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Federal Aircraft Accident Board

Final Report No. 1884

by the

Federal Aircraft Accident Board

concerning the serious incident

to aircraft AVRO 146-RJ 100, HB-IXN

operated by Swiss International Air Lines Ltd.

under flight number LX 1103

on 19 April 2005

on approach to Zurich-Kloten Airport

This final report has been prepared by the Federal Aircraft Accident Board according to art. 22 – 24 of the Ordinance relating to the Investigation of Aircraft Accidents and Serious Incidents (VFU/SR 748.126.3), based on the Investigation Report by the Air Accident Investigation Bureau on 2 March 2006.

General remarks to this report

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 investigation (art. 24 of the Air Navigation Law).

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

If not otherwise stated, all times in this report are indicated in coordinated universal time (UTC). At the time of the accident the Central European Time (CET) was valid for the area of Switzerland. This CET was equal to the local time (LT). The relation between LT, CET and UTC is: $LT = CET = UTC + 1 \text{ h}$.

The german-language version of this report is authoritative.

Final Report

Aircraft	AVRO 146-RJ 100	HB-IXN	
	Engines: 4 Allied Signal LF507-1F		
Keeper	SWISS International Airlines, Postfach, 4002 Basle		
Owner	CONSTO Mobilien-Verwaltungs-GmbH & Co., Postfach, 4002 Basle		
Commander	Swiss citizen, born 1953		
Licences	Airline Transport Pilot Licence (ATPL) A		
Flying hours	total	14 132 h during the last 90 days	109 h
	on AVRO 146-RJ	5540 h during the last 90 days	109 h
Copilot	Swiss citizen, born 1972		
Licences	Airline Transport Pilot Licence (ATPL) A		
Flying hours	total	3830 h during the last 90 days	146 h
	on AVRO 146-RJ	3660 h during the last 90 days	146 h
Location	Flight Munich - Zurich		
Coordinates	---	Altitude	approximately FL 130
Date and time	19 April 2005 approx. 09:15 UTC		
Type of operation	Scheduled flight		
Flight phase	Descent, approach to Zurich-Kloten Airport		
Serious incident	Fumes and acrid smell in the cockpit		

Damage to persons

	Crew	Passengers	Third parties
Fatally injured	--	--	--
Seriously injured	--	--	--
Slightly injured or uninjured	4	41	

Damage to the aircraft None

Damage to third parties None

1. History

Pre-flight history

On 16 April 2005, the following complaint was made by the crew of flight LX 725:

"Strong smell during descent without previous airchange in FWD area of A/C".

Measures taken by the maintenance company: All engines were examined for visible traces of oil. Engines 1, 2 and 3 were then started and the air supply was switched on and off alternately. It was not possible to reproduce the smell. Subsequently, crews were instructed to complete a specific form if the smell reoccurred.

On 18 April 2005, the following complaint was made by the crew of flight LX 1026 from Zurich to Düsseldorf:

"5NM final ILS rwy 23R oil smell and dust observed. Dust disappeared after about 2nm, smell/smoke incident report filled in".

The responsible mechanic in Düsseldorf reported the following in the work order: *"FOUND OIL COMING OUT OF TEMP CONTROL VALVE FOR HEAT EXCHANGER. PACK 1 SET INOP ACC MEL 21-50-10. DURING ENGINE RUN, NO OIL SMELL PRESENT, ALSO NO SIGNS OF OIL IN COMPRESSOR (INLET) OR EXHAUST PRESENT."*

Among other things, the following is contained in the flight crew's operations report concerning the approach in Düsseldorf: *"...we perceived smell of burned oil and shortly after that the SFO (Copilot) saw light white fumes...the situation was not dramatic we decided to continue approach and set the priority on a stable approach and safe landing. Therefore no emergency was declared and the oxygen masks were not used..."*

The subsequent flight from Düsseldorf to Zurich took place without incident.

In the night of 18 to 19 April 2005, the following, among other things, was reported by the line maintenance in Zurich: *"... Engine 1 showed increasing oil consumption, from 0.05 to 0.25 in the last 60 flight hours, although within limits."*

A boroscope inspection was carried out on engines 1 and 2 and the following result was recorded:

"BOROSCOPE INSPECTION PERFORMED ON ENGINE N° 1 + 2 BEARING SEALS 1 + 9 TO CHECK FOR OIL LEAKS IAW ENGINE MANUAL 72-00-00 02 201 SEP 30/99 AND TEMPORARY REVISION N° 72-77-07:- NO EVIDENCE OF OIL LEAKS AT BEARING SEALS OBSERVED."

In an email addressed to this superior, the mechanic responsible for the boroscope inspection made the following statement after the serious incident: *"At the same time I was responsible for the "A"-Check on IYZ with 36 planned hours work and 2 open workorders. I was also the only B1 on the aircraft responsible for five other mechanics. IXN was put in a different hangar and I had to work between the two aircraft and ensure there would be no problem for IYZ to go to stand at 6 am LT ..."*

In addition to the boroscope inspection the following work was carried out and documented as follows:

"C/O PACK BURN FOR PACK #1 IAW STANDARD PRACTICES-SATIS.

CHECKED #1 AND # 2 ENG, ENG OIL GALLERY DIFFUSER-SATIS.

#1 UND #2 ENG BEARING SEAL FAILURE, VISUAL INSP-SATIS.

STATIC AND ON ENG RUN - #1 + #2 ENG NO4 BEARING/SEAL FAILURE-SATIS. REF SIL 21-045, SECTION 2."

According to the statement by the maintenance company's responsible coordinator, these measures led to the air-conditioning pack 1 being re-activated. Activation of air-conditioning pack 1 was not recorded explicitly in a work order and consequently there was no evidence of this for the crew.

On 19 April 2005, before the flight involved in the incident, the aircraft was used for a scheduled flight from Zurich to Munich. According to the statement from the crew, this flight was without incident in terms of smoke and fumes in the cockpit. However, a problem did occur with the autopilot during the approach, causing the crew to carry out the landing manually.

History of the flight

On 19 April 2005 at 08:36 UTC, aircraft AVRO 146-RJ100, HB-IXN, began scheduled flight LX 1103 to Zurich LSZH (CH) in Munich EDDM (D). Take-off and cruise were normal. At 09:10:18 UTC the crew received the information that an instrument approach on runway 14 was to be expected.

Because of the problem with the autopilot on approach to Munich, the crew decided to make an automatic landing in Zurich to test the autopilot.

During the descent, at approximately flight level (FL) 130, an acrid smell began to permeate the cockpit and fumes appeared. The copilot began to feel unwell and immediately donned his oxygen mask. Regarding the situation the commander made the following comment versus the copilot (CVR): *"...oil, air conditioning smoke..."*.

At 09:15:11 UTC, the commander of flight LX 1103 requested landing priority as follows: *"..., for your information, we request landing priority, we have air conditioning smell in the cab..., in the cockpit and the Copilot is not feeling well, requesting ah... priority for landing."*

In order to shorten the flight path, the air traffic controller offered the crew radar vectors using heading instructions to intercept the instrument landing system for runway 16. This was refused by the crew of LX 1103, as they had already made all preparations for an approach on runway 14.

According to the commander's statement, he himself refrained from donning his oxygen mask, as he felt fine and was not experiencing any discomfort. This was also why the copilot, according to his own statement, removed his oxygen mask during the approach, though this immediately led to a recurrence of the respiratory problems and caused him to don his oxygen mask for the remainder of the flight.

At 09:22:04 UTC flight LX 1103 reported to the tower: *"..., established one four, five miles."*

Throughout the approach, the copilot, according to his statement, felt aware of events but was limited in his capability of acting.

Shortly before landing, the problem with the autopilot recurred, causing the commander to switch off the autopilot and to control and land the aircraft manually.

At 09:22:08 UTC, LX 1103 received landing clearance and the landing took place at 09:24 UTC. The aircraft then taxied under its own power to the stand, accompanied by the fire brigade. While taxiing to the parking position, Zürich apron control asked whether there would still be smoke in the cockpit. The commander answered in the negative and explained that they had smoke and fumes generated by the airconditioning system and that the copilot had been in a bad condition and therefore they had asked for landing priority. He explained further that the aircraft had a history on this.

The passengers disembarked the aircraft in the normal way.

Measures after the incident

Among other things, the following statements were made by line maintenance:

" ... Initial inspection revealed oil deposit in pack 1 and fairly high oil contamination in bleed band area..."

"... has performed boroscope and confirms No 1 bearing leakage. Engine No 1 change required."

Engine 1 was replaced.

As a reaction to the problems with the autopilot, the ILS 2 receiver was replaced.

Additional information

Among other things, the airline's operations manual A (OM A) states the following in section 8.3 Flight procedures under 2.4 Procedures in case of system degradation, paragraph V) Policy for smoke or fire in the aeroplane:

"Decision making and actions

- *For decision making we understand under the term smoke/fire of "known origin" that the source of smoke/fire is clearly identified and the elimination can reasonably be expected by application of appropriate countermeasures by checklists and procedures/equipment.*
- *By contrast, in case of "visible smoke of unknown origin" the source cannot be identified or the fire is unfightable.*
- *The crew has always to assume the worst case scenario. In this situation the following actions have to be followed immediately:*
 - 1) *Oxygen mask/smoke goggles ON;*
 - 2) *Establish communication;*
 - 3) *Descend/divert to next emergency aerodrome;*
 - 4) *Land asap*
- *Initiate an emergency descent with due consideration to terrain;*
- *Proceed ..."*

In the additionally available manufacturer's operations manual (MOM), which every pilot possesses, the first and critical point in Volume 3 Part 2 in the emergency checklist under the header: "SMOKE, FUMES OR FIRE ON FLIGHT DECK/PASSENGER CABIN/ELECTRICAL EQUIPMENT BAY/ANIMAL BAY" is as follows:

"Oxygen masks and goggles.....Flight crew done, check 100%"

During flight LX 1103 involved in the serious incident, the commander did not don his oxygen mask; nor did the crew use oxygen masks during the previous flight LX 1026 on 18 April 2005, according to the operations report (OR).

2. Analysis

2.1 Technical aspects

2.1.1 Technical procedures in maintenance operations

An "oily smell" was first complained about by a crew on 16 April 2005. Since the subsequent inspection did not reveal visible traces of any kind, a ground run was carried out at low engine power. This ground run indicated no anomalies; nor could the smell be reproduced.

On 18 April 2005 an oily smell occurred again, and this time white smoke was also observed. This indicated that the problem was still present. After traces of oil were found on air-conditioning pack No. 1, its de-activation in Düsseldorf was an appropriate measure.

The work performed in Zurich on the night of 18 to 19 April did not rectify the problem. The traces of oil found the previous day and the increased oil consumption by engine 1 recorded in the line maintenance event printout should have been recognised as a reliable indication of a bearing problem and should therefore have led to a more detailed investigation.

A high-power run-up and a subsequent boroscope inspection would very probably have allowed identifying a bearing damage. A high-power run-up would have generated an oil pressure up to three times higher and would consequently have left behind more significant traces of oil on the compressor blades of the engine in the event of a bearing damage.

According to the statement by the mechanic responsible, a boroscope inspection carried out that same night indicated no traces of bearing damage. According to his statement, some parts of the boroscope equipment recommended for a search for an oil leak according to the engine maintenance manual (EMM) were not available in Zurich.

A repeat boroscope inspection after the incident was carried out on 19 April 2005 in Zurich by a lead mechanic from Basle, experienced in engine maintenance, who by chance happened to be present. He used the same boroscope equipment which had been used the night before and within a short time detected bearing damage. According to his statement, the equipment in Zurich was quite adequate to detect bearing damage. It cannot be stated with certainty whether this lead mechanic would have detected the leak in the night of 18 to 19 April 2005.

It must remain open why the leaking bearing was not found during the boroscope inspection in the night of 18 to 19 April in Zurich.

The only consequence of the measures taken in the night was the entry in the HIL: *"PLS REPORT ANY SMELL OR DUST OF OIL FROM AIRCONDITION"*.

It is not comprehensible why, despite the earlier history of markedly increased oil consumption and the traces of oil on the air-conditioning pack, no high-power run-up was carried out to locate the source of the fault or to replace the engine, if necessary. The sole request to the crew to report any smell or fumes permits the conclusion that those responsible in the line maintenance were not aware of the effects this phenomenon can have inside a cockpit.

2.1.2 Company procedures in maintenance operations

Swiss's technical operations for the AVRO fleet are basically split between two sites. Line maintenance is located in Zurich, whilst the maintenance control center (MCC), troubleshooting and engineering are based in Basle.

Whilst broad technical knowledge is required for mechanics in line maintenance, the specific expert knowledge of troubleshooters and engineering is needed for more complex problems and for establishing complex relationships.

Air-conditioning pack 1 was de-activated according to MEL in Düsseldorf on 18 April 2005. During the following night, various measures were taken and air-conditioning pack 1 was re-activated. The technical status of the aircraft for future deployment with regard to the air-conditioning pack was not explicitly apparent from the work orders. This must be described as an error.

2.2 Human and operational aspects

2.2.1 Preparation for the flight

On 19 April, Swiss had introduced a new procedure for flight planning with regard to the alternate aerodrome. According to statements from the two pilots of LX 1103, this change caused teething troubles which left little time for flight preparation. Nonetheless, the two pilots did not feel that they were under any particular pressure of time and during preparation of the aircraft the entry in the hold item list (HIL) concerning perception of smell and fumes was discussed. The work order which was referred to in the HIL entry was not read, according to the commander's statement. However, the crew were informed verbally that there had been problems with air-conditioning pack No. 1.

2.2.2 Behaviour of the crew when confronted with smell and fumes in the cockpit

According to the statement by the commander of LX 1103, he realised the serious incapacitation of the copilot due to the smell and fumes. A flight attendant was called into the cockpit to verify if smell and fumes were also perceptible in the cabin. The flight attendant replied in the negative, but at the same time pointed out that he too noticed the smell and fumes in the cockpit.

In view of the adverse effect on the copilot it would have been appropriate for the commander to don the oxygen mask as well. This is supported by the fact that the copilot's condition worsened right away again, when he tried to breathe without the mask.

The medical examination of the copilot the next day indicated a distinct adverse effect on the vocal chords and bronchial tubes as a result of a toxic exposure.

It is striking that the crew which reported the incident on 18 April 2005 likewise did not don their oxygen masks. As an explanation the crew stated in their report: *"... and the situation was not dramatic we decided to continue the approach and set the priority on a stable approach and safe landing. Therefore no emergency was declared and the oxygen masks were not used."*

When one considers the effects of smell and fumes/smoke in a cockpit, this behaviour is incomprehensible in both cases.

The necessity of the use of the oxygen masks is underlined by the guidelines in the emergency checklist under "SMOKE, FUMES OR FIRE ON FLIGHT DECK/PASSENGER CABIN/ELECTRICAL EQUIPMENT BAY/ANIMAL BAY", which prescribe the donning of oxygen masks as the first item that has to be performed by heart.

The fact that in the case of LX 1103 and the preceding flight on 18 April 2005 this checklist was not implemented is understandable in view of the history of the flight and the current flight phase. However, implementation of the first item on the checklist, i.e. donning oxygen masks, would have been appropriate in each case.

3. Conclusions

3.1 Findings

3.1.1 Technical aspects

- Smell and fumes in the cockpit occurred during operation of HB-IXN even before the serious incident.
- The indicators for bearing damage in engine No. 1 were not analysed and pursued to eliminate the defect before the serious incident.
- The aircraft was released for flight operations several times, even though the defect had not been rectified.
- The technical status of the aircraft with regard to air-conditioning pack No. 1 was not explicitly apparent to the crew of flight LX 1103 from the work orders.

3.1.2 Crew

- The crew decided to make a priority landing on runway 14.
- The copilot was limited in his capability of acting during the approach and landing due to the effects of fumes.
- The commander did not don his oxygen mask.
- The medical examination of the copilot after the flight showed that during the flight toxic exposure took place.
- The medical examination of the commander after the flight did not show any results.

3.1.3 General conditions

- In the night before the serious incident, no appropriate engine specialist was available in Zurich to analyse the fault.

3.2 Cause

The serious incident is attributable to the fact that on approach to Zurich Airport the cockpit filled with fumes which caused a toxic effect, leading to a limited capability of acting of the copilot.

These fumes were caused by an oil leak as a result of a bearing damage in engine No. 1. The indicators for impending bearing damage were not correctly interpreted before the incident.

Berne, 6 May 2009

Federal Aircraft Accident Board

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