THE DUTCH SAFETY BOARD

GENERAL INFORMATION

Identification number:	2007088
Classification:	Serious incident
Date, time[1] of occurrence:	11 September 2007, 18.57 hours
Location of occurrence:	Near Stolwijk
Aircraft registration:	PH-SVT
Aircraft model:	Apex Robin DR400/135CDi
Type of aircraft:	Single engine propeller aircraft
Type of flight:	Training flight
Phase of operation:	Landing
Damage to aircraft:	Severe damage to engine
Cockpit crew:	Two
Passengers:	One
Injuries:	None
Other damage:	None
Light conditions:	Daylight

SUMMARY

While conducting a training flight the crew was forced to make an emergency landing in a field due to an engine failure. The aircraft sustained damage to the engine and the crew was unhurt.

This report is based on information provided by the pilot, the investigation report of the Aviation Department of the Dutch National Police Force, and information gathered by the German Federal Bureau of Aircraft Accident Investigation (Bundesstelle für Flugunfalluntersuchung).

FACTUAL INFORMATION

Description of the incident

The student pilot and instructor where conducting a training flight under visual flight rules. After flying from Rotterdam Airport to Hoogeveen Airport several emergency landings were practiced on the return flight in the practice area near Stolwijk. While preparing for the final emergency landing exercise, flying around 1300 feet altitude, the instructor noticed a drop in engine revolutions (RPM). The engine power was insufficient to maintain level flight. The engine failure emergency procedure was carried out by the instructor but did not result in regaining engine power. He reported the engine failure to air traffic control and made a successful emergency landing in a field near Stolwijk.

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1 All times in this report are local or it is noted when different.

Figure 1: PH-SVT after the emergency landing with the engine cover removed for investigative purposes

Aircraft and engine

The Apex Robin DR400/135CDi is a four-seater aircraft and equipped with a Thielert TAE 125-01[2] diesel engine. The engine has been designed to operate using Jet A1 fuel, which has similar properties compared to diesel fuel. The aircraft is equipped with a singular power lever, allowing the pilot to adjust power by using only one handle, without the need to adjust propeller pitch, fuel mixture or other engine parameters.

The engine and propeller are electronically controlled and regulated by a digital Full Authority Digital Engine Control[3] (FADEC) unit. The FADEC is equipped with two independent engine control units (ECU)[4], distinguished as ECU-A and ECU-B. Under normal conditions the engine is controlled by ECU-A, the ECU-B being redundant. By manipulating a switch, the ECU control can be selected by the pilot to automatic or manual. Standard selection is automatic, resulting in the engine being controlled by ECU-A. If the monitoring system within the FADEC detects a failure, ECU-B will take over control automatically. ECU-B also may be selected by the pilot manually. The FADEC includes a failure and data recording system, which may be utilised for engine trouble shooting. The data also may be downloaded after flight, for analysing purposes.

The pilot

The instructor possessed a valid Airline Transport Pilot License (ATPL(A)) with the ratings instrument flying multi engine (IR-ME(A)), flying instructor (FI(A)), and radiotelephony (RT). He was qualified to fly with piston engine aircraft (SEP(land) and as a captain on a Boeing 737-300/900. He possessed a valid medical certificate.

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[2] The TAE 125-01 engine is a liquid cooled, four cylinder in line, four-stroke common-rail diesel engine with a turbo compressor.

[3] Full Authority Digital Engine Control is a system utilising a digital computer, engine control units (ECU's) and accessory components for a complete aircraft power plant control.

[4] Engine Control Unit, a digital control unit determining the required output signals for engine control on the basis of input signals received from the engine sensor.

INVESTIGATION AND ANALYSIS

For the investigation FADEC data was downloaded for analysis. Careful inspection of the engine revealed there was an oil leakage. Oil was visible near the main engine block.

Analysis of FADEC data

FADEC data analysis showed the engine was started at 17.47 hours and the engine parameters at that time were within limits. At 17.52 hours an engine check was performed and ECU-B automatically selected to control the engine for five seconds.

At 17.57 hours full power (load 100%) was selected and the aircraft took off. Three minutes later the aircraft reached an altitude of approximately 1400 feet.[5] In figure 2 a graph is plotted of the barometric pressure and the altitude against the time.

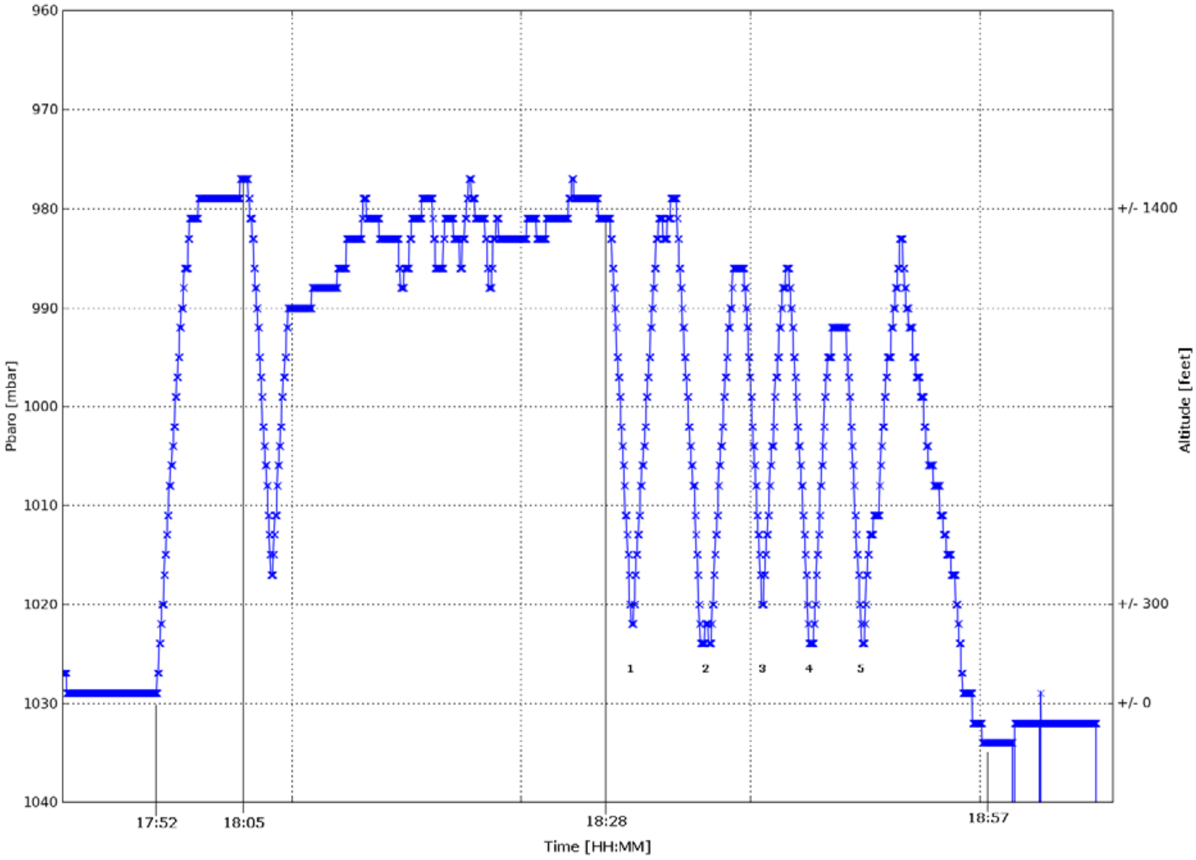

Figure 2: the barometric pressure (Pbaro) and altitude during the flight

At 18.05 hours a descent was made from 1400 feet to approximately 300 feet. Starting from 18.28 hours the barometric pressure showed five descents with the engine at idle (load 0 %). After each of these descents a load of 100% was selected and the altitude increased to approximately 1000 till 1400 feet.

At 18.49 hours a climb with 100% load was ongoing. At 18.52 hours an oil pressure of 5286 mbar was recorded, which exceeded the limit of 5200 mbar, prescribed by the manufacturer. See figure

5 Altitudes in this report are calculated using recorded barometric pressure (Pbaro) and barometric pressure on the ground.

3. Next the pressure dropped to below 5200 mbar and five seconds later the recorded oil pressure was 6133 mbar. After this the oil pressure continued to drop to 2865 mbar. A few seconds later the oil pressure stabilized between 5000 and 5200 mbar.

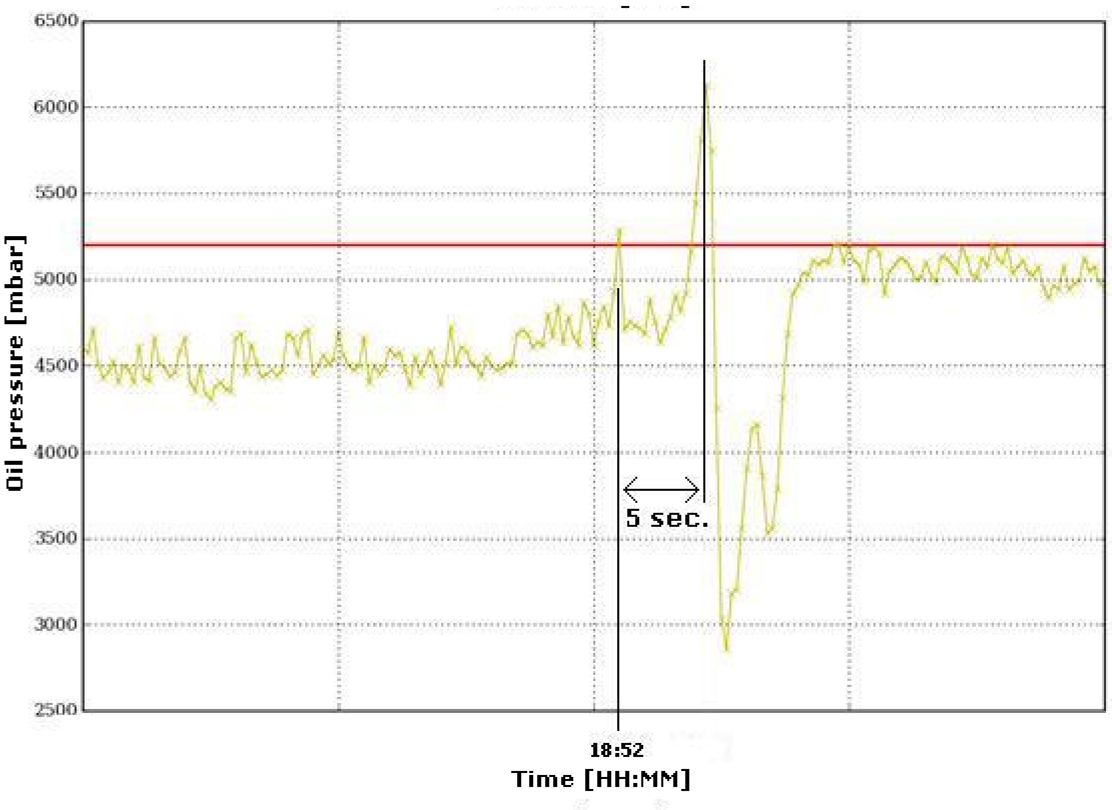

Figure 3: oil pressure (yellow) and the limit specified by the manufacture (red)

After the oil pressure spike and drop the manifold pressure (MAP) and engine revolutions (RPM) did not return to the previous stabilized limits. The RPM settled below 2000 RPM and declined over a period of time. The MAP stabilized at approximately 1500 mbar. Both the MAP and RPM indicated that a load of 60% was produced, however a load of 100% was selected. At 18.55 hours the FADEC recorded a switch to ECU B but no changes in engine parameters were recorded. The barometric pressure increased over time and at 18.57 hours a barometric pressure of 1034 mbar was recorded when the aircraft was on the ground and the engine shutdown.

No FADEC warnings were recorded during the time of the incident. Following the FADEC analysis it was decided to remove the engine from the aircraft and send it to the engine manufacturer in Germany for further examination.

Engine teardown and component testing at manufacturer Thielert Aircraft Engines GmbH (TAE)
The teardown inspection was performed on November 12th 2007 at TAE facilities in Germany. An investigator from the Bundesstelle für Flugunfalluntersuchung was present. The engine was dismantled step by step following the manufacturers teardown procedure. Also several components were tested for failures. The following anomalies were found during the teardown and testing of the engine:

- Testing revealed a loss of compression on cylinder number 2.
- Oil contamination on the number 2 exhaust duct was found.

- Severe damage on cylinder/piston number 2. A hole in the piston head was detected on the cylinder with reduced compression. The hole in the piston head had a diameter of approximately 5 millimetre. Moreover, sever scratches were found on the contact surface of the cylinder and piston (figure 4).
- The oil nozzle of cylinder number 2 and number 3 were found (figure 5).

The engine pistons are cooled by oil which is fed to the bottom of the piston heads. The cooling oil is fed by an oil line which ends with a nozzle. The investigation showed that on two of the four cylinders the oil nozzle in the lower housing was broken. These broken nozzles were found in the lower housing of the engine. One oil nozzle pipe was scrunched. On further investigation a contact pattern mark on the hollow of the piston was identified. This hollow is designed to allow sufficient clearance between the oil nozzle and the piston.

Due to the lack of clearance between the oil nozzle and the hollow in the piston skirt, the oil nozzle pipe and the oil nozzle connected on it were stressed during each cycle. As a consequence the oil nozzle pipe cracked and the oil cooling of the piston head was interrupted. The thermal overstress lead to mechanical damage of the piston. Hence the compression of the cylinder was reduced and an in-flight loss of power occurred.

Follow-up

On February 22nd 2008 a Service Bulletin[6] was published by Thielert Aircraft Engines GmbH, see appendix 1. This Service Bulletin was directed to inspect the engine for broken oil nozzles. Also during each 100 hour regular engine inspection it is now mandated to check the oil nozzles for anomalies. The production process of the oil nozzle has also been modified.

CONCLUSION

The probable cause of the engine malfunction was thermal overstress of the piston as a result of reduced cooling. The piston received insufficient oil because of a broken oil nozzle. The nozzle was broken due to inadequate clearance between the oil nozzle pipe and the piston.

Note: This report has been published in the English and Dutch language. If there are differences in interpretation the Dutch text prevails.

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6 TM TAE 125-0017 Rev 2 Piston Cooling Nozzle Inspection 080222).

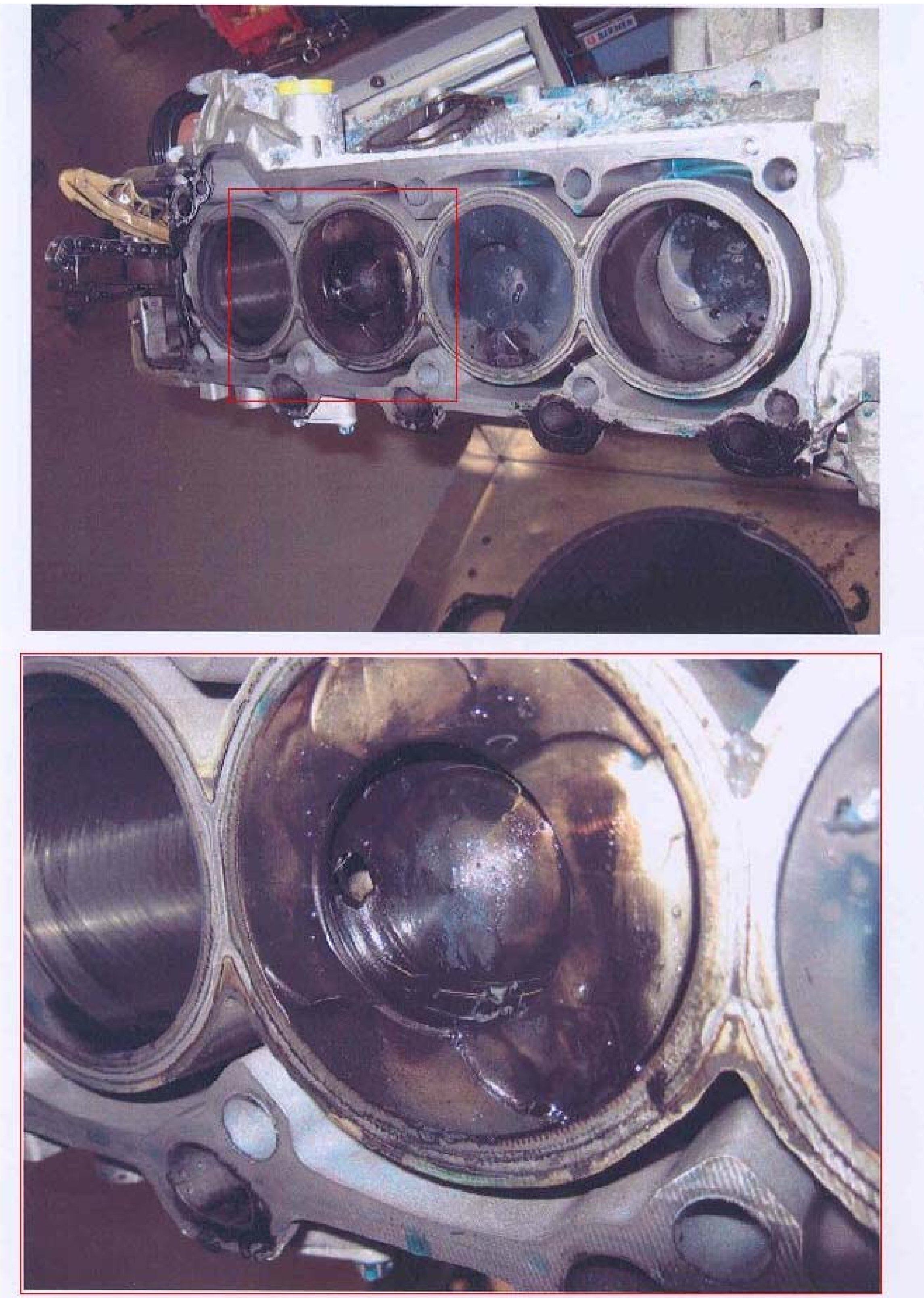

Figure 4: view of engine teardown during investigation (top) with detail of hole in the piston (bottom) (source: BFU)

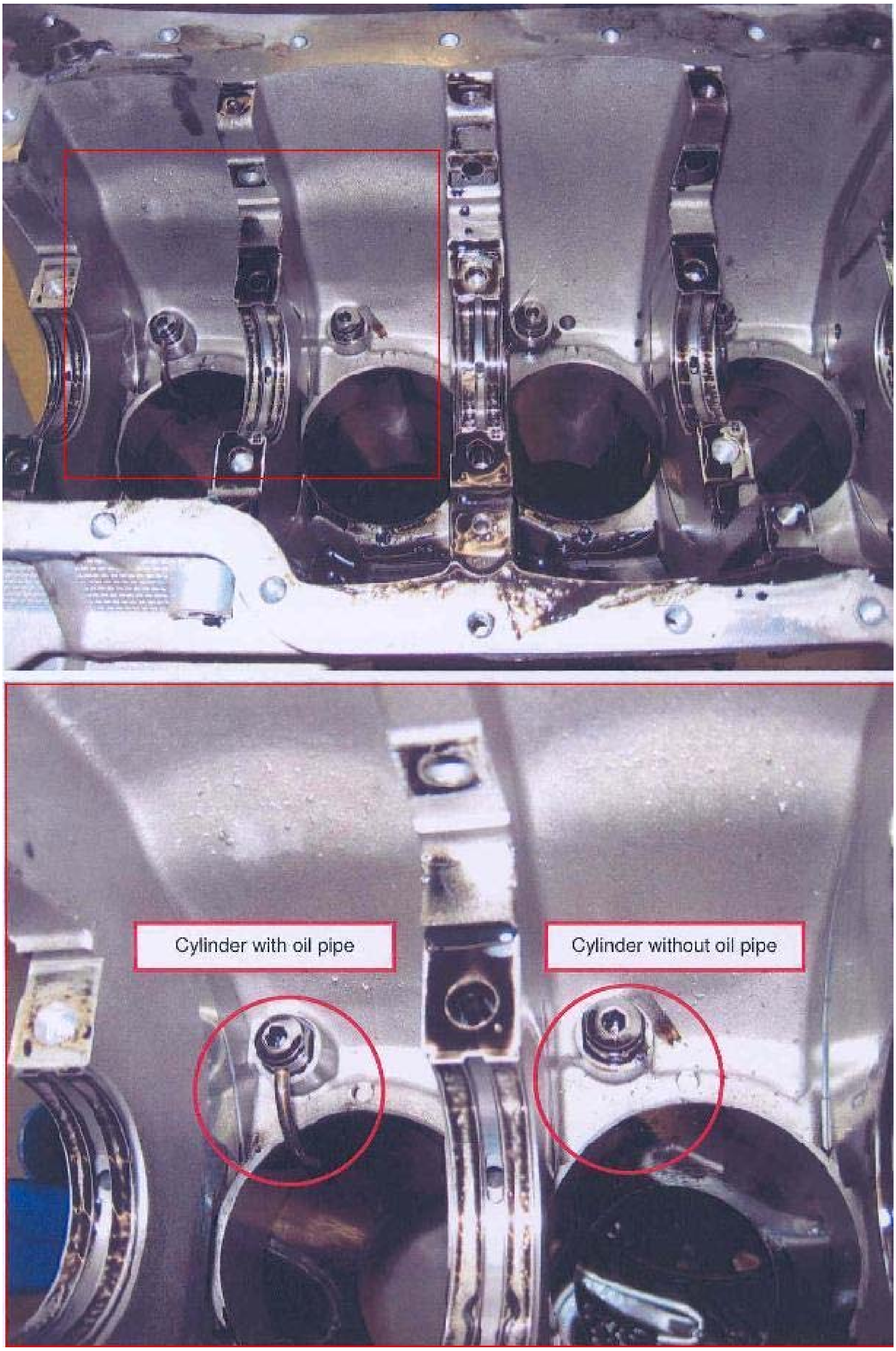

Figure 5: view of engine teardown during investigation (top) with detail of oil pipe nozzles (bottom: cylinder with and without oil pipe) (Source: BFU)

APPENDIX 1: SERVICE BULLETIN TM TAE 125-0017, REVISION 2

THIELERT AIRCRAFT ENGINES	Thielert Aircraft Engines GmbH Platanenstrasse 14 09350 Lichtenstein, Germany	Tel: +49 (37204) 696-0 Fax: +49 (37204) 696-2912 www.centurion-engines.com info@centurion-engines.com

Technische Mitteilung / Service Bulletin

Technische Mitteilung Nr. / Datum: *Service Bulletin No. / Date*	TM TAE 125-0017, Revision 2 / 22.02.2008 *TM TAE 125-0017, Revision 2 / February 22, 2008*
Betrifft: *Subject:*	Kolbenkühldüsen *Piston Cooling Nozzles*
Betroffenes Luftfahrtgerät: *Type affected:*	TAE 125-01 *TAE 125-01*
Betroffene Geräte-Nr.: *Models affected:*	Alle, ausgenommen Motoren mit Design Modification No. 2007-001 *All, except engines with Design Modification No. 2007-001*
Einstufung: *Compliance:*	Kategorie 1 – Sicherheit *Category 1 – Safety*
Dringlichkeit:	Maßnahmen sind innerhalb der nächsten 100 Flugstunden oder nach 6 Monaten oder mit der nächsten Inspektion durchzuführen; maßgebend ist das ersteintreffende Ereignis. Wenn keine abgebrochenen Kolbenkühldüsen gefunden werden, diese Inspektion bei jeder 100 Stunden Wartung durchführen.
Accomplishment:	*Measures have to be performed within the next 100 flight hours or 6 months or with the next maintenance; whichever occurs first.* *In case that no piston cooling nozzle is found, repeat this inspection at every 100 hour maintenance.*
Grund:	Seit 2003 hat Thielert Aircraft Engines GmbH mehr als 1700 Flugmotoren für zivile Installationen verkauft. In der Zwischenzeit hat die Flottenlaufzeit 700 000 Flugstunden überschritten. Im Laufe der vergangenen 4 Jahre wurden 10 Fälle von gebrochenen Kolbenkühldüsen gemeldet. Dieser Fehler kann, muss aber nicht, zu einem In-Flight Shut Down führen.
Reason:	*Since 2003 Thielert Aircraft Engines GmbH has sold more than 1700 aircraft engines installed in civil aircrafts. In between the fleet operation time passed 700,000 flight hours. Over the last four years there were 10 cases of failed piston cooling nozzles reported. This failure mode may result in an In-Flight Shut Down, but not in all cases.*

Maßnahmen:

Inspektion des Motors mit flexiblen Magneten:

1. Das Motoröl ablassen.
2. Das abgelassene Motoröl nach abgebrochenen Kolbenkühldüsen durchsuchen. Siehe Bild 3.
3. Wenn eine abgebrochene Kolbenkühldüse gefunden wird, Thielert Aircraft Engines GmbH kontaktieren.
4. Den Anschluss der Blow-by Leitung am Vorabscheider lösen. Siehe Bild 1.

▪ ACHTUNG: Beim Lösen oder Anziehen von Anschlüssen an einem Doppelnippel, muss immer am Doppelnippel gegen gehalten werden.

5. Die Schrauben und Scheiben des Vorabscheiders demontieren. Siehe Bild 2.

Ersetzt Technische Mitteilung Nr. / Datum: TM TAE 125-0017, Revision 1 / 21.12.2007 *Replaces Service Bulletin No. / Date: TM TAE 125-0017, Revision 1 / December 21, 2007*	Page 1 / 7

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