



Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2010:09e

**Accident to aircraft SE-GEE at
Gryttjom airfield, Uppsala county,
Sweden on 3 June 2009**

Case L-07/09

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Swedish Accident Investigation Board

2010-06-07

L-07/09

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Report RL 2010:09e

The Swedish Accident Investigation Board has investigated an accident that occurred on 3 June 2009 at Gryttjom airfield, Uppsala county, to an aircraft registered SE-GEE.

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

The Swedish Accident Investigation Board will be grateful to receive, by 6 December 2010 at the latest, particulars of how the recommendations included in this report are being followed up.

Carin Hellner

Henrik Elinder

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Report RL 2010:09e

L-07/09

Report finalised 2010-06-07

Aircraft; registration and type	SE-GEE, de Havilland DHC-6-300
Class, airworthiness	Normal, valid Certificate of Airworthiness
Registered owner/Operator	Skydive Airlines AB
Time of occurrence	03.06.09, time 19:05 in daylight Note: All times are given in Swedish standard time (UTC + 1 hour)
Place	Gryttjom airfield, Uppsala county (posn. 60° 17.2' N, 017° 25.8' E, approx. 40 m above sea level)
Type of flight	Non-commercial flight
Weather	According to SMHI's analysis: Wind north to north-westerly, 8-12 knots, gusting up to 18 knots, visibility more than 10 km, clouds 1-3/8 stratocumulus with base at 4-6000 feet, temp./dewpoint +12/+1 °C, QNH 1002 hPa.
Persons on board:	
crew members	1
passengers	21
Injuries to persons	None
Damage to the aircraft	Substantially damaged
Other damage	None
Commander:	
Age, licence	32 years, CPL
Total flying time	2,165.0 hours
Flying hours previous 90 days	40.9 hours
Number of landings previous 90 days	61

The Swedish Accident Investigation Board (SHK) was notified on 3 June 2009 that an aircraft with registration SE-GEE had an accident at 19:05 hours on that day at Gryttjom airfield, Uppsala county.

The accident has been investigated by SHK represented by Carin Hellner, Chairperson, Henrik Elinder, Investigator In Charge and technical investigator aviation, and Agne Widholm, operational investigator.

The investigation was followed by Niklas Svensson, Swedish Transport Agency.

Summary

The pilot intended to take off with 21 parachutists on board the aircraft. He did not notice anything abnormal, neither during the preparations for take-off nor during the initial taxiing.

After taxiing for a few minutes at low speed, suddenly the right main landing gear broke, whereupon the aircraft tipped over to the right and the right wing struck the ground. The aircraft then slowed down, turned somewhat to the right, and stopped. No person onboard was injured.

The technical examination of the aircraft has shown that the right main landing gear fractured as the result of a fatigue crack. The crack consisted of several smaller fatigue cracks that had grown and joined. The cracks had

initiated in an external welded joint and developed over an extended period of time without being detected.

The aircraft type has been exposed to landing gear fracture before as the result of fatigue cracks in the actual area. Current maintenance system prescribes NDT inspection of the landing gear within intervals of 12,000 flying hours or five years, whichever comes first.

The accident was caused by fatigue cracking in the right main landing gear. A contributory factor was an inadequate maintenance system for this type of aircraft in respect of checking for cracks.

Recommendations

It is recommended that EASA and the Swedish Transport Agency, in conjunction with the manufacturer, consider the need for supplementing the present maintenance system in respect of crack formation in the landing gear, *(RL 2010: 09 R1)*.

1 FACTUAL INFORMATION

1.1 History of the sequence of events

At the time of the accident, sport parachute jumping was taking place at Gryttjom airfield. The pilot, who was involved in these operations, intended to take off with 21 parachutists on board the aircraft for them to carry out a normal jump near to the airfield.

After the pilot had carried out the normal pre-flight checks the parachutists boarded the aircraft and the pilot began to taxi the aircraft towards the beginning of the runway for a take-off from runway 36. He did not notice anything abnormal, neither during the preparations for take-off nor during the initial taxiing.

After taxiing for a few minutes at low speed, suddenly the right main landing gear broke, whereupon the aircraft tipped over to the right and the right wing struck the ground. The aircraft then slowed down, turned somewhat to the right, and stopped.

The pilot ordered an emergency evacuation and those on boards unclipped themselves and quickly exited the aircraft via the normal parachuting door. At about the same time the pilot switched off the engines, turned off the main fuel cocks and main circuit breaker, and exited the aircraft himself.

Once outside the aircraft the pilot checked that everyone else had exited the aircraft and moved to a safe location.

The accident occurred at position 60°17.2'N, 017°25.8'E; about 40 m above sea level in daylight on 3 June 2009 at 19:05.

1.2 Injuries to persons

	Crew members	Passengers	Others	Total
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	1	21	–	22
Total	1	21	–	22

1.3 Damage to the aircraft

Substantially damaged.

1.4 Other damage

None.

1.5 The crew

1.5.1 Pilot

The pilot was 32 years old at the time and had a valid CPL Licence.

Flying hours			
Previous	24 hours	90 days	Total
All types	4.0	40.9	2165.0
This type	4.0	13.9	1050.0

Number of landings this class previous 90 days: 45.

Flight training on class carried out on 5 April 2003.

Latest OPC (Operational Proficiency Check) carried out on 25 May 2009 on a DHC-6.

1.5.2 The pilot's duty schedule

At the time of the accident the pilot had been awake for 11.5 hours, during which time he had flown for 4 hours. Before this he had slept well for 8.5 hours.

1.6 The aircraft

1.6.1 General

<i>The aircraft</i>		
Manufacturer	de Havilland	
Type	DHC-6-300	
Serial number	364	
Year of manufacture	1973	
Flight mass	Max. authorised take-off/landing mass 5,675 kg, actual 5,430 kg	
Centre of mass	Within permitted limits	
Total flying time	28,104.2 hours	
Total number of cycles	56,080	
Flying time since latest inspection	69.6 hours	
Fuel loaded before event	JET A1	
<i>Engines</i>		
Manufacture	Pratt and Whitney	
Engine model	PT6A-27	
Number of engines	2	
Engine	No. 1	No. 2
S/N	PCE-G0340	PCE-G0341
Total operating time, hrs	764.8	776.4
Operating time since overhaul	764.8	776.4
<i>Propellers</i>		
Propeller manufacturer	Hartzell	
Operating time since overhaul	73.1	73.1

The aircraft is a two-engined propeller-driven aircraft without a pressure cabin and with room for up to 22 people or just over 2,000 kg of cargo. This type of aircraft is used for various types of air transport, both civil and military. In all, 844 aircraft of this type have been manufactured, of which 590 are still in operation.

This particular aircraft is equipped with a large shutter door which can be opened in flight.



Figure 1. de Havilland DHC-6-300 (Twin Otter), SE-GEE

The aircraft had a valid Certificate of Airworthiness with valid approval certificate (ARC – Airworthiness Review Certificate).

1.6.2 *Landing gear*

This type of aircraft has fixed landing gear. The main landing gear consists of two landing gear legs which are both fitted with articulation in the lower part of the aircraft fuselage. Each landing gear leg is made from two steel pipes which are welded together. An oval hole in one of the landing gear pipes provides a location where the other pipe is welded to it. (See the illustration below.)

For external corrosion protection the pipe assembly is covered with an aluminium coating and protective paint.

The spring function is achieved with the aid of distance blocks made of a rubber-like material, which are located between each landing gear leg and the aircraft fuselage structure. These are compressed during the spring action.

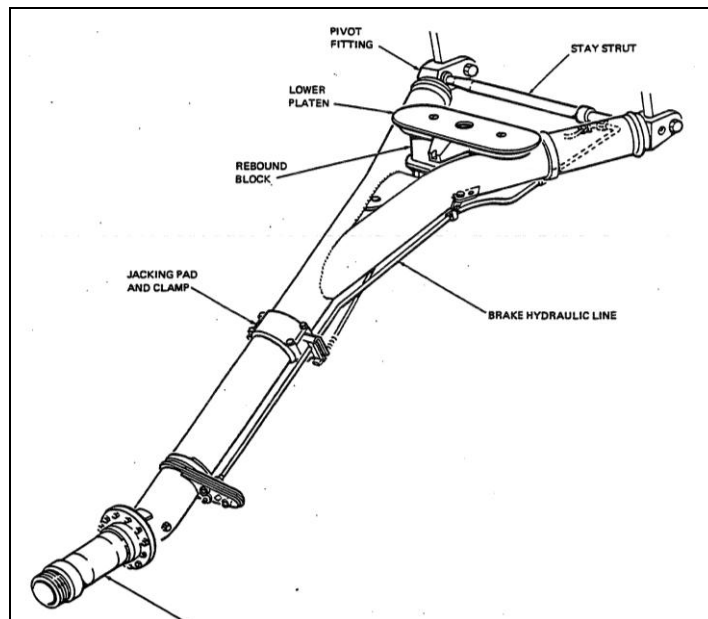


Figure 2. Left landing gear leg

The landing gear legs are enclosed in aerodynamically shaped fairings.

1.6.3 Stipulated maintenance

In the aircraft manufacturer's maintenance manual it is prescribed that the fairings must be removed and the entire landing gear assembly visually inspected for such defects as cracks, in accordance with the manufacturer's PSM 1-6-7 Part 3 instructions (see the illustration below), at intervals of 2,400 flying hours.

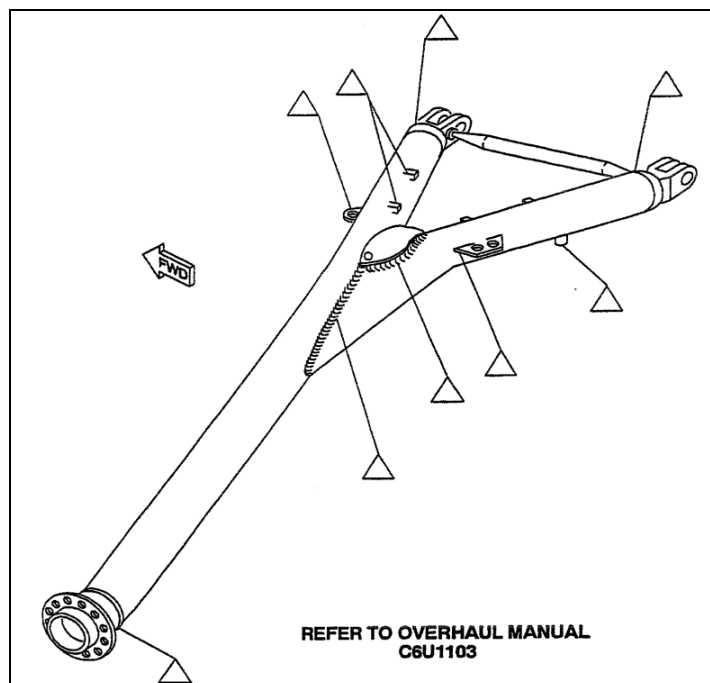


Figure 3. Inspection points according to PSM 1-6-7 Part 3

In connection with the ordinary periodic inspections of the whole aircraft is included visual inspection and grease lubrication of appropriate parts of the landing gear, although removal of the fairings is not required in these cases.

1.6.4 *Service Bulletin 6/380*

After a number of cases of landing gear fractures had occurred, resulting from fatigue cracks in a welded joint, the aircraft manufacturer introduced, on 28 April 1978, a modification, Mod. No. 6/1660, to improve internal corrosion protection for the landing gear legs.

On 20 December of the same year the manufacturer also issued a mandatory Service Bulletin (SB) No. 6/380. This SB contained the information that cracks could occur as the result of corrosion in the inner “pocket” associated with the oval hole in one of the welded landing gear pipe joints.

The affected welded joints and material adjacent to them would therefore have to be inspected for cracks. Initially this would take place in accordance with two alternative programmes; “Schedule 1” or “Schedule 2”. Subsequently further inspections would take place in the form of a recurring crack check, called “Check D”.

“Schedule 1”:

Visual inspection of the outside of the landing gear. This inspection must be carried out at regular intervals of 600 flying hours or three months, whichever comes first, up to a first “Check D”. If any abnormalities are seen, the paint layer must be removed and the surfaces crack-tested using the liquid penetrant method, which is a type of non-destructive testing (NDT).

If cracks are found, supplementary crack testing must be performed using the X-ray method, another type of NDT. If such cracks are shorter than 3 inches (76 mm) and do not extend into the underlying material, the aircraft is permitted to operate for a maximum of 1,200 flying hours or 6 months, whichever comes first, before the landing gear must be repaired.

“Schedule 2”:

Visual inspection of the outside and inside of the landing gear. This inspection must be carried out at regular intervals of 2,400 flying hours or 12 months, whichever comes first, up to a first “Check D”. If anything abnormal is found, the area concerned must be checked for cracks using the X-ray method.

If cracks are found during this type of examination, the same operational limitations apply as for “Schedule 1”.

“Check D”

During “Check D” the landing gear must be detached from the aircraft and both paint and the aluminium coating removed from the stated areas on the outside of the landing gear. These surfaces must then be checked for cracks by using the magnetic powder method, which is yet another type of NDT.

After the first time that a “Check D” has been carried out, this check must be repeated at intervals of 12,000 flying hours or five years, whichever comes first.

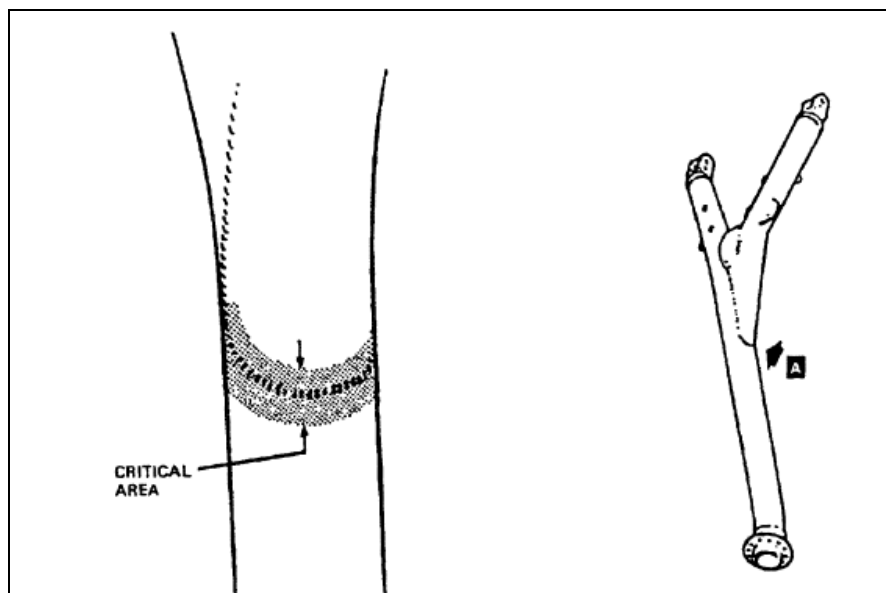


Figure 4. Critical area in accordance with SB No. 6/360.

1.6.5 Documented maintenance in respect of the landing gear

According to the technical documentation for the aircraft the first “Check D” was performed on this particular landing gear on 17 December 1990. Thereafter “Check D” had been performed at the prescribed intervals.

During the second periodic inspection, in 1995, cracks were found in some of the welded joints of the landing gear, as shown in the sketch below and these were repaired by re-welding. In the metallurgical investigation of the landing gear leg that is described in Section 1.16.1, it was not possible to define with certainty the precise extent of this welding repair in relation to the critical area according to SB No. 6/380, where the original welding was also located.

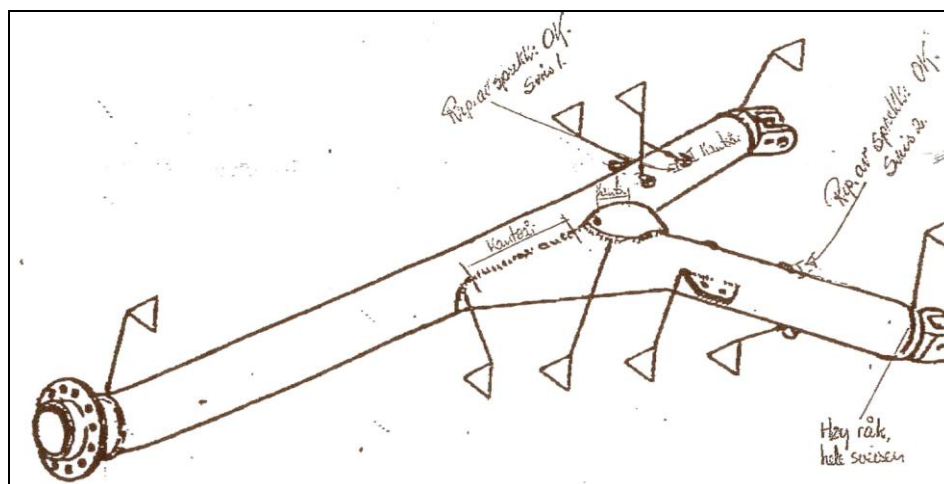


Figure 5. Sketch showing earlier cracks and repairs.

The most recent “Check D” before the accident was performed on 14 November 2005, when the total flying time of the aircraft was 26,951 hours. On the same occasion an inspection in accordance with PSM 1-6-7 Part 3 was carried out.

1.7 Meteorological information

According to SMHI's analysis: Wind north to north-westerly, 8-12 knots, gusting up to 18 knots, visibility more than 10 km, clouds 1-3/8 stratocumulus with base at 4-6000 feet, temp./dewpoint +12/+1°C, QNH 1002 hPa.

1.8 Aids to navigation

Not applicable.

1.9 Radio communications

Not applicable.

1.10 Aerodrome information

The airfield is owned and operated by Stockholm parachutists club and consists of an approximately 900 m long and 30 m wide grass strip with runway orientation 180/360. Just west of the strip there is a taxiway leading to the airfield clubhouse and parking area. At that time the taxiway and grass strip were covered with short mown grass and had no abnormal irregularities.

1.11 Flight recorders and voice recorders

None. Not required.

1.12 Location of occurrence and aircraft wreckage

1.12.1 Incident site

The accident occurred on the taxiway, about 50 metres from the runway threshold.

1.12.2 Aircraft wreckage

The aircraft remained stationary on the taxiway, where the preliminary technical examination and removal of the right side main landing gear were carried out.

1.13 Medical information

Nothing indicates that the mental and physical condition of the pilot was impaired before or during the flight.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 General

The pilot was secured by a four-point type safety belt. The cabin had no passenger seats and during taxiing the 21 parachutists were crouched on the floor, hooked on to the aircraft interior by quick-release connectors. The shutter door on the side of the aircraft was closed.

At the time of the accident the taxiing speed was low and the retardation when the landing gear fractured was moderate. The parachutists were able to keep themselves restrained in the cabin and no personal injury occurred.

1.15.2 Actions by the rescue services

Not applicable.

1.16 Tests and research

1.16.1 Examination of the right main landing gear leg

On behalf of SHK the landing gear leg was subjected to a metallurgical examination in respect of the cause of the fracture. The result of the examination has been presented in a report, EXOVA TEK09-0313.



Figure 6. Right landing gear leg

The examination showed that the fracture was due to metal fatigue that at its beginning followed the edge of a weld. In the area of the starting point, which is at the outside of the pipe section, four fatigue cracks grew almost straight into the centre of the pipe. From these cracks the fracture then grew around the outside diameter, reaching just beyond halfway. The distance from the starting point to the oval hole mentioned in SB No. 6/380 was 16-22 mm. The entire fracture was in the longer pipe section and had no connection with the edge of the hole.

The four cracked surfaces were not in the same plane; each crack plane was at a slight angle relative to the others. This kind of appearance usually indicates that torsional stress had occurred in the loading that caused the crack initiation and growth. The remainder of the fatigue fracture surface was more planar, which is probably due to purely bending stress becoming predominant.

Initially the fracture followed the outer edge of the weld, and is always present in the basic material of the pipe section. The pipe has the same wall material thickness around the entire fracture, approximately 9.6 mm.

Internally the landing gear leg was covered by a black tar-like substance providing corrosion protection.

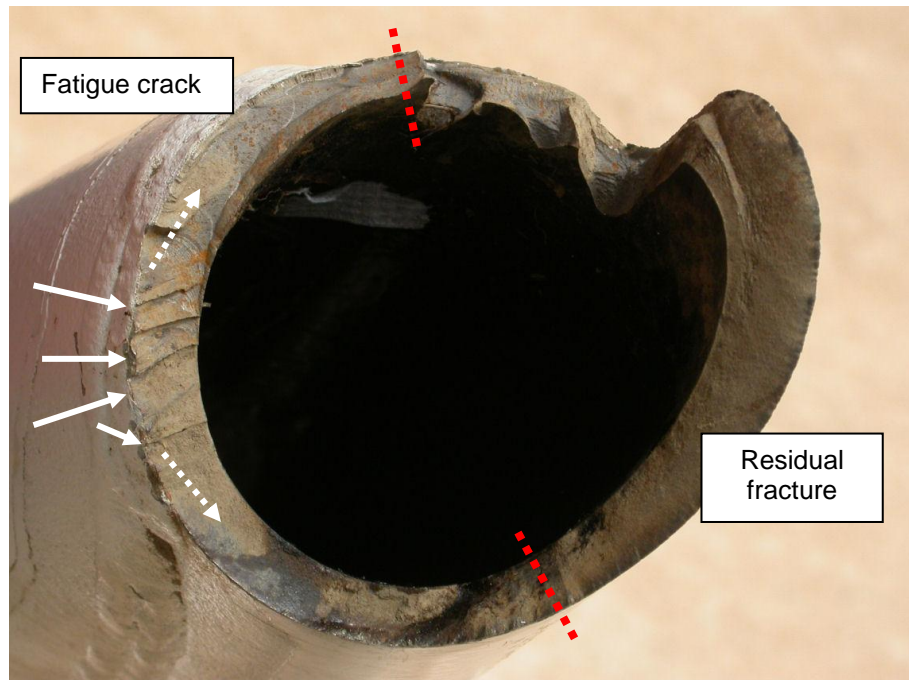


Figure 7. The fracture surface, seen in the direction facing the aircraft fuselage

The arrows in the illustration above show the fatigue fracture starting points and growth. The demarcation between the fatigue and the residual fracture has been marked by red dashed lines.

In the initial area, where the cracking is discoloured by corrosion, there are several hundred beach lines. In the remaining area up to the final fracture the fatigue surface consist of shorter areas showing fatigue, interspersed with areas where the crack has momentarily jumped several millimetres. Before the crack began to grow unstable with momentary jumps, it was about 75 mm long at the outer surface.

The total age of the fatigue cracking is difficult to judge, but probably more than a year for this particular type of flight operation.

There is no sign that corrosion had occurred in the initial area. The discoloration caused by corrosion that can be seen was formed on the fracture surface of the crack.

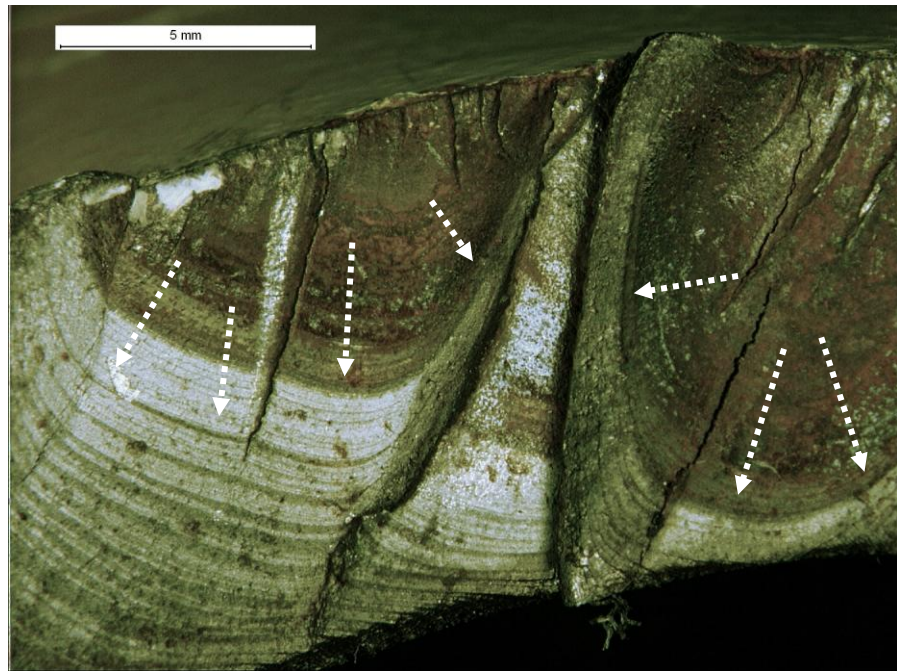


Figure 8. Beach lines on the fracture surface near to the starting point. The local direction of crack growth is marked.

1.16.2 *Preparation and implementation of crack inspection in accordance with “Check D”*

Preparation of the landing gear for a “Check D” is carried out by the maintenance facility, while the removal of the paint and aluminium coating normally is carried out by an external vendor.

The manufactures instructions for this work specify what methods can be used for the work but not how to check that all aluminium coating has been removed.

In the actual case it has not been possible to trace if this work was carried out by the maintenance facility or by an external vendor.

The examination for cracks thereafter is performed by an approved specialist workshop.

During the metallurgical examination it was found that the aluminium coating had not been completely removed in the area to be examined for cracks. The remaining coating had a thickness of 0.10-0.15 mm. An aluminium coating of this thickness can mean that crack indications using the magnetic powder method are more diffuse and cracks are more difficult to discover.

1.16.3 *Manufacturer’s examination of the landing gear leg*

The landing gear leg also underwent a metallurgical examination by the aircraft manufacturer. The result of the examination has been presented in a report, VEN: V6-CAW-3210-11.

The result of the examination was in close accordance with the result of the examination presented in Section 1.16.1. According to both reports the fatigue cracks were initiated outside the edge of the welded joint. Corrosion

on the fracture surface itself made it difficult to determine exactly where the cracking started.

The reports point out that the aluminium coating had not been removed from the surface that was checked for cracks in accordance with “Check D”. It is thought possible that this fatigue cracking was already present at the time of the latest “Check D” crack inspection, and would have been detected on that occasion if the metal surface had been prepared correctly before the crack inspection.

The manufacturer is not aware of any previous case concerning this particular type of crack initiation in a landing gear leg.

1.17 Organisational and management information

Not applicable

1.18 Other

1.18.1 Equal opportunities aspects

This event has also been examined from the point of view of equal opportunities, i.e. against the background that there are circumstances to indicate that the actual event or its effects were caused by or influenced by the women and men concerned not having the same possibilities, rights or obligations in various respects. No such circumstances were however found.

1.18.2 Environmental aspects

The incident did not have any negative environmental effects.

2 ANALYSIS

2.1 The accident

The landing gear fracture occurred while the aircraft was moving at low speed along the ground. If the event had instead occurred somewhat later, during the take-off run itself when the speed was high, serious personal injury would probably have been caused.

After the accident, the pilot acted correctly by quickly evacuating the passengers and taking the necessary measures to prevent a fire.

2.2 The landing gear collapse

2.2.1 Fracture in the landing gear leg

It was clear from the technical examination that the landing gear leg had several fatigue cracks initiating from the edge of the outer welded joint. The landing gear had been regularly subjected to large and oscillating loads, and the fatigue cracks had successively grown to join and form a common crack that penetrated the whole thickness of the material. The location of the cracking, inside the landing gear fairing, meant that the crack growth could progress for a long time without being discovered.

The landing gear fracture occurred in connection with taxiing before take-off at almost maximum take-off weight from an uneven grass surface. All the indications are that the landing gear was then subjected to such a high load that, weakened by the fatigue cracks, the landing gear leg pipe was no longer able to sustain the loads that were imposed on it, so that a momentary overload fracture took place.

2.2.2 *Crack initiation*

The affected area of the landing gear leg is subjected to high static and dynamic loads, including both bending moments and torsion forces, which bring with them the risk that fatigue cracks will arise in sensitive areas.

Initiation of this particular fatigue cracking took place in the area that according to SB No. 6/380 is critical to fatigue. The actual fracture did not however begin from any internal attack of corrosion at the welded joint, which had previously been the case. Instead, crack initiation began along a welded joint on the outside of the landing gear pipe section, something that the manufacturer had not experienced before.

In its investigation, SHK has not been able to find any definitive explanation for why the fatigue cracking was initiated on this particular landing gear leg. However it is apparent from the landing gear technical documentation that weld repairs had been made on cracks in the welded joints that are directly associated with the weld joint where the cracks began.

These weld repairs have to some extent overlapped the original welding in the critical area. Metallurgical defects had probably arisen in the area, in the form, for example, of internal stress, localised hardening or microscopic contamination of the material. It is well known that such defects promote the initiation of fatigue cracks.

2.2.3 *Crack checks*

It was found that the aluminium coating had not been completely removed from the critical metal surface during the most recent "Check D" inspection for cracks. Since the residual aluminium coating makes crack indication more diffuse, this could have meant that some possible existing cracks may not have been detected.

However this crack inspection was performed about three and a half years and more than 1,150 flying hours before the accident, which is equivalent to almost 3,000 landings. It is therefore completely possible that this particular cracking occurred after that inspection.

2.2.4 *Stipulated maintenance*

The risk of crack formation in that particular area is well known. In this case initiation probably took place in the joint of a weld repair on the outside of the landing gear pipe section, which is unusual.

Weld repairs to external cracks in this area are permitted, which carries an increased risk that similar types of fatigue cracking will arise, apart from the risk of cracks with internal initiation.

Even if a correctly performed crack inspection of the landing gear in accordance with “Check D” would in this case have eventually revealed this particular crack, there are strong indications that the current maintenance system, in respect of expert crack inspection, is inadequate.

In the opinion of SHK the current inspection interval of five years or 12,000 flying hours allows plenty of time for fatigue cracks to initiate, both on the inside and outside of the pipe section, and have time to grow to a critical length before being detected.

Considering that there is a risk of fatigue cracking taking place, and in addition that this is mainly dependent on the number of load cycles, SHK also believes that it is unfortunate that the periodicity of inspections is based on calendar time and flying hours and not the number of landings (cycles). The outcome of the load cycles ought to vary for the most part on the different uses of each aircraft by its operator.

In addition, visual inspection, in accordance with PSM 1-6-7, which is to be performed on the landing gear legs with the fairings removed and at intervals of 2,400 flying hours, seems to be inadequate in this respect. Also these inspections do not focus particularly on the critical areas where cracks could occur as specified above.

There are therefore reasons for the supervisory authority, in conjunction with the manufacturer, to consider the need for supplementing the present maintenance system in respect of crack formation in the landing gear.

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 aircraft was being operated within the permitted limits.
- d)* The strength of the right main landing gear leg was considerably reduced as the result of several fatigue cracks which had grown and joined.
- e)* The cracks had initiated in an external welded joint and developed over an extended period of time without being detected.
- f)* The aircraft type has been exposed to landing gear fracture before as the result of fatigue cracks in the actual area.
- g)* Current maintenance system prescribes NDT inspection of the landing gear within intervals of 12,000 flying hours or five years, whichever comes first.
- h)* In the preparation of the landing gear before the most recent “Check D” crack inspection all aluminium coating was not removed on the surfaces that were to be checked.

3.2 Causes of the accident

The accident was caused by fatigue cracking in the right main landing gear. A contributory factor was an inadequate maintenance system for this type of aircraft in respect of checking for cracks.

4 RECOMMENDATIONS

It is recommended that EASA and the Swedish Transport Agency, in conjunction with the manufacturer, consider the need for supplementing the present maintenance system in respect of crack formation in the landing gear, *(RL 2010:09 R1)*.