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Final Report No. 1925 by the Aircraft Accident Investigation Bureau

concerning the serious incident
to the aircraft AVRO 146-RJ100, HB-IXQ,
operated by Swiss European Air Lines
under flight number LX 778
on 5 December 2005
at Zurich-Kloten Airport

Bundeshaus Nord, CH-3003 Berne

Ursachen

Der schwere Vorfall ist darauf zurückzuführen, dass sich kurz nach dem Start in Zürich im Cockpit und in der Kabine Rauch ausbreitete, welcher auf einen Ölverlust infolge eines Schadens an einer Dichtung im Bereich der Lager No. 1 und 2 im Triebwerk No. 2 zurückzuführen war.

General information on this report

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

In accordance with Annex 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/serious incident causes and circumstances is expressly no concern of the 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 serious incident, Central European Time (CET) applied as local time (LT) in Switzerland. The relation between LT, CET and UTC is: $LT = CET = UTC + 1 \text{ hour}$

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

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Summary

Brief description

On 5 December 2005 at 08:56 UTC, the aircraft AVRO 146-RJ 100, registration HB-IXQ, of the Swiss European Air Lines company took off on a scheduled flight to Brussels.

Shortly before reaching flight level FL100, the commander noticed smoke in the area of the left side console. The copilot also noticed the smoke. On asking the senior flight attendant (*maitre de cabine* – M/C), it was apparent that the smoke was also visible in the cabin.

The flight crew donned their oxygen masks, declared an emergency at 09:02:39 UTC and asked the air traffic controller for a return to Zurich and an approach on runway 14.

During the approach, the smoke dissipated in the cockpit and cabin. According to the commander's statement, he had a continuous oxygen flow in his oxygen mask throughout the entire event, which made communication difficult for him, with both the copilot and with air traffic control. Despite various manipulations of the oxygen mask, the commander was unable to stop the continuous oxygen flow.

The approach on runway 14 and the landing were uneventful. The crew decided to taxi to the stand and to allow the passengers to disembark normally.

Investigation

The serious incident took place on 5 December 2005 at 09:02 UTC and the aircraft landed at 09:16 UTC at Zurich airport. Skyguide informed the Aircraft Accident Investigation Bureau, which subsequently initiated an investigation.

The serious incident is attributable to the fact that shortly after take-off in Zurich, smoke caused by oil loss due to a defective seal in the area of bearing No. 1 and 2 in engine No. 2 spread to the cockpit and the passenger cabin.

1 Factual Information

1.1 Pre-flight history and history of flight

1.1.1 Pre-flight history

On 3 December 2005, two days before the serious incident, the crew of aircraft HB-IXQ reported the following in the technical log (workorder WO 1504185): *ALWAYS ABOUT 1-2 MIN'S AFTER T/O MC "ENG 1 AIR VLV" COMES ON AND STAYS ON. RESETTABLE WHEN CYCLING.* The following was recorded as a measure by line maintenance:

MAINT ANN PANEL BUT OVT LATCHED:

- *DUE TO SHORT GROUND TIME X-FERRED TO D.D.*
- *AS LONG "ENG # 1 AIR VLV" IS RESETTABLE NO OPERATIONAL RESTRICTIONS.*

As the warning did not recur during the subsequent four flights, the WO was closed by line maintenance. The engineering unit responsible, in Basle, did not agree with the action taken and requested replacement of the temperature control valve concerned. This replacement took place during the night of 4 - 5 December.

1.1.2 History of flight

On 5 December 2005 at 08:56 UTC, the aircraft AVRO 146-RJ 100, registration HB-IXQ and flight number LX 778, of Swiss European Air Lines took off on a scheduled flight to Brussels. On this flight, the commander was pilot flying (PF) and the copilot was pilot not flying (PNF).

The crew performed a "no bleeds take-off". This means that during take-off the engine bleed air was not used for cockpit and cabin air conditioning. Instead, the bleed air from the auxiliary power unit (APU) was used which means that the latter was kept running. After the aircraft had passed 5000 ft QNH, the crew increased speed and retracted the flaps. The commander then instructed the copilot to execute the after take-off checklist. In the course of executing this checklist, the copilot switched the bleed air for the cabin and cockpit air-conditioning from the APU to the engines. Shortly afterwards, as the aircraft passed flight level FL100, the commander noticed smoke in the area of the left side console. The copilot also noticed the smoke. On asking the senior flight attendant (*maitre de cabine* – M/C), it was apparent that the smoke was also visible in the cabin. The commander stated that he had noticed the two caution annunciations "ENG 1 AIR FAULT" and "ENG 1 AIR VALVE" at practically the same time.

Immediately after the smoke had been noticed, the flight crew donned their oxygen masks. According to the commander's statement, he handed over control of the aircraft to the copilot. At 09:02:39 UTC, the commander declared an emergency to the Zurich Lower Sector West air traffic controller (ATCO) and requested a return to Zurich with an approach on runway 14.

The ATCO confirmed this message at 09:02:56 UTC, gave the crew a heading instruction and clearance for a descent. The crew acknowledged this and added that they would be descending to 6000 ft QNH.

The commander stated that in the interim he had intuitively switched off the engine bleed air from engine No. 1 again. He then was occupied with the emergency checklist for smoke in cockpit & cabin. While executing the emergency checklist, among other things, both air conditioning packs were switched off.

At 09:04:01 UTC, the ATCO instructed the crew of LX778 to switch to the Zurich Arrival Sector West frequency. After an enquiry concerning runway 14, the ATCO cleared the crew of LX778 to descend to 5000 ft QNH at 09:06:46 UTC. After a further clearance to 4000 ft QNH and confirmation by the crew that they were able to accept a short line-up, at 09:11:47 UTC the crew of LX778 asked whether they were cleared for the approach. The ATCO answered in the negative and instructed the crew to maintain their current heading. Shortly afterwards, he instructed the crew to descend to 3500 ft QNH. At 09:12:26 UTC, the crew received an instruction to turn onto a heading of 180° and were at the same time cleared for an instrument approach on runway 14.

During the approach, the smoke dissipated in the cockpit and cabin. For safety reasons, the crew kept their oxygen masks on. According to the commander's statement, he had a continuous oxygen flow in his oxygen mask throughout the entire event, which made communication extremely difficult for him, both with the copilot and with air traffic control. Despite various manipulations of the oxygen mask, the commander was unable to stop the continuous oxygen flow. As a result, during the approach, he also handed over to the copilot communication with air traffic control in addition to controlling the aircraft. The crew received clearance to land at 09:13:38 UTC.

The approach on runway 14 and the landing at 09:16 UTC were uneventful. The crew decided to taxi to the stand and to allow the passengers to disembark normally.

1.2 Injuries to persons

	Crew	Passengers	Third parties
Fatally injured	----	----	----
Seriously injured	----	----	----
Slightly injured or uninjured	4	59	

1.3 Damage to aircraft

There was no material 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 1968
Licence	Airline transport pilot licence (ATPL), according to JAR, first issued by the Federal Office for Civil Aviation (FOCA) on 29.10.1999
Ratings	RTI (VFR/IFR) NIT (A) IFR (A)
Ratings to be extended	AVRO RJ/BAe 146 PIC
Last proficiency check	27.10.2005
Last line check	11.03.2005
Medical fitness certificate	Class 1
Last medical examination	13.09.2005, findings: fit
Total flying experience on AVRO 146-RJ during the last 90 days	6119 hours 5200 hours 115 hours

1.5.2 Copilot

Person	Swiss citizen, born 1967
Licence	Commercial pilot licence CPL (A), according to JAR, first issued by the Federal Office for Civil Aviation (FOCA) on 13.01.2003
Ratings	RTI (VFR/IFR) NIT (A) IFR (A)
Ratings to be extended	AVRO RJ/BAe 146 COPI
Last proficiency check	23.05.2005
Last line check	06.06.2005
Medical fitness certificate	Class 1
Last medical examination	09.08.2005, findings: fit
Total flying experience on AVRO 146-RJ during the last 90 days	3600 hours 715 hours 96 hours

1.6 Aircraft information

1.6.1 General

Owner	Swiss International Air Lines Ltd.
Operator	Swiss European Air Lines AG
Aircraft type	AVRO 146-RJ100
Country of registration	Switzerland
Registration	HB-IXQ
Manufacturer	British Aerospace
Serial number	E3282
Year of construction	1996
Date of registration	27.03.1996

1.6.2 Findings after the landing

1.6.2.1 The commander's oxygen mask

After the crew had left the aircraft, an aircraft maintenance mechanic checked the commander's oxygen mask. The latter was functioning flawless but was nevertheless removed for further investigation and sent to the workshop.

1.6.2.2 Engines

The engines were inspected visually for possible leaks. Nothing unusual was found. An additional boroscopic inspection on engine No. 2 showed traces of oil which indicated possible damage of a bearing seal. A boroscope specialist was also called in to confirm this finding. He confirmed traces of oil, which originated from bearing No. 1 and 2. Engine No. 2 was subsequently replaced.

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

At the time of the serious incident, Switzerland was in an area affected by an extended trough of low pressure. Cold, humid air was flowing into the area of the Alps on a south-westerly wind.

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 3500 ft AMSL
5-7/8 at 5000 ft AMSL

Visibility: 35 km

Wind: west-south-west wind at 8 knots

Temperature/dewpoint: 07 °C / 04 °C

Atmospheric pressure: QNH LSZH 1002 hPa, QNH LSZA 1003 hPa

Position of the sun: Azimuth 148°, elevation 14°

Hazards: West wind turbulence and risk of icing

1.7.4 Aerodrome weather reports

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

TAF

LSZH 050716 24008KT 9999 SCT020 BKN060 TEMPO 0716 SHRA BKN 035

METAR

LSZH 050850 24009KT 9999 FEW022 SCT039 BKN090 06/03 Q1002 NOSIG

LSZH 050920 24007KT 210V280 9999 FEW019 BKN038 07/04 Q1002 NOSIG

1.8 Aids to navigation

The transmitters of the stations DVOR/DME KLO and the ILS14 were in normal operation at the time of the serious incident and were available to the operational services without restriction.

1.9 Communication

Radio communication between the crew and the air traffic control units took place normally. With the oxygen mask donned and the intercom continuously activated (hot mike) the commander felt heavily handicapped in communication. The conversations were recorded on the ground in full and in good quality.

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 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

1.11 Flight recorders

Aircraft HB-IXQ was equipped with a digital flight data recorder (DFDR), S/N 4699, and a cockpit voice recorder (CVR), S/N 0236, with a recording time of 30 minutes.

Since the CVR circuit breaker (CB) was not pulled until some time after the landing, the voice recordings for the approach were overwritten and could not therefore be analysed.

1.12 Wreck and impact information

Not applicable.

1.13 Medical and pathological information

No corresponding investigation was carried out.

1.14 Fire

Not applicable.

1.15 Survival aspects

Not applicable.

1.16 Test and research

Not applicable.

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 100% 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. On behalf of its parent company Swiss International Air Lines, Swiss European Air Lines handles so-called "wet lease" flights. 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 Inspection procedures for oxygen masks

The airline's procedures prescribe the following in the operations manual (OM) B, in section 1.02.20 EXPANDED CHECKLIST FFD (first flight of the day), under item 19 for the oxygen mask test:

OXY MASK	TESTED
<i>BOOM/MASK audio control</i>	<i>SELECT mask, check INT selected.</i>
<i>PRESS TO TEST&RESET slide</i>	<i>press and hold, check flower blinker momentarily changes to yellow</i>

<i>Mask EMERGENCY pressure knob</i>	<i>PRESS TO TEST, while holding the PRESS TO TEST&RESET slide, check flow blinker yellow, and black when released, check oxygen flow audible through interphone.</i>
<i>PRESS TO TEST&RESET slide</i>	<i>release</i>
<i>NORM/100%rocking lever</i>	<i>check 100% selected</i>
BOOM/MASK AUDIO CONTROL	SELECT BOOM

In order to be able to press the Mask EMERGENCY pressure knob, it must be in the normal position (see Annex 1). If this pressure knob is in the “emergency” position, it cannot be pressed.

In the course of the investigation, various pilots stated that this Mask EMERGENCY pressure knob is turned to the “emergency” position by some pilots before a flight. The result is that when the mask is donned, a continuous oxygen flow is present. It was not possible to verify if this pressure knob was in the “emergency” position in the case of the present serious incident.

1.17.2 Technical maintenance department

1.17.2.1 General

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.

1.17.2.2 Documentation of the workorder

During the investigation, the course of various defects was followed using the workorders (WO). In the process, it was found that WO 1504184 was missing. It was not recorded in the computer system and the corresponding “yellow” copy was likewise not present in the techlog.

According to a statement by a maintenance supervisor, the computer system records the WO numbers in chronological order, but does not determine if a number is missing.

1.18 Additional information

1.18.1 Oxygen mask

The commander’s oxygen mask underwent further examination in the workshop. No defect could be found during this investigation.

Moreover, the investigation found that according to the manufacturer’s information (OPERATING AND MAINTENANCE INSTRUCTIONS), the oxygen mask must be serviced and tested in the workshop every six years. According to the Swiss Maintenance department’s maintenance programme, this should take place every 2190 days. According to the documentation available, the oxygen mask concerned was last overhauled in February 1999 by a licensed company. Thus the

service interval of the oxygen mask concerned ended in February 2005, ten months before the serious incident.

In a comparison test on 30 January 2006 on aircraft HB-IXN it was found that the mask installed on this aircraft was not functioning correctly. It was possible to exhale only against considerable pressure resistance. The mask was removed and sent to the manufacturer for further examination.

Among other things, the report of this investigation states the following:

"We could not confirm the problem your customer had during this incident. The only finding we had during our inspection, was that the regulator contaminated inside and outside with coffee. We even did a second test with a higher flow (30% extra) and still the results of the flow resistance were acceptable. Probably the coffee contaminated the diaphragm with the result that the diaphragm was stuck. We can advise you to do an overhaul on this unit as a preventive action..."

1.18.2 Engine bleed air caution annunciations

On 3 December 2005, two days before the serious incident, the crew of aircraft HB-IXQ entered the following in the technical log (workorder WO 1504185): *ALWAYS ABOUT 1-2 MIN'S AFTER T/O MC "ENG 1 AIR VLV" COMES ON AND STAYS ON. RESETTABLE WHEN CYCLING.*

Since it was possible to reset the indications, no immediate measures were taken by the maintenance department due to time constraints.

The temperature control valve was replaced during the night of 4 - 5 December.

On the basis of the boroscopic inspection after the serious incident, engine No. 2 was replaced. According to a statement from a maintenance supervisor, it was assumed that this had rectified the fault which had triggered the two annunciations.

On 7 December 2005, the crew of aircraft HB-IXQ reported the following in WO 1487102: *AFTER TAKE OFF, AFTER THE AIRCHANGE OVER THE "ENG AIR FAULT" AND "ENG AIR VLV" CAUTION OF ENG # 1 CAME ON. RESETTABLE, THEREAFTER NORMAL OPS.*

As a measure in response to this complaint, the maintenance department carried out the following work: *CHECKED MTP, FOUND # 1 DUCT OVERHEAT LATCHED. CHECKED LINES IN PYLON # 1. CHECKED VALVES, INSPECTED AND CLEANED SCREEN FILTER IN # 1 AIR VALVE. GROUND RUN PERF WITH SWITCHING APU AIR TO ENGINE AIR SEVERAL TIMES AND BACKWARD WITH PACKS ON. NORMAL OPS. RUN AND TEST IAW 72-00-00 REV 83. FILTER CLEANED IAW 36-11-11.*

Subsequently, the two caution annunciations did not recur.

2 Analysis

2.1 Technical aspects

2.1.1 Smoke generation

On the basis of the boroscopic inspection of engine number 2, traces of oil, indicating a seal damage in the area of bearing No. 1 and 2, could be found. This fault was subsequently confirmed. It is highly probable that this caused oil residues to evaporate, smoke to be generated and this smoke to enter the cockpit and cabin air-conditioning circuit.

The cause of the two annunciations "*ENG 1 AIR FAULT*" and "*ENG 1 AIR VALVE*" was not eliminated by replacing a temperature control valve. The assumption that replacing engine number 2 would eliminate the cause proved to be incorrect. Only cleaning the screen filter in air valve #1 two days after the serious incident caused the caution annunciations to cease.

2.1.2 Oxygen masks

An inspection of the commander's oxygen mask confirmed that it was functioning correctly. However, in a comparison test with an oxygen mask in an aircraft of the same type, problems occurred when breathing out.

Coffee residues were found on this oxygen mask in the area of the diaphragm. Coffee residues, particularly from coffee with sugar, may clot a mask diaphragm and prevent it from functioning correctly.

The cup holder on both the commander's and the copilot's side is mounted directly above the oxygen mask. If it contains a cup from which liquid is spilled, this necessarily falls onto the oxygen mask, and this may adversely affect the functioning of the mask's diaphragm.

2.2 Human and operational aspects

2.2.1 Flight crew

Since the voice recordings of the approach on the cockpit voice recorder (CVR) were overwritten, apart from the crew's statements, only the transcript of the radio communication between the crew and the air traffic control units recorded on the ground was available for the subsequent assessment.

After the serious incident, the commander stated that he had noticed the two annunciations "*ENG 1 AIR FAULT*" and "*ENG 1 AIR VALVE*" at virtually the same time as the appearance of smoke in the cockpit. Intuitively, he then switched off the engine #1 bleed air again. This procedure can be assessed as appropriate. However, it must be assumed that smoke generation was not stopped as a result. Rather, it may be assumed that smoke generation ceased only after the crew had switched off the packs in accordance with the emergency checklist.

On the basis of the information available, it can be concluded that the flight crew's assessment of the situation and decisions taken were timely and appropriate.

2.2.2 Use of oxygen masks

The crew's oxygen masks are tested by copilots before the first flight every day. If this test is carried out in accordance with the airline's regulations (OM B 1.02.20 point 19), the Mask EMERGENCY pressure knob is in the normal position. When the pressure knob is pressed, a continuous flow of oxygen to the mask is released; this continues until the pressure knob is released.

In practice, this continuous oxygen flow is mainly used to clear any smoke which may be present from the inside of the mask. Normally, with the mask donned, briefly pressing the Mask EMERGENCY pressure knob is sufficient to do this.

If the Mask EMERGENCY pressure knob is in the emergency position, there is a continuous flow of oxygen as soon as the mask is taken out of its box. The same effect occurs if, with the mask donned, the Mask EMERGENCY pressure knob is rotated to the emergency position. On the one hand, the continuous oxygen flow means that the available oxygen is used up more quickly. On the other hand, the continuous oxygen flow has the advantage that in extreme smoke conditions penetration of smoke to the inside of the mask through points which are not air-tight is prevented.

Individual pilots stated that in the oxygen mask test they had detected a continuous oxygen flow immediately after pressing the PRESS TO TEST AND RESET slide, without having operated the Mask EMERGENCY pressure knob. One possible explanation is that according to their statements some pilots rotate the Mask EMERGENCY pressure knob to the emergency position before a flight. They justify this by saying that in simulator exercises with smoke in the cockpit they had to clear the mask of smoke and they found the necessary manipulation of the Mask EMERGENCY pressure knob to be very awkward.

If the continuous oxygen flow is no longer required, under the above-mentioned conditions the Mask EMERGENCY pressure knob must be rotated to the normal position.

For procedural reasons, the oxygen mask test is carried out only before the first flight of the day. If, during the day, a pilot rotates the Mask EMERGENCY pressure knob to the emergency position, this may go unnoticed by the next crew. Consequently, uncertainty may arise about the position of the Mask EMERGENCY pressure knob. This situation is unsatisfactory.

According to the commander's statement, he had major difficulties with verbal communication with the mask donned. In this context it is worth noting that communication with a donned oxygen mask is generally more difficult. The mask microphone can be switched on and off via the intercomswitch. When the intercomswitch is switched on, breathing noises are continuously and increased audible via the headsets and the speakers. When the Mask EMERGENCY pressure knob is in the emergency position, the audible flow of oxygen is modulated by the continuous opening and closing of the mask's diaphragm while speaking. This has an additional adverse effect on comprehensibility.

When the intercomswitch is switched off, this interfering noise is not audible. This interfering noise is also present if the intercomswitch is set to the spring-loaded R/T position; in this case communication with air traffic control units is adversely affected.

It cannot be excluded that in the case of the serious incident the intercomswitch on the commander's audio panel remained switched on.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- Oil loss occurred in engine No. 2 due to a defective seal in the area of bearing No. 1 and 2.
- The smoke was caused by vaporising oil residues which entered the air-conditioning system of the aircraft.
- The two annunciations "*ENG 1 AIR FAULT*" and "*ENG 1 AIR VALVE*" were unrelated to the serious incident.
- On the ground, no defect could be found with the commander's oxygen mask.

3.1.2 Crew

- The crew were in possession of the required licences and ratings.
- The crew acted in accordance with the airline's procedures.
- The crew's assessment of the situation and decisions taken were appropriate to the situation.

3.1.3 The maintenance department

- The service interval of the commander's oxygen mask had expired 10 months previously.

3.2 Causes

The serious incident is attributable to the fact that shortly after take-off in Zurich, smoke caused by oil loss due to a defective seal in the area of bearing No. 1 and 2 in engine No. 2 spread to the cockpit and the passenger cabin.

Berne, 23 November 2006

Aircraft Accident Investigation Bureau

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

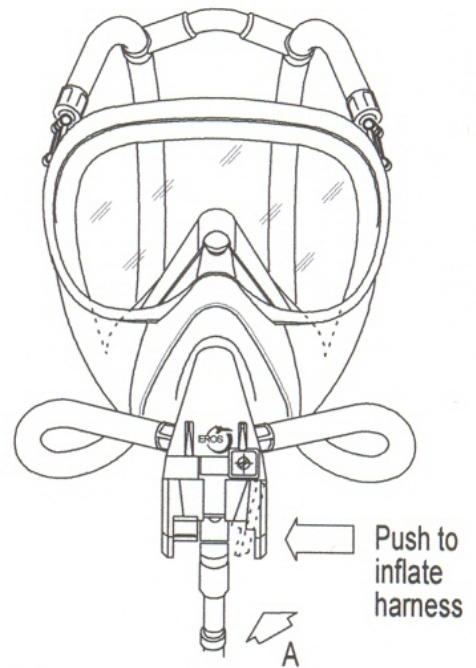
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Annex 1

EROS full face quick donning mask

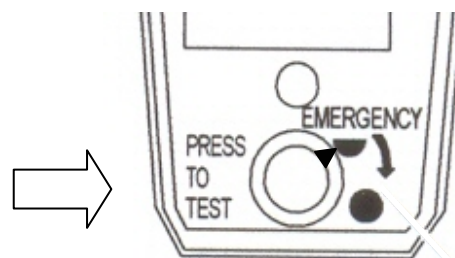
Mask box in cockpit



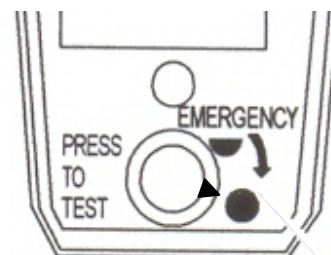
View A



Mask EMERGENCY pressure knob



Mask EMERGENCY pressure knob in the normal position



Mask EMERGENCY pressure knob in the emergency position