Report C 1994:25e

Accident to aircraft SE-INZ on 27 February 1994 at Trollhättan/Vänersborg Airport, P county

L-11/94

Translated by Tim Crosfield M.A.
from the original Swedish
at the request of the Board of Accident Investigation

1994-09-23 L-11/94

Swedish Civil Aviation Administration

601 79 NORRKÖPING

Report C 1994:25e

The Board of Accident Investigation (SHK) has investigated an aircraft accident that occurred on 27 February 1994 at Trollhättan/ Vänersborg Airport, P county, involving an aircraft with registration SE-INZ.

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

S-E Sigfridsson Henrik Elinder

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APPENDICES

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Aircraft; registration and type	SE-INZ, Shorts SD3-30
Owner	Finans Scandic AB, 103 78 Stockholm
Operator	Flying Enterprise AB, Flygfältsgatan 31, 423 37 Torslanda
Place	Trollhättan/Vänersborg Airport, ESGT, P county Pos. 5819N 1221E
Date and time	27-02-1994, 14.29 hrs Note: All times in Swedish normal time (SNT) = UTC + 1 hr
Type of flight	Scheduled traffic
Weather	Wind 350□/8 kts, CAVOK, temp/dewpoint B9/B11□C, QNH 1015 hPa
Persons on board:	Crew: 3 Passengers: 8
Injuries to persons	None
Damage to aircraft	Substantial
Captain's age, licence	57 years, Airline Transport Pilot's Licence (Swedish D)
Captain's flying hours	Approximately 8,015 hrs, of which 45 hrs on the type
First officer's age, licence	23 yrs, Commercial Pilot's Licence (Swedish B) with instrument rating
First officer's flying hours	Approximately 1,270 hrs, of which 50 on the type

The Board of Accident Investigation (SHK) was notified on 27 February 1994 that an accident had occurred involving an aircraft with registration markings SE-INZ at Trollhättan/ Vänersborg Airport, P County, at 14.29 hrs on that day.

The accident has been investigated by SHK represented by S-E Sigfridsson, Chairman, and Henrik Elinder, chief technical investigator. The Board was assisted by Kjell Svensson as expert.

The investigation was followed by Klas-Göran Bask, Swedish Civil Aviation Administration, and by Chris Protheroe as accredited representative of the UK Air Accidents Investigation Branch.

SUMMARY

The aircraft, which was in scheduled operations, landed on 25 February 1994 at Trollhättan/Vänersborg Airport, where an inspection was to be carried out. No fault in the braking system was reported at that time, nor was one entered in the aircraft's documentation. At the time of the accident the aircraft was to resume operation.

According to the crew all items on the checklist were performed in connection with start-up and preparations for taxiing. Nothing abnormal was noted. When after engine start-up and prior to taxiing the captain moved the propeller control from ≅FEATHER≅ to ≅TAXI≅, the aircraft started to roll forwards. The captain and the first officer then attempted several times but without result to brake the aircraft using the toe-brakes and the parking brake. After moving some 25 metres the aircraft collided with a terminal building. The stop was gentle and no personal injuries were incurred.

The accident was probably caused by the pre-takeoff taxiing being commenced without full hydraulic pressure being available for the brakes. Contributory has been an unusual feature of the design that may give rise to a temporary loss of braking pressure. This possibility was not known by the operator, nor was it mentioned in the flight manual.

Recommendations

The Board of Accident Investigation recommends the Swedish Civil Aviation Administration

1. to seek amendment of Shorts Flight Manual with information on the risk of temporary loss of braking effect in connection with taxiing,

2. to seek amendment of Shorts Flight Manual Check List with all the instructions contained in Shorts Information Letter SD3-IL-120 Oct 15, 1982,

3. to ensure that operators of the aircraft type are informed of the risk of such malfunction, and that the checklists affected are arranged according to Shorts Flight Manual Check List so that the risk of the malfunction may be minimised,

4. to investigate the need of corresponding measures regarding aircraft type Shorts SD3-60.

1 FACTUAL INFORMATION

1.1 History of the flight

The aircraft, which was in scheduled operations, landed at Trollhättan/Vänersborg Airport at 20.53 hrs on Friday 25 February. At the airport, engineers were to carry out the 2"A inspection (150-hour inspection) before the aircraft resumed operation on the Sunday. According to the offgoing crew, the aircraft was left with the parking brake in the ≅ON≅ position and the Emergency brake handle in the ≅EMERGENCY≅ position with brake chocks under the nose wheels. No braking system fault was reported or entered in the aircraft's documentation.

Apart from cleaning and visual inspection, no technical action was taken with regard to the braking system during the 150-hour inspection. The Emergency brake handle was not touched. After the inspection and approximately 1-2 hrs before scheduled departure time the aircraft was parked at parking place no 3 in front of the control tower.

When the crew took over the aircraft for the scheduled flight the captain noted that the nose wheels were chocked, that the parking brake was at ≅OFF≅ and that the Emergency brake handle was at ≅EMERGENCY≅. No crew member checked the pressure in the emergency cylinder.

According to the crew, all the checklist steps for start-up and preparation were performed prior to taxiing. Nothing abnormal was noted. As a final point, brake pressure was checked after the ground power unit and brake chocks had been removed.

When, after engine start-up and before taxiing, the captain moved the propeller control from ≅FEATHER≅ to ≅TAXI≅, the aircraft began to move forwards. The captain and the first officer then attempted many times but in vain to brake the aircraft with the toe-brakes. Even attempts to brake by manoeuvering the parking brake and the emergency brake handle gave no result. When the captain was also unable to bring the moving aircraft to a standstill by reversing the propellers, he concentrated on steering it towards a bank of snow in front of the control tower. The risk of colliding with obstacles on either side of the aircraft prevented him from attempting to turn. The aircraft was not completely arrested by the snow bank but collided with the building after rolling approximately 25 metres. The stop was gentle and none of the passengers was injured. After engine shut-down the passengers and crew left the aircraft. The accident occurred at the airport (position 5819N 1221E, 41 m AMSL) in full daylight.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*	***Total***
			Fatal	B
	B	B	B	
Serious	B	B	B	B
Slight	B	B	B	B
No injuries	3	8	B	11
Total	**3**	**8**	**B**	**11**

1.3Damage to the aircraft

Substantial.

1.4 Other damage

Limited damage to the control tower.

1.5 The crew

1.5.1 *The captain*

The captain was 57 years old at the time of the accident and held a valid Airline Transport Pilot's Licence (Swedish D).

Flying hours, previous...	*24 hours*	*90 days*	*Total*
All types	0	45	8,015
This type	0	45	45

Number of landings with this type previous 90 days: 59
Flight training on type concluded 1994-02-04.
Latest periodic flight training 1994-02-04 on Shorts SD3-30.

1.5.2 *The first officer*

The first officer was 23 years old at the time of the accident and held a valid Commercial Pilot's Licence (Swedish B) with instrument rating.

Flying hours, previous...	*24 hours*	*90 days*	*Total*
All types	0	170	1,270
This type	0	50	50

Number of landings with this type previous 90 days: 56
Flight training on type concluded 1994-02-03.
Latest periodic flight training 1994-02-03 on Shorts SD3-30.

1.6 The aircraft

1.6.1 *Basic data*

Owner	Finans Skandic AB, 103 78 Stockholm
Operator	Flying Enterprise AB, Flygfältsgatan 31, 423 37 Torslanda
Type:	Shorts SD3-30
Serial number:	3097
Year of manufacture:	1984
Gross weight:	Maximum permissible 10,385 kg, current 9,110 kg
Centre of gravity:	Within permitted limits
Engine manufacturer:	Pratt & Whitney
Engine model:	PT6A-452

Number of engines:	2
Fuel loaded before event:	Jet A1
Total operating time:	12,949 hrs
Operating time since last periodic inspection:	0 hrs
Engine operating hours since last full inspection:	
Left engine	1,411 hrs
Right engine	2,039 hrs
Propeller operating time since full inspection:	
Left engine	2,607 hrs
Right engine	2,868 hrs
Propeller manufacture	Hartzell

The aircraft had a valid certificate of airworthiness.

1.6.2 *Braking and emergency braking systems*

Normal brake operation is effected by means of main pressure (MP) from the aircraft's main hydraulic system, which is pressurised by the engines' hydraulic pumps.

Parking braking is effected with a ≅Parking Brake≅ lever sited in the lower part of the instrument panel. The control has two positions, ≅ON≅ and ≅OFF≅. Braking while on the ground is effected by a pilot pressing the upper part of the rudder pedals, which allows individual braking on the left or the right main wheel.

In the case of a technical fault in the main hydraulic system or if this is without pressure, the brakes can be operated by means of Emergency brake pressure (EBP) from an Emergency accumulator. This is charged automatically with pressure from the main hydraulic system as soon as an engine is running. Connection of the Emergency accumulator is by means of an ≅Emergency brake handle≅ on the lower part of the instrument panel. The handle has two positions ≅EMERGENCY≅ and ≅NORMAL≅.

When the brakes are operated with EBP, MP is blocked by a pressure-activated cut-off valve. The purpose of this function is to prevent possible pressure loss in the main hydraulic system from affecting the possibility of operating the brakes with pressure from the Emergency accumulator. The cut-off valve is shut as long as the EBP in the brake system exceeds approximately 190 PSI. Protracted parking braking is normally with the Emergency brake handle in the ≅EMERGENCY≅ position.

Pressure gauges on an instrument panel on the left side of the cockpit show the pressure in the main hydraulic system, the Emergency accumulator and in the left and the right brake cylinders. Operating pressure in the main hydraulic system is approximately 3,000 PSI. Maximum brake pressure in the brake cylinders is approximately 1,500 PSI.

1.7 Meteorological information

Wind 350□/8 kts, CAVOK, temp/dewpoint -9/-11□C, QNH 1015 hPa.

Wheel Brakes - Schematic

1.8 Navigational aids

Not applicable.

1.9 Communications

Normal with Aerodrome Flight Information Service (AFIS)

1.10 Aerodrome information

The status of Trollhättan/Vänersborg Airport was according to Aeronautical Information Publication (AIP) Sweden.

1.11 Flight recorders

The recording of the CVR of the aircraft was unintentionally erased after the accident.

1.12 Site of accident and aircraft wreckage

1.12.1 *Site of accident*

The accident took place in the airport ramp area between parking place no. 3 and the control tower. The distance between the parking place and the tower is approximately 25 metres. The ground is asphalted.

At the time of the accident the ground had been cleared of snow but patches of ice, snow and grit remained along the path of the aircraft. On its left a fuel truck was parked, while on its right an aircraft of type SAAB 340 was parked.

1.12.2 *Aircraft wreckage*

Damage was caused to the nose section of the aircraft.

1.13 Medical information

Nothing indicates otherwise than that the crew were in good physical and mental condition prior to the flight.

1.14 Fire

No fire broke out.

1.15 Survival aspects

The retardation force on collision with the station building was slight and there were no personal injuries.
The ELT was not activated.

1.16 Functional check of the brake system

On the day following the accident the Board and staff from the airline company performed a visual inspection and complete functional check of the aircraft's brake systems. Nothing abnormal was noted.

1.17 Additional information

1.17.1 *Shorts Information Letter SD3-IL-120 Oct 15, 1982*

Shorts Information Letter SD3-IL-120 Oct 15, 1982 (Appendix 2) gives information on isolated cases of brake failure. The failure has occurred in connection with parking after the emergency brake control has been moved from ≅EMERGENCY≅ to ≅NORMAL≅.
To prevent such malfunctions, three measures to be taken in connection with start-up and prior to commencement of taxiing are described. The third of these, which prescribes that the braking pressure to each brake cylinder must be physically checked prior to taxiing when the brake chocks have been removed, is incorporated in Shorts Flight Manual Check List. The Board has been unable to find any other information on the malfunction in Shorts Flight Manual or in any other of publication from the manufacturer.
During the investigation of this accident the aircraft manufacturer submitted the following supplementary information to the Board regarding how the malfunction may occur.
When the aircraft is braked for parking with the Emergency brake handle at ≅EMERGENCY≅, MP is automatically cut off through the cut-off valve as long as EBP exceeds approximately 190 PSI. If the handle is subsequently moved to ≅NORMAL≅, EBP will be "confined" within the braking system through the shutting of the connection to the Emergency accumulator. If the aircraft is parked for some time, the "confined" EBP gradually decreases through internal leakage. When it has decreased sufficiently it may be too low to give acceptable braking power, yet high enough to prevent the cut-off valve from opening for MP.

The consequence may be that full braking pressure from the main system does not reach the brake cylinders when the brakes are applied even though the Emergency brake handle is in the ≅NORMAL≅ position. To attain MP, the ≅confined≅ EBP must first be bled so that the cut-off valve returns to its open position. This can be done by working the parking brake or the toe-brakes several times. It is possible to check that full braking pressure has reached the brake cylinders by reading the relevant pressure gauges in the cockpit.

At the time of the accident nobody in the company had any knowledge of the above-mentioned risk or Information Letter SD3-IL-120 Oct 15, 1982.

1.17.2 *Practical tests*

In practical tests on the aircraft under investigation and on a Shorts SD3-60 aircraft with the same type of braking system, it has been verified that the malfunction described in 1.17.1 can occur. In the latter aircraft, the ≅confined≅ EBP pressure sank by on the average 100 PSI/hr. On one occasion, seven depressions of the brake pedals were necessary for the cut-off valve to return to its open position and release MP to the brake cylinders.

In the aircraft under investigation it was established that the pressure in the Emergency accumulator sank from 2,500 PSI to 1,150 PSI during 19 hours of parking.

1.17.3 *Relevant checklist*

In the checklist used by the pilots on the occasion of the accident, the brakes and their hydraulic systems are dealt with under the following points prior to taxiing. The corresponding points in Shorts Flight Manual are shown in italics on the next line.

PRE-FLIGHT INSPECTION

...

Parking Brake On

Parking brake On

Emergency Brakes As required

Emergency brake handle *As required*

...

Hydraulic Pressures Check

Hydraulic services pressures *Noted*

...

TURN ROUND PRE-START CHECK

Parking Brake On

...

STARTING FIRST ENGINE

...

Hydraulic Pressure 3000 psi +200/-100

Hydraulic services (pr. and cont.) *Normal*

...

AFTER STARTING ENGINES

...

Emergency Brakes Normal

Emergency brake handle *NORMAL*

...

TAXI CHECKS
Hydraulics Checked
Hydraulic services pressures *Correct*

Chocks *Away*
Brakes Check
Wheelbrakes *Release PARKING BRAKE and check toe brakes*
...

2 ANALYSIS

2.1 Design of the braking system

The design of the braking system may under special circumstances lead to full braking pressure from the main hydraulic system not reaching the brake cylinders during braking even though the Emergency brake handle is in the ≅NORMAL≅ position. The result may be that braking effect is temporarily lost while taxiing. The risk of this and how it may be countered are described in Shorts Information Letter SD3-IL-120 of 15 October 1982. The information does not, however, give any underlying technical explanation. Even though the risk of a malfunction can be minimised through training and instructions, the manufacturer of the aircraft should attempt to find a suitable technical modification to the braking system which would permit elimination of the possibility of the malfunction occurring. It is understood that the braking system on the same manufacturer's aircraft type SD3-60 is of the same basic design.

2.2 Probable course of events

When the propeller pitch prior to taxiing was changed from ≅FEATHER≅ to ≅TAXI≅, this resulted in the engines delivering a certain thrust which caused the aircraft to move forwards. When the pilots attempted to brake the aircraft they obtained no braking effect when braking with either the foot pedals or with the parking brake. No technical fault in the braking system or hydraulic system which can explain the lost braking effect has been found since the accident.

When the engines were shut down after the last landing the Emergency accumulator was probably under full pressure, i.e. 2,500B3,000 PSI. When the engines are not running, experience shows that the pressure in the accumulator sinks. In a practical test with the investigated aircraft the pressure sank from 2,500 PSI to 1,150 PSI during parking for approximately 19 hours.

When the aircraft resumed operation approximately 40 hours after the last landing, it is therefore fully possible that the accumulator pressure had decreased to a level well below 1,500 B which is required for full braking effect B but over 190 PSI B at which point the cut-off valve blocks MP.

There is much to indicate that the Emergency brake handle was in the ≅EMERGENCY≅ position when the crew started going through the checklist prior to takeoff. Under PRE-FLIGHT INSPECTION, the checklist prescribes:

...

Parking brake On
Emergency brakes As required
...

According to the crew the checklist was followed, which implies that they applied the parking brake using the low pressure in the Emergency accumulator. Subsequently they may, according to the next point in the checklist which only states ≅As required≅, already have moved the Emergency brake handle to ≅NORMAL≅.

The conditions that could lead to the malfunction described under 1.17.1 would thus be met.

Another possibility is that the crew under the AFTER STARTING ENGINES section of the checklist, which states that the handle must be moved to ≅NORMAL≅ after engine start-up, did this so early during the start-up procedure for the first engine, that there had been insufficient time for full EBP to build up.

The result would have been the same, i.e. that braking effect would be temporarily lost in connection with taxiing, which is precisely what the crew experienced.

As the final points in the checklist before taxiing, it is stated:

Hydraulics Checked
Brakes Check

Since the crew did not know of the possibility of malfunction it is probable that these points were dealt with by checking that MP and EBP were showing normal values, that the Emergency brake handle was in the ≅NORMAL≅ position and that the parking brake handle was at ≅ON≅. These actions have proved to be insufficient to eliminate the risk of malfunction.

Braking effect may have been achieved after several attempts to brake before the collision without the crew noticing this, since the aircraft may have skidded on some of the ice and snow patches on the ground. Reversing the propellers had no time to give any noticeable braking effect during the brief course of events.

2.3 Instructions and checklist

The risk of temporary loss of braking effect as above has been known to the aircraft manufacturer since 1982. Considering the serious consequences this may entail, it is a shortcoming that no information on the risk is given in Shorts Flight Manual and that all the measures in Shorts Information Letter SD3-IL-120 are not incorporated in Shorts Flight Manual Check List.

Even though Shorts Information Letter SD3-IL-120 was issued more than 11 years before the accident, its existence and content should have been known to the operator. In addition, the checklist used within the company gives insufficient guidance to ensure that taxiing is not started without full braking

capability. In the TAXI CHECKS section the only prescription regarding the brake system as the last point before taxiing is merely ≅**Check**≅, while the corresponding point in the Shorts Flight Manual Check List prescribes ≅**Release PARKING BRAKE and check toe brakes**≅.

It is only possible to check that full brake pressure reaches the brake cylinders by reading off the pressure in the brake cylinders when braking with the pedals or applying the parking brake. If this check had been performed, the accident would

probably not have occurred.

3 CONCLUSIONS

3.1 Findings

a) The pilots were qualified to perform the flight.

b) The aircraft was airworthy.

c) The aircraft had been parked for approximately 40 hours.

d) Before engine start-up the parking brake was applied with the Emergency brake handle in the ≅EMERGENCY≅ position.

e) The risk of a malfunction of the braking system and how this can be counteracted are noted in Shorts Information Letter SD3-IL-120, of 15 October 1982.

f) Practical tests have shown that the pressure in the Emergency cylinder during long-time parking can decrease by 70B100 PSI/hr.

g) Information on the malfunction and all the instructions in Shorts Information Letter SD3-IL-120 of 15 October 1982 are not incorporated in Shorts Flight Manual Check List.

h) Nobody in the airline company knew of Shorts Information Letter SD3-IL-120 or the risk of this type of malfunction.

i) There are discrepancies between the airline company's checklist and Shorts Flight Manual regarding the handling of the brake system.

3.2 Causes of the accident

The accident was probably caused by the pre-takeoff taxiing being commenced without full hydraulic pressure being available for the brakes. Contributory has been an unusual feature of the design that may give rise to a temporary loss of braking pressure. This possibility was not known by the operator, nor was it mentioned in the flight manual.

4 RECOMMENDATIONS

The Board of Accident Investigation recommends the Swedish Civil Aviation Administration

1. to seek amendment of Shorts Flight Manual with information on the risk

of temporary loss of braking effect in connection with taxiing,

2. to seek amendment of Shorts Flight Manual Check List with all the instructions contained in Shorts Information Letter SD3-IL-120 Oct 15, 1982,

3. to ensure that operators of the aircraft type are informed of the risk of such malfunction, and that the checklists affected are arranged according to Shorts Flight Manual Check List so that the risk of the malfunction may be minimised,

4. to investigate the need of corresponding measures regarding aircraft type Shorts SD3-60.

	COMPONENT
1	BRAKE MASTER CYLINDER
2	BRAKE CONTROL UNIT
3	REDUCING VALVE WITH CUT-OUT
4	NON-RETURN VALVE
5	PRESSURE REDUCING VALVE
6	CUT-OFF VALVE
7	EMERGENCY ACCUMULATOR (60 CU.IN.)
8*	PRESSURE GAUGE 0Ƀ4000 P.S.I.
9	PRESSURE GAUGE 0Ƀ2000 P.S.I. (2-OFF)
10	PRESSURE RELAY
11	TEST CONNECTORS
PRESSURE	
12	MAXARET UNIT
PRESSURE	
13	MODULATOR UNIT
14	SHUTTLE VALVE
15	BRAKE UNIT
16	CAPACITY ABSORBER (POST MOD 6540)

NOTE: ON POST MOD 5233 & 5619 AIRCRAFT
ITEM 8 IS ELECTRICALLY SIGNALLED

	PIPE IDENTIFICATION
BA	BRAKE ACCUMULATOR
BL	BRAKE LEFT
BL1	BRAKE LEFT 1ST PILOT
BL2	BRAKE LEFT 2ND PILOT
BR	BRAKE RIGHT
BR1	BRAKE RIGHT 1ST PILOT
BR2	BRAKE RIGHT 2ND PILOT
BRP	BRAKE REDUCED PRESSURE
EBL	EMERGENCY BRAKE LEFT
EBR	EMERGENCY BRAKE RIGHT
EBP	EMERGENCY BRAKE
ERP	EMERGENCY REDUCED
LGU	LANDING GEAR UP (BRAKE INHIBITING)
MP	MAIN PRESSURE
MR	MAIN RETURN