DATA SUMMARY

LOCATION

Date and time	**Monday, 11 April 2011; 14:00 local time**
Site	**Mijares (Ávila, Spain)**

AIRCRAFT

Registration	**SP-SUH**
Type and model	**PZL W-3A, PZL W-3AS**
Operator	**LPU Heliseco Ltd.**

Engines

Type and model	**PZL-10W**
Number	**2**

CREW

	Pilot	Flight Engineer
Age	**52 years old**	**59 years old**
Licence	**ATPL(H)**	**FEL (Flight Engineer License)**
Total flight hours	**7,564 h**	**1,200 h**
Flight hours on the type	**2,955 h**	**1,200 h**

INJURIES

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

DAMAGE

Aircraft	**Minor**
Third parties	**None**

FLIGHT DATA

Operation	**General aviation – Other – Test**
Phase of flight	**En route – Cruise**

REPORT

Date of approval	**28 November 2012**

1. FACTUAL INFORMATION

1.1. History of the flight

On 11 April 2011, a PZL W-3AS aircraft, registration SP-SUH, took off from the aerodrome in La Iglesuela (Toledo) on a post-maintenance test flight. Over the course of the flight, the two crewmembers heard a strange noise coming from the area of the engine and then saw smoke filling the cockpit. The crew decided to make an emergency landing on a road, which was the most suitable place they could find. They were able to land without further incident and without any personal injuries.

When they exited the helicopter they saw smoke and fire issuing from the air intake system on the engines, which they proceeded to extinguish with the onboard extinguishers.

A subsequent inspection of the aircraft revealed that several components on the engine's air intake cooling system were broken, causing a misalignment with respect to the axis of rotation. This resulted in friction inside the intake, which caused the smoke and fire.

1.2. Personnel information

1.2.1. *Pilot*

Age:	52 years old
Nationality:	Polish
Flight license:	ATPL(H) • Initial issue date: 05/04/2006 • Expiration date: 01/05/2011
Medical certificate renewed on:	21/12/2010
Medical certificate valid until:	16/12/2011
Valid ratings and date issued:	• TR Mi2, 11/01/2012 • TR W-3 Sokol, 01/05/2011 • FI, 01/10/2012 • TRI Mi2, 01/10/2012 • TRI W-3 Sokol, 01/06/2013 • AGRO (agricultural spraying), 11/01/2013 • FFF (firefighting), 11/01/2012

1.2.2. *Flight mechanic (Non JAR-FCL)*

Age:	59 years old
Nationality:	Polish

Flight license:	FEL (Flight engineer license)
	• Expiration date: 19/05/2014
Valid ratings and date issued:	W-3 Sokol, 15/10/2011

1.3. Aircraft information

Manufacturer:	WSK PZL Swidnik
Model:	PZL W3AS
Serial number:	310205
Year of manufacture:	1988
Airworthiness certificate number:	DLR/10/083, valid until 19 May 2011
Left engine:	PZL-10W, S/N: 119904031AS
Right engine:	PZL-10W, S/N: 119894020AS
Dry weight:	3,850 kg
Maximum takeoff weight:	6,400 kg
Airframe hours:	3,107 h

1.3.1. *Maintenance records*

According to the maintenance program, the aircraft's maintenance intervals are every 25, 50, 100, 300 and 600 h and every 12 and 24 months.

The last tasks performed were part of the 25-, 50-, 100- and 300-hour inspections. This work took place between 21/02/2011 and 11/04/2011. Once completed, a test flight was required in order to issue the return to service certificate.

Periodic inspection	Date	Airframe hours
25 h	11/04/2011	3,107 h
50 h	11/04/2011	3,107 h
100 h	11/04/2011	3,107 h
300 h	11/04/2011	3,107 h
600 h	20/05/2010	2,931 h
1,500 h	20/05/2010	2,931 h

Among the maintenance tasks performed, the 300-hour inspection included a check of the alignment of the fan drive shaft on the system, a check of the fan blades and of the coupling nuts. The 100-hr and/or annual inspection also includes lubricating parts of the air intake cooling system.

1.3.2. *Accessory cooling system*

The purpose of the accessory cooling system is to direct atmospheric air to those helicopter accessories that require forced cooling, to the heating system and to the ventilation or air conditioning system (Figure 1).

1.3.2.1. General description of the system

The accessory cooling system consists of a cooling fan with a diffuser and a system for distributing cooling air. Figure 2 shows the cooling assembly with the diffuser.

The function of the fan is to force outside air to flow through the oil coolers toward the accessory cooling system. The fan is turned by a drive shaft (A) that is connected to the rotor shaft on the fan itself (B).

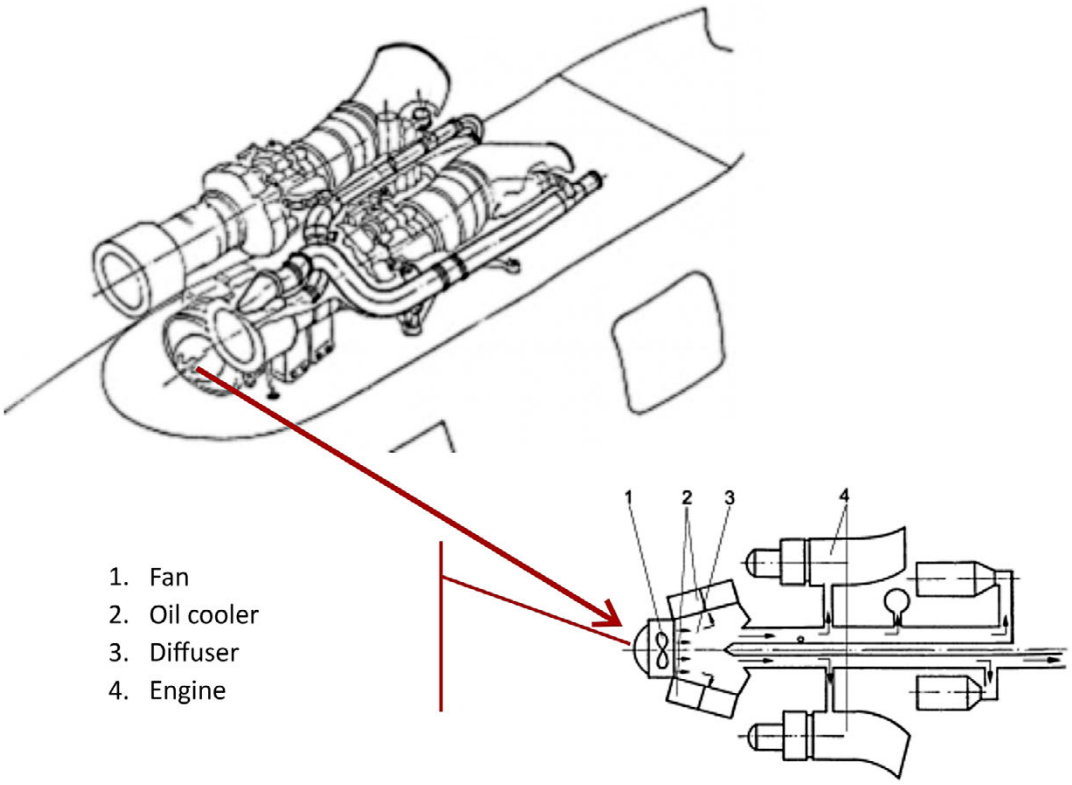

Figure 1. Accessory cooling system

The fan has two assemblies, one for the air inlet (assembly 1) (C) and one for the air outlet (assembly 2) (D). These two assemblies are connected to each other. Assembly 1 features discs with guide blades for channeling the air, while assembly 2 comprises the structural part of the fan and is attached to the fuselage by way of a strut. A diffuser (E) is attached to assembly 2 to force the cooled air through the distribution system.

The axis (B) of the fan rotor (F) turns on two bearings in the air outlet assembly. The front bearing is of the roller type (G), while the aft one is a bearing sleeve (H). The rotor shaft and the bearings are sealed using felt gaskets and labyrinth seals inside a sealed conduit which allows for lubrication.

The aft end of the rotor shaft (B) is joined to a coupling (I) that doubles as a clutch and allows it to be connected to the drive shaft (A) that turns it. The coupling between the two shafts is designed to withstand a certain amount of longitudinal and transverse motion.

The lubrication system consists of a grease nipple (J) and a conduit that is used to direct the lubricant to the fan rotor shaft. Excess grease exits through two orifices[1] that serve to check that the filling is completed with new grease.

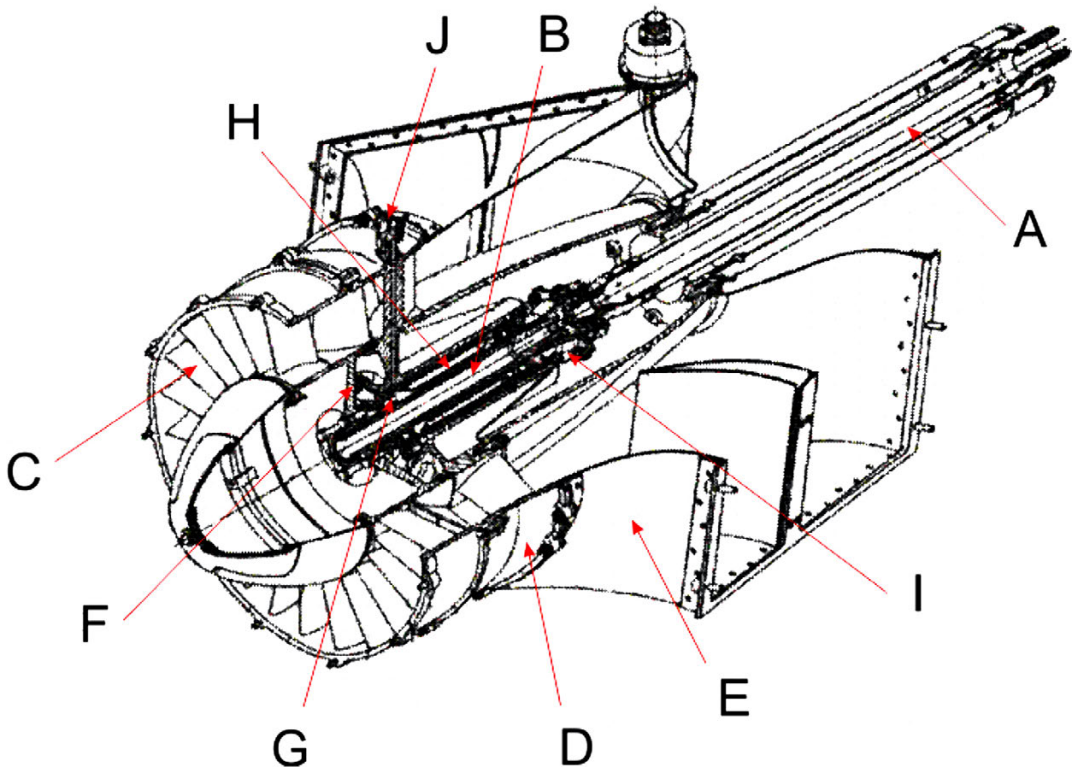

Figure 2. Fan and diffuser

[1] The two checking orifices on the fan rotor shaft are located at the front and rear of the shaft. The one in the rear is not visible during lubrication operations.

1.3.2.2. Lubrication of fan bearings

The procedure for lubricating the fan bearings is described in work sheet 37.10-1 of the Maintenance Manual. The instructions state to apply grease to the grease nipple (J) using a grease gun and then to check that the new grease issues from the inspection hole located at the front of the rotor shaft.

Section 12.20.00 of the same manual lists the type of grease that can be used and the lubricating frequency. The maintenance center used Grease 15 with a lubricating interval of 100 h or 12 months, as specified in the Maintenance Manual.

1.4. Tests and research

Under the supervision of Poland's State Commission on Aircraft Accident Investigation (SCAAI), the components of the affected fan, P/N: 2-6351-00 s. III, S/N 88048, were sent to the aircraft manufacturer (PZL Swidnik, S.A.) in coordination with the fan manufacturer (WSK Kraków Sp. Z o.o.) to determine the cause of the fracture of the fan's drive shaft.

The findings of the investigation and its conclusions are summarized in the paragraphs below.

1.4.1. *Visual inspection*

The fan drive shaft was fractured with its casing. Both had been affected by the temperature and by the torsional stress produced by the rotation of the shaft (Figure 3, A). The appearance of the aft bearing area on the rotor shaft that attaches to the clutch coupling (I) showed this to be the source of the highest temperatures (Figure 3, C).

The remains of burned grease were found inside the fan (Figure 3, B), and there were dents on the outer case that contains the lubricating grease for the bearings, see Figure 4. The lubricating grease in the clutch was also burned.

The rotor blade tips were found to have contacted the perimeter of the air conduit (Figure 3, D). They also rubbed against the outside of the stator stage aft of the rotor.

When the bearings were disassembled, damage was found to the roller cage components, the balls and the bearing seals.

Figure 3. Close-up of the fan components

Figure 4. Dents in the outer case

1.4.2. *Test conducted on the fan components*

The conditions of the clutch (component I in Figure 2) and the drive shaft (component A in Figure 2) were evaluated. The extent to which some of the clutch components

(cadmium) had melted and the color of the drive shaft material (aluminum alloy) indicated that they had been subjected to temperatures ranging from 320 °C to 766 °C.

Surface hardness tests were also conducted on various steel components from the clutch and the bearing race and balls, as well as on the aluminum material (PA7) on the drive shaft. Comparing these results to the nominal values showed that, on average, they were subjected to temperatures of around 600 °C for some 10 minutes. Likewise, the variation in the surface hardness of the drive shaft material showed that the highest temperature reached was about 490 °C, with a transition area of some 200 °C. The heat source was determined to have originated from the direction of the aft bearing on the rotor shaft.

Once the shaft was reconstructed and verified to meet the manufacturer's standards for this component, the values for the drive shaft were confirmed with a functional test that simulated the conditions to which the shaft was subjected.

Other tests were conducted to determine the effect that the grease pressure used during lubrication, the type of lubricant used, the condition of the grease and the grease gun had on the dents found on the outer case of the rotor shaft. These tests were carried out in accordance with the fan manufacturer's standards on the original fan components, except for the damaged parts.

The pressure at which the lubricant was applied was monitored during one of the tests, which revealed that at a pressure of 20 bars, the new grease issued from both check lubricating orifices. Subsequently, when the assembly was subjected to dynamic lubrication, internal pressures of approximately 50 bars were reached that caused denting of the outer case of the rotor shaft, and degraded the joints and rings that comprise the bearing seals. It even caused detached material to clog the check orifices.

1.4.3. *Causes of the failure*

The findings from the tests concluded that the failure resulted from the high grease pressure used during the lubrication of the aft bearing on the fan rotor shaft, causing it to malfunction. The internal damage caused to the bearing led to high friction inside said bearing, resulting in temperatures that, with prolonged operation, reached a value of around 600 °C. This caused the lubricating grease under the fan cover to combust and the clutch grease to ignite.

The temperature reached in the ensuing fire caused the aluminum alloy in the drive shaft to reach its melting point (between 490 and 500 °C) such that the strength of the shaft decreased by up to six times in the fracture area. This effect was exacerbated by the torsional stress to which the drive shaft was subjected.

1.4.4. *Findings and proposed measures*

The inspection conducted by the working group led to the following conclusions and actions.

1.4.4.1. Test findings

- The fan is constructed in such a way that the front bearing can easily be checked for lubrication, since the forward telltale orifice can be accessed by removing the front cover on the air intake assembly. The check orifice for the aft bearing, however, is inaccessible during greasing operations. This lack of accessibility means that if the aft orifice is clogged, an excessive amount of grease may be forced into the bearing.
  In addition, the graphite seals on the fan rotor do not allow for a full adjustment of the area between the rotor shaft and the bearings, meaning any excess grease flows toward the outside of the rotor housing.
- Grease 15 is the lubricant recommended by the fan and helicopter manufacturer, and was the type used by the operator. This grease breaks down into two components: oil and a high-density base component[2]. Based on the tests conducted, given the high density of the grease, the components that comprise the seal between the rotor and the bearings can warp if it is applied at pressures of around 50 bars.
- The references made to lubricating the fan in the manufacturer's documentation and in the helicopter Maintenance Manual revealed that:

  – There is no consensus regarding the type of lubricant (grease) used, since the Maintenance Manual allows the use of several types.
  – The action of injecting grease until it issues from the chek orifices cannot be performed by the maintenance technician since one of the orifices is not accessible, except by the manufacturer.
  – Work sheet 37.10-1 in the Maintenance Manual does not specify what action to take if the helicopter is out of service for an extended period and only offers brief lubricating instructions.
  – The same work sheet also does not specify the amount of grease to inject.
  – There is no exact equivalence between the greases listed in the helicopter Maintenance Manual (Chapter 12.20.00) for use in the fan rotor bearings and those referenced by the fan manufacturer.

1.4.4.2. Proposed measures

The working group consisting of Poland's State Commission on Aircraft Accident Investigation (SCAAI), the aircraft manufacturer, PZL Swidnik, S.A., the fan

[2] This dissociation was observed in the grease gun used by the maintenance center and in the container with new grease supplied by the fan manufacturer.

manufacturer, WSK Kraków Sp. Z o.o and the operator proposed the following measures:

- As regards the construction of the fan:

  – Consider the possibility of modifying its construction to allow checking the aft check orifice when lubricating the fan.
  – Consider the possibility of changing the graphite-felt seals to another type that provides greater damage resistance.

- As regards the lubricant used to lubricate the fan:

  – That Grease 6 be the base lubricant recommended for civil use helicopters. The recommendation is to be implemented in the fan and helicopter manufacturers' documentation.

- As regards the fan lubrication records contained in the fan's documentation and in the helicopter's documentation, the work sheet is to include aspects such as:

  – Determine the lubrication pressure,
  – Implement the lubrication pressure control,
  – The specific amount of grease needed to ensure lubrication,
  – A process for lubricating the fan after the helicopter is out of service and after the fan is placed in storage for an extended period of time,
  – Expand the period for lubricating the fan installed on helicopters that are flown regularly (currently done every 100 h).

2. ANALYSIS AND CONCLUSIONS

2.1. General

Once the work associated with the 25-, 50-, 100- and 300-hour inspections was completed, the aircraft was taken on the test flight that is procedurally required before its return to service.

Over the course of the flight, the crewmembers heard a strange noise coming from the engine area and saw smoke filling the cockpit. The crew decided to perform an emergency landing, which was completed without further incident.

An initial inspection of the aircraft revealed that the accessory cooling system (Figure 1), specifically the fan, was damaged and exhibited the effects of the fire. A more detailed inspection was conducted later by a working group consisting of, among others, technicians for the aircraft and fan manufacturers, the findings of which are summarized in Section 1.4 of this report.

2.2. Findings and cause of the failure of the cooling system fan

In order to determine the cause of the malfunction in the accessory cooling system, the components of said system that were damaged in the event were tested and a series of functional and material tests scheduled in an effort to find the origin of the failure and the process that led to the fracture of the fan drive shaft.

As noted in Section 1.4, the analysis of the results concluded that the failure occurred due to the malfunction of the aft bearing on the fan rotor shaft, resulting from the high grease pressure to which it had been subjected during the lubricating operation. The internal damage to the bearing caused friction in the bearing and, as a consequence, a gradual increase in temperature over the course of operations that ended with the fracture of the drive shaft.

The experiments carried out, however, also underscored the important aspects discovered as a result of these tests, as detailed in Section 1.4.1.1, most notably:

- That the construction of the fan impedes proper access to verify the lubrication of the aft bearing on the rotor shaft or any other problems that may be present during or after the greasing.
- That the characteristics of the recommended lubricant (Grease 15), which was used in the tests, can cause degradation of the sealing elements and of the parts to be lubricated.
- That certain aspects of the documentation detailing the task of lubricating the fan can be improved, such as the type of lubricant used, how to monitor the amount of lubricant to be applied, addressing the impossibility of having the maintenance technician verify the lubrication of the aft bearing and improving work sheet 37.10-1 in the aircraft Maintenance Manual.

2.3. Measures proposed

The technicians representing the aircraft manufacturer, PZL Swidnik, S.A., and the cooling system manufacturer, WSL Kraków Sp. Z o.o, who took part in the investigation proposed the corrective actions mentioned in Section 1.4.4.2.

In light of the documentation supplied to investigators, this Commission is of the opinion that the corrective actions proposed for PZL W-3AS are adequate, and thus includes three Safety Recommendations directed at the following parties: the Civil Aviation Authority of Poland, as the country of manufacture and registration of the aircraft; the aircraft manufacturer, PZL Swidnik, S.A., and the manufacturer of the fan, WSK Kraków Sp. o.o. To the former, that it ensures the implementation of the corrective actions proposed as a result of the investigation into the incident involving the PZL W-3AS aircraft, registration SP-SUH, in Spain, and to both manufacturers, that they develop and implement said proposed corrective measures.

3. SAFETY RECOMMENDATIONS

REC 97/12. It is recommended that the aircraft manufacturer, PZL Swidnik, S.A., carry out the actions detailed below involving the PZL W-3AS aircraft and proposed in the wake of the investigation into the cooling system fan on said aircraft:

- As regards the construction of the fan:
  - Consider the possibility of modifying its construction to allow checking the aft telltale orifice when lubricating the fan.
  - Consider the possibility of changing the graphite-felt seals to another type that provides greater damage resistance.
- As regards the lubricant used to lubricate the fan:
  - That Grease 6 be the base lubricant recommended for civil use helicopters. The recommendation is to be implemented in the fan and helicopter manufacturers' documentation.
- As regards the fan lubrication records contained in the fan's documentation and in the helicopter's documentation, the work sheet is to include aspects such as:
  - Determine the lubrication pressure,
  - Implement the lubrication pressure control,
  - The specific amount of grease needed to ensure lubrication,
  - A process for lubricating the fan after the helicopter is out of service and after the fan is placed in storage for an extended period of time,
  - Expand the period for lubricating the fan installed on helicopters that are flown regularly (currently done every 100 h).

REC 98/12. It is recommended that the fan manufacturer, WSK Kraków Sp. Z. o.o, carry out the actions detailed below involving the fan on the cooling system on PZL W-3AS aircraft and proposed in the wake of the investigation into the cooling system fan on said aircraft:

- As regards the construction of the fan:
  - Consider the possibility of modifying its construction to allow checking the aft telltale orifice when lubricating the fan.
  - Consider the possibility of changing the graphite-felt seals to another type that provides greater damage resistance.

- As regards the lubricant used to lubricate the fan:

  – That Grease 6 be the base lubricant recommended for civil use helicopters. The recommendation is to be implemented in the fan and helicopter manufacturers' documentation.

- As regards the fan lubrication records contained in the fan's documentation and in the helicopter's documentation, the work sheet is to include aspects such as:

  – Determine the lubrication pressure,
  – Implement the lubrication pressure control,
  – The specific amount of grease needed to ensure lubrication,
  – A process for lubricating the fan after the helicopter is out of service and after the fan is placed in storage for an extended period of time,
  – Expand the period for lubricating the fan installed on helicopters that are flown regularly (currently done every 100 h).

REC 99/12. It is recommended that Poland's Civil Aviation Authority ensure that both the manufacturer of the aircraft, PZL Swidnik, S.A., and the manufacturer of the fan, WSK Kraków Sp. Z o.o, implement the corrective actions proposed as a result of the investigation into the incident involving the WSK PZL Swidnik W-3AS aircraft, registration SP-SUH, in Spain.