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Report RL 2003:03e

Accident involving aircraft SE-EEU in the airspace approximately 20 km south of Linköping, E County, Sweden, on the 23rd of July 2001

Dnr L-046/01

SHK investigates accidents and incidents with regard to safety. The sole objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

Translated from the original Swedish text by Dennis Lynn Anderson; at the request of The Board of Accident Investigation.

In the event of discrepancies between the English and the Swedish texts, the Swedish version is to be considered the authoritative version.

The report is also available on our Website: www.havkom.se

Statens haverikommission (SHK) Board of Accident Investigation

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2003-01-30 L-046/01

Swedish Civil Aviation Administration

601 79 NORRKÖPING

Report RL 2003:03e

The Board of Accident Investigation (Statens haverikommission, SHK) has investigated an accident that occurred on the 23rd of July 2001 in the airspace approximately 20 km south of Linköping, E County, Sweden, involving an aircraft with registration SE-EEU.

In accordance with section 14 of The Ordinance on the Investigation of Accidents (1990:717), The Board herewith submits a final report on the investigation.

Göran Rosvall

Monica J. Wismar Henrik Elinder

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APPENDIX

1 Extract from Register of Licenses regarding the pilot (to the Swedish Civil Aviation Administration only)

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Report finalized 2003-01-30

Aircraft; registration, type	SE-EEU, Beech D95A
Class, airworthiness	Normal, valid certificate of airworthiness
Owner/Operator	Lundbäck Flyg AB
Date and time	2001-07-23, 14:50 hours in daylight *Note:* All times in this report refer to Swedish Daylight Savings Time (UTC + 2 hours)
Place of occurrence	In the airspace approximately 20 km south of Linköping, E County, Sweden, (approximate position 5812N 01540E; 2,000 m above sea level)
Type of flight	Private
Weather	According to SMHI's analysis: wind 260°, variable between 220 and 320 degrees, 6 knots, visibility > 10 km, clouds 2-4/8 cumulus with bases at 4,000 feet, temp./dew point +23/+13 °C, QNH 1018 hPa.
Persons on board:	
Crew	1
Passengers	1
Injuries to persons	None
Damage to aircraft	Substantial
Other damage	None
The pilot:	
Age, certificate	56 years old, A with Instrument Rating
Total flying time	1,074 hours, of which 550 hours on the type
Flying hours previous 90 days	22 hours, all on the type
Number of landings previous 90 days	18

The Board of Accident Investigation (SHK) was notified on the 23rd of July 2001 that an accident involving an aircraft with registration SE-EEU had taken place in the airspace south of Linköping, E County, Sweden, on that same day at 14:50 hours.

The accident has been investigated by SHK, represented by Sven-Erik Sigfridsson, Chairperson until the 30th of November 2001, Olle Lundström, Chairperson until the 15th of September 2002, Göran Rosvall Chairperson, Monica J. Wismar, Chief Investigator Flight Operations and Henrik Elinder, Cheif Technical Investigator (aviation).

The investigation has been followed by the Swedish Civil Aviation Administration through Gun Ström and Daniel Hummerdal.

Accredited representative from the NTSB[1] has been David Keenan.

[1] NTSB – National Transportation Safety Board

Summary

The flight under investigation was an IFR-flight[2] from Göteborg/Säve airport to Norrköping airport with a light twin-engine aircraft of type Beech D95A. During the approach to the Norrköping airport a sudden heavy bang was heard and at the same time the right-hand engine began to vibrate violently. At that instant, engine power diminished on the right-hand engine and a strong yaw and roll tendency to the right developed.

The pilot immediately shut down the right-hand engine, feathered the propeller and disengaged the autopilot. In order to be able to continue the flight he was forced to decrease power on the left-hand engine and apply full rudder and aileron counter trim. In spite of this, maximum rudder and aileron deflection were periodically required. The indicated airspeed of the aircraft decreased to 120 knots and the rate of descent increased to 700-800 feet/min.

An emergency message was transmitted to Östgöta Control, which subsequently provided the aircraft with radar vectoring to Linköping/SAAB airport, where the aircraft was able to land without further problems.

The investigation has revealed that one propeller blade on the right-hand propeller had fractured about ten centimeters from the blade root flange and separated from the propeller hub. The metallurgical investigation of the broken blade has shown that the fracture originated as the result of a fatigue crack within the blade. An irregular turning groove in the blade root has initiated the crack.

Special inspections are prescribed within the area in question due to the risk of crack development and according to the technical documentation of the aircraft, the prescribed inspections have been carried-out. The propeller manufacturer does not intend to take any further measures in connection with the accident.

The accident was caused by the failure of a propeller blade during flight. The fracture originated as a consequence of a fatigue crack, which was initiated within a defective area of the blade root.

Recommendations

The Civil Aviation Administration is recommended to insure that a suitable operating hour limit is introduced for the propeller type; alternatively that a more reliable method is developed for the inspection of the propeller blade's critical areas. *(RL 2003:03 R1)*

[2] IFR – according to instrument flight rules

1 FACTUAL INFORMATION

1.1 History of the flight

The pilot, along with one passenger, departed from Göteborg/Säve airport for an IFR flight at Flight Level 090 (approximately 2,750 meters) to Norrköping airport. The passenger, who held a commercial pilot's license, assisted the pilot during the flight by managing the radio communications.

When the position of the aircraft was approximately 10 nautical miles (18.5 kilometers) south of Linköping, descending to 3,000 feet[3] on approach to Norrköpings airport; suddenly a heavy bang was heard and simultaneously the right-hand engine began to vibrate violently. At the same instant the engine power on the right-hand engine diminished, causing a strong yaw and roll tendency to the right. Furthermore the pilot observed that the fuselage sheet metal on the nose of the aircraft had been deformed. The indicated airspeed of the aircraft was 160 knots[4] and the rate of descent approximately 300 feet/min.

The pilot immediately shut down the right-hand engine, feathered the propeller and disengaged the autopilot. In order to be able to continue the flight he was forced to decrease the power on the left-hand engine and apply full rudder and aileron counter trim. In spite of this, maximum rudder and aileron deflection were periodically required. The indicated airspeed of the aircraft decreased to 120 knots and the rate of descent increased to 700-800 feet/min.

An emergency message containing information concerning what had occurred was transmitted to Östgöta Control with a request for information on course and distance to the nearest suitable airport. They then received radar vectors to Linköping/SAAB airport. During the flight towards the airport the pilot succeeded in reducing the rate of descent by increasing engine power on the left-hand engine.

When contact had been established with the air traffic controller in the tower assistance was requested for a visual check to verify that the landing gear was down and locked prior to the landing. The pilot decided to perform the landing without the normal speed reduction and without the use of landing flaps. The landing gear was extended at a late stage on final and the power on the left-hand engine was first reduced when the aircraft was over the runway at a height of about ½ meter. The air traffic controller gave no information concerning the status of the landing gear, despite the fact that the pilots made several inquires prior to touchdown.

The touchdown was accomplished without any problems, contact being made with the left main wheel first. After deceleration braking the pilot stopped the aircraft on the runway and shutdown the engine. Thereafter assistance was rendered to tow the aircraft to a parking stand.

The accident took place at the approximate position of 5812N 01540E; 2,000 meters above sea level.

[3] foot – 0.3 meters
[4] knot – 1.852 km/hr

1.2 Injuries to persons

	Crew	*Passengers*	*Other*	*Total*
Fatal	–	–	–	–
Seriously injured	–	–	–	–
Slightly injured	–	–	–	–
No injuries	1	1	–	2
Total	1	1	–	2

1.3 Damage to aircraft

Substantial.

1.4 Other damage

None.

1.5 The crew

The pilot was 56 years old at the time and held a valid Private Pilots License with an Instrument Rating.

Flying hours			
previous	*24 hours*	*90 days*	*Total*
All types	-	22	1,074
This type	-	22	550

Number of landings this type previous 90 days: 18.
Flight training on the type completed in the spring of 1993.
Latest PC (proficiency check) carried-out 2000-12-07 on the Beech D95A.
A passenger who was on board held a commercial pilot's license with an instrument rating. He, among other things, assisted with the radio communications.

1.6 The aircraft

1.6.1 General

THE AIRCRAFT	
Manufacturer	Beech
Type	D95A
Serial number	TD 540
Year of manufacture	1963
Gross weight	Maximum allowable 1,905 kg, actual 1,787 kg
Center of gravity	Within allowable limits
Total flight hours	7,023 hours
Number of cycles	Unknown
Operating hours since latest periodic check	65 hours
Fuel uplifted prior to the event	100LL

ENGINES	
Engine manufacturer	Lycoming

Engine model	IO-360-B1B	
Number of engines	2	
Engine	Nr 1	Nr 2
Total operating hours	3,749	3,476
Operating hours since latest overhaul	1,618	1,618
Cycles after overhaul	Unknown	Unknown

PROPELLERS	
Propeller manufacturer	Hartzell
Operating hours since complete overhaul	
Propeller 1	1,895 hours
Propeller 2	1,095 hours

The aircraft had a valid Certificate of Airworthiness.

1.6.2 Propellers

The aircraft is equipped with twinblade adjustable propellers of type HC-92ZK-2B/8447-12A, manufactured by Hartzell. The overhaul time interval is 2,000 hours.

The blade root of each blade contains a guide channel with a cylindrical formed bearing bushing manufactured in bronze. The propeller hub has two opposing trunnions upon which the propeller blades are mounted and secured. By means of a mechanism within the propeller nose cone, which is connected to the respective propeller root, the propeller blades can be adjusted to varying angles of attack.

1.7 Meteorological information

According to SMHI's analysis: wind 260°, variable between 220 and 320 degrees, 6 knots, visibility > 10 km, clouds 2-4/8 cumulus with bases at 4,000 feet, temp./dew point +23/+13 °C, QNH 1018 hPa.

1.8 Aids to navigation

Linköping/SAAB airport's runway 29 was equipped with ILS[5]. The aircraft was equipped for instrument flight. The pilot received radar vectoring to the airport until he obtained visual contact with the runway. Thereafter he completed the approach visually.

1.9 Communications

The air traffic controller at Östgöta Control received the emergency message from the aircraft and attended to the radar vectoring towards Linköping/SAAB airport. The traffic controller at the airport had a listening watch on Östgöta Control's frequency and was therefore informed of the situation when Östgöta Control contacted him and notified him that the aircraft would be arriving at the airport for an emergency landing. Shortly thereafter the air traffic controller in the tower was contacted by the pilot, who informed the controller that they feared that one of the engines might

[5] ILS – Instrument Landing System

separate from the wing and that they might not be capable of reaching the airport. At this time the air traffic controller sounded the alarm according to the so-called ”Green Checklist”. This meant, among other things, that ARCC (the Search and Rescue Service) was to be alerted via the SOS-Alarm and that the municipal emergency services were to be alerted as a compliment to the airport’s own rescue service.

When the aircraft was on approach to the airport the pilot requested assistance in confirming that the landing gear was extended and at the same time reiterated that they might not be able to reach the airport. The air traffic controller requested a landing gear check by the rescue effort commander from the airport fire department. When the aircraft was on short final to runway 29 the tower controller himself, with the help of binoculars, could see that the landing gear was extended. The rescue effort commander also confirmed this. Shortly thereafter the aircraft landed.

The recorded radio communication between the tower and the aircraft verifies that the pilot’s inquiry concerning the landing gear was never answered. The tower controller has stated that the landing gear was extended so late prior to touchdown that he did not have time to report that it was indeed extended. He did not apprehend the pilot’s repeated inquires prior to touchdown.

1.10 Aerodrome information

The airport had operational status in accordance with the Swedish AIP (Aeronautical Information Publication).

1.11 Flight and voice recorders

There was no requirement to carry a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR) on board the aircraft and neither was fitted.

1.12 Accident site and aircraft

1.12.1 The accident site

The accident occurred in the airspace south of Linköping at an altitude of approximately 2,000 meters.

1.12.2 The aircraft

Immediately after the landing it could be determined that one of the two propeller blades on the right-hand engine had fractured close to the propeller hub and separated from the propeller. All of the engine brackets on the right-hand engine had broken and the engine was hanging down into its cowlings with a 20 to 25 degree angle. Several portions of the engine installation had been broken. The propeller blade that had separated had, among other things, caused damage to the nose section of the aircraft and the right-hand aileron.

1.13 Medical information

Nothing has been found that would indicate that the mental or physical condition of the pilot was impaired prior to the flight.

1.14 Fire

There was no fire.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 The right-hand propeller

One propeller blade on the right-hand propeller had fractured about ten centimeters from the blade root flange and separated from the propeller hub. The separated propeller blade has not been recovered. The opposing propeller blade was intact. During removal of the propeller hub no failure or abnormality was found.

1.16.2 *Metallurgical investigation of the broken propeller blade*

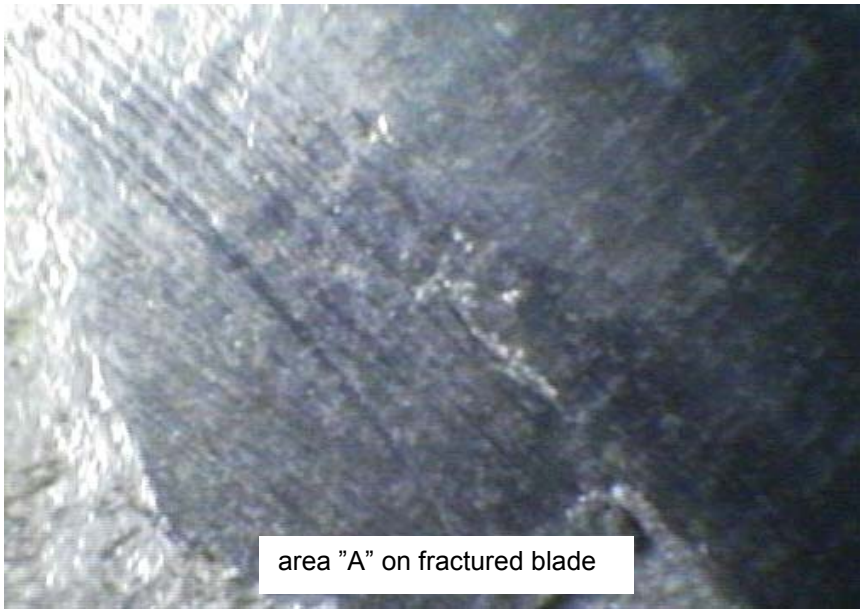
The remaining portion of the broken blade, with the part number DWG. No 8447-12A, SR. No A55376V, has been investigated by CSM Materialteknik in Linköping. In the technical report from the investigation, TEK01-0686, it is stated, among other things, that:

- The fracture took place as a consequence of a fatigue crack in area”A”. (Se 1.16.4)
- The fatigue crack has originated along an approximately 0.2 mm deep ”irregular turning groove”.
- The ”irregular turning groove ” could have originated during manufacturing as the consequence of a damaged cutting tool.
- In the vicinity of the fracture surface, a certain amount of porosity is evident in the material, however this is not considered to have had any significance in fracture development.
- There are some minor burns on the bronze bushing (probably from lightning strikes). These are also deemed not to have had any significance in fracture development.
- The material in the blade, AA 2025, fulfils applicable specifications.
- Concerning undercutting, see section 1.16.3.

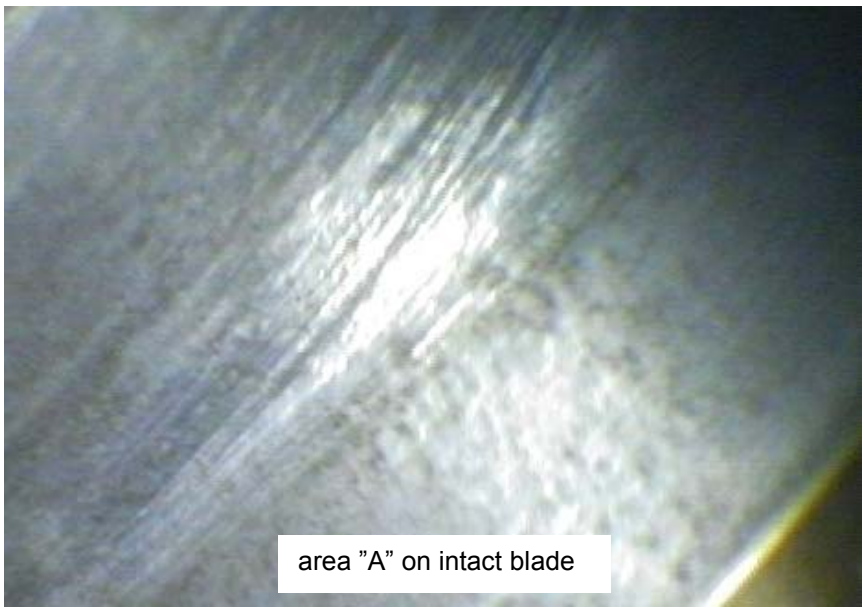
1.16.3 Metallurgical investigation of the intact propeller blade

The intact propeller blade, with the part number DWG. No 8447-12A, SR. No A55521V, has been investigated by CSM Materialteknik in Linköping. In the technical report from the investigation, TEK01-0093, it is stated, among other things, that:

- Inspection of area"A" according to applicable instructions in SB 136H (se 1.16.4) is in actuality difficult to accomplish.
- In area"A" the same type of surface was found as in the fractured blade. (See photo below) The so-called undercut within area"A" was measured to between 0.32 and 0.37 mm. According to the blueprints in SB 136H, the undercut may be a maximum of 0.25 mm (0.010 in).
- About the same values were obtained during inspection measurement of the undercut on the fractured blade.



area "A" on fractured blade



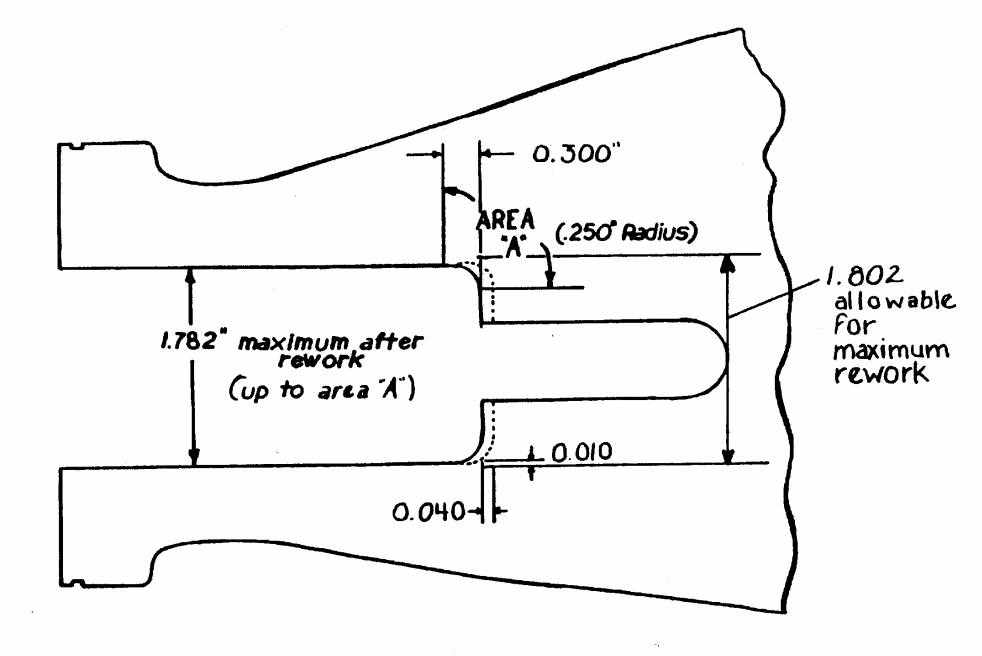
area "A" on intact blade

To sum up, the report shows that the fracture took place due to a fatigue crack. The crack has originated in a turning groove in a fillet in the blade

root's guide channel (area "A"). Contributory has been that the undercut in the fillet was too deep.

1.16.4 Hartzell Service Bulletin No 136

The propeller manufacturer Hartzell issued a Service Bulletin, (SB) 136E on 14 October 1988, which concerns, among other things, the propeller type in question. The bulletin stipulated that a special inspection, and if required a polishing of an indicated (area"A") in the propeller root guide channel was to be accomplished at the latest during the next overhaul of the blade. The inspection could be accomplished without removal of the bearing bushing within the channel. The reason behind the inspection was stated to be the desire to avoid scratches and machine tool marks in this area that could lead to the emergence of corrosion.



In 1991 a propeller of the same type was subjected to a blade failure. The cause was considered to be a fatigue crack, which was initiated by corrosion damage in this area (area"A").

This induced Hartzell to issue a Revised Version (SB136G) of the previously issued bulletin on the 15th of November 1991. In this, among other things, a requirement is made to remove the bushing sleeve prior to inspection and possible treatment. This in order to be able to accomplish the work with better precision. On the 12th of March 1993 the manufacturer issued yet another Revised Version of the bulletin, SB 136H, containing complementary instructions for inspecting and polishing of the surfaces concerned. According to the bulletin the inspection shall be accomplished with a borescope or with a light and a mirror.

The latest overhaul of the propeller in question was accomplished by the aviation workshop Scan Aviation in Denmark and was approved on the 13th of May 1996. In the technical journal from the overhaul it is stated in a document designated "Inspection Record" that SB 136E had been performed. In another document from the same overhaul, designated "Modification Record", it is stated that SB 136H had been performed. According to the head of quality control for the company, the bulletin was performed according to SB 136H and the bearing sleeve was removed prior to the inspection. The blade failure took place 1,095 operating hours after this procedure.

According to Scan Aviation it is in actuality very difficult to discover a manufacturing defect such as that under discussion solely by use of the method that is provided in SB 136H. To do this requires the use of instruments with some form of magnification. Even the measurement of the undercut within area ”A” is difficult to accomplish with precision without the help of special instrumentation. CSM Materialteknik shares this opinion.

There is no requirement for periodic inspection of the actual area between overhauls. Subsequent to the overhaul the propeller accumulated 1,095 operating hours before the blade failure took place.

1.16.5 LVA 997

On the 10th of September 1975 the Civil Aviation Administration issued Airworthiness Directive (LVA) 997, based on the aircraft manufacturer's (Beechcraft) Service Instruction (SI) 0723-241, Hartzell Service Bulletin (SB) 107A and the American Federal Aviation Administration's (FAA) Airworthiness Directive (AD) 75-13-02.

In LVA 997 it is prescribed that the aircraft's instrument panel shall be equipped with a sign with the text: ”DO NOT EXCEED 23 HG. M.P. BELOW 2300 RPM”. In addition, a periodic calibration of the engine tachometer and manifold pressure gauge is prescribed every other year.

The reason for these directions was to avoid the operation of the propeller at a rotation speed where the propeller blades could end up in a natural oscillation that can damage the material strength of the propellers.

The sign was mounted on the instrument panel of the aircraft in question and in the technical documentation it is possible to derive notations concerning measures accomplished according to LVA 997 from 81-01-15.

1.17 Organizational and management information

Not applicable.

1.18 Hartzell

The propeller manufacturer Hartzell estimates that there are about 2,000 propellers of this type in operation worldwide. Hartzell has been provided the opportunity to investigate the propeller blades referred to under the auspices of the NTSB and the results of the investigation have been accounted for in NTSB Report No. 02-097, dated October 24, 2002.

In the report it is stated in summary that the fracture took place as a consequence of a fatigue crack. The crack has been initiated at several points along a “circumferential gouge” in proximity to area” A” in the blade root's guide channel. It was also stated that the diameter of the guide channel was too large in the area in question. According to the American report, the gouge and the incorrect dimension were not a consequence of the manufacturing of the blade, but of a later reworking of the surfaces in question.

Hartzell is of the opinion that the case in question is an isolated and unique one and that there is no need for further control measures.

2 ANALYSIS

2.1 The flight

The blade failure occurred without forewarning and placed those on board in a critical situation. The separated propeller blade created such large im-

balance forces that the right-hand engine mounting broke and the engine partially separated from the wing. By the engine and the engine nacelle ending-up in an abnormal position, an asymmetric aerodynamic drag was created, which explains the large yaw and roll tendencies to the right that the pilots experienced during the continued flight.

Despite this aerodynamic disturbance and the lack of thrust from the right-hand engine, the pilot succeeded in maintaining control of the aircraft, fly it to a nearby airport and there perform a successful landing.

The air traffic controllers at Östgöta Control and at Linköping/SAAB airport understood that the aircraft was in an emergency situation, alerted the authorities concerned and assisted the pilot during the approach. The reason why the traffic controller in the tower did not report the landing gear's position, despite the pilot's repeated inquiry, may have been that the sequence of events occurred rapidly and that the situation was stressed. Owing to the fact that the landing gear actually was down and locked, the lack of this information was of no consequence to the sequence of events.

2.2 The propeller failure

Both the Swedish and the American metallurgical investigations have shown that the fracture was caused by a fatigue crack that originated in a groove in a fillet in the blade root guide channel (area"A") in combination with the fact that the undercut was too deep. However, there is a difference of opinion concerning when the damage and the incorrect dimension arose.

Regardless of when the damage arose, the control measures that are prescribed in SB 136E, G and H indicate that the propeller manufacturer was aware that defects can exist in this area and that the area is critical with respect to crack development. The intention of the Service Bulletin is to insure that dimensions and surface smoothness fulfill applicable specifications so that the risk of crack development shall be minimal.

According to the technical documentation of the aircraft, all of the obligatory maintenance procedures on the propeller blade have been accomplished. SHK has no reason to doubt that these steps have actually been carried out according to the method prescribed. Also, the directives that have been issued concerning how engines with this type of propeller shall be operated have been adhered to. Despite this it has been established, in addition to this investigation, that defects have also previously existed within the critical area on propeller blades of this type so that a fatigue crack was initiated and was able to widen until the occurrence of blade failure. This indicates that the measures taken have not been sufficient.

The blade failures that have occurred would also indicate that the inspection methods that are stipulated in SB 136 are not adequately reliable. Both CSM Materialteknik, who has accomplished the metallurgical investigation of the propeller blades, and ScanAviation, who carried-out the inspection, are of the opinion that more accurate methods and tools are required than those that are prescribed in SB 136 in order to be able to safely determine that dimensions and surface smoothness fulfill the specified requirements.

Considering the serious consequences that a blade failure of this type can have and that there is still a large number of propellers of this type in operation; SHK is of the opinion that there is reason to introduce some type of operating hour limit and/or a more reliable inspection method.

3 CONCLUSIONS

3.1 Findings

a) The pilot was qualified to perform the flight.
b) The aircraft had a valid certificate of airworthiness.
c) The propeller blade broke as a consequence of a fatigue crack.
d) An “irregular turning groove” in the blade root has instigated the crack.
e) Special inspections of the area in question are prescribed due to the risk of crack development.
f) According to the technical documentation of the aircraft, the prescribed inspections have been performed.
g) The propeller manufacturer does not intend to take further steps in connection with the accident.

3.2 Causes of the accident

The accident was caused by the failure of a propeller blade during flight. The fracture originated as a consequence of a fatigue crack, which was initiated in a defective area within the blade root.

4 RECOMMENDATIONS

The Civil Aviation Administration is recommended to insure that a suitable operating hour limit is introduced for the propeller type; alternatively that a more reliable method is developed for inspection of the propeller blade’s critical areas. *(RL 2003:03 R1)*