Location".

The post-accident engine inspection also revealed the presence of excessive sealing material over the length of the through-studs, as a result of attempting to seal the stud holes, and at the base of the no. 3 cylinder. It was also noted that this same cylinder was installed new during the overhaul and was subsequently replaced.

All of these circumstances confirm the fact that over the course of its operating lifetime, this engine showed some leaks, which was located in the general area of the base of the no. 3 cylinder and not to the faulty installation of the half bearings, as was concluded by the metallurgical study, apart from consuming oil.

The aforementioned actions indicate that the engine overhaul procedures were not properly executed and that the maintenance actions that followed from that point until the time of the accident was also inadequate and not in keeping with the engine manufacturer's recommendations. In summary, procedures were either lacking or were not adhered to.

Also of note is the fact that the Authority's repeated renewals of the airworthiness certificate did not detect the deficient maintenance practices carried out on the engine, as was made apparent by the presence of the sealing material.

As a result, this report includes two safety recommendations, one for the Centro Tecnológico Are, S.L., to update or implement maintenance procedures that ensure proper maintenance and adhere to the manufacturer's indications, and the other for Spain's Aviation Safety Agency to ensure that the aforementioned procedures are suited to the maintenance tasks involved.

3. CONCLUSION

3.1. Findings

- The instructor was properly licensed for the flight.
- The aircraft had a valid Airworthiness Certificate.
- The engine stopped during the flight.
- The crankshaft broke as the result of a fatigue process.
- The fatigue process was a consequence of the improper installation of the crankshaft's central support half bearings.

- The maintenance procedures performed during the overhaul did not conform to the manufacturer's approved methods.
- The periodic maintenance tasks performed after the overhaul did not attempt to find and correct the cause of the oil leak noted from the no. 3 cylinder, but rather to alleviate the leak.
- No safety-related issues were detected during the Airworthiness Certificate renewal process begun after the overhaul.
- The aircraft's emergency beacon was inoperative due to a lack of maintenance.
- The resources used to locate and rescue the aircraft's occupants were not properly managed or coordinated.

3.2. Causes

The accident was caused by the in-flight fracture by fatigue of the crankshaft as the result of the improper installation of the central support half bearings.

Other relevant factors that contributed to the eventual fracture were the improper practices during the engine overhaul and the subsequent maintenance tasks that were performed.

4. RECOMMENDATIONS

REC 43/11. It is recommended that Centro Tecnológico ARE, S.L., review and update its aircraft maintenance procedures, and in particular that said procedures reflect the methods approved by the aircraft and/or component manufacturers.

REC 44/11. It is recommended that Spain's Aviation Safety Agency (AESA) ensure that the maintenance procedures of Centro Tecnológico ARE S.L., are appropriate for the level of authorized maintenance.