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Aircraft accident investigation bureau

Final Report No. 1890 by the Aircraft Accident Investigation Bureau

concerning the serious incident
to aircraft AVRO 146-RJ 100, HB-IXX,
operated by Swiss International Air Lines Ltd.
under flight number LX 1014
on 13 December 2003
at Zurich-Kloten Airport

Ursachen

Der schwere Vorfall ist darauf zurückzuführen, dass sich nach dem Start in Zürich in der Passagierkabine Rauch ausbreitete, so dass der Flug abgebrochen werden musste.

Die Untersuchung hat folgende kausale Faktoren für den schweren Vorfall ermittelt:

- Beim Austausch des *bleed air valves* des Triebwerkes Nr. 3 wurde ein O-Ring fälschlicherweise mit *petroleum jelly* geschmiert. Als die Triebwerke während des Steigfluges mit hoher Leistung betrieben wurden, verbrannten Rückstände dieses Schmiermittels und erzeugten Rauch, welcher durch die Kabinenbelüftung in das Innere des Flugzeuges gelangte.
- Ein Standlauf mit hoher Triebwerkleistung wurde nicht durchgeführt.

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General information regarding this report

In accordance with the Convention on International Civil Aviation (ICAO Annexe 13), the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. It is not the purpose of this investigation to determine blame or clarify questions of liability.

According to the Swiss Air Navigation Law, the legal assessment of aircraft accident/incident circumstances and causes is no concern of the incident investigation.

The masculine form is used in this report regardless of gender for reasons of data protection

All times in this report, unless otherwise indicated, are indicated in coordinated universal time (UTC) format. At the time of the accident, Central European Time (CET) applied as local time (LT) in Switzerland. The relation between LT, CET and UTC is: $LT = CET = UTC + 1 \text{ h}$.

The report in the German language contains the valid formulations.

The Aircraft Accident Investigation Bureau thanks the authorities and organisations for the support given to it in the course of the investigation.

Final Report

Owner	Metra Mobilienverwaltung GmbH
Operator	Swiss International Air Lines
Aircraft type	AVRO 146-RJ 100
Country of manufacture	United Kingdom
Registration	HB-IXX
Location	Climb after take-off from Zurich
Date and time	13 December 2003, 07:06 UTC

Summary

Brief description

On 13 December 2003 at 06:54 UTC, the AVRO 146-RJ 100 aircraft, registration HB-IXX, of Swiss International Air Lines, took off on a scheduled flight to Düsseldorf.

Twelve minutes after take-off, still climbing, the cabin crew reported to the flight crew that smoke was spreading in the cabin, associated with a strong smell. The smell could also be noticed in the cockpit on the right hand side. The flight crew decided to return to Zurich.

During the descent, smoke and smell diminished in the cabin and the smell also diminished in the cockpit. The subsequent approach and landing on runway 14 in Zurich took place without incident. The flight crew decided to taxi to the assigned stand. The passengers disembarked the aircraft in the normal way.

Investigation

The serious incident took place on 13 December 2003 at 07:06 UTC and the aircraft landed at 07:20 at Zurich airport. The Swiss Air Rescue Organisation (Rega) notified the Aircraft Accident Investigation Bureau, which subsequently opened an investigation.

Causes

The serious incident is attributable to the fact that after take-off in Zurich smoke spread in the passenger cabin, so the flight had to be aborted.

The investigation determined the following causal factors for the serious incident:

- When the bleed air valve on engine No. 3 was replaced, an O-ring was incorrectly lubricated with petroleum jelly. When the engines were being operated at high power during the climb, residues of this lubricant combusted and generated smoke, which penetrated inside the aircraft via the air conditioning system.
- A ground run at high engine power was not carried out.

1 Factual Information

The following findings are based on the recordings of the cockpit voice recorder (CVR) and flight data recorder (FDR), and on the corresponding reports and statements from those involved.

1.1 Pre-flight history and history of flight

On 12 December 2003, on the day before the serious incident, after the flight from London City LYC to Zurich ZRH, the flight crew entered the following complaint in the aircraft log: *"WHEN PERFORMING THE TAKE OFF WITH APU AIR (IE ENGINE AIR OFF) THE ENGINE #3 AIR VALVE NIPS ILLUMINATES AT 60 PERCENT N2. SELECTING ENGINE #3 AIR ON PRODUCES NO CHANGE IN EGT."*

According to the technical log system (TLS), work order 1414387, the following measure was taken: *"FAULT CONFIRMED #3 ENGINE. P.R.S. ON REPLACED WITH A REPAIRED ONE AS PER AMM REV. 77. CH 36-11-11. OPERATIONEL CHECK C/O SATIS."*

According to the TLS, this work took 4:30 hours and was completed at 03:30 UTC.

On 13 December, a different flight crew took over the aircraft and at 06:40 taxied away from the stand. At 06:54 UTC the aircraft took off on a scheduled flight to Düsseldorf.

Twelve minutes after take-off, the flight attendant who was in the rear galley noticed smoke in the cabin and informed his colleagues in the forward galley by telephone. The latter informed the commander about the situation as follows: *"Dunst, nebelartiger Rauch, ca. in der Mitte der Kabine, ausbreitend nach oben mit beissendem, schmörzeligem Rauch - Fumes, fog-like smoke, approximately at the centre of the cabin, spreading upwards with an acrid, scorching smell"*.

After a personal inspection, the commander decided to abort the flight and return to Zurich.

During the return to Zurich the cabin crew tried to determine the source of the smoke. Passengers supported this action by informing the cabin crew of their perceptions. During the descent back to Zurich, the situation improved. The volume of the smoke and smell diminished.

The airport fire brigade, which had been alerted, accompanied the aircraft to the stand after it had landed at 07:20, after a flying time of 26 minutes. On the basis of his assessment of the prevailing situation, the commander decided to taxi to the stand and disembark the passengers at the gate in accordance with the normal procedure. The engines were shut down at 07:25 UTC.

1.2 Injuries to persons

	Crew	Passengers	Third parties
Fatally injured	----	----	----
Seriously injured	----	----	----
Slightly injured or uninjured	5	33	

1.3 Damage to aircraft

There was no damage to the aircraft.

1.4 Other damage

There was no damage to third parties.

1.5 Personnel information**1.5.1 Commander**

Person	Swiss citizen, born 1952
Licence	Air transport pilot licence (ATPL), according to JAR, first issued by the Federal Office for Civil Aviation (FOCA) on 23.09.1988
Ratings	RTI (VFR/IFR) NIT (A) IFR (A)
Ratings to be extended	AVRO RJ/BAe 146 PIC TRI (A) IRI (A)
Last proficiency check	23.12.2002
Last line check	15.08.2003
Medical fitness certificate	Class 1
Last medical examination	21.08.2003, result: fit to fly, spectacles wearer
Total flying experience	10 100 h
on AVRO 146-RJ	3300 h
during the last 90 days	100 h

1.5.2 Copilot

Person	French citizen, born 1972
Licence	Commercial pilot licence CPL (A), according to JAR, first issued by the Federal Office for Civil Aviation (FOCA) on 07.06.2001
Ratings	RTI (VFR/IFR) NIT (A) IFR (A)
Ratings to be extended	AVRO RJ/BAe 146 COPI
Last proficiency check	10.08.2003
Last line check	31.01.2003
Medical fitness certificate	Class 1
Last medical examination	20.09.2003, result: fit to fly, spectacles wearer
Total flying experience	1170 h
on AVRO 146-RJ	970 h
during the last 90 days	108 h

1.5.3 Cabin crew

Flight attendant A	Swiss citizen, M/C SH, teamleader flight attendants
Flight attendant B	Swiss citizen, M/C SH
Flight attendant C	Swiss citizen, flight attendant

1.5.4 Mechanic

Person	Greek citizen
Ratings	B1: AR 1/8 RUN UP AND TAXIING, no limitation B1: AR 1/8 ENGINE BOROSCOPE ALF 500 SERIES, no limitation B1: BAE 146/RJ (AVRO-LYC ALF 500 SERIES), limitation: ELEC POW GEN&DISTR SYST+AVIONIC LRUS X: BASIC-COMPANY INTRODUCT&PROCEDURE, no limitation

1.6 Aircraft information

1.6.1 Aircraft HB-IXX

Type	FGBB1472 AVRO 146-RJ100
Registration	HB-IXX
Manufacturer	British Aerospace
Serial number	E3262
Year of construction	1995
Engines	4 Allied Signal LF507-1F
Owner	Metra Mobilienverwaltung GmbH
Operator	Swiss International Air Lines
Date of registration	19 October 1995

1.6.2 Findings after landing

1.6.2.1 Initial situation

After a discussion with the crew, clarification by the maintenance department took place under consideration of the following facts:

- The aircraft was not de-iced before the flight.
- At the time the smoke was noticed, the engine bleed air was being used for air conditioning.
- When the bleed air from the auxiliary power unit (APU) was used, the smoke diminished.

1.6.2.2 Cabin

In the central part of the cabin, ceiling panels were removed to search for scorched components or components which were producing smoke. In the area of seat rows 7 to 9 RH, the side-wall panels were removed and the electrical lighting transformers were examined. These visual inspections indicated no damage.

1.6.2.3 Engines

The engines were examined for foreign object damage (FOD) and then for visible traces of oil. This investigation produced no results.

An investigation according to the maintenance department's work order (W/O 1414391) revealed that grease residue was present on an O-ring seal in a bleed air valve on engine number 3. This valve had been replaced during the previous night.

1.7 Meteorological information

1.7.1 General

The following data were provided by SwissMeteo.

1.7.2 General weather situation

At the time of the serious incident, Switzerland was at the southern edge of a warm front. This warm front caused stratified banks of cloud in northern Switzerland.

1.7.3 Weather conditions at Zurich airport

At the time of the serious incident, the weather at Zurich airport was as follows:

Cloud: 1-2/8 at 4600 ft AAL
3-4/8 at 5200 ft AAL
5-7/8 at 13 400 ft AAL

Visibility: 12 km

Wind: south-south-east at 2 to 4 knots

Temperature/dewpoint: 04 °C / 03 °C

Zero degree level: 9500 ft AMSL

Atmospheric pressure: QNH LSZH 1024 hPa, QNH LSGG 1026 hPa

Hazards: not evident

1.7.4 Aerodrome weather reports

At the time of the serious incident, the following Metar reports were being transmitted:

LSZH 130650Z 14004KT 9999 FEW032 SCT038 BKN070 04/03 Q1024 NOSIG
LFSB 130630Z 17005KT 6000 BKN027 06/04 Q1023 NOSIG
LSGG 130650Z 14004KT 9999 FEW032 SCT040 BKN250 M00/M01 Q1026 NOSIG

1.8 Aids to navigation

The DVOR/DME KLO and the ILS14 transmitters were in normal operation on 13.12.2003 during the time period of flight LX 1014 and were available to the operational services without restriction.

1.9 Communication

Radiocommunications between the crew and the air traffic control units were recorded in high quality and with no gaps.

1.10 Aerodrome information

Zurich Airport is located in north-east Switzerland. The airport reference point (ARP) has coordinates N 47 27.5 / E 008 32.9. The reference elevation of the airport is 1416 ft AMSL and the reference temperature is specified as 24 °C.

The Zurich airport runways have the following parameters:

Runway	Dimensions	Elevation of ends of runways
16/34	3700 x 60 m	1390/1386 ft AMSL
14/32	3300 x 60 m	1402/1402 ft AMSL
10/28	2500 x 60 m	1391/1416 ft AMSL

1.11 Flight recorders

Aircraft HB-IXX was equipped with a digital flight data recorder (DFDR), P/N 980-4700 S/N 29177.

1.12 Wreckage and impact information

Not relevant.

1.13 Medical and pathological information

The alcohol breath test carried out immediately after the serious incident produced a negative result for both pilots.

1.14 Fire

Not relevant.

1.15 Survival aspects

Not relevant.

1.16 Tests and research

None.

1.17 Organizational and management information

1.17.1 Operator Swiss

Swiss International Air Lines (Swiss) was founded in 2002 from the former Swissair airline and the former regional airline Crossair. The operator Swiss is certified according to JAR-OPS 1.

The individual fleets are each managed by a fleet manager and are jointly under the Flight Operations manager.

1.17.2 Technical maintenance department

1.17.2.1 General

The department responsible for technical maintenance is based in Basle and was acquired as a complete unit from the former Crossair company. The maintenance department, certified according to JAR-145, is responsible for aircraft types of the former Crossair company.

1.17.2.2 Procedure for replacement of the bleed air valve

The procedure for replacing the bleed air valve in question is described in the aircraft maintenance manual (AMM), section 36-11-11-201. This specification does not mention lubricating the O-ring in question.

In a technical information sheet of the maintenance department (technical flash info, ATA 21 control number: 004 Rev 0, 08 May 03) it is mentioned that this O-ring must not be greased, as on various occasions this had given rise to complaints about a "smell" in the cabin (see Annex 5.1).

Among other things, the procedure described in the AMM states that a test must be carried out after replacing the bleed air valve. This test includes starting up the engine and setting a power of 85% N2¹ until the engine exhaust gas temperature has stabilised.

This high power setting is required to test the system's seals integrity. It has the additional side-effect of burning off any residues. Such a power setting on the ground means that the aircraft must be positioned at a location specially provided for the purpose and additionally requires the approval of the responsible ground control unit.

1.17.2.3 Replacement of the bleed air valve by the mechanic

According to the mechanic's statement, he was very familiar with replacing such a bleed air valve, thanks to many years of experience on this aircraft type with a previous employer. He stated that such a replacement was a very demanding task. For technical reasons, and on the basis of his experience, at least two people are required to perform it. If possible, the work should be performed in a hangar.

Since fitting an ungreased O-ring can cause damage to it, the mechanic decided to use a 'petroleum jelly' for this procedure. Experience had apparently shown him that when high engine power was subsequently set, combustion of the lubricant residue led to a more pleasant odour than the silicone grease forbidden in the "technical flash info".

Experience had also shown him that during the test at high engine power a lot of smoke was produced for a short time, but that this smoke diminished after less than three minutes. However, this is also the reason why such a ground test had to be carried out at high engine power.

According to the mechanic's statement, he had known the "technical flash info" which expressly forbade lubricating the O-ring.

1.18 Additional information

None.

1.19 Useful and effective investigation techniques

None.

¹ Speed of high-pressure compressor and high-pressure turbine in relation to the nominal speed

2 Analysis

2.1 Technical aspects

As the investigation showed, the smoke was generated because residues of a lubricant vaporised when the engines were operated at high power.

2.2 Human and operational aspects

2.2.1 Flight crew

The conversations recorded by the cockpit voice recorder (CVR) permit the conclusion that the procedures drawn up by the airline were complied with. The assessment of the situation and the decision taken by the commander were made in good time and were suitable.

The copilot supported the commander in all respects and the CVR recordings permit the conclusion that the copilot showed considerable initiative.

On the basis of the CVR recordings, it may be concluded that the cooperation of the crew corresponded to the instructions recommended or prescribed in the crew resource management (CRM) training courses held by the airline.

2.2.2 Mechanic

Two mechanic should be used to replace the bleed air valve and this work should preferably be performed in a hangar.

The mechanic was required to carry out the replacement of the bleed air valve on his own and on the apron. During this work, temperatures were just above freezing point and a torch was the only source of light. Moreover, only a ladder was available to reach the bleed air valve. Such working conditions are questionable.

On the basis of his experience, the mechanic decided to lubricate the O-ring with petroleum jelly, so that it was easier to insert. This was contrary to the info flash which permitted soap water only for this purpose. At this time, he had the intention of carrying out a test run as prescribed, which in his experience would have led to vaporisation of the lubricant residue within a short time.

After replacing the bleed air valve, the mechanic had to perform the test run at an engine power lower than that prescribed. A test run at high engine power was forbidden at night-time for noise reasons. On the morning before the aircraft was dispatched, there would not have been sufficient time for such a ground run, as the aircraft would have had to be moved from the apron to a run-up area provided for this purpose.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The fitting of an O-ring did not take place in accordance with the regulations in force.
- The smoke was caused by the vaporisation of lubricant residue in the bleed air valve.

3.1.2 Crew

- According to the available documentation the crew were in possession of appropriate licences.

3.1.3 Mechanic

- According to the available documentation the mechanic was in possession of an appropriate licence.
- The procedures and regulations in force for replacing a bleed air valve were known to the mechanic.

3.1.4 General conditions

- The mechanic had to carry out his work under unsuitable conditions.

3.2 Causes

The serious incident is attributable to the fact that after take-off in Zurich smoke spread in the passenger cabin, so the flight had to be aborted.

The investigation determined the following causal factors for the serious incident:

- When the bleed air valve on engine No. 3 was replaced, an O-ring was incorrectly lubricated with petroleum jelly. When the engines were being operated at high power during the climb, residues of this lubricant combusted and generated smoke, which penetrated inside the aircraft via the air conditioning system.
- A ground run at high engine power was not carried out.

Berne, 21 April 2006

Aircraft Accident Investigation Bureau

This report has been prepared solely for the purpose of accident/incident prevention. The legal assessment of accident/incident causes and circumstances is no concern of the incident investigation (Art. 24 of the Air Navigation Law).

4 Glossary

A

AAIB	Aircraft Accident Investigation Bureau (Büro für Flugunfalluntersuchungen)
AMSL	Above mean sea level
APU	Auxiliary power control unit
ATC	Air traffic control
ATPL	Air transport pilot licence

C

CRM	Crew resource management
CVR	Cockpit voice recorder

D

DFDR	Digital flight data recorder
DME	Distance measuring equipment
DVOR	Doppler VOR

F

FDR	Flight data recorder
FOCA	Federal Office of Civil Aviation (Bundesamt für Zivilluftfahrt)
FOD	Foreign object damage

H

hPa	Hecto pascal
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I

ICAO	International Civil Aviation Organization
ILS	Instrument landing system
IFR	Instrument flight rules
JAR	Joint Aviation Regulation

M

M/C	Maitre de cabine
METAR	Aviation routine weather report

Q

QNH	Air pressure reduced to mean seal level, using the ICAO profile of the standard atmosphere
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S

SH	Short haul
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T

TLS	Technical log system
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U

UTC	Universal time coordinated
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V


VFR	Visual flight rules
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W

W/O	Work order
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5 Annexes

5.1 Technical flash info

 Technical flash info	
ATA 21 Control number: 004 Rev 0	08. May 03
A/C TYPE: ALL	ENGINE: N/A
SUBJECT: Bleed Air ducts contamination by silicon grease.	Issued by TEMS/CST

Dear All

Due to often reported complains and delay cancellations , because of smell in the cabin .
Pls note that the use of Silicon grease like MS4 or DC4 type, for installation of the bleed air ducts or sleeves is not allowed, due to smell when in contact with hot air gases
Use of soap water if needed as a lubricant for the installation of rubber sleeves on bleed air ducts.

TEMS/CST

ATTENTION:

This Technical Flash Info is for assistance only and will not be revised. This Technical Flash Info is not intended to constitute an Approved Data per said. This Technical Flash Info it will remain in effect until this information is incorporated into the applicable Crossair approved manuals (Approved Data), or cancelled by the Department's Originator.

MPM-CRX-MOE-TE-2.13-043