Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2010:15e

Accident to aircraft SE-LYK at Vinsta, Stockholm County, Sweden, on 8 August 2008

Case L-20/08

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.

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Statens haverikommission (SHK) Swedish Accident Investigation Board

Postal address	*Visitors*	*Phone*	*Facsimile*	*E-mail Internet*
P.O. Box 12538	Teknologgatan 8 C	Nat 08-508 862 00	Nat 08 508 862 90	info@havkom.se
SE-102 29 Stockholm Sweden	Stockholm	Int +46 8 508 862 00	Int +46 8 508 862 90	www.havkom.se

Statens haverikommission
Swedish Accident Investigation Board

15 December 2010 L-20/08

The Swedish Transport Agency

SE-601 73 NORRKÖPING, Sweden

Report RL 2010:15e

The Swedish Accident Investigation Board has investigated an accident that occurred on 8 August 2008 at Vinsta, Stockholm County, involving an aircraft with registration SE-LYK.

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 Board will be grateful to receive, by 1 April 2011 at the latest, particulars of how the recommendations included in this report are being followed up.

Göran Rosvall Sakari Havbrandt

Copy to the Swedish Civil Contingencies Agency (MSB).

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L-20/08

Report finalised 15 December 2010

Aircraft; registration and type	SE-LYK, Diamond DA 42
Class, airworthiness	Normal, valid Certificate of Airworthiness
Owner	Alfa Flight – Flygpilen Ek. association
Time of occurrence	8 August 2008, at 12:00 in daylight Note: All times are given in Swedish daylight saving time (UTC + 2 hours)
Place	Vinsta, Stockholm County, (posn. 5923′ N 01752′ E; 14 m above sea level)
Type of flight	Private
Weather	According to SMHI's[1] analysis: Wind north to north-westerly, 10-12 knots, visibility greater than 10 km, clouds 3-4/8 with base 300 feet, clouds 5-7/8 with base at 400 to 500 feet, temp./dewpoint +17/+16 °C, QNH 992 hPa
Persons on board:	
crew members	1
passengers	3
Injuries to persons	Pilot and one passenger seriously injured, others on board slightly injured
Damage to the aircraft	Completely destroyed
Other damage	Limited damage to vegetation
The pilot:	
Age, certification	49 years old, PPL, ME/IR
Total flying time	800 hours, of which 40 hours on type
Flying hours previous 90 days	4 hours, all on type
Number of landings previous 90 days	5

The Swedish Accident Investigation Board (SHK) was notified on 8 August 2008 that an aircraft with registration SE-LYK had an accident at 12:00 hours on that day at Vinsta, Stockholm County.

The accident was investigated by SHK represented by Göran Rosvall, Chairperson, Lars Alveståł, Investigator in Charge until 14 April 2009, and thereafter Sakari Havbrandt, Henrik Elinder, Technical Investigator, and Urban Kjellberg, Fire and Rescue Investigator.

SHK was assisted by Liselotte Yregård as a medical expert.

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

Summary

The purpose of the flight was to fly in IFR conditions from Stockholm/ Bromma to Eskilstuna and Västerås with a return to Stockholm/Bromma.

The take-off from runway 30 and departure took place as normal. While climbing out, when the aircraft had reached an altitude of 2,800 feet, the right engine stopped. The pilot performed the actions according to the checklist and tried to restart the engine three or four times without success.

[1] SMHI: Swedish Meteorological and Hydrological Institute

The aircraft could not maintain height, and was descending at the rate of approximately 300 feet per minute. The pilot requested radar guidance to runway 12 at Stockholm/Bromma, as the ILS transmitter at Stockholm/ Bromma was temporarily unserviceable.

As the aircraft approached Stockholm/Bromma, the pilot had drifted to the right and did not obtain visual contact with the ground, passing instead to the right of the runway. He turned 180 degrees to the left and flew round Stockholm/Bromma airport. He then flew westwards in order to find a place to perform an emergency landing.

The pilot made visual contact with the ground at an altitude of 500 feet while on a westerly track, with the runway behind him, and decided to land in a wooded area.

The aircraft caught fire immediately on impact. The three passengers were able to exit the aircraft themselves. The pilot was unable to get out of his seat and had to be helped free by people who had seen the accident and rushed to assist.

The engine had stopped due to a fault in a solenoid valve in the propeller pitch change mechanism, which had caused the propeller to change pitch to the fully feathered position.

It was found after the accident that the aircraft was overloaded by about 200 kg and that the rudder trim had not been used, which meant that the aircraft probably flew during its single-engine flight with side-slip, i.e. not in an optimal manner for maintaining height.

The accident was caused by the lack of operational conditions that would permit a safe way of managing the loss of one engine.

Recommendations

It is recommended that the Swedish Civil Contingencies Agency (MSB) ensures that:

• well-defined tactical procedures are prepared after consultation with other collaborating authorities and organisations, and that a general method is developed for the use of the necessary protective equipment and decontamination for rescue services personnel during rescue operations where there is a risk that composite material may be present *(RL 2010:15 R1)*, and that

• rescue services personnel receive the necessary information and training in order to identify and consider the risks, and be able to implement safe and efficient rescue operations in the presence of composite materials *(RL 2010:15 R2)*.

1 FACTUAL INFORMATION

1.1 History of the sequence of events

The purpose of the flight was to provide a bridegroom-to-be some flying experience in connection with a “stag party”. The weather did not permit VFR flying, so that an IFR flight from Stockholm/Bromma to Eskilstuna and Västerås with a return to Stockholm/Bromma was planned.

The take-off from runway 30 and departure took place as normal. While climbing out, when the aircraft had reached an altitude of 2,800 feet, the right engine stopped. The pilot performed the actions according to the emergency checklist and tried to restart the engine three or four times without success.

It was apparent that the aircraft could not maintain height, and was descending at the rate of approximately 300 feet per minute. The pilot requested radar guidance to runway 12 at Stockholm/Bromma, as the ILS transmitter at Stockholm/Bromma was temporarily unserviceable.

Although the pilot did not formally declare an emergency, air traffic control nevertheless regarded this as an emergency situation, and treated it as such.

Air traffic control stated the bearing to Stockholm/Bromma and kept other traffic clear.

As the aircraft approached Stockholm/Bromma, the pilot had drifted to the right and did not obtain visual contact with the ground, passing instead to the right of the runway. He turned 180 degrees to the left and flew round Stockholm/Bromma airport. He then flew westwards in order to find a place to perform a forced landing.

The pilot made visual contact with the ground at an altitude of 500 feet while on a westerly track and with the runway behind him. He saw power transmission lines, an industrial area and a residential area, with a grove of trees along the track of the aircraft. He decided to land in the wooded area, then switched off the engine that had been providing power and the master electrical switch before the aircraft impacted with the wooded area.

The aircraft caught fire immediately on impact. The three passengers were able to exit the aircraft themselves. The pilot was unable to get out of his seat and had to be helped free by people who had seen the accident and rushed to assist.

The pilot has stated that after the engine stopped he had not applied rudder trim, instead concentrating on trying to maintain the correct speed and the wings level.

The day before this particular flight, another pilot had planned a long flight and therefore filled the aircraft tanks full of fuel. That flight was not however carried out. The refuelling had not been recorded in the aircraft log book, nor entered into the electronic instrumentation of the aircraft.

1.2 Injuries to persons

	Crew members	Passengers	Others	Total
Fatal	–	–	–	–
Serious	1	1	–	2
Minor	-	2	–	2
None	–	–	–	–
Total	1	3	–	4

The pilot suffered an unstable fracture of the sixth cervical vertebra, a fracture at the bottom of an eye socket, several fractures of the lumbar vertebrae, a fractured ankle and cuts to the face.

The passenger in the right front seat had minor injuries. He suffered cuts to the arms and lower legs.

The passenger in the right rear seat escaped with minor injuries. He suffered cuts on a finger and a foot, along with back and chest pain.

The passenger in the left rear seat was seriously injured. In addition to several cuts, he suffered two fractures, one to the sternum and another to a toe.

1.3 Damage to the aircraft

Completely destroyed.

1.4 Other damage

The accident site was contaminated by particles from the burned carbon fibre composite. There was limited damage to vegetation.

1.5 The crew

1.5.1 Pilot

The pilot was 49 years old at the time and had a valid Private Pilot's Licence (PPL), with ME/IR ratings.

Flying hours			
Previous	24 hours	90 days	Total
All types	0	4	800
This type	0	4	40

Number of landings this type previous 90 days: 5.
Flight training on type carried out on 21 March 2007.
Latest PC (Proficiency Check) carried out on 11 May 2008 on a DA 42.
The pilot had a valid Class 2 medical certificate.

1.6 The aircraft

1.6.1 General

The aircraft		
Manufacturer	Diamond Aircraft Industries	
Type	DA 42	
Serial number	42.116	
Year of manufacture	2006	
Flight mass	Max. authorised take-off mass 1,785 kg, actual approx. 1,985 kg	
Centre of mass	Beyond the mass and balance diagram	
Total flying time	895.9 hours	
Number of cycles	1052	
Flying time since latest inspection	85.5 hours	
Fuel loaded before event	Jet A1	
Engines		
Manufacture	Thielert Aircraft Engines GmbH	
Model	TAE 125-01	
Number of engines	2	
Engine	*No. 1*	*No. 2*
S/N	02-01-0657	02-01-0658
Running time since new	895.9	895.9
Number of cycles since new	1,052	1,052
Propellers		
Propeller manufacturer	MTV-Propeller	
Model	MTV-6-A-C-F/CF187-129	
S/N	06090	06091
Running time since new	895.9	895.9
Number of cycles since new	1,052	1,052

The aircraft had a valid Certificate of Airworthiness.

1.6.2 The aircraft type

The Diamond DA 42 is a light twin-engined aircraft manufactured of glass fibre/carbon fibre composite, seating four people. The type has piston engines (diesel/kerosene) with variable pitch propellers.

Figure 1. Diamond DA 42

1.6.3 Propeller pitch change mechanism

The aircraft is equipped with a control system which permits the engine power to be regulated for each engine by means of a single control (Engine Throttle Lever). This control is connected to a computerised control unit, called the Full Authority Digital Engine Control (FADEC), which automatically regulates both the engine speed and propeller blade pitch angle to optimum states.

Alteration of the propeller blade angle takes place both mechanically and hydraulically. Balance weights in the propeller hub act to increase the blade angle with increasing propeller speed. A hydraulic system in the propeller hub ensures that the forces of the balance weights are resisted so that the blade angle decreases with increasing hydraulic pressure. The system is regulated via a control unit, called the Constant Speed Unit (CSU), which receives its control signals from the FADEC. Refer to the following system diagram.

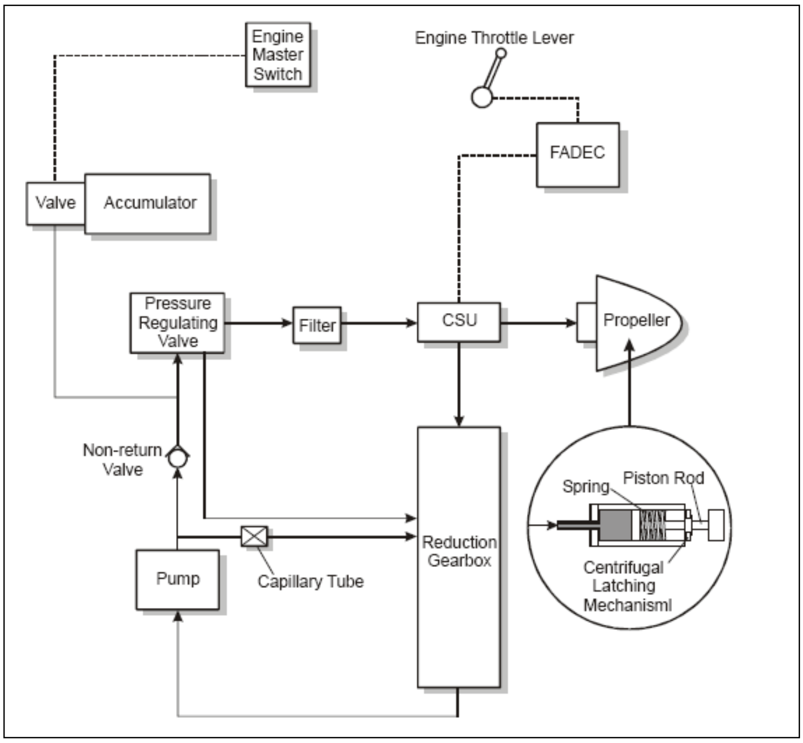

Figure 2. Propeller pitch change mechanism

Hydraulic oil from the engine hydraulic pump is pumped to the pitch change mechanism in the propeller hub. An electrically-operated valve called the Proportional Pressure Reducing Valve (PPRV), included in the CSU, regulates the flow of oil from the propeller hub. This enables the hydraulic pressure in the system to be regulated. The valve is a solenoid valve, which consists of a simple magnetic coil with a movable soft iron core connected to a valve piston.

If the engine speed is too high, the PPRV opens so that the oil pressure in the propeller hub reduces, thereby increasing the propeller blade angle, resulting in a reduction in engine speed. If the engine speed is too low, the PPRV closes so that the oil pressure in the propeller hub increases, thereby reducing the propeller blade angle, resulting in the engine speed increasing.

At propeller speeds of less than 1,300 rpm the maximum blade angle is limited by a mechanical stop, which makes it possible for the starter motor to have enough power to turn the engine during starting.

If the engine stops during operation, or if the supply of hydraulic oil to the pitch change mechanism should reduce while the speed is greater than 1,300 rpm, the balance weights will move the blades to the greatest possible angle, 81°±1° (feathered position).

1.6.4 *Maintenance Directive concerning the propeller pitch change mechanism*

The CSU is mounted on the propeller gearbox and forms one of its components. The major inspection interval for the gearbox is 1,000 flying hours, and its routine inspection interval is 300 hours.

Because faults have occurred in the propeller pitch change mechanism, the engine manufacturer published Service Bulletin (SB) TM TAE 125-0018 on 19 June 2008. This prescribes that PPRV units which have been installed on gearboxes and have accumulated between 300 and 400 flying hours must be replaced within 10 flying hours or during the next periodic maintenance inspection, whichever occurs first. If a PPRV unit has accumulated more than 400 flying hours it must be replaced within 50 flying hours or during the next periodic maintenance inspection, whichever occurs first. The valve must thereafter be replaced by a newly reconditioned unit at every 300 hours.

On 15 July 2008 the European Aviation Safety Agency (EASA) published Airworthiness Directive (AD) No. 2008-0130 in respect of Type TAE125-01 engines. This AD prescribes that PPRV units which have been installed on gearboxes and have accumulated more than a total of 400 flying hours must be replaced within 55 flying hours counted from 29 July 2008 or during the next scheduled maintenance, whichever occurs first. The valve must thereafter be replaced by a newly reconditioned unit at every 300 hours.

On 1 August 2008 EASA replaced AD No. 2008-0130 by EASA AD No. 2008-0145, which prescribed that the valve must be changed on both engine types TAE125-01 and TAE125-02-99.

1.6.5 *The fuel system*

This type of aircraft is equipped with four fuel tanks, one main tank in each wing and an auxiliary tank in each engine nacelle. The main tanks hold 95 litres and the auxiliary tanks 50 litres each.

The auxiliary fuel tanks do not have fuel gauges. The shapes of the filler pipes do not permit visual inspection of the amount of fuel or sounding of the fuel level with a dipstick. It can only be determined if the tanks are completely full by means of a visual inspection, or if they are completely empty by trying to transfer fuel from the auxiliary tanks to the main tanks, whereupon warnings will be generated when the auxiliary tanks are empty.

1.6.6 *Performance*

The aircraft has a modern aerodynamic shape and laminar profile wings, which means that the drag is considerably less than that of earlier designs of light twin-engined aircraft. This makes it possible to use engines of comparatively low power. Each of the engines on a DA 42 can produce a maximum output of 125 horsepower while traditional aircraft in this class seldom have engine outputs of less than 180 horsepower.

What normally determines the minimum engine power in the design of twin-engined aircraft is the climb performance with one engine shut down.

According to the flight manual for this type of aircraft, it will climb at 150 feet/min (0.7 m/s), at maximum flying mass, with one engine shut down, providing that:

- the propeller of the engine that is shut down is feathered,
- the landing gear is retracted,
- the wing flaps are retracted,
- the aircraft is banked 3-5 degrees towards the operating engine,
- the aircraft is not side-slipping and
- the indicated air speed is 82 knots.

1.6.7 Use and maintenance of the aircraft

The aircraft was used for both private and training flights. Technical maintenance and follow-up were performed by an approved maintenance facility. According to information obtained by SHK, the technical maintenance was carried out in accordance with the applicable regulations.

The technical documentation showed that the right hand engine gearbox was installed on 18 January 2008. The running time of the gearbox (including the PPRV) since inspection was at that time 300 flying hours, and the total flying time of the aircraft was 609.3 hours.

On 27 May 2008, when the aircraft flying time had amounted to 810.4 hours, the 100 + 200 hour inspections were carried out.

The flying time of the aircraft at the time of publication of the Thielert SB (Service Bulletin), TAE 125-0018 was 857.8 hours, and at the time of publication of the EASA AD No 2008-0145, 871.7 hours.

The PPRV for the right hand engine was therefore limited in its operating time to the aircraft flying time of 907.8 hours.

1.6.8 Aircraft mass and balance

The aircraft flight manual contains the following mass and balance diagram.

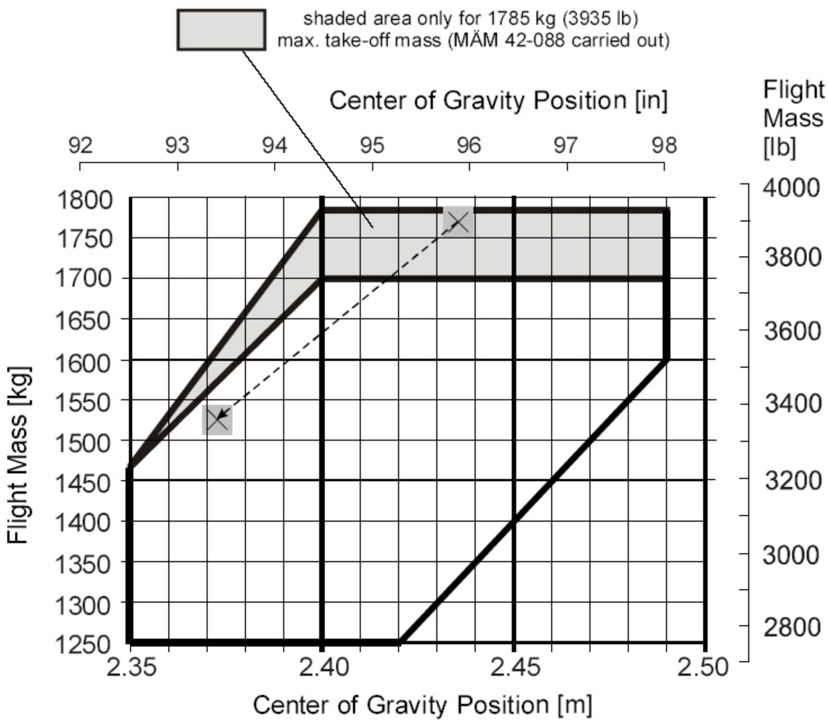

Figure 3. Mass and balance diagram

In addition there is a limitation for the maximum aircraft zero fuel mass, which is 1,650 kg.

The flight mass in this case was 1,985 kg and the position of the centre of mass was 2.49 m behind the reference plane, according to the following calculations:

	Mass Kg	Moment arm m	Mass moment Kg/m
Empty mass	1336.5	2.405	3214.3
Persons in the front seats	223.0	2.300	512.9
Persons in the rear seats	164.0	3.250	533.0
Baggage in the cockpit	0.0	0.600	0.0
Baggage in the front	0.0	3.890	0.0
Baggage in the rear	0.0	4.540	0.0
De-icing fluid	33.0	1.000	33.0
Total Zero-fuel mass & mass moment	**1756.5**	**2.44**	**4293.2**
Fuel in the main tanks	151.6	2.630	398.7
Fuel in the auxiliary tanks	80.0	3.200	256.0
Total take-off mass & mass moment	**1988.1**		**4947.9**
Calculated moment arm at take-off		**2.49**	

The actual position was located outside the applicable mass and balance diagram.

1.7 Meteorological information

According to SMHI's analysis: Wind north to north-westerly, 10-12 knots, visibility greater than 10 km, clouds 5-7/8 with base at 400 to 500 feet, temp./dewpoint +17/+16°C, QNH 992 hPa.

The photograph below, that was taken from inside the aircraft, shows that rain was present during the flight.

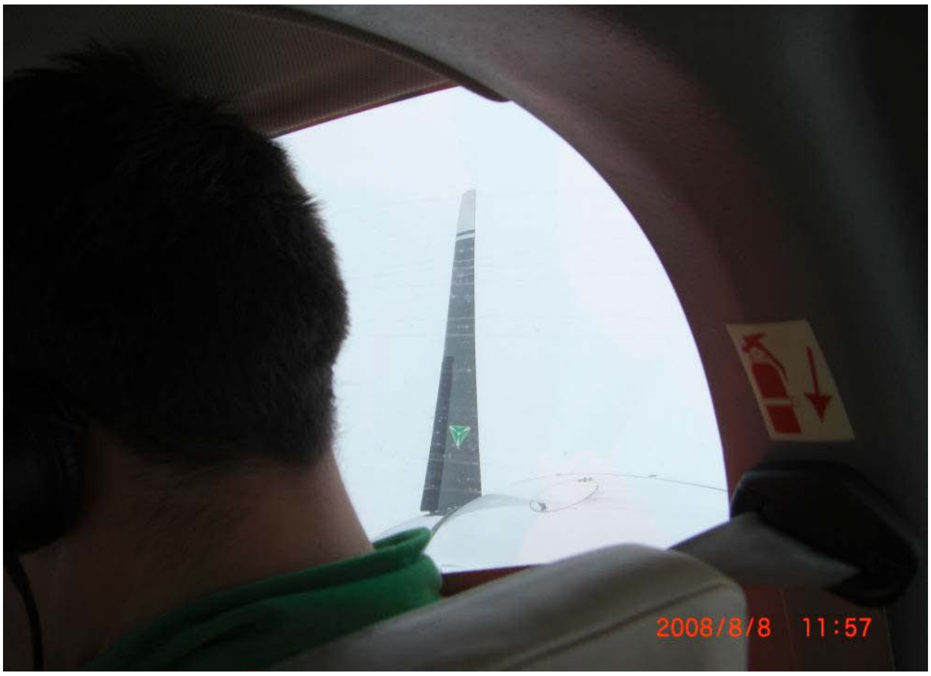

Figure 4. Photograph taken during the accident flight.

1.8 Aids to navigation

The aircraft was equipped with a modern “glass cockpit”, consisting of two electronic displays showing all the flight, navigation and engine instrument information. Besides the standard equipment for instrument flying there was a dual GPS[2] with “moving map”. The system also included an FMS[3] into which the planned route could be programmed.

1.9 Radio communications

Radio communication was established with the air traffic control tower at Stockholm/Bromma airport in conjunction with the take-off, and thereafter with Sweden air traffic control.

1.10 Aerodrome information

The airport status was in accordance with AIP[4]-Sverige/Sweden with the exception that the localizer for runway 12 was unserviceable.

1.11 Flight recorders and voice recorders

1.11.1 Recording equipment in the aircraft

In the electronic engine control system there are memory units which record a number of parameters. These units were retrieved after the accident. Attempts to obtain information from these memory units were made by both the French and German accident investigation authorities, and also by the engine manufacturer. However the damage to the units turned out to be too great to permit examination of the information.

1.11.2 Radar recording

The flight path of the aircraft had been recorded via radar. Based on this information, its route, altitude profile and speed could be established.

[2] GPS: Satellite-based navigation system
[3] FMS: “Flight Management System”
[4] AIP – Aeronautical Information Publication

The Figure below shows the aircraft route in terms of radar tracking, overlaid on a map with important events marked.

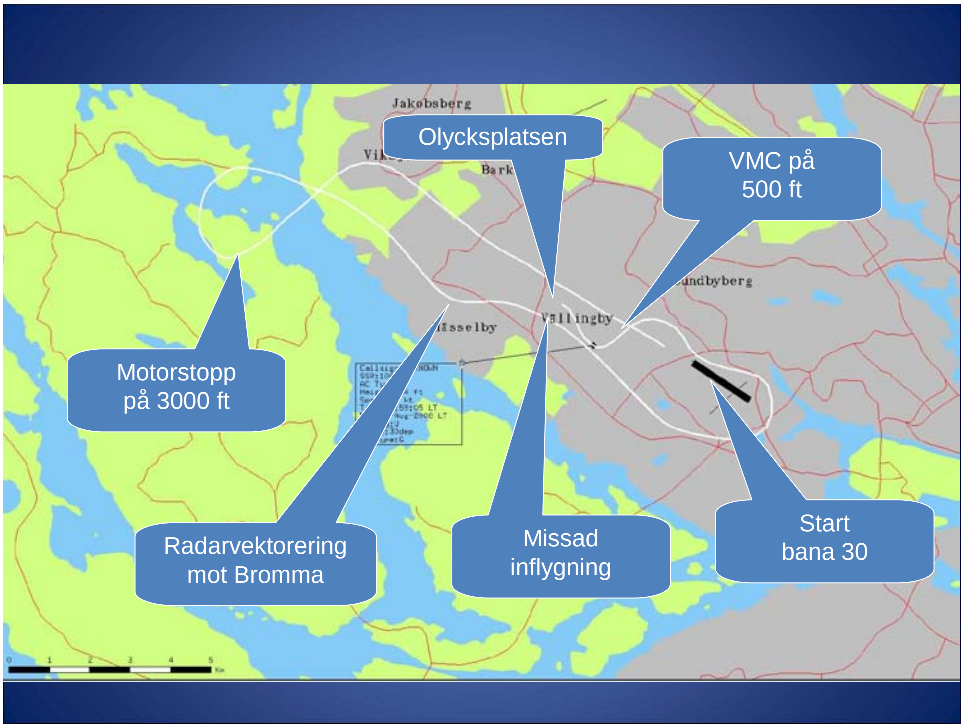

Figure 5. Radar plot

Olycksplatsen	Accident site
VMC på 500 ft	VMC at 500 ft
Start bana 30	Take-off from runway 30
Missad inflygning	Missed approach
Radarvektorering mot Bromma	Radar vectoring towards Bromma
Motorstopp på 3000 ft	Engine stopped at 3,000 ft

The following Figure shows the altitude profile of the flight:

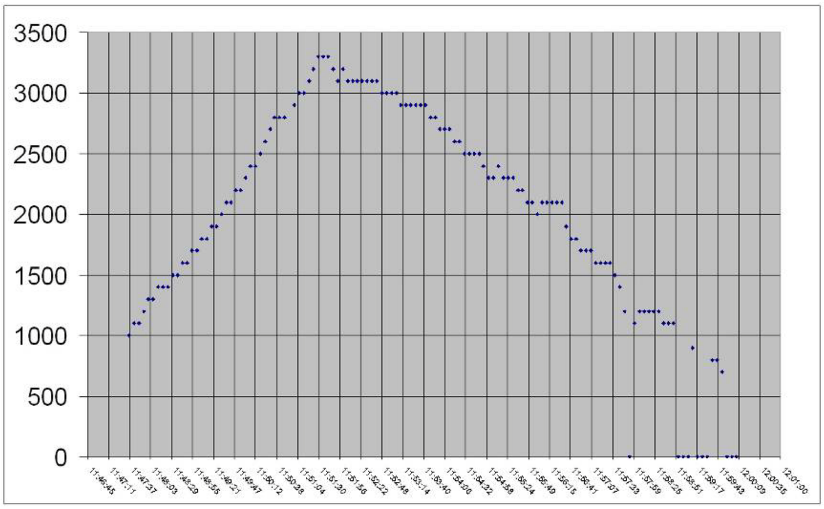

Figure 6. Altitude profile of the flight

The altitudes are stated with reference to the pressure level of 1013 hPa. Taking into account the air pressure at the time and the height of the airport above sea level, the stated altitudes must be reduced by approximately 500 feet to obtain the height above the airport. The engine stoppage occurred at the highest altitude on the curve, after which the altitude reduced relatively smoothly at about 300 ft/min.

The following diagram shows the speed in knots relative to the ground during the flight:

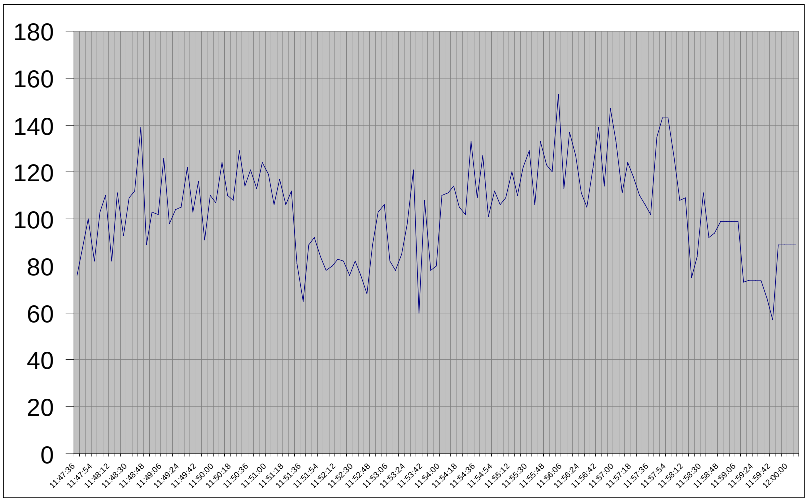

Figure 7. Ground speed of the flight

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

The accident site was a wooded area located between an industrial area and a residential area.

Figure 8. Photograph of the accident site

The yellow arrow indicates the direction of approach and the red cross indicates the accident site.

1.12.2 Aircraft wreckage

The aircraft burned out almost completely. Only the two engines and propellers, some metal parts and small composite pieces remained.

Figure 9. The aircraft wreckage

1.13 Medical information

The pilot had undergone the prescribed examination by an aviation physician and had a valid aviation medical certificate.

SHK however found that the pilot, at the time of the accident, had for several years been using medication for a metabolic disorder and for long term exhaustion and depression. According to information from the pilot and the physician who was treating him, the pilot was receiving proper treatment, tolerated the medication well and considered himself to be psychologically and physically well balanced.

In the aviation medical certificate concerning the most recent examination by an aviation physician it does not state that the pilot was being treated for any illness or was taking medicine.

According to JAR-FCL 3, the medical regulations applicable to the issue of aviation medical certificates, the diagnosis of long term exhaustion and depression and medication with anti-depressant drugs prevent the issue of a medical certificate.

According to JAR-FCL 1, the holder of a medical certificate must not be taking any prescription medicine, if they are not completely certain that the medicine will not have a negative effect on their ability to perform their tasks in a safe manner.

In the case of any uncertainty, advice must be sought from the Transport Agency, an aviation medicine centre or an aviation physician.

The holder of an aviation medical certificate must, in the case of regular use of a medication, without unreasonable delay seek advice from the Transport Agency, an aviation medicine centre or an aviation physician.

The Swedish Civil Aviation Authority (now the Transport Agency) had, however, no knowledge of the pilot’s illnesses and medication treatment.

The day before the accident the pilot had had a normal night's sleep and felt well.

1.14 Fire

The aircraft began to burn immediately in connection with the impact. The fire spread quickly and the entire aircraft was on fire when the rescue services arrived.

1.15 Survival aspects

1.15.1 General

A controlled landing of a light aircraft in woodland seldom results in such forces that serious personal injury is caused during the impact itself. The greatest risk is that of fire, in combination with difficulties incurred in evacuation. Evacuation may be made more difficult by terrain conditions, being trapped or by personal injury that is not intrinsically life-threatening, but can hinder or completely prevent those on board from getting out of the aircraft without assistance.

In this particular case the pilot had suffered several fractures and was sitting trapped. He probably would not have been able to leave the aircraft without external assistance.

1.15.2 The rescue efforts – alarm and turn-out

The rescue services at Stockholm/Bromma airport received the alarm from air traffic control in the control tower at 11:50. From their premises the rescue crew saw the aircraft cross above the runway and then disappear in a left turn on an approximately westerly course. Soon thereafter the services received information that the aircraft was missing. At about the same time, a smoke plume could be seen to the west. After this, the aircraft rescue services followed the events via communications radio until the group returned to ground-based conditions.

The crash alarm warning was received by the SOS centre in Stockholm at 11:53. The ambulance, emergency vehicle and police command centre received the alarm at 11:56. The district rescue services at the fire stations in Kista and Johannes received the alarm minutes later. The Karolinska university hospital and Söder hospital were also informed.

Air traffic control in the control tower contacted the SOS centre in Stockholm in order to be connected to the ARCC[5], which received the information concerning an aircraft with engine problems at 11:54. At this stage it was reported that there were two persons on board. The ARCC sent an alarm to the rescue helicopter in Stockholm three minutes after receiving an alarm concerning the event. The helicopter went to the accident site, where it landed at 12:24.

A civilian telephoned the emergency number 112 at 12:00 to report that a small aircraft had crashed at Vällingby. The person who called was very agitated and not sure of the address concerned, which was finally stated as being Linjemästarvägen 88. The ARCC, the rescue services command centre and the ambulance operator at the SOS centre were switched in to the telephone conversation, during which it was also stated that the aircraft was on fire and that everyone was said to be out of it.

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[5] ARCC = Aeronautical Rescue Coordination Centre, or aviation search and rescue centre

The fire station closest to the accident was Vällingby fire station, which received the alarm at 12:04. The Linjemästarvägen 88 address turned out to be incorrect and the arrival at the accident site next to Korgvidegränd was delayed until 12:10. After the first 112 emergency call several other calls reported the accident, giving different addresses within the Vinsta district. The exact address was clearly given by a 112 emergency call at 12:06, during which it was reported that the injured persons were in the yard of industrial premises at Korgvidegränd 5. A few minutes later, the ARCC supplied information to the SOS centre that according to the air traffic control tower at Bromma there had been four persons on board the crashed aircraft.

Altogether five different medical emergency units went to the accident site. These were three road ambulances, one emergency response vehicle and one ambulance helicopter, all of which had arrived at the accident site by 12:15. The doctor on the helicopter then received a report from the ambulance nurse who had arrived just before, that all the occupants were out of the aircraft and that their injuries were relatively minor. With assistance from the rescue services personnel, the medical staff took care of the injured and prepared them for transport to hospital. The four injured people who had been on board the aircraft were transported from the accident site at 12:43.

1.15.3 The rescue efforts – rescue and fire extinguishing

The basic tactical intentions of the first unit of the rescue services to arrive at the accident site were to save lives and limit then extinguish the fire. At a relatively early stage of their work, information was received that all four occupants had got out of the aircraft and were safe, near to the adjacent industrial premises. It was in fact one of the employees of that industrial business who had helped to pull out the pilot, who had been trapped by one leg while the interior of the aircraft was burning. The rescue services extinguished the initial fire with water, and then later changed to extinguishing with foam.

The transfer from the rescue commander at ARCC to the local district rescue services commander took place at 12:29, whereupon the national aviation rescue commitment ceased. After this it was the responsibility of the Stockholm Fire Services to continue the rescue work in accordance with LSO 2003:778 - the Swedish Accident Prevention Act, with an assigned rescue commander to manage and co-ordinate the efforts. The rescue services stage ended at 13:05, when responsibility for the site was handed over to the police. The police had already, during the rescue stage, cordoned off the area.

1.15.4 Actions by the rescue services – safety risks

Only after the fire had been extinguished and the rescue services personnel had returned to the fire station at Vällingby was information received that the principal construction material of the aircraft consisted of a carbon fibre composite. During the rescue action, therefore, the special risks to health associated with carbon fibre composite were not taken into account. Apart from sharp-edged pieces of wreckage, broken composite poses the risk of stiff and sharp reinforcement fibres which can easily penetrate the skin and even enter the lungs by being breathed in. Carbon fibre is not inherently toxic, but can carry with it hazardous particles. The risks are considerably increased in association with fire, when very small particles are released, which if breathed in cause discomfort and illness that can be compared with the more well known risks to health caused by breathing in asbestos fibres or stone dust.

The rescue services personnel were generally aware of the risks posed by composite material from a personal health viewpoint. At the same time there were no particular tactics or other suitable procedures to avoid the consequences of contact with such substances. At the accident site, only some of the firemen used breathing protection when they were at or adjacent to the location of the fire itself. The emergency clothing of the rescue personnel was not dealt with appropriately, and no form of decontamination was performed at the accident site.

After the Vällingby fire station rescue personnel had returned to the fire station, they received information from the command centre that carbon fibre composite had been involved, and were told of the risks. The equipment they had used was then cleaned at the fire station and their emergency clothing put into plastic bags and sent away to be washed.

1.16 Tests and research

1.16.1 Technical examination of the aircraft

The damage to the aircraft was so comprehensive that a detailed technical examination of the wreckage was not possible. However the engines and propellers were retrieved and examined.

1.16.2 Examination of the right hand engine

The right hand engine, including the propeller installation, was technically examined by the engine manufacturer, supervised by an SHK representative. During the technical examination no faults were found and there were no abnormalities in the engine or its auxiliary systems.

During the examination of the propeller pitch change mechanism it was found that the PPRV was not working and was in its fully open position.

1.16.3 PPRV fault tracing

During fault tracing on the PPRV it was found that faulty operation of the valve was caused by an electrical open circuit in its solenoid winding. The copper wire of the winding had broken at the soldered junction to one of the two connection pins of the valve, due to a fatigue crack. (See the photograph below.)

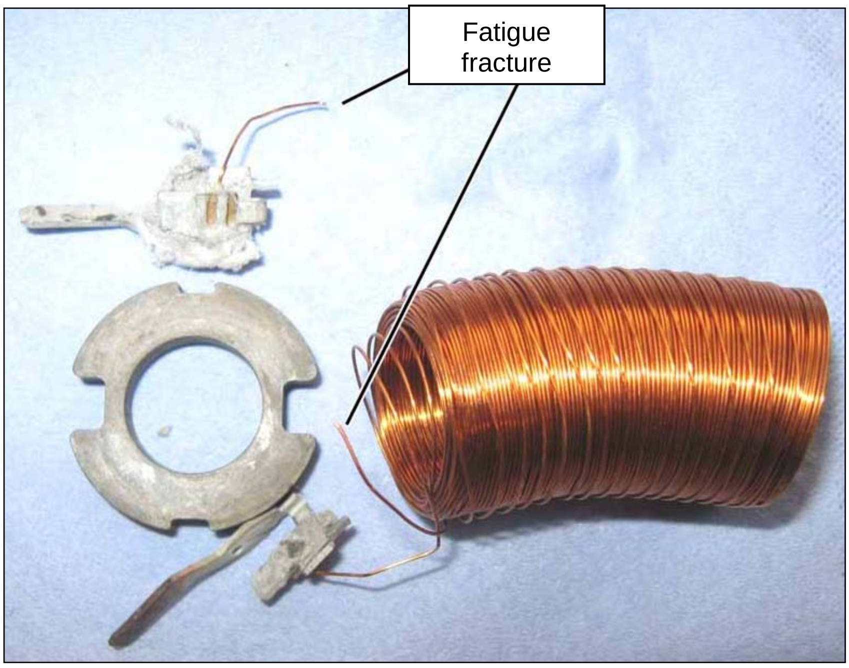


Figure 10. Solenoid winding of the PPRV valve

According to the engine manufacturer seven previous cases had been documented where there had been serious engine malfunctions caused by faulty operation of the PPRV. In all these cases it had been found that the copper wire forming the solenoid winding had broken. It was suspected that the breaks were due to metal fatigue resulting from vibration of the gearbox.

In order to solve the problem a modified attachment of the CSU to the propeller gearbox had been developed, in accordance with Section 1.18.1.

1.17 Organisational and management information

Not applicable.

1.18 Other

1.18.1 Measures taken after the accident

After this accident, the engine manufacturer developed a modified and more flexible installation of the CSU on the propeller gearbox, intended to reduce the risk of damaging vibrations affecting the PPRV during operation. According to the Thielert SB TAE 125-0020 dated 20 August 2009, this modification must be implemented within 50 flying hours after the issue date or during the next periodic maintenance inspection, whichever occurs first.

EASA published on 27 August 2009 AD No.: 2009-0193, which among other things prescribes that the measures in accordance with Thielert SB TAE 125-0020 must be implemented within 55 flying hours after the issue date.

1.18.2 Equal opportunities aspects

Not applicable.

1.18.3 Environmental aspects

The principal construction material of this type of aircraft consists of carbon fibre composite. When carbon fibre burns at a high temperature, small carbon particles are released, which if breathed in cause discomfort and illness that can be compared with the better known problems that can arise caused by breathing in asbestos fibres or stone dust. In addition, carbon is a material which can take up toxic substances from fire gases and thereby carry them to any person who breathes in the particles.

The fibres in composite material are small and light, so that particularly in conjunction with fire they can be blown by the wind over a considerable distance. The fibres do not naturally decompose and must therefore be removed from the site of an accident and dealt with in a safe manner. Rainy weather or, for example, the application of fire fighting foam binds the particles together and reduces the spread.

The wreckage was taken away for destruction and the accident site was decontaminated by the local district authority.

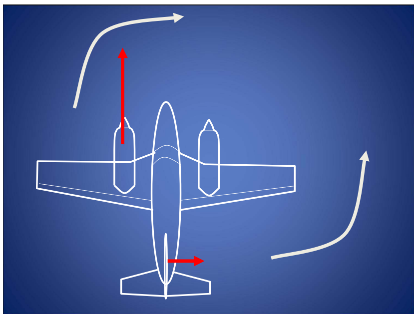
1.18.4 Performance studies carried out by Kungliga Tekniska högskolan (the Swedish Royal Institute of Technology)

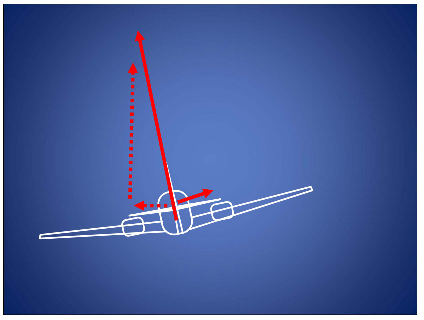
On the behalf of SHK the Swedish Royal Institute of Technology carried out performance studies in respect of the single engine performance with this particular overload and rain conditions. The conclusions of the studies were that it would not be possible to climb, but that it would probably have been possible to maintain height in the conditions that prevailed.

1.18.5 *Flying with asymmetric drag*

Asymmetric drag occurs for a twin-engined aircraft when it is flying with the power of only one engine. Because the engine is located some metres away from the centreline of the aircraft, a moment is applied in the yaw plane, i.e. if the right hand engine stops the aircraft will yaw to the right. This can be compensated for by applying left rudder, which counteracts the turning moment from the engine that is supplying power.

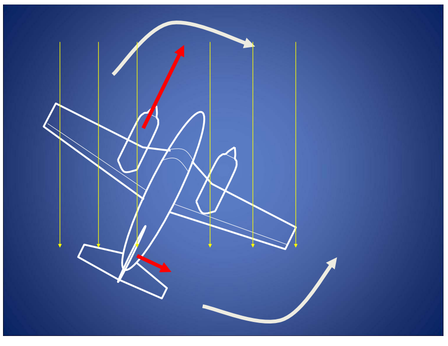
However the rudder forces provide a sideways result that tries to push the aircraft to the right. To compensate for this, the aircraft must have a few degrees of bank to oppose the engine providing the power. The horizontal vector of the lift forces will then counteract the rudder forces. When these forces are in balance, the aircraft will fly without side-slip, which means that its longitudinal axis is parallel to the direction of movement. See also the following Figures.





The above Figures show the forces that arise when the asymmetric drag is compensated for in an optimal way.

If there is no or too little rudder applied, the aircraft can become stabilised in a yawed state, with side-slip. The tail fin will then act as a weather vane and generate a side force that compensates for the asymmetric drag. In that case the longitudinal axis of the aircraft will not be parallel with the direction of movement, meaning that the wind speed from ahead will push on the aircraft from one side (side slip). This in turn means that there will be an increase in drag due partly to the fuselage and engine nacelles “crabbing” through the air, and partly because the efficiency of the wings reduces, so that their ability to produce a lifting force falls as the drag increases. This in turn results in an increase in the lowest possible flying speed. The aerodynamic vibrations that indicate too low a speed can then be felt at a higher speed than normal. See also the following Figures.



The above Figure shows the forces that arise if insufficient rudder is applied.

A flying instructor has stated that he tested a DA 42 at almost its maximum permitted flight mass with only one engine running and incorrect rudder application. The result was that it was impossible to maintain height when he did not use the rudder. When he flew correctly, he was able to maintain a climb rate of approximately 150 feet/minute.

1.18.6 Certification requirements

The DA 42 is certified in accordance with the JAR-23 design standard, which was the applicable design standard in Europe at the time its certification process began. Later, since EASA was formed in 2003, design standard CS 23 has applied to new designs.

In the case of twin-engined aircraft with a stalling speed of less than 61 knots, both JAR-23 and CS 23 prescribe that single-engine performance must be stipulated. There is no requirement that the aircraft must be able to maintain height or be able to climb on one engine.

1.18.7 Earlier recommendations

The Swedish Rescue Services Agency was recommended, in the SHK Report RM 2008:01, after an accident in 2007 concerning a JAS 39 Gripen, where composites were involved in connection with a fire, to strive for better education and training for rescue services personnel in contaminated areas.

2 ANALYSIS

2.1 Loss of power

2.1.1 The engine failure

No technical faults were found in the right hand engine, except for the fault that was found in the PPRV in the propeller pitch change system. The faulty operation of the valve, which meant that it suddenly opened completely, meant that the hydraulic pressure in the pitch change mechanism immediately fell. Since the engine stoppage occurred during normal flight, the propeller rotation speed was greater than 1,300 rpm. The loss of pressure meant that the balance weights in the pitch change mechanism could without hindrance alter the blade angle to the maximum, i.e. 81°, which is equivalent to “fully feathered”.

The high blade angle resulted in a powerfully increased resistance to rotation for the propeller. Several cases of faulty operation that had occurred previously showed that the engine in such a situation was unable to maintain its rotation speed. When the engine speed decreased to below a certain level it ceased to operate normally and stopped, which is exactly what happened in this particular case. The fact that this happens if the PPRV ceases to function and remains in a fully open position during normal operation was verified by the engine manufacturer.

In the opinion of SHK it is a flaw in the engine/propeller installation that such a relatively simple fault can result in a complete loss of engine power, completely without any warning.

2.1.2 The PPRV

As stated in Section 1.6.4, faulty PPRV operation was already a familiar problem for this engine/propeller combination, which prompted both the engine manufacturer and the supervisory authority to publish several SBs and ADs with running time restrictions imposed on the PPRV. The purpose was that the units should be taken out of operation in good time, before a possible failure could occur.

These regulations limited this particular PPRV unit, installed on the engine's propeller gearbox on the aircraft, to operation up to flying times of 907.8 and 926.7 hours respectively. At the time of the accident the aircraft had flown 895.9 hours, which meant that the PPRV should have been fully fit for use in flight.

The modification to the CSU installation on the propeller gearbox that was initiated by the manufacturer after the accident, and that was prescribed in the Thielert SB TAE 125-0020, was, in the SHK view, relevant to solving the problem and ensuring flight safety. This measure was also prescribed in the EASA AD No.: 2009-0193, and SHK sees therefore no reason to issue any recommendation in this respect.

2.2 The overloading

The aircraft had an overload of about 200 kg. 80 kg of this was fuel in the auxiliary tanks that the pilot did not know about and was unable to check. The remaining 120 kg is more difficult to explain. With full main tanks and empty auxiliary tanks the aircraft had a load capacity of 264 kg, i.e. an average passenger weight of 66 kg. On that particular flight the average weight of the passengers was 96 kg.

2.3 The flight after the engine failed

The studies carried out by the Swedish Royal Institute of Technology showed that the aircraft had no climb capability with only one engine providing power, but that when being flown correctly it would have been able to maintain height.

The fact that the pilot did not use rudder trim to reduce the operating force required to move the rudder probably meant that he did not completely compensate for the moment from the asymmetric drag forces, which led to side slipping and increased drag.

The radar recording shows that the speed relative to the ground was high during much of the flight. Even if the ground speed is corrected by wind speed, it is probable that the air speed was higher than that recommended for single-engine flying, i.e. 82 knots.

The fact that the aircraft steadily lost height can be explained by the combined affects of overload, rain, side-slipping and excessive speed.

2.4 The accident

When the pilot emerged from cloud and realised that he would not be able to land at Stockholm/Bromma he made the decision to fly towards the west to find an emergency landing area beyond the built-up area. His decision to carry out a controlled forced landing in a wooded area probably contributed to the injuries suffered by those on board not being more serious, and that no-one on the ground was injured.

2.5 Medical analysis

At the time of the accident the pilot was under medication, for long term exhaustion and for a metabolic disorder. The information was that the treatment was beneficial and the pilot felt well.

According to the JAR FCL regulations, depressive illness and treatment with anti-depressive medication are obstructions to the issue of a medical certificate. Despite his depressive illness, he had a valid medical certificate.

The Swedish Transport Agency (formerly the Swedish Civil Aviation Authority) aviation medicine unit did not know either about the pilot's medical problems.

A condition of depression often means that the individual, in addition to feeling low, suffers from a reduced ability to concentrate, fatigue – even after minor efforts, lack of energy and lowered self-confidence. Even though treatment of a depressive condition is seen as effective, it does not definitely mean that all the symptoms of the illness are normalised completely.

It often happens that anti-depressive medicaments can have side effects in the form of such problems as sleeping difficulty, nervousness, anxiety and inability to concentrate, along with eyesight symptoms in the form of blurred vision.

Long term exhaustion and its treatment with anti-depressive medicine can thereby mean that there are bouts of a tendency to loss of concentration, exhaustion, nervousness and anxiety problems for the individual.

This means that it cannot be excluded that such factors may have limited the ability of the pilot to manage the unexpected and stressful situation associated with the engine failure.

During the investigation it has emerged that there is in general poor knowledge among pilots and physicians who do not have competence in aviation medicine of which rules apply in the case of illness and the rendering of treatment, and of how these must be managed in respect of those who are active in the field of aviation.

2.6 Actions by the rescue services

The alarm raised in connection with the aircraft's reported engine problems and the issue of alarms to the medical and rescue services after the accident, including information to the police, fully met the need for resources which were able to intervene. The fact that there was uncertainty concerning the precise location of the accident site was due to different address information coming in from the general public who called 112, the emergency number. Despite this, the first rescue services vehicle arrived at the accident site ten minutes after the first call to 112. Initially the correct information as to the number of people on board the aircraft was not available until the rescue commander at the ARCC followed up and confirmed that the correct number was four.

Outside the accident site itself, in the adjacent industrial premises yard, the medical personnel prepared the injured in a routine manner for transport to the hospital.

In accordance with normal procedures, the first task of the rescue services was to save lives and put out the fire. After it had been quite quickly established that all four occupants had been taken care of and were located in the adjacent yard, it remained to complete the efforts that had already begun to completely extinguish the fire.

The information and risks due to the aircraft being principally constructed of carbon fibre composites was not sought during the time that the rescue efforts were in progress, neither by the national nor the subsequent local district rescue services. The actions of the rescue services at the accident site show that no-one asked for the information that was needed to confirm or exclude the presence of common composite materials and their associated risks. It is the assessment of SHK that neither can it be ruled out that questions not posed in this case are just as likely to be missed in other rescue efforts elsewhere in Sweden. This must be seen as a deficiency, in that procedures are not laid down for work in an environment where carbon composites are burning. Such procedures should be in place, which among other things state what protective equipment should be used and which decontamination measures, including the handling of contaminated clothing and other waste must be taken.

It is very important from the personal safety point of view, but also for preservation of the environment, that the Swedish rescue services and other organisations which work at an accident site are informed and given the opportunity to receive suitable education concerning composite materials and their associated risks. On the basis of such risks there must be evolved suitable tactics and appropriate personal protection, along with procedures for decontamination where composite materials have been damaged by crash impact and/or fire. Also the use of helicopters close to the accident site should be questioned, as the powerful downdraught from rotor blades can blow up hazardous dust and spread it further.

Most modern civil and military aircraft contain composites in their construction and it is therefore necessary to set up well-defined procedures and a general method of operation for the use of the necessary protective equipment, not just for rescue personnel but for the personnel of all the organisations that are involved. In the case of an aircraft accident the fundamental assumption should always be made that the aircraft contains composite materials until it is confirmed otherwise.

What has been stated in respect of the risks that are associated with composites that have been affected by severe impact or fire in connection with an aircraft accident may probably also apply in, for example, other accident cases involving modern means of transport, such as trains, boats, buses, cars, caravans, etc.

3 CONCLUSIONS

3.1 Findings

a) The pilot was formally qualified to perform the flight.
b) The aircraft had a valid Certificate of Airworthiness.
c) The engine stopped due to a component failure in the propeller pitch change mechanism.
d) The aircraft was overloaded.
e) Rudder trim was not applied.
f) The air speed during the single-engine flight was probably greater than that recommended for the best climb performance.
g) On this type of aircraft there is no method of determining the amount of fuel in the auxiliary tanks.
h) The pilot was suffering from an illness, and taking a type of medication which normally prevents the issue of an aviation medical certificate.
i) The rescue and medical efforts were performed in a routine manner.
j) Information concerning carbon fibre composites and their associated risks was not sought, nor taken into account during the rescue operation.
k) There were no suitable procedures for rescue efforts in the case of burning composite material in respect of personal safety and decontamination measures.

3.2 Causes of the accident

The accident was caused by the lack of operational conditions that would permit a safe way of managing the loss of one engine.

4 RECOMMENDATIONS

It is recommended that the Swedish Civil Contingencies Agency (MSB) ensures that:

- well-defined tactical procedures are prepared after consultation with other collaborating authorities and organisations and that a general method is developed for the use of the necessary protective equipment and decontamination for rescue services personnel during rescue operations where there is a risk that composite materials may be present *(RL 2010:15 R1)*, and that

- rescue services personnel receive the necessary information and training in order to identify and consider the risks and be able to implement safe and efficient rescue operations in the presence of composite materials *(RL 2010:15 R2)*.