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Aircraft Accident Investigation Bureau AAIB

Final Report No. 1935 by the Aircraft Accident Investigation Bureau

concerning the serious incident

to the aircraft AVRO 146-RJ100, HB-IXS

operated by Swiss European Air Lines

under flight number LX 639

on 19 March 2006

at Zurich Airport

Bundeshaus Nord, CH-3003 Berne

Ursache

Der schwere Vorfall ist mit grosser Wahrscheinlichkeit darauf zurückzuführen, dass Rauch aus dem Hilfsaggregat (*auxiliary power unit* – APU) über das Druckbelüftungssystem ins Flugzeug gelangte.

General information on this report

This report contains the AAIB's conclusions on the circumstances and causes of the serious incident which is the subject of the investigation.

In accordance with appendix 13 of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Law, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, follow the universal time coordinated (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 hour

For reasons of protection of privacy, the masculine form is used in this report for all natural persons, regardless of their gender.

Contents

Final Report

Owner	Swiss International Air Lines Ltd, CH-4002 Basel
Operator	Swiss European Air Lines Ltd, CH-4052 Basel
Aircraft type	AVRO 146-RJ100
Country of manufacture	Great Britain
Country of registration	Switzerland
Registration	HB-IXS
Flight rules	Instrument flight rules (IFR)
Location	Zurich Airport
Date and time	19 March 2006, 15:30 UTC

General

Brief description

On 19 March 2006, the AVRO 146-RJ100 aircraft, HB-IXS, took off in Paris (LFPG) on a scheduled flight, number LX 639, to Zurich (LSZH). Shortly before touchdown, smoke developed on the right side of the cockpit. The landing was uneventful.

After landing, the crew noticed an increase in smoke in the cockpit. The source could not be found. The aircraft was brought to a hold on taxiway H1.

The density of the smoke in the cockpit then reduced. No smoke was detectable in the cabin at this time. On the basis of this situation, the commander decided to taxi to the assigned stand A49. Shortly afterwards, the responsible flight attendant reported that there was now smoke in the cabin as well.

The aircraft was parked in the area of taxiway H1. The commander immediately decided to evacuate the passengers and crew via the emergency slides. No intervention by the fire brigade was necesssary.

Investigation

The Aircraft Accident Investigation Bureau (AAIB) was informed about the serious incident by the airport authority on 19 March 2006 and opened an investigation on the same day.

The digital flight data recorder (DFDR) and the cockpit voice recorder (CVR) were removed from the aircraft and analysed.

The serious incident is very probably attributable to the fact that smoke from the auxiliary power unit (APU) entered the aircraft via the air conditioning system.

1 Factual Information

1.1 History of flight

On 19 March, the AVRO 146-RJ100 aircraft, HB-IXS, took off at 14:38 UTC in Paris (LFPG) on scheduled flight, number LX 639, to Zurich (LSZH). Take-off, cruise and approach went normally. At 15:28:53 UTC the crew received landing clearance for runway 14. A few seconds before touchdown, the copilot noticed smoke developing on the right side of the cockpit and immediately reported this to the commander. The landing was uneventful.

After landing, still on the runway, the crew noticed an increase in the smoke in the cockpit. The source could not be established. The oxygen masks were not donned by the flight crew. According to the crew's statement, the smoke had a blue coloration with no discernible smell. During the landing roll, still on the tower frequency, the crew requested the fire brigade: "*,.. we are vacating the runway, please call the fire brigade, we have smoke in the cockpit".* The aircraft was stopped on taxiway H1.

The crew wished to analyse the situation more closely. At this time, the density of the smoke in the cockpit reduced. The copilot asked the responsible flight attendant whether smoke was also detectable in the cabin. The flight attendant replied in the negative. The commander then decided, in agreement with the copilot, to taxi to the assigned stand, A49.

While the copilot was obtaining clearance to continue taxiing, the commander was monitoring the internal communication between the two flight attendants. As he did so, he heard the flight attendant in the rear section of the cabin report to his colleague that that there was a lot of smoke in the cabin. The commander now asked the responsible flight attendant in the front section of the cabin whether smoke was visible. The flight attendant confirmed that there was now smoke in the cabin too. There was not much, but one could smell it.

The aircraft was parked in the area of taxiway H1 and the engines were shut down. The commander decided immediately to evacuate the passengers and crew. At 15:33:02 UTC the crew reported to the tower: "*Mayday, mayday, mayday, we vacate at this position, swiss six three nine, we vacate at this position".* According to the recording of the cockpit conversation, the commander initiated the evacuation with the following order: "*cabin crew evacuate*".

The evacuation of passengers and crew took place via the emergency slides on all four doors and was supported by the fire brigade. According to the crew's statement, this procedure took less than 90 seconds. No further intervention by the fire brigade was necessary. Although individual passengers did not slide down in the usual sitting position on the emergency slides, neither passengers nor crew were injured. The passengers were taken in hand and cared for by the appropriate airport services.

Since the fire brigade's forces were concentrated on this serious incident, the airport was closed for 12 minutes.

1.2 Injuries to persons

	Crew	Passengers	Third parties
Fatally injured	---	---	---
Seriously injured	---	---	---
Slightly injured or uninjured	4	95	

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 1964
Licence	Airline Transport Pilot Licence (ATPL), according to JAR, issued by the Federal Office for Civil Aviation (FOCA) on 07.12.2005, valid till 07.12.2010
Ratings	RTI (VFR/IFR), NIT (A), IFR (A)
Last proficiency check (OPC)	26.11.2005
Last line check (LC)	09.12.2005
Registered aircraft types	AVRORJ/BAe146
Medical fitness certificate	Class 1
Last medical examination	30 September 2005, findings: fit
Total flying experience	6100 hours
on AVRO 146-RJ	1400 hours
during the last 90 days	190 hours

1.5.2 Copilot

Person	Swiss citizen, born 1968
Licence	Airline Transport Pilot Licence (ATPL), issued by the Federal Office for Civil Aviation (FOCA) on 22.08.2005, valid till 22.08.2010
Ratings	RTI (VFR/IFR), NIT (A), IFR (A)
Last proficiency check (OPC)	08.08.2005
Last line check (LC)	06.05.2005
Registered aircraft types	AVRORJ/BAe146
Medical fitness certificate	Class 1
Last medical examination	29 August 2005, findings: fit
Total flying experience	3864 hours
on AVRO 146-RJ	3588 hours
during the last 90 days	153 hours

1.5.3 Cabin crew

Persons	Two flight attendants

1.6 Aircraft information

1.6.1 General information

Aircraft type	AVRO 146-RJ100
Manufacturer	British Aerospace Ltd., Woodford, Cheshire, England
Characteristics	Commercial aircraft with four jet engines
Year of construction	1996
Serial number	E3280
Engines	4 Allied Signal LF507-1F
Certification	Cat. IIIA RVR 150m / DH 50 ft LVTO RVR 125 m RVSM RNP 5 Dangerous goods
Airworthiness certificate	Issued on: 01.11.2005/2
Maintenance	Swiss Maintenance Basel
Fuel	Jet A1

1.6.2 Sources and arrangement of compressed air in the aircraft

The air conditioning system of the AVRO 146-RJ100 features system redundancy. Among other things, it includes two air conditioning packs, which supply air to the cockpit and passenger cabin. One air conditioning pack is sufficient for the entire air supply. The two air conditioning packs are located in the tail of the aircraft.

Air conditioning pack #1 is supplied with compressed air from the left bleed air system and air conditioning pack #2 from the right bleed air system. The left bleed air system can be supplied with bleed air[1] from engine #1 and/or #2 and the right one can be supplied with bleed air from engine #3 and/or #4. Both bleed air systems can be supplied simultaneously with bleed air by the APU (auxiliary power unit).

During cruise, the air conditioning system is normally supplied with bleed air from the engines. However, in order to increase engine power, it may be necessary, for the take-off, depending on the aerodrome elevation and the outside temperature, to switch the bleed air source from the engines to the APU (air change-over). Under certain conditions, this change-over must also take place before landing, in order to ensure that sufficient engine power is available for a possible go-around. In the present case, the change-over to APU bleed air took place shortly before landing. A more detailed description of the utilisation of the different sources of bleed air is provided in section 1.18.2.

Normally, air conditioning pack #1 and #2 supply fresh air to the passenger cabin. This enters the aircraft via air nozzles which are located on the side walls and above the passenger seats. Air conditioning pack #1 additionally supplies fresh air to the cockpit. In the cockpit the air is also used, among other things, for removing vapour from the panes and for instrument cooling.

1.6.3 APU replacement before the serious incident

The APU, part number 4501690A and serial number SPE957426, according to work order (WO) 1515725, was replaced on 12 March 2006. Replacement was preceded by a fairly long series of faults. In several cases, poor acceleration or automatic shut down after APU start was reported as a fault.

As a replacement, APU part number 4501690A and serial number SPE957424 was fitted.

1.6.4 Measures after the serious incident

After the serious incident on 19 March 2006, a check was carried out on all four engines in accordance with a service information letter (SIL) from the aircraft manufacturer. Among other things, SIL21/45 describes the procedure in the event of presumed oil contamination of the environmental control system by an engine. A so-called boroscope is used in such cases by which the compressor

[1] Bleed air is drawn from the compressor of an engine or from the APU. Because of compression, the bleed air is very hot and must be cooled for use in the air conditioning system. If bleed air is contaminated by the engine or the APU, this affects the quality of the air in the aircraft (smoke, unpleasant smell).

chamber can be checked for leaking bearings. No traces of oil could be found on any of the four engines.

The APU was also checked in accordance with the information in SIL21/45. No irregularities were found. The opportunity was taken to replace the catalytic converter.

In addition, various components of the environmental control system were checked for oil contamination. Here too, no irregularities were found.

In the galley, ovens and coffee makers were switched on. Electrical and electronic systems were switched on in the cockpit. None of this produced anything abnormal.

On 21 March 2006, a control flight of HB-IXS was carried out which was uneventful. Subsequently, visual checks were again carried out on all four engines using the boroscope and the aircraft was then released for service.

1.6.5 Further incident on 24 March 2006

On 24 March 2006, shortly before landing of flight LX2810, an unusual smell was perceived both in the cockpit and in the passenger cabin. The smell was described as follows: "*Smell was not of oil and made throat and nose uncomfortable*". According to the flight crew, the smell occurred after switching the bleed air from the engines to the APU. When the bleed air was switched back to the engines, the smell disappeared. According to the flight crew, the aircraft had not been de-iced before take-off in Geneva. During the take-off, bleed air was also supplied from the APU, but without any smell developing.

On the occasion of a check after the flight, traces of oil were found in the area of the APU air inlet. It was also found that the air inlet smelt of oil.

On 24 March 2006, the APU part number 4501690A and serial number SPE957424 was removed and sent to the workshop for more detailed inspection. Subsequently, the air conditioning packs were subjected to a high temperature, in order to vaporise any oil residues.

On 26 March 2006, a control flight was carried out which was uneventful. Since then, no further complaints have been reported.

1.7 Meteorological information

1.7.1 General

The information in sections 1.7.2 to 1.7.4 was provided by MeteoSwiss.

1.7.2 General weather situation

Switzerland was under the influence of an anticyclone, which extended from the British Isles to the Black Sea.

1.7.3 Weather at the time of the serious incident at Zurich Airport

Weather/cloud	No clouds
Visibility	8 km

Wind	020°/3 kt variable between 320° and 060°
Temperature/dewpoint	8 °C/-1 °C
Atmospheric pressure	QNH 1009 hPa
Hazards	None

1.7.4 Aerodrome weather reports

At the time of the serious incident, the following reports were published for Zurich-Kloten airport:

METAR Zurich (LSZH)

LSZH 191420Z VRB04KT 8000 SKC 09/M00 Q1010 NOSIG=
LSZH 191450Z 02003KT 310V080 8000 SKC 08/M01 Q1009 NOSIG=
LSZH 191520Z 02003KT 320V060 8000 SKC 08/M01 Q1009 NOSIG=

1.7.5 Automatic terminal information service

ATIS Zurich (LSZH)

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

INFO OSCAR
QAM LSZH 1450Z
VRB 2 KT
VIS 8 KM
SKC
+08/-01
QNH 1009 ZERO NINE
QFE THR 14 959
QFE THR 16 960
QFE THR 28 959
NOSIG
INCREASED BIRD ACTIVITY AT AND AROUND AD

INFO PAPA
QAM LSZH 1520Z
050 DEG 4 KT
VIS 8 KM
SKC
+08/-01
QNH 1009 ZERO NINE
QFE THR 14 959
QFE THR 16 959
QFE THR 28 959
NOSIG
INCREASED BIRD ACTIVITY AT AND AROUND AD

1.8 Aids to navigation

Not applicable.

1.9 Communication

There are no indications of any irregularities in radiocommunication with the tower air traffic control unit. The request for the fire brigade was made on this frequency.

The corresponding recordings were complete and easily comprehensible.

1.10 Aerodrome information

1.10.1 General

Zurich Airport is located in north-east Switzerland. The airport reference point (ARP) has coordinates N 47 27.5 / E 008 32.9 and an ELEV of 1384 ft.

The dimensions of Zurich airport runways are as follows:

Runway	Dimensions	Elevation of the runway thresholds
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

Taxiway Hotel 1 (H1) is situated to the right of runway 14 and begins approximately 2400 metres after the runway threshold. It provides the first possibility of vacating the runway after landing. The taxiway is approximately 25 metres wide.

1.10.2 Locations of the professional fire brigade

The arrangement of the professional fire-brigade comprises 3 locations:

- Main Watch: to the west of the threshold of runway 34, two fire engines
- North Watch: near to the threshold of runway 16, two fire engines
- Satellite dock A (A59) at the end of Terminal 1, one fire engine

1.11 Flight recorders

The digital flight data recorder (DFDR) P/N 980-4700-003 and the cockpit voice recorder (CVR) P/N 980-6020-001 were evaluated.

The recordings were of good quality.

1.12 Wreckage and impact information

Not applicable.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

Not applicable.

1.15 Survival aspects

After the commander had given the order for an immediate evacuation, the cabin crew opened all four doors available and all four slides were ejected and inflated. The evacuation of passengers and crew were according to the instructions and procedures as laid down in the cabin safety procedure manual (CSPM). Although some individuals did not slide down in the normal sitting position, neither passengers nor crew were hurt.

1.16 Test and research

The residues found during an inspection of APU S/N SPE957424 in the workshop (cf. 1.18.2) were examined together with samples of Type I, II and IV de-icing fluid. A comparison was carried out between the samples and the residues (contamination). This comparison was made by means of IR measurements.

The result of the comparison was summarised as follows:

"The contamination consists in part of a de-icing agent, and in addition one can assume as further organic contamination esters (carbonyl bands at approximately 1750 cm $^{-1}$), plus inorganic salts."

1.17 Organisational and management information

1.17.1 The Swiss European Air Lines

1.17.1.1 General

Swiss European Air Lines is a fully-owned subsidiary of Swiss International Air Lines. In the autumn of 2005, the latter had decided to split off regional transport to a separate operating company.

The Federal Office for Civil Aviation (FOCA) issued an operating licence to Swiss European Air Lines on 1 November 2005. Swiss European Air Lines carries out flights on behalf of its parent company Swiss. All of Swiss International Air Lines' regional fleet aircraft (AVRO RJ85/100 and Embraer 145) were transferred to the new company.

1.17.1.2 Regulations and procedures concerning evacuation

Cockpit:

The evacuation procedures applicable within the airline are specified in the airline's Operations Manual (OM) A, section 8.3.20.

The relevant procedures are specified in the airline's "Abnormal and Emergency" checklist.

The corresponding actions (activities) by pilots in the event of an on ground emergency are defined in the procedure under the heading "EMERGENCY EVACUATION". The tasks of the commander and those of the copilot are defined as follows:

CAPTAIN:

AIRCRAFT ..... STOP
WHEELBRAKES ..... PARK
THRUST LEVERS ..... FUEL OFF
PA ..... order evacuation

The order to evacuate is normally given via the public address system, but may also be given using a megaphone.

CO-PILOT

Pressurization ..... MAN-OPEN
APU ..... STOP
APU FIRE EXT ..... DISCH
FIRE HANDLES ..... Pull to full extent
Rotate to EXT 1 or 2
As required

Call ATC on RMP1/VHF COMM No. 1

BATT POWER ..... Leave ON

According to OM B 1.11.10, the wording for an evacuation order is as follows:

"Emergency – open seat belt – evacuate"

Cabin:

In the Cabin Safety Procedures Manual (CSPM), section 5 "Emergency Evacuation Procedures" states under 5.4: "*The commander gives a clear order if and when he wants an evacuation to be started*".

If an evacuation is initiated, the wording of the order is: *"Emergency – open seat belt – evacuate"* (section 5.4.1 "Initiating Evacuation").

1.17.2 Technical maintenance department

The department responsible for technical maintenance is based in Basle and was taken over as a complete unit from the former Crossair company. The maintenance department, certificated according to EASA part 145, is responsible for the aircraft types of the former Crossair company.

The technical operations for the AVRO fleet are basically split between two sites. A line maintenance station is located in Zurich. The maintenance control centre (MCC), troubleshooting, engineering, base maintenance and another line maintenance station are located in Basle.

1.17.3 The airport operator

Unique is the owner of the infrastructure of Zurich Airport. It guarantees operation of public aviation transport in Zurich and exercises all functions which are indispensable to the maintenance and smooth running of the operation. Among other things, this includes the professional fire brigade.

1.17.3.1 Professional fire brigade

Zurich Airport has a Category 9 (ICAO Annex 9) professional fire brigade which is on call 24 hours a day. The concept requires the fire brigade to reach any location within the airport area within 3 minutes. To meet this requirement, it is split

between two main sites, the Main Watch and the North Watch. Both watches each have two fire engines. In addition, a station is available at the end of Terminal 1, Satellite dock A. This has a general-purpose fire engine which can also be used on fires in buildings (including cargo).

The command centre is located in the Main Watch. The chief officer on duty has his own service vehicle from which he can coordinate the intervention and assemble a fire-fighting team. The chief officer is in radio contact with the control tower. Any necessary communication with pilots cannot be established directly, but only via this unit.

1.17.3.2 Alarm concept at Zurich Airport

An alarm can be triggered by one of the following units (ALARM star):

- the control tower
- apron control
- airport authority
- the professional fire brigade
- the cantonal police

When triggered, the alarm is received in the other units of the ALARM star. In addition other units are automatically informed via permanently installed or mobile pagers. In some cases, the airport authority mobilises other units and informs predetermined organisations. The Airport Manager also initiates the necessary activities, which may include, among other things, closing a runway or the entire aerodrome. In the present case, the airport was closed for 12 minutes, because the fire brigade's forces were tied up in the serious incident.

The alarm concept is split into three alarm stages. These are further divided into sub-categories (aircraft, building, criminal incidents, operational malfunctions and epidemics). The present case was one with an alarm code of A21. Such an alarm is used for an incident with an aircraft in so far as the alarm time amounts to less than 15 minutes.

1.18 Additional information

1.18.1 Aircraft de-icing

Aircraft HB-IXS was not treated with de-icing agent, neither on 19 March 2006 in Zurich before the flight to Paris nor before the return flight to Zurich.

1.18.2 Use of the different bleed air sources

1.18.2.1 General

In flight, bleed air can be taken either from the engines or from the APU. The maximum altitude at which bleed air can be taken from the APU is 15 000 ft.

The APU bleed air is basically available when the compressor speed (N1) is at least 95%. In OM B, it is recommended to switch to the APU only after a warm-up time of one minute. The bleed air is switched on by means of the APU AIR switch.

1.18.2.2 Use of APU bleed air during an approach

Depending on which consumers (cabin pressurisation, engine anti-ice and airframe anti-ice) are drawing bleed air, it may be necessary to switch to APU bleed air for air conditioning. In this context, five options for an approach are published in the OM B.

In the present case the APU was started and the APU bleed air was switched on during the final approach.

1.18.3 Examinations of the APU S/N SPE957424

After the incidents on 19 and 24 March 2006, the APU was partially dismantled under the manufacturer's supervision in the workshop of the maintenance department in Basel. Since nothing concrete was found, the so-called hydro pad, as one possible cause, was replaced.

1.18.4 Further incident after installation of APU S/N SPE957424 in another aircraft

After the two incidents on 19 and 24 March 2006 on HB-IXS, the APU S/N SPE957424 was removed and subjected to detailed inspection. This APU was then installed in HB-IXO, whereupon another incident occurred on 17 May 2006.

After the doors were closed, white smoke and a smell developed in the passenger cabin. The passengers were immediately disembarked from the aircraft via the passenger bridge. At this time the engines were not yet running. However, the APU was running and the bleed air for cabin ventilation had been switched on shortly before.

The APU S/N SPE957424 was then sent to the manufacturer for detailed examination. At the time of issuing this report, the manufacturer's report had not arrived at the Swiss AAIB.

1.19 Useful or effective investigation techniques

Not applicable.

2 Analysis

2.1 Technical aspects

The analysis of the operational sequence during the approach (cf. 2.2.1) comes to the conclusion that contaminated bleed air (smoke) must have entered the aircraft from the APU. This was noticed in the cabin, with some delay. This can be explained on the one hand by the substantially larger volume of the cabin and on the other hand by the specific distribution of the air into the cockpit and the cabin. The fact that the smoke in the cockpit diminished after landing is probably attributable to a pressure gradient between the cockpit and the cabin.

The APU part number 4501690A and serial number SPE957424 had been installed a few days previously and was still on aircraft HB-IXS at the time of the serious incident.

On 24 March 2006 there was another incident. This time a "toxic smell" was reported which spread inside the aircraft a few seconds after switching to the APU bleed air. After switching back to engine bleed air, the contaminated air cleared again. At this time the same APU as at the time of the serious incident of 19 March was installed in HB-IXS.

After the incident on 24 March 2006, the APU was removed from HB-IXS and subjected to detailed inspection in the workshop. Nothing could be found, that was clearly identifiable as the cause of the two incidents on 19 and 24 March. The APU was subsequently installed on HB-IXO.

On 17 June 2006, the APU serial number SPE957424 caused another incident on HB-IXO. This time the crew reported that smoke and a smell developed whilst undocking from the passenger bridge. Passengers were again disembarked immediately. After this incident, the APU was removed from HB-IXO and sent to the manufacturer for inspection and repair. No results were available by the time the investigation was concluded.

The chronology of events involving the same APU (S/N SPE957424) on different aircraft very probably allows the conclusion that this APU was the cause.

2.2 Human and operational aspects

2.2.1 Operational procedures during the approach

The flight from Paris to Zurich was uneventful until just before landing. According to the voice recordings, lively communication on topics not relevant to the flight took place in the cockpit until just before the outer marker.

In the approach briefing, the commander mentioned that he intended to switch on the APU for the approach. For this case, the airline's operations manual (OM) B[2] specifies that the APU is started when the aircraft receives clearance for a pressure altitude or at the latest when it receives approach clearance ("*when cleared to an altitude or latest when cleared for approach"*).

[2] Reference: OM B, 1.02.30 "Transition during descent"

According to crew statements, the APU was started at the outer marker. This was too late and is in contradiction with the OM B, according to which the APU, if it is being used, must be started when cleared to a pressure altitude. From the CVR it is apparent that the commander did not order the APU to be started. On the basis of the chronological sequence[3] it can be assumed that the pilot not flying (PNF) noticed that the APU was not yet running only when processing the "prior landing" check, i.e. a little more than a minute before touchdown.

It is specified that during processing of the "prior landing" check[4] the APU bleed air is switched on if this has been requested by the pilot flying (PF) in the approach briefing.

Between the "prior landing" order and the "prior landing completed" confirmation, 40 seconds elapsed. This indicates that during this time the APU was started and bleed air switched to the APU. The "prior landing completed" confirmation came approximately half a minute before touchdown and after the "final check".

A few seconds before the aircraft touched down on the runway, the copilot reported that smoke was developing on the right side of the cockpit. The time between changing to APU bleed air and the occurrence of the smoke was about 15 seconds, leading to the conclusion that the bleed air from the APU was contaminated.

2.2.2 Operational procedures after landing

After landing, whilst still on the runway, the crew noticed an increase in the smoke in the cockpit. The source could not be identified. According to the crew's statement, the smoke had a blue colouration, without a definable smell. The crew's decision to call in the fire brigade to the aircraft was appropriate, as it was not possible to assess the future development of the situation. As the smoke in the cockpit was clearing, the commander's decision to taxi to the stand was appropriate. For the same reason it is understandable that the flight crew did not don oxygen masks. However, when the responsible flight attendant then reported smoke in the passenger cabin, the conditions were met for the commander to evacuate the aircraft without delay.

The Operations Manual (OM A), section 8.3.20.2, Competence states among other things, "*by declaring an emergency the PIC is entitled to divert from standard operating procedures and checklists if required in the interest of safety"*.

According to the recording of the cockpit conversations, the commander initiated the evacuation with the following order: *"Cabin crew evacuate"*.

However, according to OM B, the wording for an evacuation order is as follows:

"Emergency – open seat belt – evacuate"

According to the Cabin Safety Procedures Manual (CSPM), the cabin crew were expecting the order: *"Emergency – open seat belt – evacuate"*.

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[3] CVR recordings

[4] Reference: OM B, 1.02.30 "Prior landing"

Regardless of the formulation chosen by the commander, which was calm in tone and not very accentuated, the cabin crew followed the instructions published in the CSPM.

Although the commander is free in his actions in the event of an emergency situation, it is appropriate to carry out an evacuation in accordance with the existing regulations as far as possible. This provides the best guarantee that all crew members carry out correctly the procedures they have learned and practised.

In the present case, the evacuation took place efficiently and within the specified time of 90 seconds.

The cockpit actions specified according to the emergency evacuation checklist were carried out only partially. The engines were switched off according to the “normal checklist”. When there is any deviation from prescribed procedures, this must be communicated clearly. This deviation was not addressed between the pilots.

2.2.3 Cooperation by the ground organisations

According to the “airport authority unique” duty log, the control tower triggered the "alarm 21" at 15:29 UTC because the pilot of flight LX 639 which had just landed with 95 passengers on board reported smoke in the cockpit.

The Airport Steering Committee was activated. The actions initiated between the air traffic control (ATC) unit, the professional fire brigade and the airport operator "unique" were taken professionally and without any delay.

3 Conclusions

3.1 Findings

- The pilots were in possession of the necessary licences.
- The APU involved caused two further events with smoke and a smell after the serious incident.
- The APU was switched on late with regard to the published procedure.
- The period between changing over to APU bleed air and the development of smoke inside the aircraft allows the conclusion that the smoke was very probably caused by the APU.
- During the roll-out, the smoke in the cockpit abated. After some delay, it increased in the cabin.
- The command to initiate and carry out an evacuation by the cockpit crew did not correspond consistently to the regulations.
- The evacuation took place efficiently and within the specified time of 90 seconds.

3.2 Causes

The serious incident is very probably attributable to the fact that smoke from the auxiliary power unit (APU) entered the aircraft via the air conditioning system.

4 Safety recommendations

None

Berne, 16 February 2007 Aircraft Accident Investigation Bureau

Annex 1