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## **Report RL 2001: 22e**

***Incident involving aircraft SE-LIP  
in the airspace between Jönköping  
and Linköping, Sweden on the 22<sup>nd</sup> of  
December 2000***

**Case L-001/01**

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Translated by Dennis Lynn Anderson  
From the original Swedish at the request of the Board of Accident Investigation.

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

Swedish Civil Aviation Administration

601 79 NORRKÖPING

**Report RL 2001: 22e**

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The Board of Accident Investigation (Statens haverikommission, SHK) has investigated an incident that occurred on the 22<sup>nd</sup> of December 2000 in the airspace between Jönköping and Linköping, Sweden, involving an aircraft with registration SE-LIP.

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

A translation to English of the report is enclosed.

S-E Sigfridsson

Monica J Wismar

Henrik Elinder

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#### **APPENDIX**

1	Extracts from Register of Licenses regarding the pilots, (to the Swedish Civil Aviation Administration only)
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## Report RL 2001:22e

### L-001/01

Report finalized 2001-08-24

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<i>Aircraft: registration, type</i>	<b>SE-LIP, Fokker F27 MK050</b>
<i>Class/airworthiness</i>	Normal, valid certificate of airworthiness
<i>Owner/Operator</i>	Aircraft Financing & Trading B.V. / Skyways Express AB, P.O. Box 1537, 581 15 Linköping
<i>Date and time</i>	The 22 <sup>nd</sup> of December 2000 at 20:26 hrs. during darkness <i>Note: All times in this report are given in Swedish Standard Time = UTC + 1 hour</i>
<i>Place of occurrence</i>	In the airspace between Jönköping and Linköping, (approximate position 5805N 01516E, 17,000 feet (5,182 meters) above sea level)
<i>Type of flight</i>	Scheduled traffic
<i>Weather</i>	Actual weather in Linköping: wind 270°/09 knots variable between 240 and 310°, visi- bility > 10 km, overcast with the cloud base at 1,800 feet, temperature/dewpoint +1/ -1°C, QNH 1012 hPa.
<i>Persons onboard: crew</i>	2/1
<i>passengers</i>	15
<i>Injuries to persons</i>	None
<i>Damage to aircraft</i>	None
<i>Other damage</i>	None
<i>The commander's:</i>	
<i>age, certificate</i>	35 years old, ATPL (Airline Transport Pilot's License)
<i>total flying time</i>	3,500 hours, of which 1, 500 hours on the type
<i>flying time previous 90 days</i>	155 hours, all on the type
<i>number of landings previous 90 days</i>	151
<i>The Co-pilot's:</i>	
<i>age, certificate</i>	35 years old, CPL (Commercial Pilot's License) with Instrument Rating
<i>total flying time</i>	3,400 hours, of which 400 hours on the type
<i>flying time previous 90 days</i>	132 hours, all on the type
<i>number of landings previous 90 days</i>	130
<i>Cabin attendant:</i>	Employed since 1989

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The Board of Accident Investigation (SHK) was notified on the 2<sup>nd</sup> of January 2001 that an aircraft with registration SE-LIP had been involved in an incident, which occurred in the airspace between Jönköping and Linköping, Sweden on the 22<sup>nd</sup> of December 2000 at 20:26 hrs.

The incident has been investigated by SHK represented by Sven-Erik Sigfridsson, Chairman, Monica J Wismar, Chief Investigator Flight Operations, and Henrik Elinder, Chief Technical Investigator Aviation.

The investigation has been followed by the Swedish Civil Aviation Administration through Max Danielsson.

### **Summary**

The aircraft was operating the regular flight between Copenhagen and Linköping. The flight departed from Kastrup at 19:46 hrs. Initially the flight proceeded normally. Just prior to initiation of the descent towards Linköping, the pilots perceived a burning odor, as if an electrical component had been burnt. With the lighting on in the cockpit the pilots thought that they could detect a faint mist of smoke.

The pilots took out their oxygen masks but did not don them because they felt that the odor subsided. During the approach into Linköping, additional faults appeared on the aircraft.

They were radar vectored to a left-base turn to runway 29 and landed visually without any difficulties. As the pilots had not declared an emergency; an alert report, according to valid rules for aircraft in distress, was not forwarded by Air Traffic Control. Prior to the landing, the air traffic controller at the airport alerted the airport search and rescue services, which were placed on alert.

The investigation has revealed that there were two independent technical malfunctions in the electrical system of the aircraft. One was in the DC-system and was probably the malfunction that i.a. caused disturbances in the instruments. The other one was in the AC-system and was probably the one that caused smell and smoke on flight deck. The cable to the ovens of the aircraft was burnt. Since the ovens were removed, the malfunction had not been observed. For reason unknown the circuit breaker to the ovens was not inactivated which meant that the cable was alive.

The incident was probably caused by one or several transient electrical shorts in the aircraft's AC-power system.

### **Recommendations**

None.

## 1 FACTUAL INFORMATION

### 1.1 History of the flight

On the 22<sup>nd</sup> of December 2000 Skyways Express AB's regular flight JZ 609 was operating between Copenhagen/Kastrup airport in Denmark and Linköping/SAAB airport in Sweden. The flight departed from Kastrup at 19:46 hrs. with the commander as flying pilot. Initially the flight proceeded normally. Just prior to initiation of the descent towards Linköping, the pilots perceived a burning odor, as if an electrical component had been burnt. With the lighting on in the cockpit the pilots thought that they could detect a faint mist of smoke. The commander delegated the flight to the co-pilot and initiated trouble shooting.

The commander reported to Air Traffic Control that they probably had an electrical problem and requested clearance to initiate the descent and fly direct to Linköping; which was granted. He called the cabin attendant into the cockpit and informed her of the smell. He also informed her that they hadn't localized the source of the smell. He asked her to check if there was any smoke or smell of fire in the passenger cabin. As the cabin attendant was checking the cabin for the possible smell of smoke, she got out a pair of gloves and placed fire-extinguishers in the forward and aft section of the cabin as preparation. She did not experience any smell of smoke in the cabin, which she reported to the commander.

The pilots took out their oxygen masks but did not don them because they felt that the odor subsided. They didn't think that there was any applicable point in the emergency checklist for the malfunction they had. During the approach into Linköping, additional faults appeared on the aircraft. The DME<sup>1</sup> circuit breaker had tripped and they received a warning that the de-icing system for the left engine was not functional. A warning that the autopilot trim was not functional was activated. Due to this, the co-pilot transitioned to manual flying. The intercom system between the passenger cabin and the cockpit was also not functioning and the pilots had static in their headphones.

They were radar vectored to a left-base turn to runway 29 and landed visually without any difficulties. As the pilots had not declared an emergency; an alert report, according to valid rules for aircraft in distress, was not forwarded by Air Traffic Control. Prior to the landing, the air traffic controller at Linköping/SAAB airport alerted the airport search and rescue services, which were placed on alert.

In order not to cause unnecessary concern among the passengers, after landing the crew agreed not to inform the passengers about the incident, because there had been no noticeable abnormality in the passenger cabin and the landing had taken place normally. After the passengers had left the aircraft, the commander held a de-briefing with the crew regarding the occurrence. Thereafter he wrote a flight occurrence report which he faxed to his company operations in Stockholm.

The incident occurred at the approximate position of 5805N 01516E; 17,000 feet (5,182 m) above sea level.

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<sup>1</sup> DME – Distance Measuring Equipment

## 1.2 Injuries to persons

	<i>Crew</i>	<i>Passengers</i>	<i>Other</i>	<i>Total</i>
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	3	15	–	18
Total	3	15	–	18

## 1.3 Damage to aircraft

None.

## 1.4 Other damage

None.

## 1.5 The crew

### 1.5.1 *The commander*

The commander was 35 years old at the time and had a valid ATPL-certificate.

#### *Flying time (hours)*

<i>previous</i>	<i>24 hours</i>	<i>90 days</i>	<i>Total</i>
All types	4	155	3,500
This type	4	155	1,500

Number of landings actual type previous 90 days: 150.

Flight training on type concluded in March of 1998.

Latest proficiency check (PC) was carried out on the 12<sup>th</sup> of June 2000 in the F27 MK050 simulator .

### 1.5.2 *The co-pilot*

The co-pilot was 35 years old at the time and had a valid CPL-certificate with Instrument Rating.

#### *Flying time (hours)*

<i>previous</i>	<i>24 hours</i>	<i>90 days</i>	<i>Total</i>
All types	4	132	3,400
This type	4	132	400

Number of landings actual type previous 90 days: 130.

Flight training on type concluded in March of 2000.

Latest proficiency check (PC) was carried out on the 4<sup>th</sup> of October 2000 in the F27 MK050 simulator.

### 1.5.3 *Other crew members*

A cabin attendant was included in the crew. She was employed by the company in 1989, and completed her latest emergency training on the 25<sup>th</sup> of May 2000.



#### 1.5.4 The pilots' work schedule

The week prior to the occurrence the pilots had the following schedule:

	<i>The commander</i>	<i>Number of flights</i>	<i>The Co-pilot</i>	<i>Number of flights</i>
2000-12-16	day off		day off	
2000-12-17	day off		day off	
2000-12-18	05:55-15:28 hrs	2+1passive	standby	
2000-12-19	09:30-17:30 hrs	meeting	16:00-23:51 hrs	4
2000-12-20	standby		16:00-23:48 hrs	4
2000-12-21	16:00-23:44	4	16:00-23:44 hrs	4
2000-12-22	16:00-21:01	2	16:00-21:01 hrs	2

## 1.6 Aircraft information

### 1.6.1 General

#### THE AIRCRAFT

<i>Manufacturer:</i>	Fokker VFM B.V.	
<i>Type:</i>	Fokker F27 MK050	
<i>Serial number:</i>	20147	
<i>Year of manufacture:</i>	1989	
<i>Gross weight:</i>	Maximum allowed 20,820 kg, actual 16,345 kg	
<i>Center of gravity:</i>	30,3 % MAC	
<i>Total flying time:</i>	18,100 hours	
<i>Number of cycles:</i>		
<i>Flying hours since latest</i>		
<i>Periodic check:</i>	2,838 hours	
<i>Fuel uplifted before event:</i>	Jet A1	

#### ENGINE

<i>Manufacturer:</i>	Pratt & Whitney	
<i>Model:</i>	125B	
<i>Number of engines:</i>	2	
<i>Engine</i>	No. 1	No. 2
<i>Time since overhaul:</i>	5,564	4,383
<i>Cycles since overhaul:</i>	6,350	4,911

#### PROPELLER

<i>Manufacturer:</i>	Dowty	
<i>Propeller:</i>	No. 1	No. 2
<i>Time since overhaul:</i>	2,836	3,397

The aircraft had a valid certificate of airworthiness.

### 1.6.2 Electrical system

This aircraft type has a direct current system (DC-power) and an alternating current system (AC-power) for power supply to the aircraft's various electrical systems. Both systems are separated into left and right sub-systems, which are independent of each other. The AC-power system, which operates with 115/200 V, 400 Hz three phase alternating current, is supplied with power from the engine generators but can also be supplied with electricity via a ground power unit. The DC-power system, which

operates on 28 V direct current, is normally powered by two transformer/rectifiers, TRU<sup>2</sup>, but can also be supplied with power from the aircraft's two batteries. TRU no. 1 and no. 2 supply the aircraft's left and right DC-power sub-systems respectively.

The two TRU-units are connected to the AC-power system via two contactors (TRU-CONTACTORS) which complete the circuit when certain criteria regarding the incoming alternating current are met. Each TRU-CONTACTOR's construction is essentially a mechanical electrical relay with one set of breaker points for each of the three phases. The breaker points and their mechanism are enclosed within a hermetically sealed box.

Included in the left DC-power system, which is fed power from TRU no. 1, are the busbars EMER DC BUS 1 and MAIN DC BUS. The MAIN DC BUS supplies power to a number of electrical systems for the control of the aircraft, radio communication and navigation, i.e.:

- DME
- L/R EFIS<sup>3</sup> control panel.

The aircraft's electrical system has been certified according to JAR 25 change 9 respective FAR 25 amendment 56.

### 1.6.3 Galley

In the aft section of the passenger cabin there is an area for the preparation of food and drink (galley). In this area there are, among other things, ovens, water boilers and coffee makers, which are all powered by the AC-electrical system of the aircraft. At the time of the incident the ovens were removed.

## 1.7 Meteorological information

Reported weather at Linköping airport: wind 270°/09 knots, variable between 240 and 310 °, visibility > 10 km, overcast with the cloud base at 1,800 feet, temp./dewpoint +1/-1 °C, QNH 1012 hPa.

## 1.8 Aids to navigation

Linköping/SAAB airport (ESSL) runway 29 was equipped with ILS<sup>4</sup>. The aircraft was equipped for instrument flying. The approach was carried out under IMC (instrument meteorological conditions) with radar vectoring. The landing took place visually and in darkness.

## 1.9 Communications

Normal communications took place between the crew and Air Traffic Control at Östgöta Control and the tower controller at Linköping/SAAB airport.

## 1.10 Aerodrome information

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

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<sup>2</sup> TRU – Transformer Rectifier Unit

<sup>3</sup> EFIS – Electronic Flight Instrumentation System

<sup>4</sup> ILS – Instrument Landing System

## 1.11 Flight recorders

Information regarding the incident first reached SHK on the 2<sup>nd</sup> of January 2001. The aircraft was at that time back in traffic and the flight and voice recorder data had not been preserved.

## 1.12 Incident site and aircraft

### 1.12.1 Incident site

The incident occurred in the airspace between Jönköping and Linköping at an altitude of 5,182 meters above sea level.

### 1.12.2 Aircraft

With the exception of the damage that is accounted for in section 1.16, there was no damage to the aircraft.

## 1.13 Medical information

Nothing indicates that the mental or physical condition of the pilots had been impaired prior to or during the flight.

## 1.14 Fire

There was no fire.

## 1.15 Survival aspects

Not applicable.

## 1.16 Tests and research

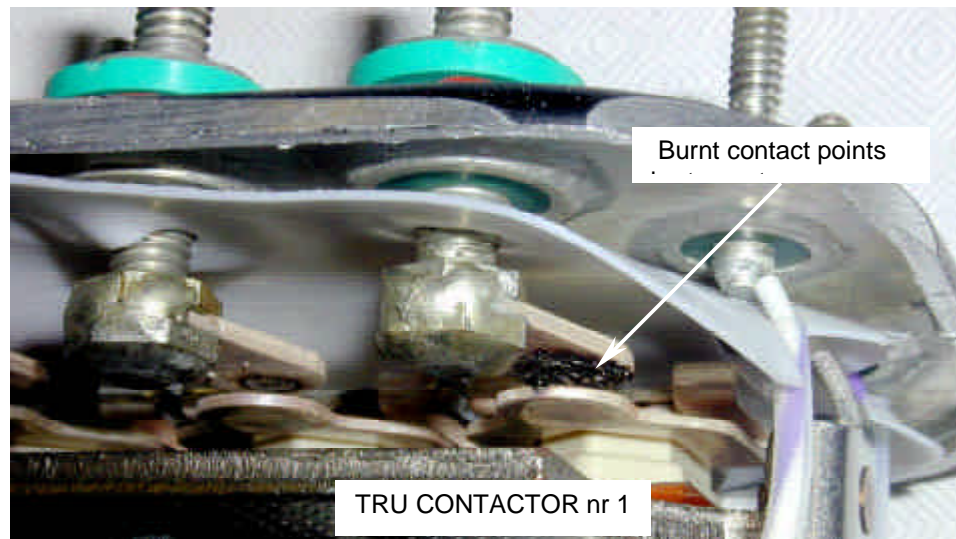
### 1.16.1 General

After the incident, trouble-shooting was performed on the aircraft in attempt to localize the source of the smell of smoke and the cause of the faults in the electrical systems. Two independent malfunctions were found in the aircraft's electrical system; one in the DC-power system and one in the AC-power system. The latter was first discovered a few weeks after the aircraft had been returned to operation subsequent to the incident.

### 1.16.2 Direct current system (DC power)

The parts in the DC-power system associated with the incident have been investigated. Several units within the system were removed from the aircraft and investigated in a special laboratory. With the exception of TRU CONTACTOR no. 1 (left system) no malfunction or abnormality was found.

At the time of the functional test of TRU-CONTACTOR no. 1, the contact for one of the phases in the closed position was found to be sporadic. The unit was opened and it was found that the breaker points of the actual phase were substantially burnt. The consequences of this malfunction was that the subsequent component in the system, TRU no. 1, periodically was fed with only two-phase current (2 x 115/200V, 400Hz).



Tests have been performed by feeding a TRU with only two phases to ascertain what the effects of this are on the TRU's downstream direct current. During the investigation it was found that the voltage decreased and the direct current's so called ripple<sup>5</sup> increased with a factor of ten in relation to approved limits.

#### 1.16.3 Previous system faults

Some of the malfunctions that the pilots experienced during the actual flight had previously occurred temporarily on this specific aircraft. After replacement of the malfunctioning TRU-CONTACTOR in connection with the trouble-shooting, these malfunction symptoms ceased.

#### 1.16.4 Alternating current system (AC power)

As a coincidence in connection with aircraft maintenance, it was discovered that the feed cable in the left AC-power system, which provides power to the ovens in the aircraft's galley, was burnt through at a cable connector in an obscure area in the aft section of the aircraft. The burnt-off cable was live and hanging free.

Discoloration and soot in the vicinity of the breach indicated that local arcing and overheating had occurred. As the ovens were removed the fault had not been discovered. It hasn't been possible to determine when the feed cable was burnt off.

## 1.17 Organizational and management information

### 1.17.1 General

Skyways Express AB is an airline company with its headquarters in Linköping. The company has an operational permit (AOC<sup>6</sup>) according to JAR-OPS<sup>7</sup> 1. The company is a part of Skyways Holding AB with approximately 1,000 employees and it pursues scheduled and non-scheduled air traffic with 46 aircraft of type Embraer EMB-145, Fokker F27 MK050 and SAAB SF340.

<sup>5</sup> ripple – the difference between the highest and lowest downstream voltage.

<sup>6</sup> AOC – Air Operator Certificate

<sup>7</sup> JAR-OPS - Joint Aviation Requirements - Operations

### 1.17.2 Emergency checklist

For the aircraft model there is a checklist for emergency procedures. In this checklist "Electrical Smoke" and "Smoke Removal" is addressed.

ELECTRICAL SMOKE		SMOKE REMOVAL	
OXY MASK/OOGGLES	AS REQD	FLIGHT DECK DOOR	CLOSED
CREW COMMUNICATION	ESTABLISH	OXY MASK/OOGGLES	ON
RECIRC FANS	BOTH OFF	CREW COMMUNICATION	ESTABLISH
ECONOMY	OFF	SEAT BELTING SMKG	ON
GEN 1 and 2	OFF	RECIRC FANS	BOTH OFF
AVOID ICING CONDITIONS		ECONOMY	OFF
LAND AS SOON AS PRACTICABLE		DESCENT (10 000 ft MEAN)	INITIATE
■ If unable to land within 30 min:		EDS ALT	3000 ft
AUTO AC X-FEED	OFF	CABIN RATE LIM	MAX INCR
GEN 1	ON	■ If after descent smoke persists:	
■ If smoke re-appears:		PRESS CONTROL	MAN
GEN 2	ON	MANUAL CONTROL LEVER	UP
GEN 1	OFF	MANUAL RATE CONTROL	MAX INCR
SMOKE REMOVAL PROC (IF REQD)	APPLY	SEAT BELTING SMKG	ON
		LAND AS SOON AS PRACTICABLE	

### 1.17.3 Reporting system

According to the company's operations manual, a flight occurrence report of type Flight Safety Report (FSR) shall always be submitted at the time of an incident. Thereafter it is supposed to be sent to the flight operations department, which files a copy and sends the original to the Swedish Civil Aviation Administration. In the case in question, the FSR was written on the 22<sup>nd</sup> of December 2000 and was treated by the flight operations department on the 30<sup>th</sup> of December 2000. A copy was at that time faxed to the Swedish Civil Aviation Administration, which forwarded it to SHK via fax on the 2<sup>nd</sup> of January 2001.

## 1.18 Other

### 1.18.1 SHK's investigation

The occurrence was initially dealt with as a minor incident. Because of this, SHK was not informed of the incident until eleven days later. The measures taken on the aircraft by the airline during this period of time were therefore performed without the participation of any representative from SHK. However, SHK has full confidence in the trouble-shooting measures that were taken, the factual information that the company provided regarding this process and the observations that were made during this time.

### 1.18.2 Another case involving a faulty TRU CONTACTOR

Less than four months after the incident under investigation, intermittent malfunctions occurred in various systems connected to the right-hand DC-power system on another one of the company's aircraft of the same type. During trouble-shooting the same type of malfunction was observed in the corresponding TRU CONTACTOR in the right AC-power system. The malfunctions ceased when the faulty TRU CONTACTOR had been replaced.

### 1.18.3 Measures taken by the airline

Subsequent to these two identical malfunctions, the airline has introduced an operational time limit of 5,000 flight hours for TRU CONTACTORs in these locations. (The same type of relay is also placed at other locations in the aircraft's electrical system, but these have a lesser electrical load.)

#### 1.18.4 *Measures taken by the aircraft manufacturer*

As a consequence of the incidences that have occurred, the aircraft manufacturer has initiated a safety analysis of the electrical system components affected, according to JAR/FAR 25.1309.

#### 1.18.5 *Lightning strike*

The aircraft was subjected to a heavy lightning strike on the 2<sup>nd</sup> of November 2000 during a flight between Visby and Arlanda. At the time of the lightning strike a crackling sound was heard and thereafter a low oil pressure warning illuminated on the left engine. The result of this was that the pilots had to shut the left engine down. The flight could however be carried out without difficulties.

## 2 ANALYSIS

### 2.1 The flight

Gases contained in smoke or fire can be poisonous and can rapidly render crewmembers unconscious or drastically decrease their functional capacity. It is certainly true that the pilots experienced the smell and smoke as faint and subsiding; but despite this they should have immediately donned their oxygen masks, even if the first point of the emergency checklist states that they are to be used as required.

As the source of the smell and the smoke was unknown, and could very well have been associated with the technical malfunctions that also appeared, the situation was to be considered as very serious with respect to flight safety. Considering the fact that the pilots were not able to determine how the problem was going to develop during the flight to Linköping, they should have at that time utilized the possibility of declaring an emergency. This action would have activated the search and rescue services, which then would have been better prepared, had the problems become aggravated and the aircraft had crashed prior to reaching the airport.

Otherwise, in the opinion of SHK, all crewmembers took correct action in accordance with valid regulations. Despite the technical malfunctions that occurred during the approach to Linköping/SAAB airport, the crew succeeded in accomplishing a safe landing there.

### 2.2 Aircraft electrical system faults

After the incident two independent malfunctions in the aircraft's electrical system have been found. One of these was in the DC-power system and was the malfunction that probably caused certain instrument failures etc. The other was in the AC-power system and probably the malfunction that caused the smell and the smoke in the cockpit.

#### *The DC-power system*

With the exception of breaker point malfunction, which was located in the left low-voltage system's TRU CONTACTOR, no malfunction has been found in the components that have been examined. The breaker point malfunction can not have caused the smoke or the burnt odor that the pilots experienced since the failure was isolated in a sealed box.

As is evident from section 1.16.2, the malfunction did however possibly cause the output DC-power from the system's TRU to temporarily become too low and instable. The DC-power system provides electrical power to a

large number of systems and instruments. The instrument failures that the pilots experienced during the flight, some of which had occurred previously on this specific aircraft, can all be explained by the fact that the voltage in the system periodically decreased below the minimal specifications of the instruments resulting in malfunctions. This is confirmed by the fact that these malfunctions have not occurred again after the TRU CONTACTOR was replaced. This was also true concerning the subsequent case mentioned with a faulty TRU CONTACTOR.

#### *The AC-power system*

The feed cable to the aircraft ovens was burned-off, but due to the fact that the ovens were removed from the aircraft, this failure had not been observed. The oven circuit breaker had not tripped, due to causes unknown, which meant that the cable was electrified. The presence of discoloration and soot deposits in the vicinity of the end of the cable is highly indicative of electrical arcing being the cause of the smell that the pilots experienced during the flight; when the free end of the cable, under the influence of aircraft movement, one or several times temporarily shorted-out against a grounded component. The current power that then arose was however not sufficiently high to trip the oven's circuit breaker. Therefore the electrical short could occur repeatedly.

As was mentioned in section 1.16.3, it has not been possible to determine when the cable was burned-off. One possibility is that it took place in connection with the heavy lightning strike the aircraft was subjected to on the 2<sup>nd</sup> of November 2000.

### **2.3 The low current system's safety level**

Despite the certification of the aircraft type according to both JAR 25 and FAR 25, the incident shows that in the worst case an individual component failure in the electrical system can almost entirely disable one of the two DC-power systems. The condition has been attended to by the aircraft manufacturer, which has initiated a safety analysis of the system. Therefore, SHK does not find it necessary to make any recommendations with respect to the incident.

## **3 CONCLUSIONS**

### **3.1 Findings**

- a) The pilots were qualified to perform the flight.
- b) The aircraft had a valid Certificate of Airworthiness.
- c) The crew did not declare an emergency.
- d) Two independent electrical malfunctions were ascertained on the aircraft.
- e) An individual component failure can, in the worst case scenario, disable a large portion of one of the two DC-power systems.
- f) The aircraft manufacturer has initiated a safety analysis of the affected components of the electrical system.

### **3.2 Causes**

The incident was probably caused by one or several transient electrical shorts in the aircraft's AC-power system.

#### **4 RECOMMENDATIONS**

None.