Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2006:12e

Accident involving aircraft SE-GOP at Optand airport, Z county, Sweden, on 6 August 2004

Case Number L-31/04

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

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

Translated by Tim Crosfield, M.A., from the original Swedish at the request of the Swedish Accident Investigation Board. In a case of discrepancies between the English and the Swedish texts, the Swedish text is to be considered the authoritative version.

Statens haverikommission (SHK) Swedish Accident Investigation Board

Postadress/Postal address	*Besöksadress/Visitors*	*Telefon/Phone*	*Fax/Facsimile*	*E-mail Internet*
P.O. Box 12538	Teknologgatan 8 C	Nat 08-441 38 20	Nat 08 441 38 21	info@havkom.se
SE-102 29 Stockholm Sweden	Stockholm	Int +46 8 441 38 20	Int +46 8 441 38 21	www.havkom.se

Statens haverikommission
Swedish Accident Investigation Board

2006-05-15 L-31/04

Swedish Civil Aviation Authority

601 73 NORRKÖPING

Report RL 2006:12e

The Swedish Accident Investigation Board (Statens haverikommission, SHK) has investigated an accident that occurred on 6 August at Optand Airport, Z county, Sweden, involving an aircraft with registration SE-GOP.

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

The Board will be grateful to receive, by 16 November at the latest, particulars of how the recommendations included in this Report are being followed up.

Göran Rosvall Urban Kjellberg

Dan Åkerman Sakari Havbrandt

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APPENDIX

1 Excerpt from Register of Licences regarding the pilot (Swedish Civil Aviation Authority only)

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L-31/04
Report finalised 15-05-2006

Aircraft; registration, type	SE-GOP, Cessna U 206 G
Class, airworthiness	Normal, valid certificate of airworthiness
Owner	Östersund Parachute Club
Time of event	06-08-2004, 16.25 hrs in daylight *Note: All times are given in Swedish daylight saving time (UTC+2 hour)*
Place	Approximately 750 m SSW Optand airport, Z county, Sweden, (GPS pos. 63 07.084N 014 48.373E; 386 m above sea level)
Type of flight	Private
Weather	According to SMHI analysis: southerly wind 5-10 knots, good visibility, 1-2/8 cumulus with base above 5 000 feet, temp./dew point 24/12 °C, QNH 1019 hPa
Numbers on board:	
crew	1
passengers	6
Injuries to persons	4 fatal, 3 severely injured
Damage to aircraft	Total write-off
Other damage	Forest damage
The pilot:	
Sex, age, licence	Man, 60 yrs, A-licence
Total flying time	1 352 hours, of which >85 hours on type
Flying hours, previous 90 days	67, of which 27 on type
Number of landings, previous 90 days	250, of which 50 on type

The Swedish Accident Investigation Board (SHK) was informed on 6 August 2004 that an accident had occurred involving an aircraft with registration number SE-GOP at Östersund/Optand airport, Z county, Sweden, on that day at 16.25 hrs.

The accident has been investigated by SHK represented by Göran Rosvall, Chair, Mats Öfverstedt, Chief Operational Investigator until and including 15 February 2005, subsequently Sakari Havbrandt and Dan Åkerman, Chief Technical Investigator, and Urban Kjellberg, Chief Investigator, Rescue Services.

SHK was assisted by Mats Aldman as medical expert.

The investigation was followed by the Civil Aviation Authority in the person of Gun Ström.

Summary

During the day the pilot had done a number of “lifts” with parachutists. After refuelling the pilot and six parachutists went on board.

The following description of the flight is based on testimony from the survivors and witnesses on the ground.

When the aircraft had been climbing for a short while speed fell off and the engine began to run irregularly. The pilot cursed and started operating the controls; it is unclear which. He put the aircraft into a glide and performed a gentle left turn. The engine ran more and more irregularly with

thumps and vibrations. The aircraft glided down into the trees until it finally stopped upside down against a group of trees. Fire broke out almost immediately.

Three of those on board were able to get out or were thrown out, and came to outside the wreckage. The clothes of all three were burning, but they managed to put the fires out by rolling on the ground. The fire in the aircraft then rapidly became so intense that rescue of those inside would have been impossible. The survivors, all with burn and smoke injuries, made their way to a nearby road to call for help.

The Board of Accident Investigation has been unable to establish the cause of the accident.

Recommendations

The Swedish Civil Aviation Authority is recommended to:

- Issue information to the effect that on different aircraft types there are great differences in the measures to be taken in the event of engine failure, and that it is essential that the emergency checklist for the aircraft in question be taken out and carefully gone through prior to takeoff *(RL 2006:12e R1)*.

- Seek to ensure that the contents of the above recommendation are incorporated in basic training *(RL 2006:12e R2)*.

- Seek the introduction of a differential training requirement for aircraft with the Continental company's fuel-injection systems and, where required, also for aircraft with other types of engine control system where emergency procedures differ decisively from those in general use *(RL 2006:12e R3)*.

- In its supervisory activity ensure that correct emergency checklists are available in all aircraft *(RL 2006:12e R4)*.

- Seek to ensure that cleaning of the FCU filter is introduced into Cessna inspection lists for those aircraft that may be relevant *(RL 2006:12e R5)*.

1 FACTUAL INFORMATION

1.1 History of the flight

The aircraft was owned and operated by the Östersund Parachute Club based on the Ope Field near Östersund. During the day the pilot had performed a number of ”lifts” with parachutists. During a break on the ground before the accident flight the aircraft was refuelled while the pilot went to the club house for a short time for refreshments. The refuelling was supervised by the jump leader for the next flight.

The aircraft was normally flown on the starboard tank, while the port tank was considered as a reserve and usually contained about 30 litres of fuel. For the flight in question, it is probable that only the starboard tank was refuelled and, if the routines were being followed, the port tank was not.

The aircraft’s starboard tank being refuelled before the accident flight. Picture from amateur video.

After refuelling, the pilot and the parachutists went on board. The parachutists sat directly on the floor in the cabin with their backs in the direction of travel. Only the pilot seat had a safety belt. The engine started normally and the aircraft taxied from the club area to the far end of the runway. A stop was made approximately half-way to pick up a "streamer", a coloured strip of cloth thrown from the parachutists’ aircraft before the first jump to judge wind direction and strength. The jump exit, a roll-front door, was open during the taxiing. At the takeoff point, a short wait was necessary for another aircraft which taxied behind. Before takeoff, the jump exit was shut.

The following description of the flight is based on testimony from the survivors and witnesses on the ground:

Acceleration along the runway was initially normal. When the aircraft had climbed briefly, speed diminished somewhat and the engine began to run unevenly. The pilot uttered an expletive in a loud voice and started to move the controls but it is not clear which ones. Shortly after this he put the aircraft into a glide and made a gentle turn to the left. Meanwhile the engine started to run more and more unevenly with thumps and vibrations. The aircraft glided down through the trees until it finally came to a stop upside-down against a group of trees. Fire broke out almost at once.

Three of those on board were able to make their way out or were thrown out and came to outside the wreck. All had burning clothes which they extinguished by rolling around on the ground. The fire inside the wreck then quickly became too intense for an attempt to rescue those still inside to be possible. The survivors, all with severe burn and smoke injuries, made their way to an adjacent road to call for help.

Immediately after the crash one of the survivors reported that the fire had started before the crash and that he had jumped out shortly before impact. In a later interview he had no memory of this. None of the other witnesses was aware of burning before the impact.

The accident occurred at (GPS) pos. 63 07.084N 014, 48.373E; 386 m above sea level.

1.2 Personal injuries

	Crew	*Passengers*	*Others*	*Total*
Fatal	1	3	–	4
Seriously injured	–	3	–	3
Slightly injured	–	–	–	–
No injuries	–	–	–	–
Total	1	6	–	7

1.3 Damage to the aircraft

The aircraft was totally damaged.

1.4 Other damage

Limited fire and mechanical damage to forest.

1.5 Personnel information

The pilot, a man was 60 years old at the time and held a valid A licence.

Flying time (hours)			
Latest	*24 hours*	*90 days*	*Total*
All types	Unknown	67	1 352
This type	Unknown	27	>85*

*Since 11-03-2002 11 according to available flight log book.

Number of landings this type latest 90 days: 50.
Unknown when type training performed.
Latest flight training 27-12-2001 and 28-09-2003 on Piper PA-28.

1.6 The aircraft

THE AIRCRAFT	
Manufacturer	Cessna Aircraft Company, USA
Type	U 206 G
Serial number	U 20603528
Year of manufacture	1976
Gross mass	Max permitted takeoff mass 1 635 kg, actual 1 573 kg
Centre of mass	Within permitted limits (approx 120.3 cm)
Total flying time	4 920 hours

Number of cycles	Unknown
Flying time since latest periodical inspection	24 hours
Fuel loaded before event	100LL

ENGINE	
ENGINE MANUFACTURER	TELEDYNE CONTINENTAL
MODEL	IO 520 F9B
NUMBER OF ENGINES	1
Total operating time, hours	Unknown
Operating time since overhaul	1 637
Cycles since overhaul	Unknown

PROPELLER	
Propeller manufacturer	McCauley
Propeller operating time since overhaul	24 hours

The aircraft had a valid Certificate of Airworthiness

1.6.1 Checklists

The emergency checklist for the Cessna 206 has the following appearance.

SECTION 3
EMERGENCY PROCEDURES

CESSNA
MODEL U206G

ENGINE FAILURE IMMEDIATELY AFTER TAKEOFF

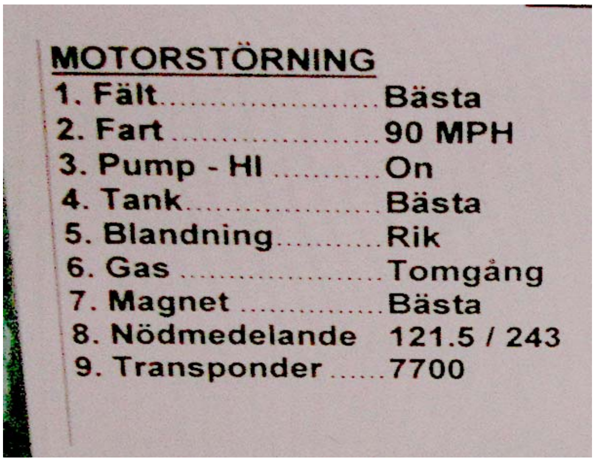
(1) Airspeed -- 80 KIAS.
(2) Mixture -- IDLE CUT-OFF.
(3) Fuel Selector Valve -- OFF.
(4) Ignition Switch -- OFF.
(5) Wing Flaps -- AS REQUIRED (40° recommended).
(6) Master Switch -- OFF.

ENGINE FAILURE DURING FLIGHT

(1) Airspeed -- 75 KIAS.
(2) Fuel Selector Valve and Quantity -- CHECK.
(3) Mixture -- RICH.
(4) Auxiliary Fuel Pump -- ON for 3-5 seconds with throttle 1/2 open; then OFF.
(5) Ignition Switch -- BOTH (or START if propeller is stopped).
(6) Throttle -- ADVANCE slowly.

It has been established that there was a fixed, mounted, emergency checklist in SE-GOP. However, it has not been possible to determine its exact contents.

When inspecting a similar Cessna 206, the Board found the following emergency checklist.



MOTORSTÖRNING

1. Fält .... Bästa
2. Fart .... 90 MPH
3. Pump - HI .... On
4. Tank .... Bästa
5. Blandning .... Rik
6. Gas .... Tomgång
7. Magnet .... Bästa
8. Nödmedelande 121.5 / 243
9. Transponder 7700

<u>ENGINE FAILURE</u>

1.	Field	Best
2.	Speed	90 mph
3.	Pump – HI	On
4.	Tank	Best
5.	Mixture	Rich
6.	Throttle	Idling
7.	Magneto	Best
8.	Emergency message	121.5 / 243
9.	Transponder	7700

The flight handbook specifies the following procedures if a tank runs dry during a flight:

- Change tanks at the first sign of fuel shortage
- Electric pump (right half) 3-5 sec at half throttle
- If pump is run for longer, engine may flood

If the engine has stopped, the following applies:

- Change tanks
- Electric pump (right half)
- Advance throttle until fuel flow meter is halfway into green area for one-to-two seconds
- Throttle back
- Turn off fuel pump
- Start engine

1.7 Meteorological information

According to SMHI analysis: southerly wind 5-10 knots, good visibility, 1-2/8 cumulus with base over 5 000 feet, temp./dew point 24/12 °C, QNH 1019 hPa.

1.8 Navigational aids

Not applicable.

1.9 Radio communications

Not applicable.

1.10 Aerodrome information

Airport status was according to AIP[1]-Sweden.

1.11 Flight recorders

Not carried. Not required.

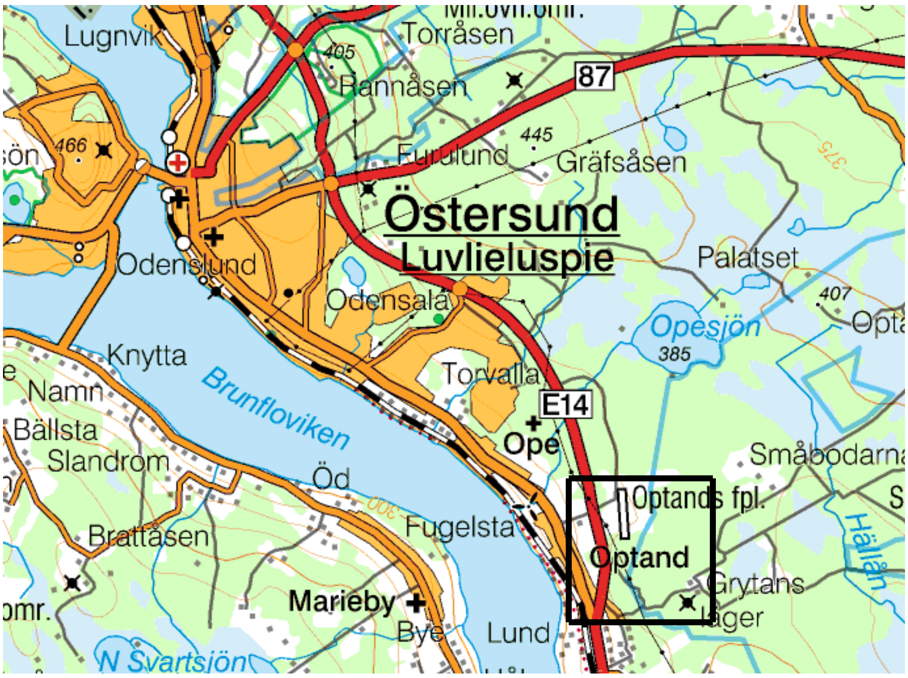
1.12 Site of accident

1.12.1 The accident site

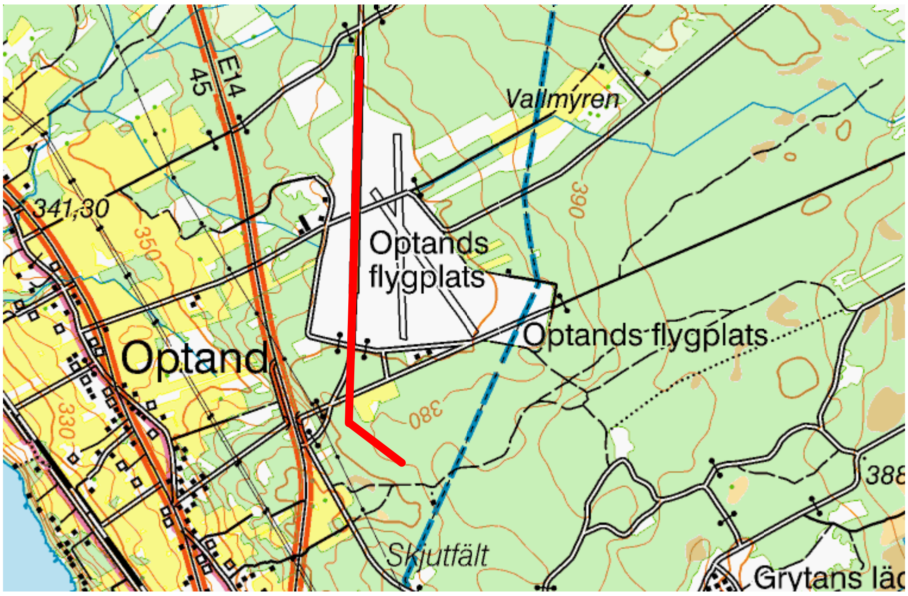
The aircraft struck the ground approximately 750 m from the southern end of the runway at Optand Airport, direction 163°.

The path of the aircraft through the forest was measured to approximately 75 m from the first contact with the treetops to the actual crash site, in a direction of 125°. Following traces after the first impact with the trees, the angle of inclination of the flight path was estimated to approximately 13°, corresponding to a rate of sink of 4.5. Parts of the wings and tailplane were torn off against the trees before the aircraft came to a standstill on the ground against a group of firs and pines. A number of cuts from the propeller were observed on tree-trunks along the whole path.

When the aircraft stopped, fire broke out almost immediately.



[1] AIP – Aeronautical information publication



Map of Optand airport. The aircraft's flight path drawn in..

1.12.2 *Aircraft wreckage*

The aircraft sustained extensive damage in the emergency landing in the forest. When rescue personnel arrived on scene it was lying upside down with the whole cabin section of the fuselage and the inner parts of the wings more or less destroyed by fire.

1.13 Medical information

Nothing has emerged to indicate that the pilot's physical or mental condition had been impaired before or during the flight.

1.14 Fire

Following the impact, the aircraft started to burn, probably because the wing fuel tanks had been damaged and fuel had leaked out and been ignited. Practically the whole of the cabin section and the inner parts of the wings were destroyed by the fire, which was relatively brief but very intensive. The fire was confined to the actual aircraft wreckage and the area immediately around the crash site and did not spread further in the forest terrain.

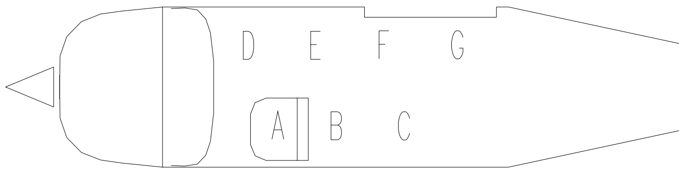
1.15 Survival aspects

Aircraft equipped for parachute-jumping normally have no seats for the passengers (the parachutists). Instead, the latter sit directly on the floor with their backs in the direction of travel. In most cases no safety belt is used.

For the accident flight, the passengers were placed according to the diagram below. No safety belts were used. On takeoff, those who survived the accident sat in places B, C and D. Note that the pilot, the only one who was belted, was not among them.

The jump exit on SE-GOP consisted of a roll-front that was pulled up for jumping. On takeoff it was normally shut.

The emergency transmitter, type EBC-102A, was totally destroyed in the fire after the crash.



1.16 Tests and research

1.16.1 The aircraft wreckage

The aircraft wreckage was examined and documented partly at the accident site and partly after transport to other premises. The investigation was hampered by the fact that the inner part of the wings containing the fuel tanks, together with the cabin section, had been destroyed by the fire. All engine and propeller controls were fire-damaged but, as far as can be judged, had functioned during the flight.

The partially-melted fuel selector valve was set so that the right-hand tank was chosen.

1.16.2 The engine and its auxiliary systems

The engine was transported to a special workshop where it was dismantled and examined in the presence of representatives of the Board, the aircraft manufacturer Cessna, and the engine manufacturer Teledyne Continental Motors (TCM).

The outside of the engine, and pipes, cables etc were fire-damaged, but otherwise the engine was largely intact. The oil sump had a practically square hole of about 30 x 30 millimeters with the edges bent inwards.

The internal components of the engine such as crankshaft and connecting rods with their bearings; the camshaft with its lifters, etc, were in good condition and without abnormal wear.

The sparking plugs and combustion chambers with their valves appeared normal. The ignition cables were consumed by fire.

Despite the heat damage, the magnetos were test-run with an approved result both at room temperature and at +65°C. All spark plugs functioned when checked in a test apparatus.

The fuel lines had been burned, but the other parts of the system appeared to have been functional prior to the fire. All the injection nozzles were of the correct size and had correct spray profiles.

The engine-driven fuel pump could not be rotated by hand but its components appear to have been intact before the fire.

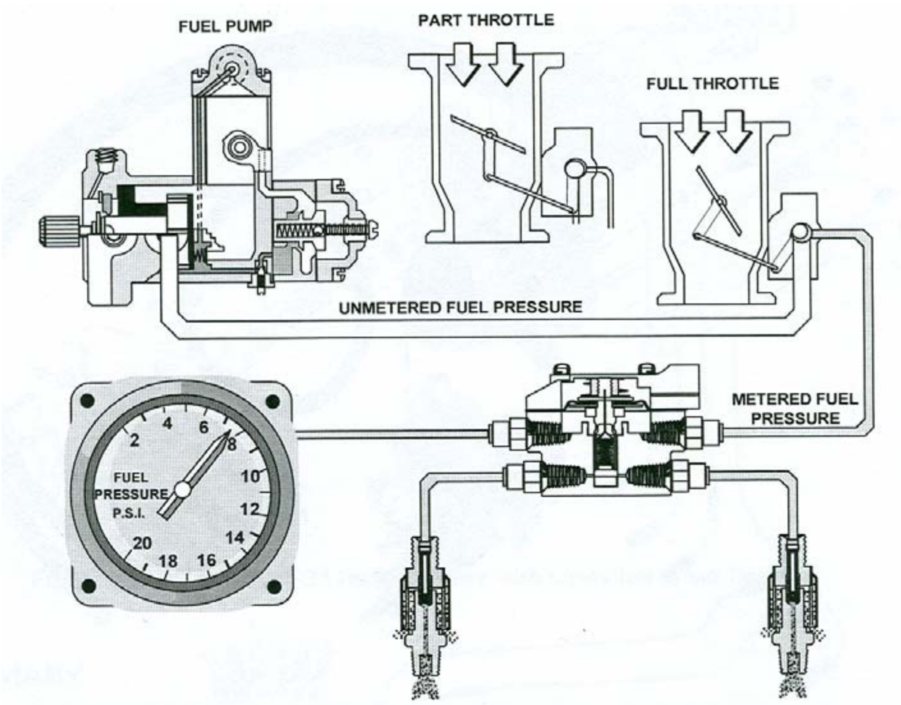
The engine manufacturer, TCM, published on 25 April 2001 its Critical Service Bulletin CSB 01-1 ”Fuel Pump Inspection and Seal Leak Test” stating that fuel pumps manufactured between 1 July 1998 and 31 May 2000 must be checked to ensure that the seal on the fuel side of the drive shaft is intact.

The pump in question appears according to the engine logbook not to be affected, but the consequences of a defective seal are interesting. If the pump is leaking, fuel leaks out through a drainage pipe on the underside of the aircraft when the electric pump is run. When the electric pump is not running the engine-driven pump sucks air past the seal. Engine revolutions may then, according to information received, sink to approximately 1000 r.p.m.

The seal in question had been hardened by the fire but exhibited no obvious defects, and in static tests performed by the Swedish Testing Institute it proved to be leak-free.

The fuel system

Fuel is injected into the cylinder inlet channel using Continental's own injection system. This consists of an engine-driven fuel pump that supplies fuel under pressure to a double fuel control unit (FCU). One of its valves is coupled to the throttle valve in the inlet manifold and operated by the throttle control at the pilot's seat. The other control valve is linked to the mixture control.



The meter in the illustration shows fuel pressure. In most installations, including SE-GOP, it is marked to show fuel flow instead.

Fuel System Discrepancies

The following emerged from examination of the fuel system:

1. All external combustible parts were either charred or consumed by fire.
2. All non-combustible parts showed signs of excessive heating.
3. All internal O-rings, membranes, etc, were much affected by heat and entirely or partly melted or charred.
4. The FCU inlet filter was covered with a hardened, black, mass which as far as could be judged had flowed in the same direction as the normal fuel route and then solidified in the filter, see illustration.
5. The cover on top of the manifold valve (M/V) had traces of a hard, yellowish substance at the ventilation tube inlet, see illustration.

FCU filter with contamination

M/V cover with contamination. Ventilation tube inlet to the right.

To investigate what the foreign material in the fuel filter and on the M/V cover consisted of they were analysed by Applied Technical Services (ATS) in Marietta, Georgia, USA and by the Swedish National Testing and Research Institute (SP) in Borås.

The ATS testing was carried out using the FT-IR method and 10 x stereo microscopy. This method showed only that the material on the filter consisted mostly of carbon, i.e. was probably a carbonised substance. The material found in the cover was nylon.

After the crash the aircraft wreck, as mentioned earlier, lay practically upside-down. In consequence of this the fuel line into the clogged filter was higher than the filter. The rubber part of the line was completely destroyed by the fire that broke out at the time of the crash. Since the black substance, and its quantity, could not be linked with contamination normally to be found in this filter, the Board decided to check whether the substance could be remains of the burnt-up fuel line.

This investigation was divided into two parts: the filter with the contamination was sent to SP for analysis with the TOF-SIMS method, which can detect very small quantities of substances on the surface of a sample.

To investigate whether the fuel line can have melted during the burning and run down into the filter, the Board also requested SP to burn fuel lines of the same specification under laboratory conditions. Possible burnt remains were to be collected and analysed in the same way as the coating on the filter to see any similarities or differences.

While it may often be difficult or impossible to reproduce real conditions in a laboratory, the test showed that the fuel line type in question can melt on the inside while the outside is burned up if the line is filled with petrol.

The TOF-SIMS analysis showed certain similarities between the material in the filter and the remnants of the test line.

Vapour Lock

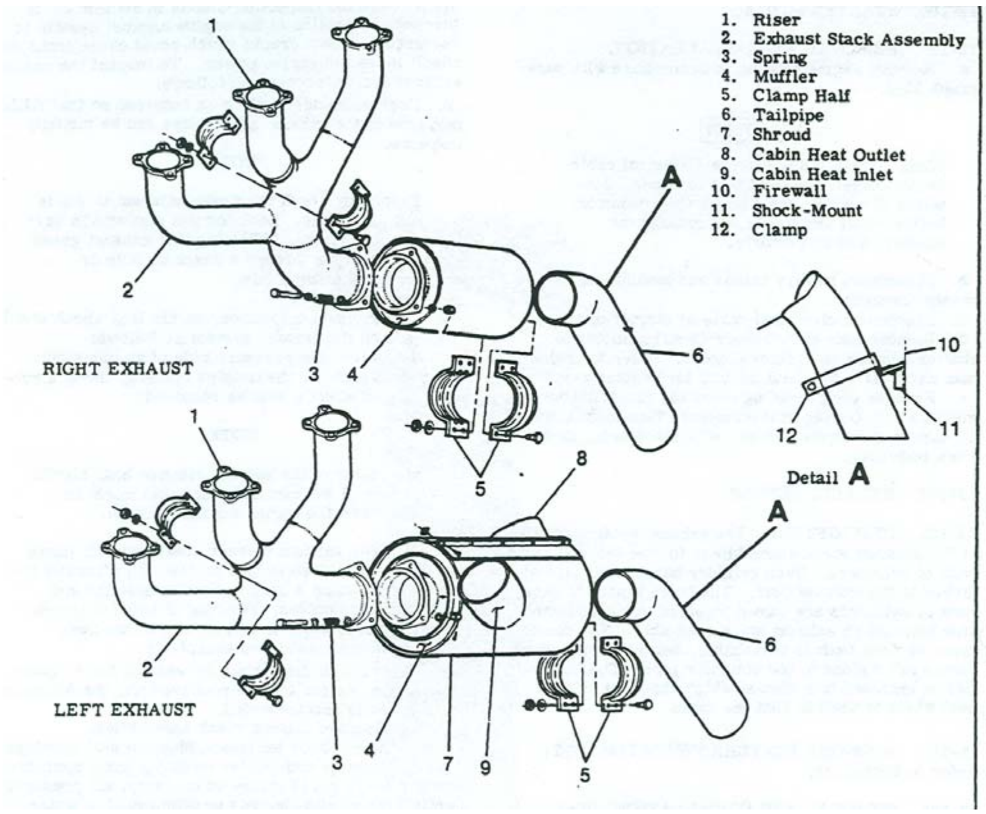
Under certain conditions, a "vapour lock" can occur in the engine's fuel system. This either prevents the engine from starting or causes engine misfiring in flight.

When starting a hot engine on a hot day, vapour bubbles in the fuel lines can prevent fuel from reaching the cylinders and thus prevent starting. The problem is dealt with according to the checklist. As and when the engine starts, the problem is solved.

A vapour lock can come about on a hot day with warm fuel in the tanks and a rapid climb to thinner air. It is normally evident by irregular running and indicated variations in fuel flow. Vapour locks do not often occur near the ground.

In Cessna's and TCM's experience, considerably higher air temperatures than those common in Sweden are required for a vapour lock to occur during a climb.

The exhaust system



The exhaust system consists of a left half and a right half (see illustration). After each manifold a silencer (muffler) is mounted. The one on the left is designed as a heat exchanger to produce warm air to heat the cabin.

The illustration above shows the left silencer from the input side. Around its inside are flanged studs. These increase the heat-transferring surface and are also fixing points for three sheet metal cones mounted in series to conduct the exhaust gases onto the studs. As seen in the illustration, the first cone has collapsed and parts thereof are resting against cone number 2.

Below, the loose parts are shown separately.

The right silencer is of similar design but without heat exchanger and therefore studs. Three sheet metal cones are included so that left and right silencers shall have the same flow resistance. Here also the first cone is damaged but it is still in its position.

To further reduce noise, SE-GOP had two silencers mounted after the original exhaust system. The installation was fairly simple and appears to have functioned as intended.

To form an idea of how much blockage is required to reduce engine output appreciably, the Board requested TCM to equip an engine similar to the accident aircraft's with an adjustable valve on the exhaust system on one side. The engine was run with the valve ¼-, ½- and ¾ shut. At ¾ shut, the engine still delivered about 70 % power, which should be more than enough for level flight.

Fuel

After the event a fuel sample was taken from the cistern from which the aircraft had been refuelled. The sample was analysed by the then CSM Materialteknik. All analysis points were well within the limit values published in Defence Standard (FSD) 8606, except for the resin content which exceeded the permissible upper limit. CSM judged that this was probably due to traces of oil in the sample.

The effect of oil may be to reduce the octane value of a fuel, but in the case in question the value was 104. The minimum value stated in FSD 8606 is 100.

1.16.3 Maintenance

The clogged fuel filter prompted examination of the inspection reports so as to establish when it had last been cleaned. The maintainer used Cessna inspection list 2-54 in the ”Model 206 & T206 Series Service Manual”. It was found, however, that no inspection item prescribing disassembly and cleaning of the filter exists. Other engine maintenance items such as change of oil and oil filter are specified, however.

The engine manufacturer, TCM, includes the item in the ”IO-520 Operator's Manual”, to be done during 100–hour inspections. The item is also given on the ”TCM Link” web service, where it is included in the ”100-hour Inspection (Naturally Aspirated Fuel Injection Engines) list.

1.16.4 Relevant regulations under BCL-M 3.2

7.3.1.1 Those responsible for maintenance of aviation materiel are to have access to, and to apply, the regulations in force regarding maintenance and the amendments that apply to the materiel type, unless the Civil Aviation Inspectorate has dispensed otherwise (LFS 1996:64).

By regulations in force is meant maintenance regulations or corresponding documents established for the materiel type by whoever holds the type certificate or type approval, and which are supplemented and revised through periodically published additional provisions (Service Bulletins, Service Instructions etc).

1.17 Organisational and management information

Not applicable.

1.18 Additional information

1.18.1 Emergency checklist for Piper PA 28

The emergency checklist for the Piper PA 28 has the following contents.

ENGINE POWER LOSS IN FLIGHT

Fuel selector .... switch to tank containing fuel
Electric fuel pump .... ON
Mixture .... RICH
Carburetor heat .... ON
Engine gauges .... check for indication of cause of power loss
Primer .... check locked
If no fuel pressure is indicated, check tank selector position to be sure it is on a tank containing fuel.

When power is restored:
Carburetor heat .... OFF
Electric fuel pump .... OFF
If power is not restored prepare for power off landing.
Trim for 76 KIAS.

1.18.2 The rescue operation

General

According to the Act (2003:778) on Protection against Accidents, it is the state or the municipalities that is/are responsible for rescue operations in the event of accidents.

At the time of the accident, the Civil Aviation Administration (Lfv)[2] was responsible for air rescue services. These include searching for missing aircraft. When the aircraft seeking help needs air rescue the SOS Alarm emergency services telephone operator shall without delay connect the call to the Lfv Aeronautical Rescue Coordination Centre (ARCC) in Göteborg.

When the position of the crash site is known, and established as being in a municipality's area of responsibility, responsibility for the rescue operation passes to that municipality's rescue services.

The crash in question occurred in Östersund municipality, where the municipal rescue service is provided by the North Jämtland Rescue Service Federation. SOS Alarm AB alerts the Federation's operational forces from the alarm centre in Östersund. Ambulance operations under the Jämtland County Council are also alerted and directed from the same centre.

Alerting

An aircraft that took off from Optand Airport shortly after the accident aircraft observed that it had crashed and attempted to make contact with the OPE Flying Club by radio. The air traffic controller at the F4 air base, however, intervened and answered the radio call. The aircraft then reported that an air crash had occurred approximately 500 metres south of the runway and about 2-300 metres east of the approach path. The pilot reported fierce burning at the crash site and that the point of impact was in rough terrain with dense forest.

The air traffic controller alerted the ambulance helicopter directly. This was about to land with a patient at Göviken in Östersund. The helicopter subsequently took off for the crash site after delivering the patient and refuelling.

The air traffic controller also telephoned direct to the SOS emergency centre in Östersund at 16.26 hrs (reference time[3]: + 0 min) at the same time as the pilot in the aircraft was giving supplementary information on the

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[2] Civil Aviation Authority as from March 2005.
[3] 16.26 hrs is the reference time for further time comparisons.

crash site. The air rescue centre was connected at the same time in a three-party call with the air traffic controller and the SOS centre.

An alarm message also came from the jump leader at Ope Parachute Club. He notified the SOS centre that there were six people on board including the pilot. The information was later corrected to seven including the pilot.

The SOS centre emergency operator alerted the Östersund fire station at 16.28 (+ 2 min). When the force commander acknowledged the alert he was informed that an aircraft with seven persons on board had crashed in the forest south of Optand airport and that there was fire at the site. The force commander asked for the Brunflo part-time corps and the part-time corps at Östersund fire station to be alerted. He later manned a back-up staff group at Östersund fire station. The alerting conforms by and large with the event- type plan following which the SOS centre is to alert the various instances when a crash has occurred.

The part-time unit in Brunflo, which is closest to Optand Airport, was alerted by the SOS centre at 16.30 hrs (+ 4 min). The part-time unit in Östersund was alerted three minutes later.

From the air rescue centre, the rescue helicopter in Sundsvall was alerted at 16.30 hrs (+ 4 min).

An ambulance that was at the emergency department entrance at Östersund Hospital to deliver a patient was alerted at 16.31 hrs (+ 5 min). A second ambulance was in the vicinity of the hospital on the way to deliver a patient when its crew received the alert. In view of the information about a fire, the ambulance personnel took extra liquid and sterile sheets with them from the emergency department entrance. The equipment was subsequently very useful in the care of those with burn injuries.

The ambulances and the ambulance helicopter were on their way to the accident site at 16.37 hrs (+ 11 min).

The ambulance personnel also requested that a medicare team be alerted from the hospital. This was transported to the accident site by ambulance.

The police were informed of the crash from the SOS centre.

Information was given via the 112 emergency number to the SOS centre by private persons who had found the three people with burn injuries from the aircraft. These casualties were on the road to the Grytan artillery range by the route E14 turn. The same information was received via 112 from the jump leader at the parachute club.

The SOS centre also cooperated in activating the disaster alert issued at Östersund Hospital.

Operations at the crash site

As the fire-fighting personnel and the ambulance personnel approached the Optand Airport along the E14, they saw smoke from the fire at the accident site.

Following instructions from the emergency operator at the SOS centre, the fire engines from Östersund and one of those from Brunflo turned in from route E14 via the airport approach road. This had been given as a suitable route by one of the persons who had given the alert via 112. Private persons meeting the vehicles then showed the way to the edge of the forest about 150 metres from the crash site.

Two of the fire engines from Brunflo drove in towards the Grytan artillery range following instructions from private persons at the E 14 exit. One of the people with burn injuries informed the fire personnel that they could follow the forest track to the crash site. The fire truck drove the way indicated to the site. When it arrived at 16.45 hrs (+ 19 min), after an 11-minute drive, there was fire with flames several metres high around the aircraft wreckage. At the same time the firemen from Östersund arrived at the crash site through the forest.

Fire-fighting was started immediately with the powder extinguishers brought by the Östersund personnel. Firemen from Brunflo then continued putting out the fire with foam. Four dead persons were found in the completely burnt-out aircraft wreckage.

The first ambulance to reach Optand Airport took the same road as the Östersund fire engines. This ambulance was initially stationed in the same place as the fire engines.

The ambulance helicopter arrived in the crash area at 16.42 hrs (+ 16 min). Its personnel did not see the people with burn injuries among vehicles and private persons on the way in to Grytan artillery range; nor did they have any information that any injured persons were on the road. The medical personnel were therefore set down on bare rock about 80 metres from the burning aircraft wreckage.

Ambulances two and three arrived at about the same time, 16.46 hrs (+ 20 min), at the spot where the three people with burn injuries were.

Reports differed concerning the number of injured persons on the Grytan artillery range road, and it was therefore feared that someone from the aircraft was missing. A search party was therefore organised by rescue services personnel and volunteers on the spot. The search was soon broken off when it became clear that no-one was missing.

The ambulances left the site at 17.15–17.18 hrs (+ 49–52 min). They reached Östersund Hospital emergency ward shortly before 17.30 hrs.

The rescue helicopter from Sundsvall arrived at the accident site at 17.17 hrs (+ 51 min). However there was no need for its contribution in this phase.

A fifth ambulance arrived at the airport at 17.30 hrs, but was not needed and so left the site for a new job.

No breakoff point for arriving ambulance and rescue vehicles was specified by the force leader from the Östersund fire station, who was director of rescue during the rescue operation.

Radio traffic was initially extensive, with certain difficulties in making contact. According to routine, the ambulances used the same frequency as the rescue service. No separate injury site channel was in use at any time for radio traffic at the actual accident site.

The rescue services phase was concluded at about 18.00 hrs when the police took over via the police officer in charge at the site.

2 ANALYSIS

2.1 The flight

The flight was normal until the engine malfunction started. In this situation it was no longer possible to land on the airfield. The pilot attempted to deal with the engine problem and when this failed he flew the aircraft under control down into the forest.

When the aircraft struck the ground the passengers were probably thrown about in the cabin. One survivor may have been thrown out through the jump exit, which may well have come open on impact.

2.2 The technical investigation

The Swedish Accident Investigation Board has found no technical reason for the engine failure. The clogged fuel filter could be one, but even though the TOF-SIMS analysis and the fire tests cannot be claimed to prove that it was remnants of the fuel line that were found in the filter, a balanced analysis shows this hypothesis to be the most plausible.

The yellow impurities in the M/V cover can only have been deposited there after the aircraft turned upside-down. A blocked ventilation hole in the cover is not likely to have caused such serious engine malfunctioning as that in the present case.

The damage to the exhaust system is a possibility, since blocked silencers/mufflers have caused many emergency landings. The Board considers it less likely that the loose parts in the left silencer could have blocked this so much that the engine largely stopped delivering thrust. The TCM tests support this view. An engine installation such as the one in question is naturally less vulnerable than one in which all the cylinders exhaust into a common silencer.

A leaking fuel pump is another possibility. If a seal suddenly starts to leak during a climb, the engine loses practically all thrust. If the pilot in such a situation follows the emergency checklist and starts the electric pump, fuel will spray out under the aircraft and possibly hasten the start of a fire. That fire started before impact must, however, be judged as less probable. The fact that the seal was leak-free when tested by the Swedish Testing Institute supports this.

The damage to the oil sump is judged to have occurred on impact.

It is of course also conceivable that a malfunction in some system destroyed in the fire and therefore impossible to investigate caused the engine failure.

2.3 Management of the fuel system

The fuel injection system in question regulates the quantity of fuel delivered to the engine by opening and shutting a valve using the throttle control. The quantity of fuel reaching the engine is thus determined by the position of the throttle control and the pressure in the engine-driven fuel pump, which depends on engine speed. If the electric pump is switched on, the pressure increases – and therefore the fuel flow.

If the engine for some reason rotates more slowly than what corresponds to the throttle position, and the electric pump is started, the engine will receive too much fuel and therefore risk being flooded.

Against this background, the procedure for changing tanks becomes understandable (see 1.6 above). It is therefore essential to throttle back and run the electric pump only for a few seconds.

If when flying a Cessna 206 an engine failure is experienced or a tank runs dry and the Piper PA-28 emergency checklist is followed – i.e. change tanks, switch on electric pump – the engine will in all probability be flooded and will not restart.

Restarting the Continental fuel-injection engine is evidently a complicated manoeuvre which in some parts is the direct opposite of the procedure applying to many other aircraft.

2.4 Possible course of events

Since the pilot requested refuelling before the accident flight, it may be assumed that the quantity of fuel in the right tank was low. It is further conceivable that the pilot during the previous flight had for this reason switched to the left tank – and done this in good time before a change of tanks had become urgent. If he had then forgotten to switch to the right tank before the last takeoff, the engine may well have stopped owing to shortage of fuel in the left tank. One circumstance supporting this scenario is that the fuel selector valve was found to be set to the right tank.

The pilot had done his most recent flight training on a Piper PA-28 and was thus drilled that the first action on engine failure was to change tanks and then switch on the fuel pump. It is known that people in situations for which they are unprepared may fall back on “old” behaviour, entirely forgetting what has been learned more recently. However, as may be seen from points 1.6 and 2.3 above, following the same procedure in a Cessna 206 as in a Cessna 206 PA 28 in all probability renders the engine impossible to re-start. It is however not inappropriate to change tanks on a Cessna U206G in the event of engine failure.

Testimony from one of those on board partly supports this scenario. According to the witness, the pilot swore when the engine started malfunctioning, and started to operate the controls. The fuel selector valve in the Cessna U206G is situated on the floor between the pilot and the place where the witness was sitting and is one of the controls in the witness’s immediate field of vision.

It is also conceivable that a momentary engine malfunction of some different kind occurred and that the pilot reacted by changing tanks and turning on the electric pump, which may also be enough for the engine to flood and stop entirely.

2.5 Design and control of emergency checklists

In another Cessna 206 which the Board has studied there was an emergency checklist which, if followed, would probably lead to total engine failure. The Board has no opinion as to whether this is an isolated case or a systemic problem. However the Board views this circumstance as being so serious that it cannot be left unresolved.

2.6 Maintenance

In the Board’s view the FCU filter had become clogged owing to the fire after the crash. However it is remarkable that Cessna do not prescribe cleaning in their maintenance lists. Since other maintenance items appear to be included, it is understandable that those responsible for the engine installation have not noticed this shortcoming. All who perform aircraft maintenance must of course obtain the entire information available (see 1.16.4) but when the aircraft manufacturer’s material has been used – which, moreover, appears complete – it is natural not to seek further information.

3 CONCLUSIONS

3.1 Findings

a) The pilot was qualified to conduct the flight.
b) The aircraft had a valid certificate of airworthiness.
c) No serious technical fault was found.
d) Cessna's maintenance documentation does not prescribe cleaning of the FCU fuel filter.
e) Engines with the Continental fuel-injection system have different characteristics in terms of re-starting from those of the majority of aircraft engines.
f) The municipal rescue service was alerted and conducted a rescue operation that fulfilled the requirements normally placed upon a rescue organisation.

3.2 Causes of the accident

The Swedish Board of Accident Investigation has been unable to establish the cause of the accident.

4 RECOMMENDATIONS

The Swedish Civil Aviation Authority is recommended to:

- Issue information to the effect that on different aircraft types there are great differences in the measures to be taken in the event of engine failure, and that it is essential that the emergency checklist for the aircraft in question be taken out and carefully gone through prior to takeoff *(RL 2006:12e R1)*.

- Seek to ensure that the contents of the above recommendation are incorporated in basic training *(RL 2006:12e R2)*.

- Seek the introduction of a differential training requirement for aircraft with the Continental company's fuel-injection systems and, where required, also for aircraft with other types of engine control system where emergency procedures differ decisively from those in general use *(RL 2006:12e R3)*.

- In its supervisory activity ensure that correct emergency checklists are available in all aircraft *(RL 2006:12e R4)*.

- Seek to ensure that cleaning of the FCU filter is introduced into Cessna inspection lists for those aircraft that may be relevant *(RL 2006:12e R5)*.