



Investigation report

C11/2010L

A330 Jetliners' Engine Bleed Air System Failures: Serious Incidents on 11 and 22 December 2010

Translation of the original Finnish report

OH-LTO

OH-LTS

AIRBUS A330-302

According to Annex 13 to the Convention on International Civil Aviation, paragraph 3.1, the sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability. This basic rule is also contained in the Safety Investigation Act (525/2011) and European Union Regulation No 996/2010. Use of the report for reasons other than improvement of safety should be avoided.

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SUMMARY

A330 JETLINERS' ENGINE BLEED AIR SYSTEM FAILURES: SERIOUS INCIDENTS ON 11 DECEMBER 2010 AND 22 DECEMBER 2010

In December 2010 two similar serious incidents occurred to Airbus S.A.S manufactured and Finnair Plc -operated A330-302 aircraft in Russian airspace as results of engine bleed air system malfunctions.

The first serious incident occurred on 11 December 2010, approximately 300 km northeast of the city of Arkhangelsk. The aircraft, registration OH-LTO, was on a scheduled flight from Osaka, Japan to Helsinki-Vantaa airport. Apart from the three crew members in the cockpit, the aircraft was empty.

The second serious incident occurred south of Moscow on 22 December 2010. The aircraft, registration OH-LTS, was on a scheduled chartered flight from Krabi, Thailand to Helsinki-Vantaa airport. There were 286 passengers and 15 crew members onboard.

Both aircraft experienced a loss of pressurisation due to dual engine bleed air system failures. The flight crews donned their emergency oxygen masks because of the decrease of cabin pressure. On OH-LTO the cabin emergency oxygen masks also deployed automatically.

OH-LTO flight crew initiated an emergency descent from cruise level about five minutes after the loss of pressurisation and about two minutes after the excessive cabin altitude warning which is a master warning. Due to a bigger fuel consumption than anticipated OH-LTO diverted to Kuopio airport.

OH-LTS flight crew initiated a rapid descent from cruise level about two minutes after the loss of pressurisation. Excessive cabin altitude warning came on during the descent after which the flight crew continued by an emergency descent. OH-LTS continued to Helsinki-Vantaa airport, its planned destination. Neither serious incident resulted in injuries to persons or damage to equipment.

In cooperation with the aircraft manufacturer and the manufacturer of the pressure transducer as well as the operator, the investigation searched for the causes of the engine bleed air system's dual bleed faults and the resultant reduced cabin air pressures. A dual bleed loss on A330, due to overpressure in engines' bleed air system during cruise/descent, was first reported to Airbus in 2008 with a number of occurrences increasing during the 2009/2010 winter season period. The Finnish Meteorological Institute also assisted the investigation to analyse the role of an extremely cold air mass with regard to engine bleed air system malfunctions. In addition, analysis also focused on aircrew action during said malfunctions as well as the recording time capacity of a cockpit voice recorder from the standpoint of safety investigation.

Both serious incidents were caused by malfunctioning of the engines' bleed regulated pressure transducers' (Pr). The malfunctioning was caused by freezing of water that had accumulated in the bleed regulated pressure transducers' pressure cell rooms, extremely confined by design.

Due to malfunctioning the transducers provided faulty pressure information to bleed monitoring computers. Due to the erroneous information the computers closed both engines' bleed air systems which resulted loss of pressurisation in cabin, i.e. an increase in cabin air pressure altitude. The extremely cold air mass enroute during a long time period contributed to the fact that the water froze in the pressure cell rooms. Furthermore, the relatively rapidly increasing ambient temperatures enroute may have contributed to the engine's bleed air system faults.

The investigation commission issued four safety recommendations. The European Aviation Safety Agency (EASA) was recommended to: 1) require that Airbus S.A.S. replace the pressure transducers on both engines of A330 aircraft with such transducers that function in conditions approved for the A330 fleet and 2) require that Airbus S.A.S. also include Dual Bleed Loss abnormal procedures in the A330 electronic centralized aircraft monitor action. EASA and International Civil Aviation Organization (ICAO) were recommended to: 3) sufficiently lengthen the time recording capacity of cockpit voice recorders so as to cover the entire routing of the flight. Finally, Airbus S.A.S. was recommended to: 4) improve the procedures of promulgating its operational bulletins by distributing them via communications channels intended for operational divisions.



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History of OH-LTS's flight based on FDR data
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ABBREVIATIONS

A330-302	Airbus A330-302
ACARS	ARINC Communication Addressing and Reporting System
ACMM	Abbreviated Component Maintenance Manual
AIP	Aeronautical Information Publication
AIRMAN	AIRcraft Maintenance ANalysis
AMM	Aircraft Maintenance Manual
APP	Approach Control
APU	Auxiliary Power Unit
ASR	Air Safety Report
ATC	Air Traffic Control
ATSU	Air Traffic Service Unit
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
BMC	Bleed-air Monitoring Computer
°C	Degree Celsius
CIS	Crew Information System
CMS	Central Maintenance System
CVR	Cockpit Voice Recorder
DBL	Dual Bleed Loss
EASA	European Aviation Safety Agency
ECAM	Electronic Centralized Aircraft Monitor
EFHK	Helsinki-Vantaa Airport
EFIN	Area Control Centre Finland
EFKU	Kuopio Airport
EFRO	Rovaniemi Airport
EIS	Electronic Instrument System
ENG	Engine
ERC	Emergency Response Centre
ETOPS	Extended-range Twin-engine Operational Performance Standards
FAV	Fan Air Valve
FAVT	Federal Air Transport Agency
FC	Flight Cycle



FCOM	Flight Crew Operating Manual
FDR	Flight Data Recorder
FH	Flight Hour
FL	Flight Level
FOT	Flight Operations Telex
ft	Feet
FTS	Finnair Technical Services Ltd
GE	General Electric
GFS	Global Forecast System
GPU	Ground Power Unit
h	Hour
HP	High Pressure
hPa	Hectopascal
HPV	High Pressure Valve
ICAO	International Civil Aviation Organization
IP	Intermediate Pressure
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
kg	Kilogramme
kt	Knots
m	Metre
LT	Local Time
Ltd	Limited
MEL	Minimum Equipment List
METAR	Aviation routine weather report
min	Minute
MSA	Minimum Safe Altitude
MSN	Manufactured Serial Number
NCC	Network Control Center (Finnair Plc)
NOTAM	NOtices To AirMen
OEB	Operations Engineering Bulletin
OIT	Operator Information Telex
OM-A	Operation Manual



OML	Open MEL Item Reference List
OPV	Over Pressure Valve
PCE	Precooler Exchanger
p/n	Part Number
Pr	Bleed regulated pressure transducer
PRV	Pressure Regulating Valve
PRVs	PRV Control solenoid
psi	pounds per square inch
Pt	Bleed transferred pressure transducer
QRH	Quick Reference Handbook
RJBB	Osaka Kansai International Airport
SAR	Search And Rescue
s/n	Serial Number
SNOWTAM	SNOW notices To AirMen
SWC	Significant Weather Chart
TAF	Aerodrome forecast
TFU	Technical Follow Up
THS	Thermostat solenoid
TWR	Aerodrome Control Tower
ULPP	Petrozavodsk/Peski
UTC	Co-ordinated Universal Time
V	Volt
vrk	Day
VTSG	Krabi Airport

SYNOPSIS

OH-LTO, Airbus A330-302

On 11 December 2010 a serious incident occurred in Russian airspace northeast of the city of Arkhangelsk on scheduled flight FIN78, enroute from Osaka (RJBB), Japan to Helsinki-Vantaa (EFHK) airport. The aircraft was a twin-engine Airbus A330-302 jetliner, operated by Finnair Plc, registration OH-LTO. There were no passengers, only three flight crew members were onboard the aircraft.

During the cruise, both engines' bleed air system failed. The cabin pressure dropped. The flight crew stated that they donned their auxiliary oxygen masks and initiated an emergency descent after the Excessive Cabin Altitude warning came on. The cabin pressure altitude increased beyond 14 000 ft (ca 4600 m). Consequently, cabin emergency oxygen masks automatically deployed. The aircraft continued its flight at a lower flight level and diverted to Kuopio airport (EF-KU). The occurrence did not result in injuries to persons or damage to equipment. The pilot-in-command and the persons on duty at the Air Traffic Control filed the appropriate Air Safety Reports.

Safety Investigation Authority, Finland classified the occurrence as a serious incident and on 17 December 2010 appointed commission C11/2010L to investigate this occurrence. Investigator Timo Heikkilä was named investigator-in-charge, accompanied by investigators Juha Salo and Pertti Kalttonen as members of the commission.

OH-LTS, Airbus A330-302

A similar serious incident occurred on 22 December 2010 in Russian airspace south of Moscow on scheduled chartered flight FIN 1968, enroute from Krabi (VTSG), Thailand to Helsinki-Vantaa (EFHK) airport. The aircraft was a twin-engine Airbus A330-302 jetliner, operated by Finnair Plc, registration OH-LTS. There were 286 passengers and 15 crew members onboard.

During the cruise, both engines' bleed air system failed. The cabin pressure dropped. The flight crew stated that they donned their auxiliary oxygen masks and initiated a rapid descent to a lower cruising altitude. Excessive Cabin Altitude warning came on during the descent after which the flight crew continued by an emergency descent. Cabin air pressure altitude reached approximately 10800 ft (ca 3300 m), at its highest. The flight crew started the APU bleed during the descent. At the lower cruising altitude (FL220) the flight crew was able to continue flying to Helsinki-Vantaa airport, the planned destination, with the cabin pressurized on APU bleed. About half an hour before landing the flight crew was able to start the both engines' bleed air system. The occurrence did not result in injuries to persons or damage to equipment. The pilot-in-command filed the appropriate Air Safety Report.

Safety Investigation Authority, Finland classified the occurrence as a serious incident and on 23 December 2010 decided to assign its investigation to the previously appointed investigation commission C11/2010L. Investigator Risto Timgren was appointed as an additional member to the commission and Esko Kauppinen from Finnair Plc was invited as a technical expert to the commission.

Additional information

Following the occurrences, Safety Investigation Authority Finland sent notifications to the International Civil Aviation Organization (ICAO), the European Aviation Safety Agency (EASA), the French air safety investigation authority Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), the US National Transportation Safety Board (NTSB), and to the Federal Air Transport Agency of Russia (FAVT). Pursuant to ICAO Annex 13, BEA designated two accredited representatives, Thierry Hespel and Sylvain Mole, to the investigation. During the investigation the investigation commission was frequently in contact with Finnair Plc, BEA, Airbus and EASA.

As of 10 June 2011 SIA released investigator Juha Salo from the investigation commission. Investigator Erja Savela was appointed as a new member and the technical secretary of the commission.

Investigator Tero Järvinen served as an expert to the investigation commission. The other experts to the commission were MSc Hannu Manninen (pressure transducers), Professor Olli Saarela from Aalto University (aeronautical engineering) as well as experts from the Finnish Meteorological Institute.

Both serious incidents were analysed through information recorded by Flight Data Recorders (FDR), Cockpit Voice Recorders (CVR), the air traffic control, and by interviewing the interested parties as well as by analysing the messages sent by the Air Traffic Service Unit (ATSU).

All times in this investigation report are in Coordinated Universal Time (UTC).

In the sub-paragraphs of this investigation report the incidents are identified as per the aircraft's registrations (OH-LTO or OH-LTS). Regarding Airbus S.A.S. and Esterline-Auxitrol S.A. the report uses their short versions Airbus and Esterline-Auxitrol, respectively.

Comments on the report were requested from the parties concerned, Finavia Corporation, Finnair Plc, Finnish Meteorological Institute and Finnish Transport Safety Agency as well as from BEA, Airbus, Esterline-Auxitrol, EASA and ICAO. The comments were received by 4.7.2012. Summary of the comments received is presented in appendix 1.

The Finnish language version of the report is the official document. The Finnish investigation report and the material used in the investigation are stored at Safety Investigation Authority, Finland.

1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 OH-LTO

A serious incident occurred on Saturday, 11 December 2010 on scheduled Finnair flight FIN 78, enroute from Osaka (RJBB), Japan to Helsinki-Vantaa (EFHK) airport. The aircraft was a twin-engine Airbus A330-302 jetliner, registration OH-LTO. There were three flight crew members onboard, one of the co-pilots was resting in the aircrew rest compartment outside the cockpit when the serious incident occurred. As an exception, there were no cabin crew members or passengers onboard the aircraft.

The flight crew started their shift in Osaka at 01:50 (10:50 LT) on 11.12.2010. Flight planning proceeded uneventfully and, according to the captain's interview, all of them were fit to fly. They took off from Osaka at 02:17.

Following takeoff their first leg took them north towards the city of Khabarovsk in Russia. From then on they continued to fly over Siberia: north of Mirny and Polyarny and over Norilsk towards the city of Arkhangelsk.

The flight was flown in Russian airspace at flight level 12100 m (39700 ft) in an extremely cold air mass. During the flight the flight crew noted the exceptionally cold ambient temperature. For about two and a half hours the ambient temperature stayed below -60 °C, dropping down as low as -77 °C. The minimum certified operating temperature of an A330-302 is -78 °C. As the flight progressed the ambient temperature increased by 17 °C within approximately thirty minutes.

At 10:34, approximately 300 km northeast of the city of Arkhangelsk, the bleed air system of the right engine malfunctioned (AIR ENG 2 BLEED FAULT). The flight crew completed the abnormal procedures as per the Electronic Centralized Aircraft Monitor, (ECAM).

The flight crew did not manage to reset the engine bleed air system. They continued to fly at the planned cruising altitude with the bleed air system of the right engine being inoperative.

At 10:37 the bleed air system of the left engine also malfunctioned (AIR ENG 1 BLEED FAULT). Despite the Quick Reference Handbook (QRH) checklists (AIR DUAL BLEED FAULT section 2.24-5) (Appendix 3) the flight crew maintained their cruising altitude and monitored the rising cabin air pressure altitude. At this stage the resting member of the flight crew was summoned to the cockpit.

The flight crew noticed that ECAM indicated that the faulty bleed air system's pressure was high. According to the captain they considered the high pressure to be the cause of the bleed air fault.

At 10:39 an ECAM Cabin Pressure page is displayed indicating an increase in cabin air pressure altitude.

When cabin altitude exceeded the threshold value (9550 ft) at 10:40, an ECAM warning (Excess Cabin Altitude warning) appeared. The flight crew donned their emergency oxygen masks.

At 10:43 the flight crew initiated an emergency descent. Cabin air pressure decreased and cabin altitude continued to increase. In accordance with Russian aviation regulations the flight crew turned to the right off the airway and reported the emergency descent to ACC Arkhangelsk as they left flight level 12100 m (39700 ft). When cabin altitude exceeded approximately 14000 ft the oxygen masks in the cabin automatically deployed.

The co-pilot donned an emergency oxygen mask upon returning to the cockpit and verbally confirmed with the other members of the flight crew that they were fit to fly. Following this, the co-pilot began to assist the other crew members, among other things, by checking the enroute chart for possibly required information and by obtaining weather data.

During the descent ACC Arkhangelsk cleared them to flight level 3300 m (10800 ft) and queried about the nature of the malfunction as well as the need to declare an emergency. The pilot-in-command decided against declaring an emergency.

Approximately five minutes after the onset of the emergency descent they reached 3300 m. The flight crew pondered whether to reset the engine bleed air system but the captain decided against further reset attempts, lest the pressure lines possibly break.

According to FDR data, about 15 minutes after the both engines' bleed air system fault, the faulty pressure value given by the left engine's bleed air system was 240 psi at the highest and the faulty pressure value given by the right engine's bleed air system was 233 psi at the highest.

Investigation revealed that while, in reality, bleed air pressure was normal the indicated pressure, provided by the pressure transducers, was incorrect.

The flight crew re-planned the remaining leg of the flight. At 10:59 they requested a clearance to Rovaniemi (EFRO); according to their calculations they had sufficient fuel to reach this route alternate airport. After having talked to their Network Control Center, (NCC) they chose to divert to Kuopio airport (EFKU) since Kuopio was as far from them as Rovaniemi. They headed towards Kuopio at 11:15.

The approach and landing at Kuopio airport, which took place at 12:15, proceeded uneventfully. Following the landing, for the purposes of safety investigation, the flight crew attempted to preserve the Cockpit Voice Recorder (CVR) recording in the avionics bay by following the instructions of the operator's technical personnel. However, they did not succeed in doing it.

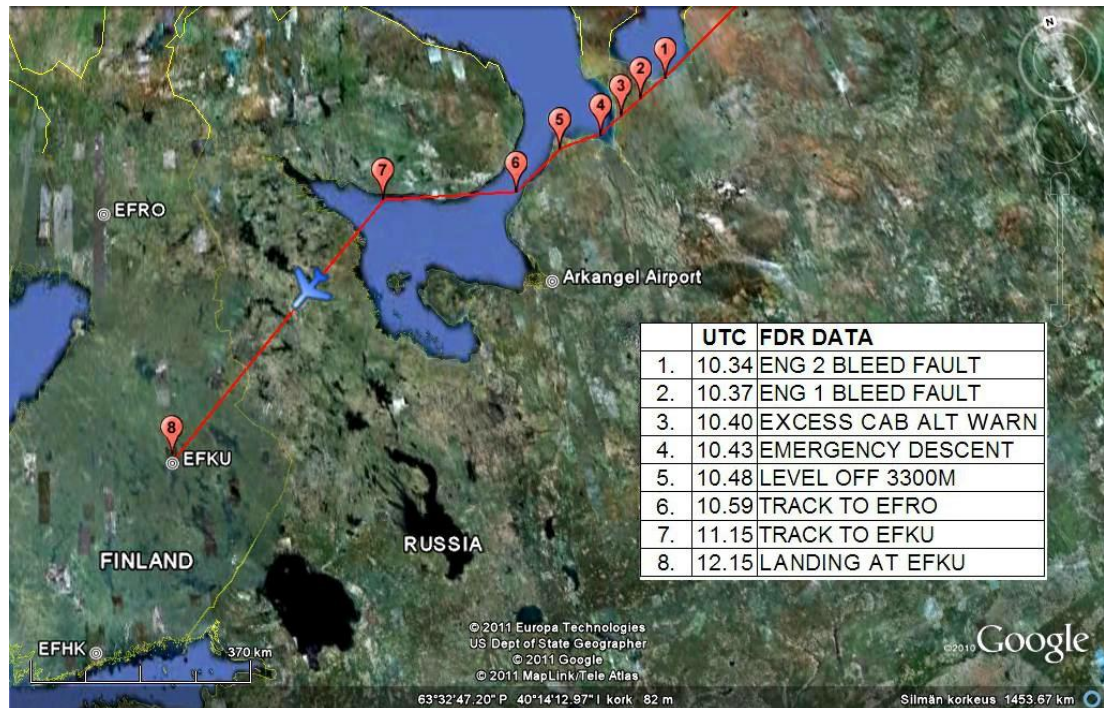


Figure 1. Key events associated with the serious incident of OH-LTO.

Following the flight the flight crew discussed the occurrence. They unanimously decided against organising a defusing session.

The flight crew filed an Air Safety Report (ASR) with the authorities regarding the occurrence, which jeopardized flight safety. Also Kuopio ATS and Area Control Centre Finland (EFIN) filed the appropriate air safety reports. The investigation commission did not have access to the air safety reports filed by ACC Arkhangelsk or ACC Petrozavodsk, if there were any.

1.1.2 OH-LTS

A serious incident occurred on Wednesday, 22 December 2010 on Finnair's scheduled chartered flight FIN 1968, enroute from Krabi (VTSG), Thailand to Helsinki-Vantaa (EFHK) airport. The aircraft was an Airbus A330-302 jetliner, registration OH-LTS. There were 286 passengers, three flight crew and 12 cabin crew members onboard. One of the co-pilots was resting in the aircrew rest compartment outside the cockpit when the serious incident occurred.

The aircrew's shift began in Krabi at 07:30 (14:30 LT), delayed by approximately six hours due to the late arrival of the aircraft. Flight planning proceeded as usual and, according to interviews, the flight crew were fit to fly. They took off from Krabi at 08:20.

The first leg of the flight crossed the Bay of Bengal towards India. From then on they continued south of Kolkata and over Delhi into Pakistan, whence their route took them over Afghanistan and the Caspian Sea towards Moscow.

The flight was flown in Russian airspace at flight level 11600 m (38100 ft) in an extremely cold air mass. During the flight the flight crew noted the exceptionally cold ambient temperature. For about three and a half hours the ambient temperature stayed below -60 °C, dropping down as low as -71 °C. As the flight progressed the ambient temperature increased by 8 °C within approximately forty minutes.

At 18:26, approximately 240 km south of Moscow, the bleed air system of the left engine malfunctioned (AIR ENG 1 BLEED FAULT). The flight crew completed the abnormal procedures as per the ECAM. Following this, they continued to fly at the planned cruising altitude with the left engine's bleed air system being inoperative.

The flight crew had read the Finnair Plc Airbus fleet chief's bulletin on the Crew Information System (CIS) regarding the serious incident that had occurred to OH-LTO on 11 Dec 2010 (Appendix 5). Preparing for, and anticipating, the possible failure of the second engine's bleed air system the flight crew started the Auxiliary Power Unit (APU) at 18:38.

At 18:38 the bleed air system of the right engine failed as well (AIR ENG 2 BLEED FAULT). The flight crew requested that ACC Moscow clear them to a lower altitude because cabin altitude was on the rise. A moment later they received a clearance down to flight level 5400 m (17700 ft). The flight crew tried to reset the bleed air system of the left engine, which had malfunctioned earlier, to no avail. Following this, they continued to fly with both engines' bleed air systems being inoperative.

At 18:40, anticipating loss of pressurisation in cabin, the flight crew donned their emergency oxygen masks and initiated a descent in accordance with QRH instructions. When cabin altitude exceeded the threshold value (9550 ft) at 18:41, an ECAM warning (Excess Cabin Altitude warning) appeared after which the flight crew continued by an emergency descent. As they passed 6900 m (22500 ft) the flight crew selected the bleed air to operate through the APU. Since cabin altitude never exceeded 14000 ft the emergency oxygen masks in the cabin did not deploy. The flight crew saw no need to declare an emergency. The aircraft reached flight level 5400 m (17700 ft) at 18:45.

At 18:52 they began to climb to FL 217 (6600 m), reaching it in two minutes. They continued to fly to Helsinki-Vantaa airport, the planned destination, at this new cruising altitude. During the final leg the flight crew managed to reset the bleed air systems of both engines.

The relief co-pilot was not called back to the cockpit from the rest compartment. Instead, he returned about an hour from the onset of the bleed air system fault.

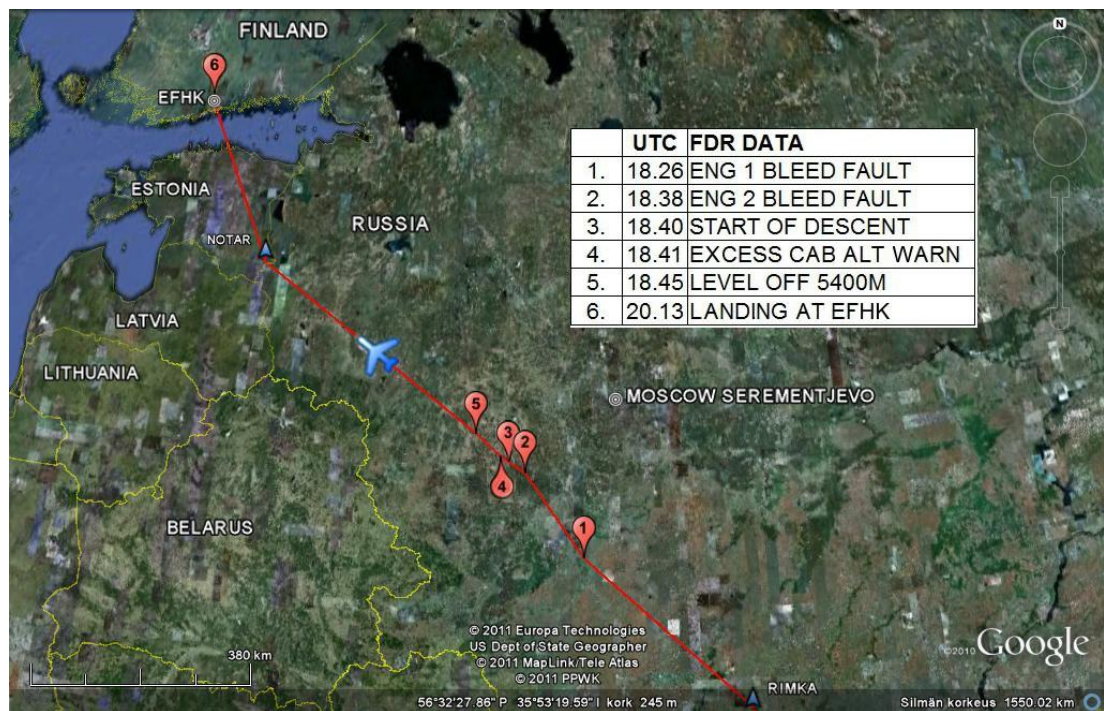


Figure 2. Key events associated with the serious incident of OH-LTS.

At 20:13 the aircraft made a normal landing at Helsinki-Vantaa airport. The flight crew did not declare an emergency to the air traffic control. The flight crew filed an Air Safety Report to the aviation authorities.

The flight crew and the cabin crew unanimously decided against organising a defusing session.

1.2 Injuries to persons

There were no injuries to persons.

1.3 Damage to aircraft

There was no damage to the aircraft.

1.4 Other damage

There was no other damage.

1.5 Personnel information

The flying experience tables only represent the flying hours flown on aircraft operated by Finnair Plc.

1.5.1 OH-LTO

OH-LTO pilot-in-command: Age 52.

Licences: Air Transport Pilot's Licence, valid until 19 Dec 2010.

Medical certificate: Class 1, valid until 28 May 2011.

Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total hours
All types	0 h	66 h	181 h	14 298 h
Type in question	0 h	47 h	142 h	809 h

OH-LTO co-pilot: Age 40.

Licences: Air Transport Pilot's Licence, valid until 16 Jun 2013.

Medical certificate: Class 1, valid until 16 Jun 2011.

Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total hours
All types	0 h	56 h	240 h	6 335 h
Type in question	0 h	24 h	139 h	1020 h

OH-LTO relief pilot: Age 32.

Licences: Commercial Pilot Licence, valid until 13 Jan 2016.

Medical certificate: Class 1, valid until 23 Mar 2011.

Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total hours
All types	0 h	44 h	121 h	2 671 h
Type in question	0 h	30 h	68 h	464 h

Technical personnel

All required ratings of the Finnair Technical Services Ltd (FTS) technical representative at Kuopio airport were valid.

1.5.2 OH-LTS

OH-LTS pilot-in-command: Age 45.

Licences: Air Transport Pilot's Licence, valid until 22 Feb 2013.

Medical certificate: Class 1, valid until 17 Feb 2011.

Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total hours
All types	0 h	71 h	199 h	13 975 h
Type in question	0 h	57 h	165 h	847 h

OH-LTS co-pilot: Age 30.

Licences: Air Transport Pilot's Licence, valid until 18 Dec 2015.

Medical certificate: Class 1, valid until 6 Mar 2011.

Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total hours
All types	0 h	80 h	144 h	3 600 h
Type in question	0 h	50 h	78 h	579 h

OH-LTS relief pilot: Age 46.

Licences: Commercial Pilot Licence, valid until 30 Jul 2013.

Medical certificate: Class 1, valid until 11 Apr 2011.

Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total hours
All types	0 h	72 h	173 h	4 442 h
Type in question	0 h	64 h	114 h	884 h

1.6 Aircraft information

1.6.1 OH-LTO

Type: A330-302

Nationality and registration: OH-LTO

Airworthiness certificate: Valid until 15 May 2011

Manufacturer: Airbus S.A.S.

Number and year of manufacture: 1013, 2009

Total hours and landings: 8 251 FH, 976 FC

Maximum takeoff weight: 233 000 kg

Takeoff weight on the occurrence flight: 181 200 kg

Owner: Finnair Aircraft Finance Ltd

Operator: Finnair Plc

Number of engines and engine type 2 × GE CF6-80E1

1.6.2 OH-LTS

Type: A330-302

Nationality and registration: OH-LTS

Airworthiness certificate: Valid until 11 Feb 2011

Manufacturer: Airbus S.A.S.

Number and year of manufacture: 1078, 2010

Total hours and landings: 4 161 FH, 490 FC

Maximum takeoff weight: 233 000 kg

Takeoff weight on the occurrence flight:	226 871 kg
Owner:	Aino Aviation Ltd
Operator:	Finnair Plc
Number of engines and engine type:	2 x GE CF6-80E1

1.6.3 Supplementary information

The maintenance intervals of A330-302 aircraft that Finnair Plc operates are determined in the Maintenance Program approved by the Finnish Civil Aviation Authority on 18 Nov 2009. According to the Program the A check is done each 800 flying hours and the C check every 18 months. Both occurrence aircraft had their latest A checks properly completed as per the Maintenance Program. The latest C check of OH-LTO prior to the occurrence flight was done in Hong Kong on 18 Oct 2010 at total hours 7486 and 882 landings. OH-LTS had not yet reached its first C check time limit.

According to logbook information the masses and centres of gravity on both flights were in the permissible range.



Figure 3. Airbus A330-302 Copyright: Mikko Maliniemi.

1.7 Meteorological information

1.7.1 Meteorological data used in flight planning by the flight crews

OH-LTO

The Significant Weather Chart (SWC) valid 12 UTC 11 Dec 2010 (Figure 4) that was used in flight planning indicates a strong upper atmosphere jet stream at 9450 m (FL310), east of the Kola Peninsula and close to the location of the occurrence. The occurrence flight's route first crossed the jet stream approximately two hours before the incident and then momentarily before the incident.

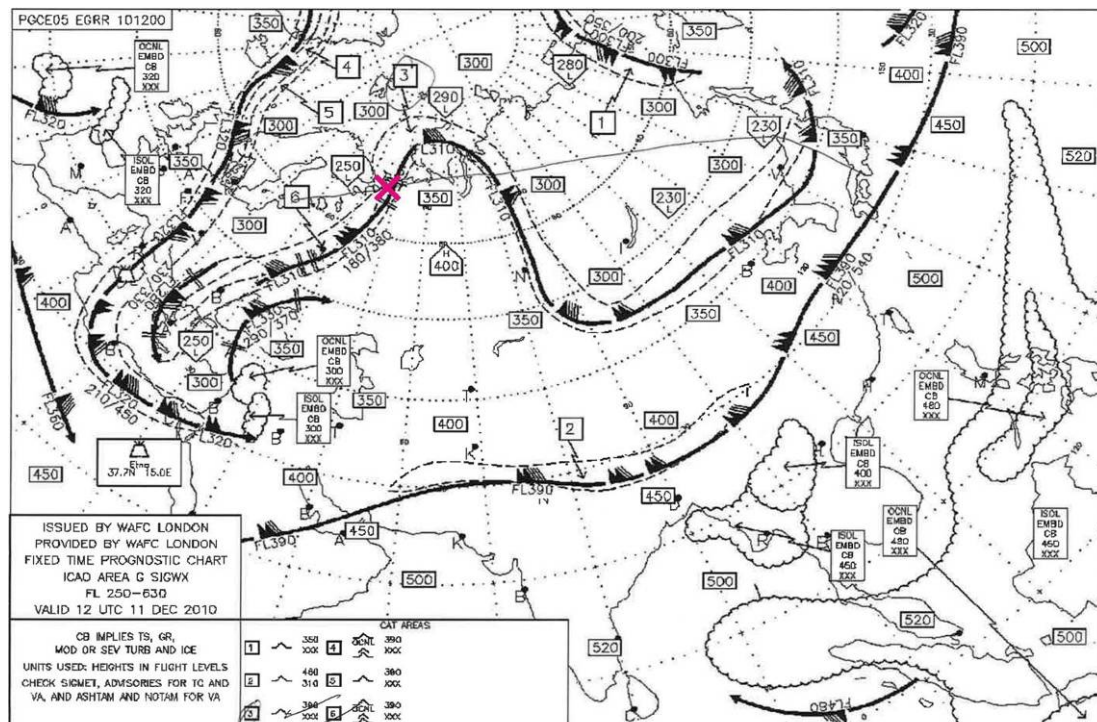


Figure 4. The flight crew's SWC valid 12 UTC 11 Dec 2010. The location of the occurrence was later marked with a red X.

In addition, the flight crew had access to a vertical flight profile (Figure 5). The profile forecasted the tropopause¹ at their planned cruising altitude, close to the location of the occurrence. Moreover, the coldest ambient temperatures enroute, below -70 °C, are also forecasted for the same area where the incident occurred. The coldest FDR-recorded temperature in this area was -77 °C. The red-dotted line in Figure 5 represents the first malfunctioning of the bleed air system.

¹ The inversion that forms the upper boundary of the lower atmosphere is called the tropopause.

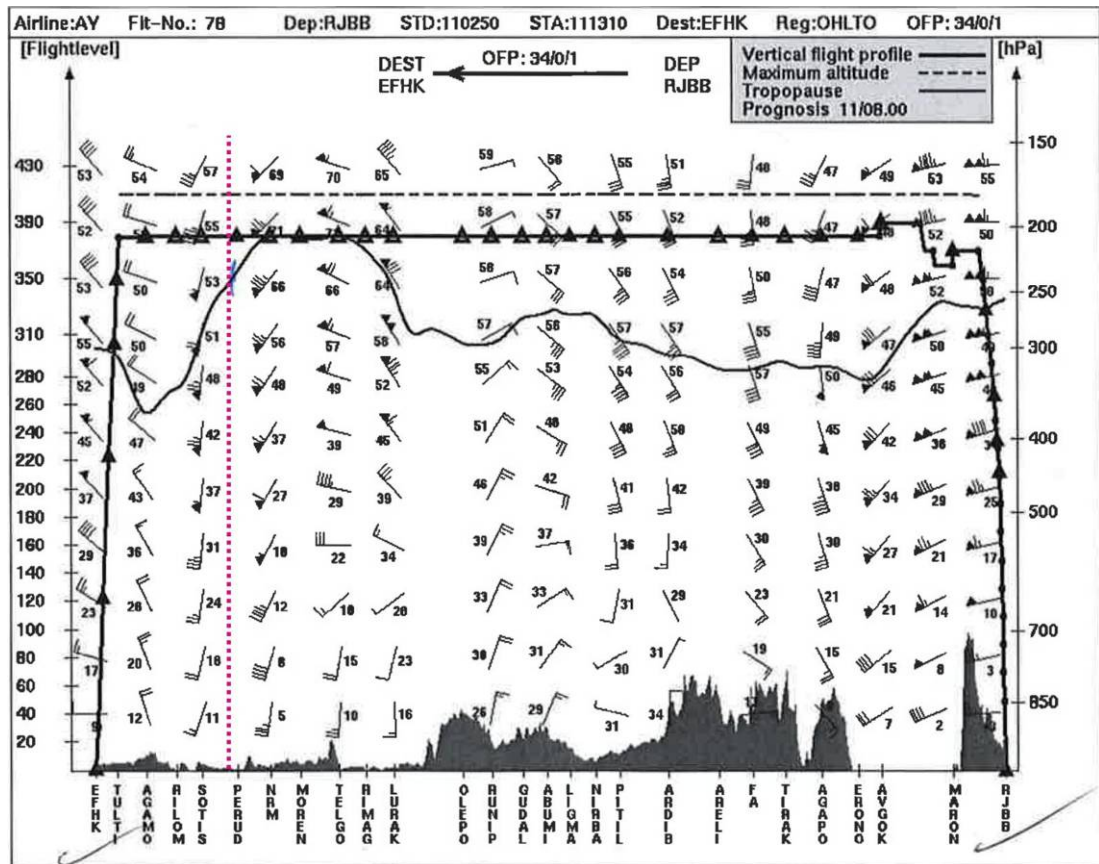


Figure 5. The flight crew's vertical flight profile for the flight on 11 Dec 2010. The red-dotted line was added later.

In addition, the flight crew had aerodrome forecasts (TAF) and aviation routine weather reports (METAR) for all pertinent aerodromes. They only had the SNOWTAM for Helsinki-Vantaa airport. All weather data were in black-and-white.

OH-LTS

The Significant Weather Chart (SWC) valid 18 UTC 22 Dec 2010 (Figure 6) that was used in flight planning indicates one upper atmosphere jet stream at 10600 m (FL350) south of Moscow and another one at 9750 m (FL320) at the city of Moscow, close to the location of the occurrence. The occurrence flight's route crossed both jet streams momentarily before the incident.

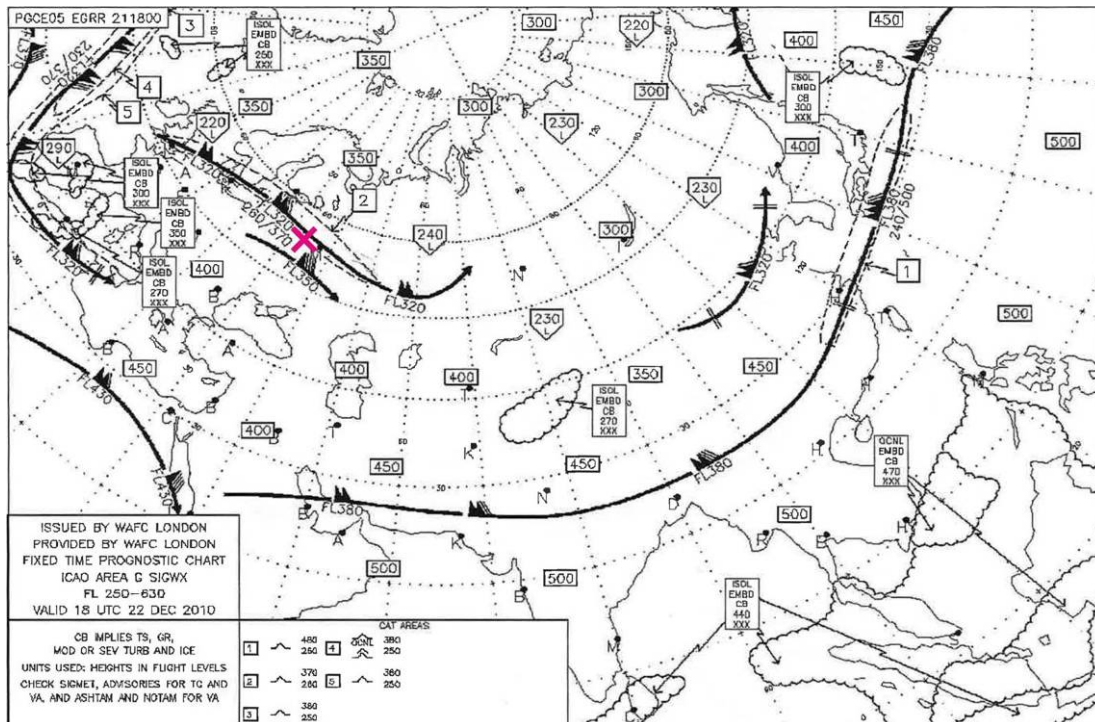


Figure 6. The flight crew's SWC valid 18 UTC 22 Dec 2010. The location of the occurrence was later marked with a red X.

In addition, the flight crew had access to a vertical flight profile (Figure 7). The profile forecasts the tropopause at their planned cruising altitude before the location of the occurrence. Moreover, the coldest ambient temperatures enroute, below -60°C , are also forecasted to the same area where the incident occurred. The coldest FDR-recorded temperature in this area was -71°C . The red-dotted line in Figure 7 represents the first bleed air loss.

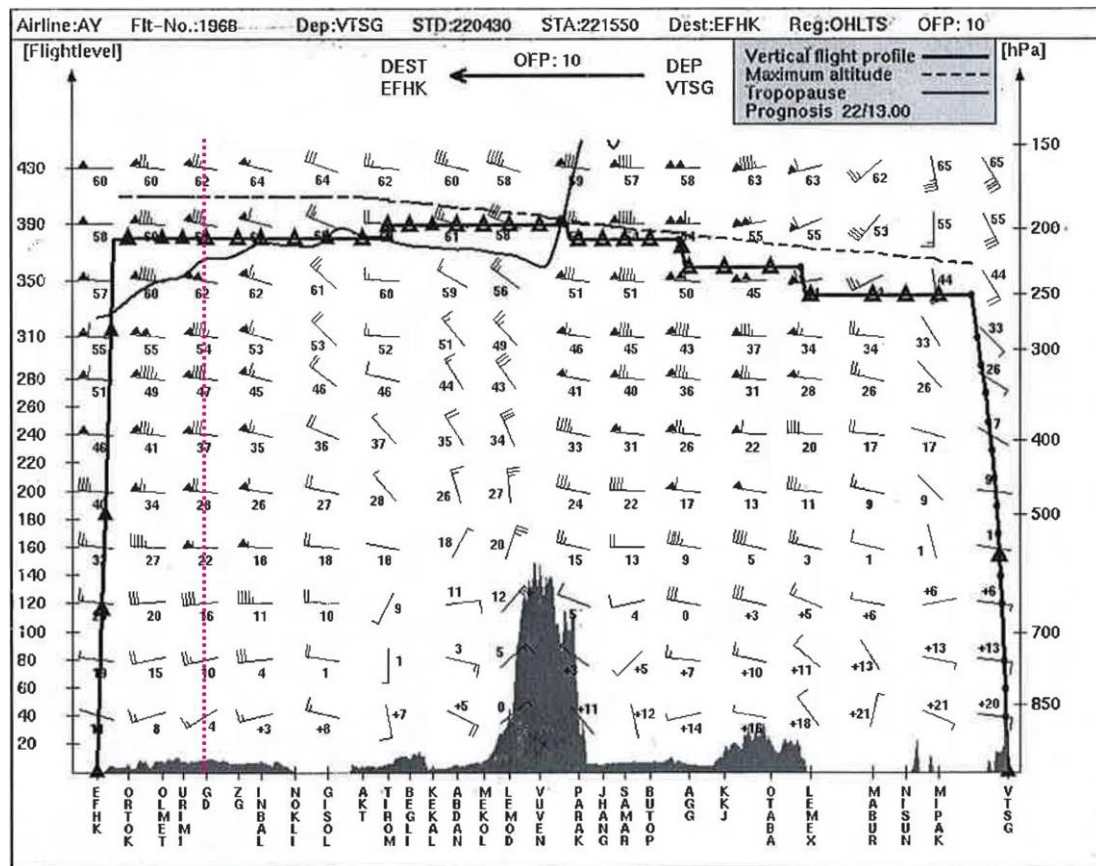


Figure 7. The flight crew's vertical flight profile for the flight on 22 Dec 2010. The red-dotted line was added later.

In addition, the flight crew had aerodrome forecasts (TAF) and aviation routine weather reports (METAR) for all pertinent aerodromes. They only had the SNOTAM for Helsinki-Vantaa airport. All weather data were in black-and-white.

1.7.2 Weather at the aerodromes of departure and destination as well as alternate aerodromes

Weather at the aerodromes of departure and destination as well as alternate aerodromes played no role in either occurrence.

1.7.3 The extremely cold weather types on the occurrence flights

Finnish wintertime radio-soundings for December–February routinely measure temperatures between -55°C and -70°C in the troposphere. Judging by the radio-soundings made during the past 50 years the incidence of temperatures colder than -70°C is in the range of 0.5–1 %. Less than ten per cent of these are below -74°C . For example, in the history of Finnish radio-sounding the temperature of -78°C has only been measured twice at the level of 200 hPa (at approximately FL390). Against this research backdrop it can be stated that the occurrence of an extremely cold air mass, such as the ones that prevailed on the occurrence flights, is exceptional.

OH-LTO

In early December a large low-pressure area formed over Scandinavia, extending all the way down to the Balkans. Simultaneously, a ridge of high pressure in the Caspian Sea area strengthened towards Siberia, pushing along an air mass from the mid-latitudes and lifting the tropopause close to FL400 (ca. 12000 m). The temperature of this air mass dropped below -70°C in wide-ranging areas.

At the time of the occurrence flight a strong thermal gradient formed between the high-pressure ridge and the upper trough (from Novaya Zemlya over the Kola Peninsula towards the southeast). According to FDR data the ambient temperature rose from -77°C to -60°C in less than an hour of flying. The cruising altitude was at the height of the tropopause as well as within the range of the strongest thermal gradient.

Figure 8 depicts a reanalysis of 200 hPa streamlines (at approx FL390) at 12 UTC 11 Dec 2010, generated by the American Global Forecast System (GFS). It's different colours represent the large-scale low pressure system (amber) extending from Scandinavia to the Balkans as well as the Siberian High (violet). In addition, the green X and red X on the chart indicate Naryan-Mar and Kem weather stations, respectively, in northern Russia. Their actual radio-soundings are shown in figures 9 and 10.

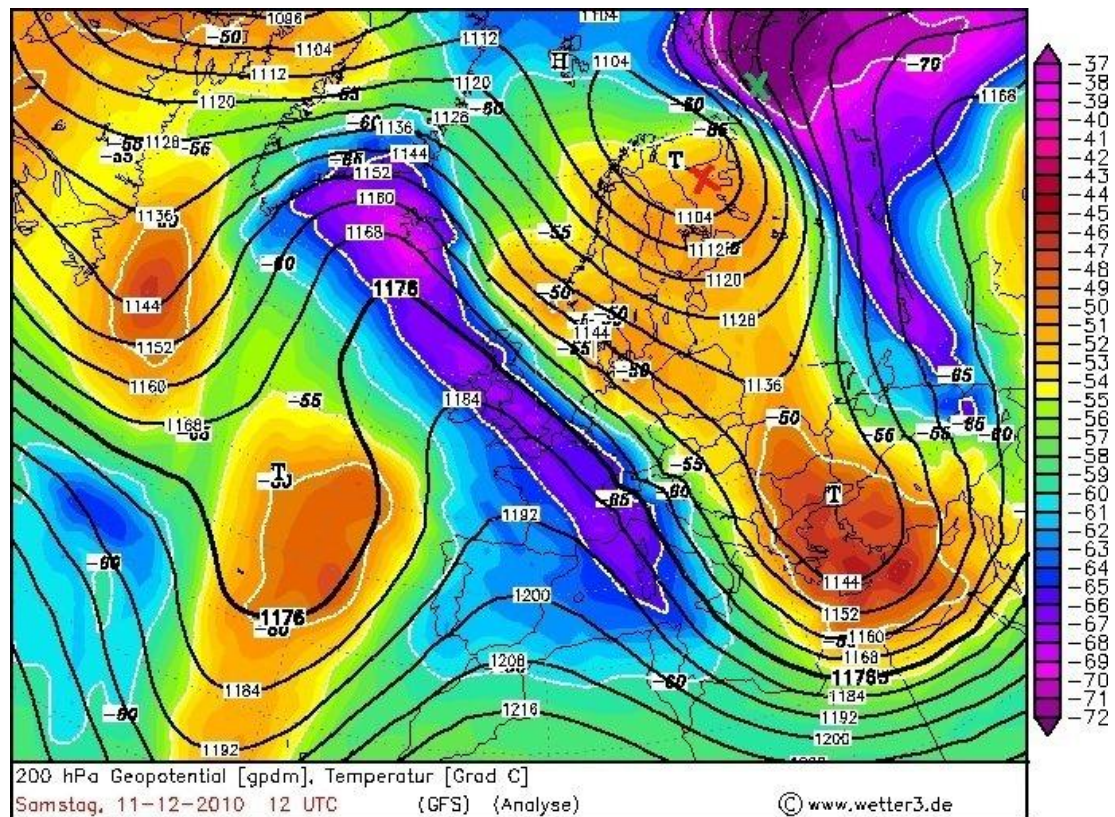
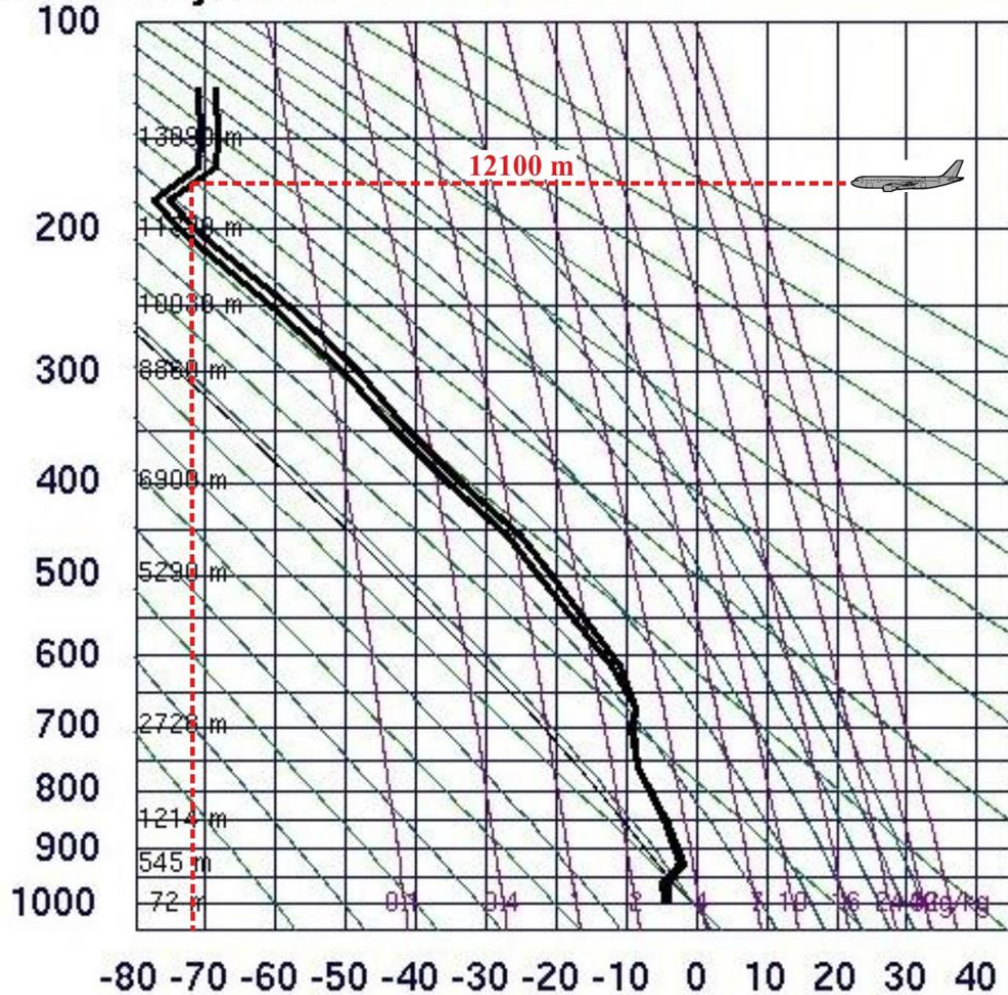


Figure 8. GFS weather model reanalysis for 200 hPa streamlines at 12 UTC 11 Dec 2010. Source: www.wetter3.de.

The Naryan-Mar radio-sounding (Figure 9) depicts the (mid-latitudes) air mass of the typically very high (ca. 11800 m) and cold (ca. -75°C) tropopause. The cruising altitude (12100 m, 39700 ft) of the occurrence flight was at the height of the extremely cold and well-defined tropopause.

23205 Narjan-Mar



12Z 11 Dec 2010

University of Wyoming

Figure 9. Atmospheric temperature as a function of altitude in the Naryan-Mar sounding. The horizontal axis shows temperature [$^{\circ}\text{C}$] and the vertical axis pressure altitudes [hPa] and metres. The left plot is the dewpoint curve and the right one is the air temperature curve. Source: weather.uwyo.edu.

The Kem weather station sounding (Figure 10) depicts an air mass with a clearly lower (ca. 6500 m) and warmer (ca. -50°C) tropopause.

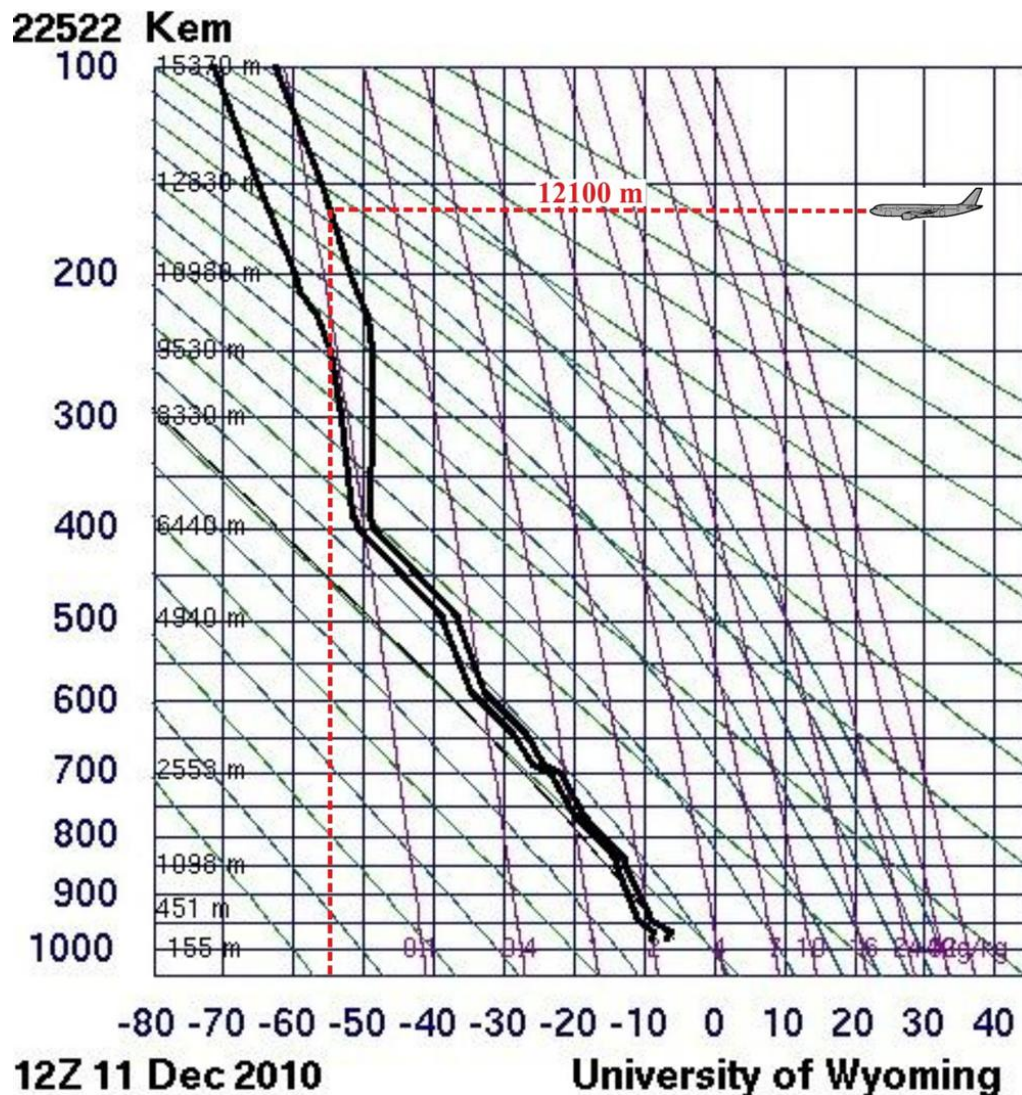


Figure 10. Atmospheric temperature as a function of altitude in the Kem sounding. The horizontal axis shows temperature [°C] and the vertical axis pressure altitudes [hPa] and metres. The left plot is the dewpoint curve and the right one is the air temperature curve. Source: weather.uwyo.edu.

OH-LTS

A strong westerly flow prevailed from central Europe to Russia in the east and there was a front over Moscow. The north-south temperature gradient in the frontal zone was large and the strong jet stream slightly over FL300 extended from southern Scandinavia over Moscow to the east. As the front moved east it was replaced by a mid-latitudes air mass which had a colder and a higher tropopause.

Figure 11 depicts a reanalysis of 200 hPa streamlines (at approx FL390) at 18 UTC 22 Dec 2010, generated by GFS. It's different colours represent the low pressure system (green) extending from Iceland to Siberia and the high-pressure area (violet) extending from central Europe to the east. The temperature of the air mass north of Moscow is approximately -56 °C. The coldest air mass, approximately -70 °C, is further south and

west-southwest. According to FDR data the ambient temperature rose from -71°C to -63°C within about an hour's flight time.

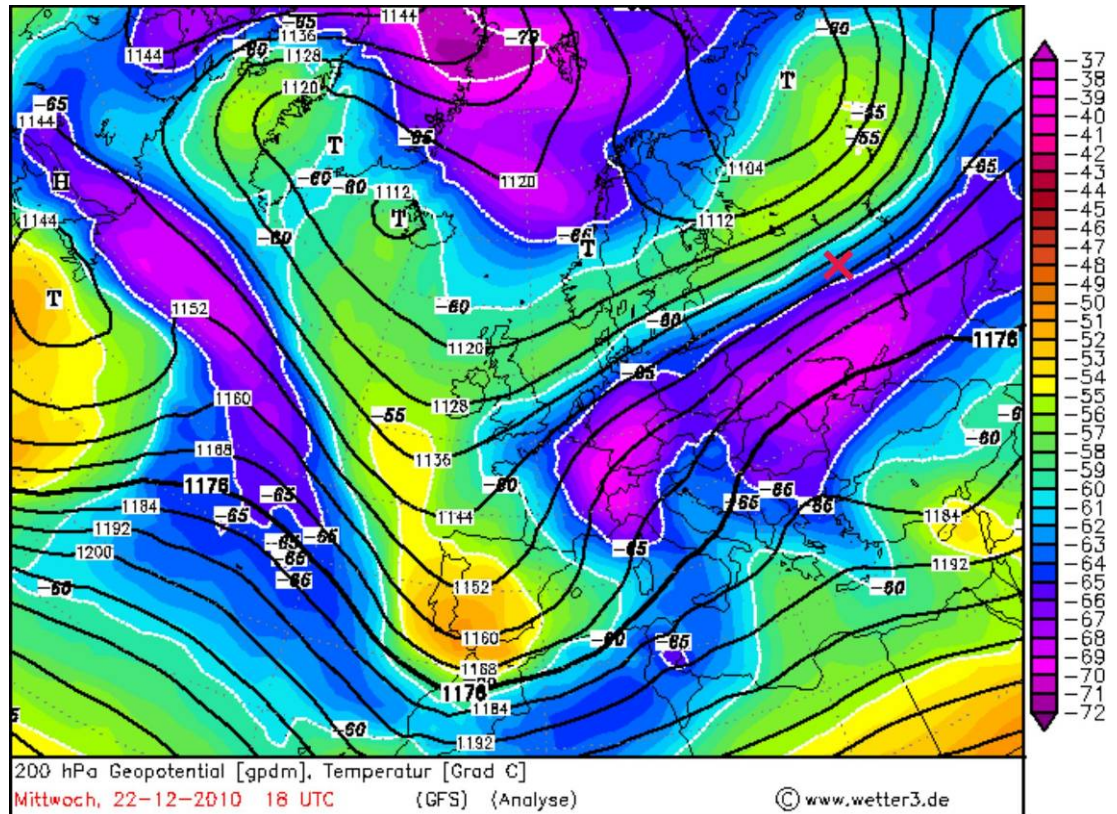


Figure 11. GFS weather model reanalysis for 200 hPa streamlines at 18 UTC 22 Dec 2010. The red x indicates the location of Ryazan. Source: www.wetter3.de.

In figure 12 the circumstances with the occurrence flight are shown on a radio-sounding diagram (at 00.00 UTC 23 Dec 2010) from Ryazan, approximately 200 km southeast from Moscow. It shows the cold (ca. -65°C) and mid-latitudes air mass with a high (ca. 11400 m) tropopause. The cruising altitude of the occurrence flight was 11600 m (38100 ft).

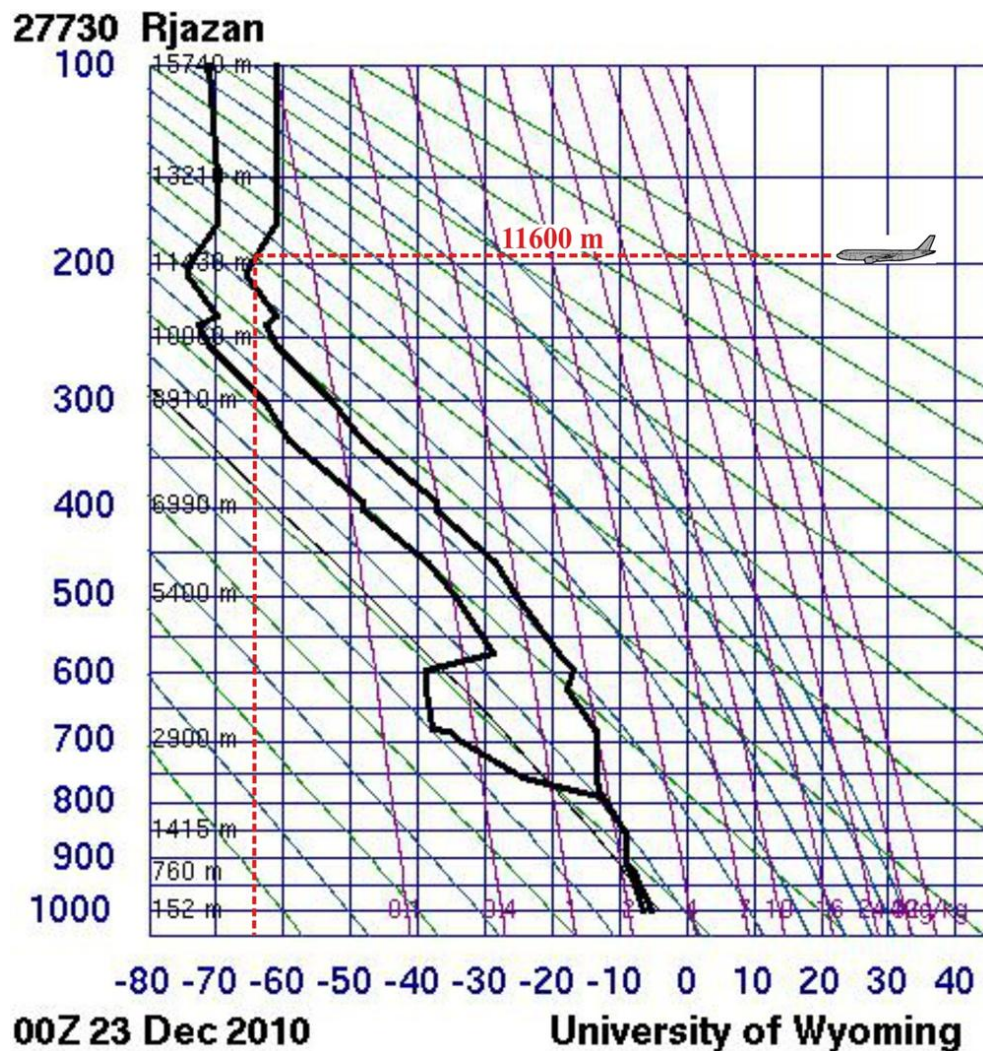


Figure 12. Atmospheric temperature as a function of altitude in the Ryazan sounding. The horizontal axis shows temperature [°C] and the vertical axis pressure altitudes [hPa] and metres. The left plot is the dewpoint curve and the right one is the air temperature curve. Source: weather.uwyo.edu.

1.8 Aids to navigation

Aids to navigation had no role in the occurrences.

1.9 Communications

1.9.1 OH-LTO

The investigation commission had access to Kuopio ATC radio communication recordings as well as the recorded telephone calls between Kuopio ATC and ACC Finland (EFIN). The investigation commission did not have access to recorded communications from the Area Control Centres of Arkhangelsk, Petrozavodsk or Murmansk.

Communications did not have any role in the occurrence.

1.9.2 OH-LTS

The investigation commission did not have access to recorded communications from ACC Moscow.

Communications did not have any role in the occurrence.

1.10 Aerodrome information

1.10.1 OH-LTO

Kansai international airport (RJBB) in Osaka, Japan was the aerodrome of departure for OH-LTO. Kuopio airport (EFKU) was the landing aerodrome. Aerodrome information can be found in the Aeronautical Information Publications (AIP) of Japan and Finland.

The serious incident occurred in Arkhangelsk Flight Information Region (FIR), approximately 900 km east-northeast from Kuopio.

1.10.2 OH-LTS

Krabi airport (VTSG) in Krabi, Thailand was the aerodrome of departure for OH-LTS. Helsinki airport (EFHK) was the landing aerodrome. Aerodrome information can be found in AIPs of Thailand and Finland.

The serious incident occurred in Moscow FIR, approximately 850 km southeast from Helsinki.

1.11 Flight recorders

An Airbus A330 has two flight recorders: a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR). They are located in the rear fuselage of the aircraft. Both recorders were in proper condition and they worked normally.

The recorders were manufactured by Honeywell International Inc. and they are SSCVR- and SSFDR series-recorders. Solid State Cockpit Voice Recorders (SSCVR) and Solid State Flight Data Recorders (SSFDR) are fully electronic (i.e. contain no moving parts). This investigation report refers to them as CVR and FDR.

The CVR retains two hours and the FDR 25 hours of information, respectively.

During the flight the CVR is continuously ON. On the ground the CVR operates if at least one engine is running. The CVR turns OFF automatically five minutes after last engine shutdown on the ground. After that recording on the ground provides that electrical supply is maintained (typically by APU or Ground Power Unit, GPU).

In an A330 it is only possible to manually stop the recording of the CVR from the avionics bay below the cockpit. The CVR's circuit breakers, CVR Control c/b and CVR c/b, are situated in this bay at two different locations. If both circuit breakers are pulled, re-recording in any situation is prevented. If only the CVR Control c/b is pulled, this will af-

fect the 28 VDC supply for the logic relays and will set the start/stop logic in a permanent recording state by default (provided the aircraft is supplied with power). The CVR will then continue recording automatically on ground with engines OFF.

1.11.1 OH-LTO

Cockpit Voice Recorder (CVR)

The CVR was a Honeywell 6022, serial number 12660. It was removed at Kuopio airport and sent to BEA, which downloaded the recorded information.

When the recording was analysed at Safety Investigation Authority, Finland, it became apparent that the recording did not contain information from the occurrence flight, because when the recorder was stopped the recording from the time of the occurrence was erased. The investigation commission did not receive any information from it regarding flight crew action.

Flight Data Recorder (FDR)

The FDR was a Honeywell 4700, serial number 16860. It was removed from the aircraft at Kuopio airport and sent to BEA, which downloaded the recorded information. BEA provided FDR data in numerical format as well as graphs. These were utilised in the analysis of the flight and in establishing the course of events.

1.11.2 OH-LTS

Cockpit Voice Recorder (CVR)

The CVR was a Honeywell 6022, serial number 12316. It was removed at Helsinki-Vantaa airport and downloaded at FTS avionics repair shop under the supervision of the Safety Investigation Authority, Finland. The recording was analysed at the Safety Investigation Authority, Finland and it was utilised in the analysis of the flight and in establishing the course of events.

Flight Data Recorder (FDR)

The FDR was a Honeywell 4700, serial number 16977. It was removed from the aircraft at Helsinki-Vantaa airport. The raw data therein was sent to BEA, which downloaded the recorded information. BEA provided FDR data in numerical format as well as graphs. These were utilised in the analysis of the flight and in establishing the course of events.

1.12 Wreckage and impact information

Neither occurrence warranted wreckage and impact investigation.

1.13 Medical and pathological information

No medical or toxicological tests were conducted in either occurrence.

1.14 Fire

There was no fire in either occurrence.

1.15 Survival aspects

1.15.1 OH-LTO

At 11:10 ACC Petrozavodsk (ULPP) contacted ACC Finland (EFIN) and reported that OH-LTO would have insufficient fuel to reach Helsinki-Vantaa airport, its planned destination. This being the case, OH-LTO was heading towards Rovaniemi airport (EFRO) at the altitude of 3300 m.

EFIN notified Rovaniemi Air Traffic Control (ATC) about approaching OH-LTO. Following this, EFIN contacted Finnair's Network Control Center (NCC), which replied that OH-LTO was experiencing problems with its bleed air system and that they only had a limited amount of fuel available. Therefore, the flight crew had selected Kuopio airport (EFKU) as their new route alternate aerodrome. In addition, NCC informed EFIN that the only occupants on OH-LTO were the three-man flight crew. There were no passengers or dangerous cargo onboard the aircraft.

At 11:23 ULPP informed EFIN that OH-LTO had changed its course and was now heading towards Kuopio at 3300 m. The area control centres agreed that ULPP would hand over OH-LTO fully released to Kuopio TWR directly to its frequency.

At 11:28 EFIN informed Kuopio ATC that OH-LTO would land at Kuopio airport because it had problems with pressurisation and that it did not have enough fuel to reach its original destination.

At that time there were two air traffic controllers on duty at Kuopio ATC. One of them was responsible for approach control and the other took care of tower control. They decided to combine the TWR and APP work stations so as to more efficiently manage the incident. Kuopio TWR immediately made the required incident alerts as per alerting instructions. Thereafter, Kuopio TWR contacted the NCC for additional information. NCC replied that there were no passengers or dangerous cargo onboard the aircraft and that the only occupants on OH-LTO were the three-man flight crew.

While still in Russian airspace at 11:43 OH-LTO called Kuopio ATC and said that they would land in Kuopio due to pressurisation problems. The flight crew reported that they had 5300 kg of fuel which would be more than enough for the approach and landing. In addition, the flight crew said that the aircraft was working normally. At 11:45 ULPP handed over OH-LTO to Kuopio TWR which cleared it to approach runway 33 via GASKU2A standard arrival route. OH-LTO landed at Kuopio airport at 12:15.

In addition to the rescue units of Kuopio airport, units from Emergency Response Centre (ERC) of North Savo also participated in the alert. According to the report of the ERC their response met the requirements of the reported task. The responders manned their stations within the required time frame. Rescue operations were not needed.

1.15.2 OH-LTS

OH-LTS landed normally at Helsinki-Vantaa airport. Helsinki-Vantaa ATC did not issue an alert because the flight crew did not declare an emergency at any time during the flight.

1.16 Test and research

1.16.1 Functional description of the A330-302 engine bleed air system

Bleed air is used in several systems of the aircraft. Among other things, bleed air is used in cabin pressurisation and in anti-icing. Normally, the bleed air system operates automatically.

Bleed air system components are mostly inside the aircraft's engines and engine pylons. Appendix 6 shows the positioning, relative size and shape of bleed air system components.

Two Bleed-air Monitoring Computers (BMC) control and monitor the operation of the engines' bleed air system. Each engine has one BMC. Flight crews can monitor the operation of the bleed air system on ECAM displays, situated in the cockpit.

Air is bled from two different compressor stages of the engine. The Pressure Regulating Valve (PRV) regulates bleed air pressure. For the most part, bleed air comes from the 8th compressor stage (Intermediate Pressure, IP). If this pressure is low, bleed air is automatically collected from the 14th stage (High Pressure, HP). The closing of the pneumatically operated High pressure bleed valve (HPV) is controlled by an electric solenoid. The BMC monitors and controls the HPV and PRV. The regulation of the bleed air pressure by HPV and PRV is purely pneumatic. Flight crews can manually close the PRV from the cockpit, after which the HPV closes as well.

Each engine bleed air system has two pressure transducers: Pr (Regulated Pressure Transducer) and Pt (Transferred Pressure Transducer). They are identical in design and characteristics. Pressure transducers measure engine bleed air pressure in sense lines.

Pr measures engine bleed air pressure downstream of the PRV, after which the pressure information is relayed to both engines' BMCs.

The PRV normally maintains fully automatically system pressure at approximately 48 psi. The BMC receives pressure data from the Pr. If this pressure exceeds 60 psi for 15 seconds the BMC will command the closure of the PRV, after which the HPV closes as well. In such case the ECAM display in the cockpit will display the following warning: AIR ENG 1/2 BLEED FAULT. If the bleed air pressure increases beyond 75 to 85 psi the OPV closes. It is to be noted that the OPV is a fully pneumatic valve not controlled by the BMC.

If Pr gives faulty pressure value to the BMC, the BMC cannot detect faulty pressure value received.

Pt measures bleed air pressure upstream of the PRV; this pressure information is relayed to the BMC of that engine. Pt pressure information is used by the BMC for Bleed System monitoring to cover specific failure modes and also in maintenance for troubleshooting.

The schematic in figure 13 illustrates the functioning of the left engine bleed air system. The working diagram of the right engine is similar.

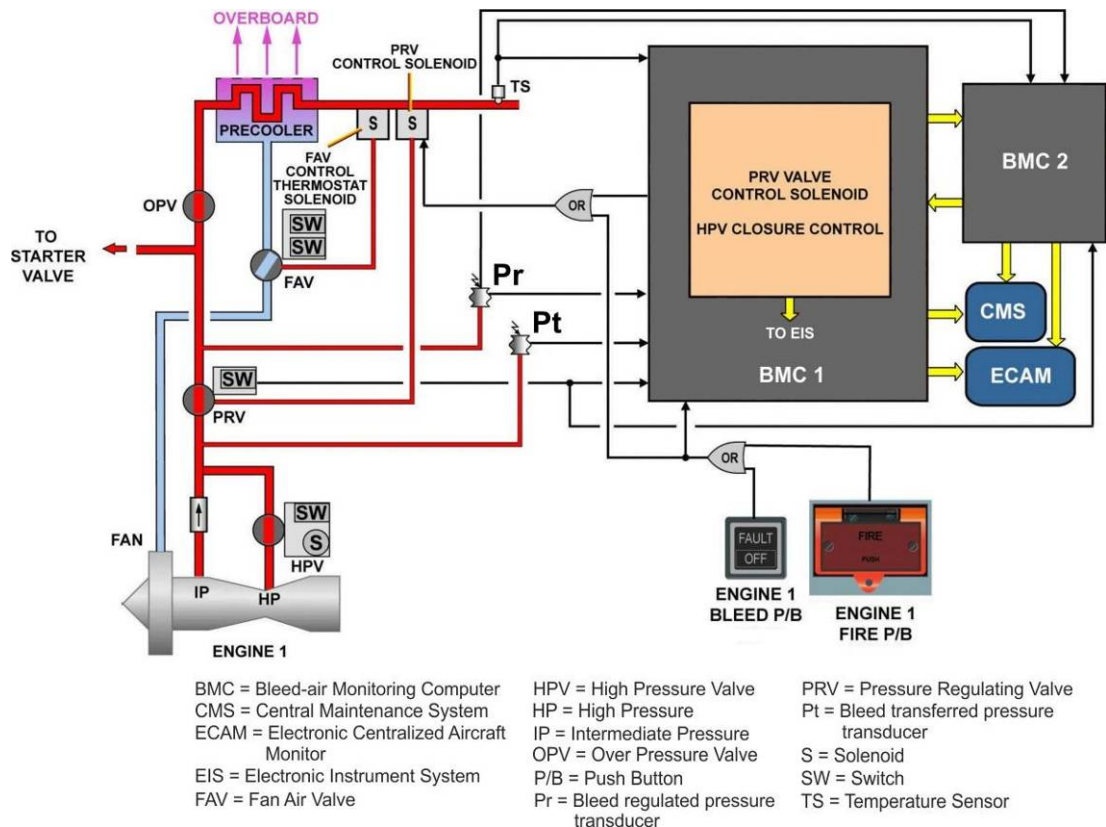


Figure 13. The schematic of the left engine's bleed air system including its components. Source: Airbus.

Auxiliary Power Unit (APU)

If necessary, the bleed air can be obtained from the APU below the altitude of 22500 ft (approximately 6900 m). In case the flight crew sets the APU Bleed to ON, the BMC commands the closure of the PRV's, and if conditions allow opens the cross bleed valve to enable the supply of the two air conditioning packs. The APU's bleed air system operates independently of the engine bleed air system. It cannot be used for anti-icing. The schematic of the A330 bleed air system is presented in appendix 7.

1.16.2 The design, characteristics and functioning of pressure transducers

All pressure transducers related to this investigation are manufactured by Esterline-Auxitrol. The bleed air system used two different versions: p/n ZRA1990030 and p/n ZRA380-00. The first version, p/n ZRA1990030 has been discontinued. The second ver-

sion, p/n ZRA380-00 was introduced in 2003 and the third version, p/n ZRA691-00 was introduced during the time of this investigation.

The versions vary in their internal design. For the purposes of this investigation the biggest difference is the volume of the pressure cell room. The second version has the smallest pressure cell room and, according to the manufacturer, in case of presence of moisture in the pressure cell it is more sensitive to the subject freezing related failures than the other versions. The third version's pressure cell room is the largest; the shape of the pressure cell room has also been changed. The designs of the second and third versions are presented in appendix 8.

Table 1 presents the general characteristics of pressure transducers ZRA380-00 and ZRA1990030 as given by Esterline-Auxitrol. The pressure transducers are designed and specified to operate in the pressure and temperature zones depicted in the table.

Table 1. General characteristics of pressure transducers p/n ZRA380-00/ZRA1990030.

Weight	0,27 kg
Pressure range	0–30 bar (0–435,0 psi)
Proof pressure	45 bar (652,5 psi)
Temperature range	-40...+80 °C
Extreme operation temperature	-55...+110 °C

Three of the four pressure transducers on OH-LTO were p/n ZRA380-00 (2 Pr and 1 Pt) and the fourth one was p/n ZRA1990030 (Pt). All four pressure transducers on OH-LTS were p/n ZRA380-00.

All three pressure transducer versions are identical in form and fit. Figure 14 presents an overview of a pressure transducer's external design and dimensions.

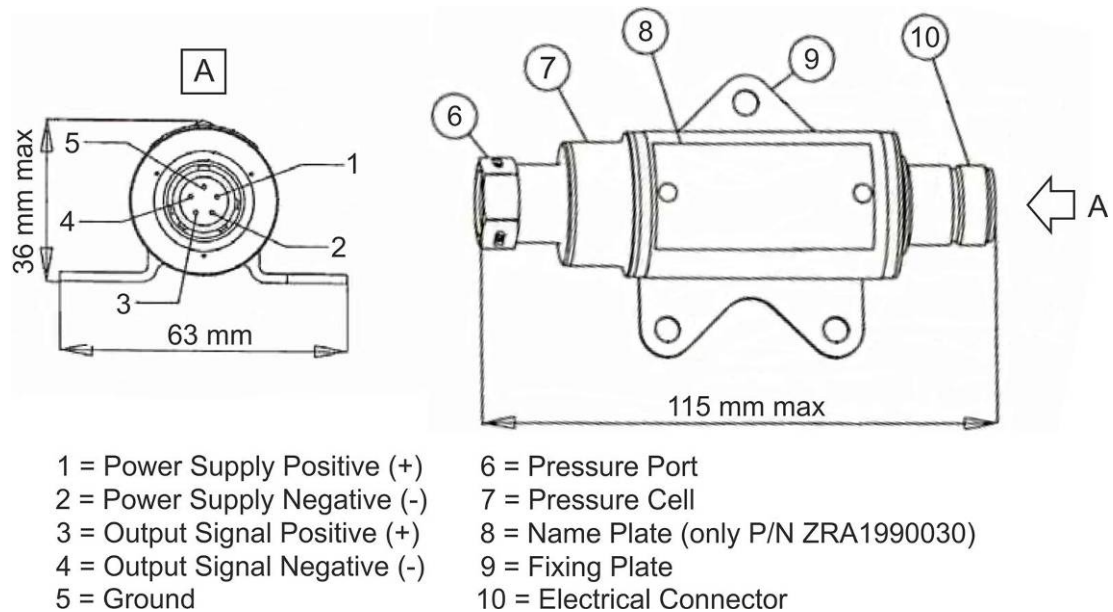


Figure 14. The external design, dimensions and parts of a pressure transducer. Source: Esterline-Auxitrol².

Pressure transducers convert bleed air pressure into an output signal. Ambient pressure is used as the reference pressure. The sense line is connected to pressure port 6 and the measured value is received from electrical connector 10.

The pressure transducer operates by measuring the change of stresses applied on a silicon sensing element (located in the silicon oil cavity) caused by the pressure change. The pressure cell is a sub-assembly that protects the membrane sensing element from environment. The sensing element enclosure is filled with silicone oil that transmits the pressure applied on the metallic diaphragm (that closes the sensing element enclosure) to the silicon sensing element. Electronics compensates and amplifies the sensing element output to an output signal which varies linearly, responding to the pressure. For example, 0 bar pressure generates a 1 Volt output signal and a 30 bar pressure generates a 9 Volt output signal. Pressure transducer is supplied by the 28Vdc A/C network.

Figure 15 shows a cross-sectional view of the pressure port and pressure cell room of pressure transducer p/n ZRA380-00.

² These schematics are the property of Auxitrol S.A. and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol S.A. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol S.A. and is considered proprietary of Auxitrol S.A.

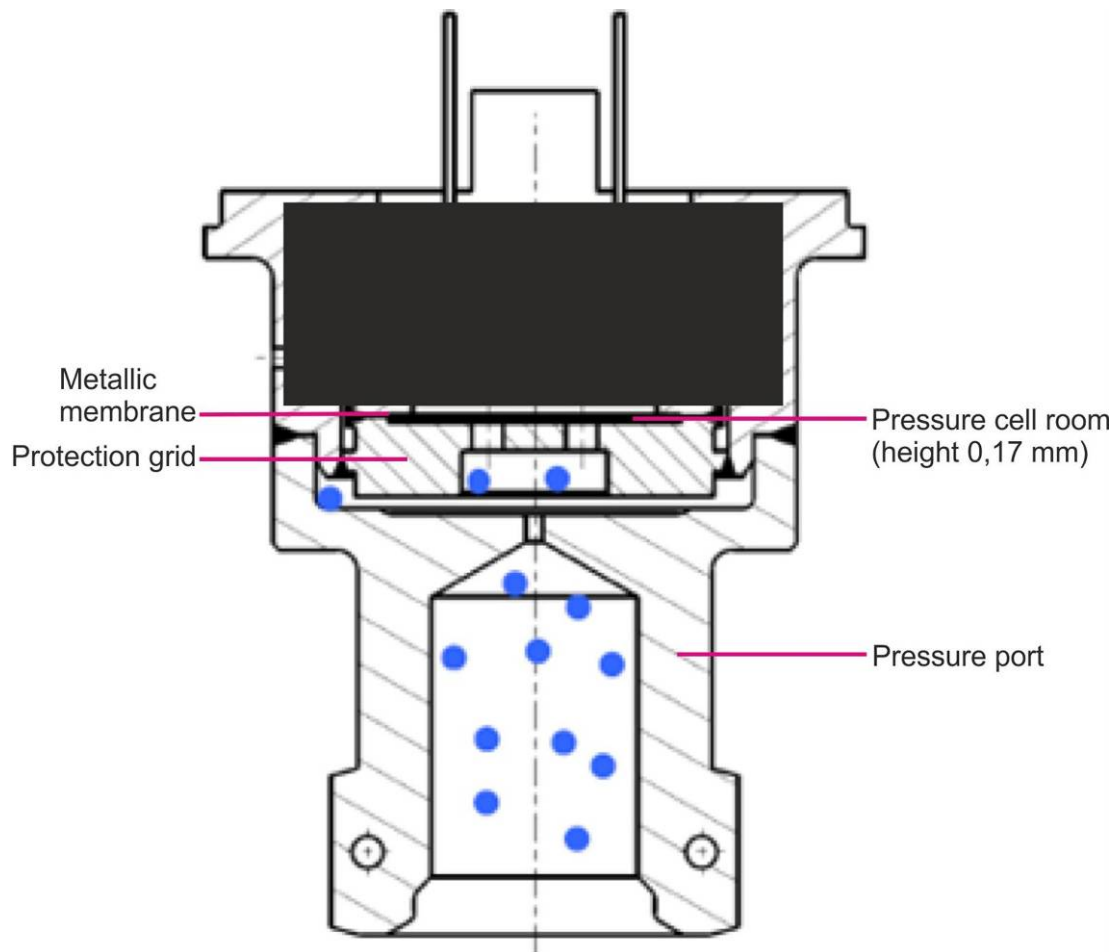


Figure 15. A cross-sectional view of the pressure port and pressure cell room of pressure transducer p/n ZRA380-00. The blue dots represent water droplets. Part of the pressure cell's design is masked on the request of the manufacturer. Source: Esterline-Auxitrol³.

No pressure transducer version prevents the accumulation of moisture inside the pressure cell room. Temperature changes and changes in humidity may cause moisture condensation in bleed air system's sense lines and pressure transducer's pressure ports. Condensed water droplets may travel to the pressure cell room and condensation may also directly occur in that space.

When the water freezes between the metallic membrane and the grid, the membrane displacement may be blocked. Silicon oil contained in the sensing element enclosure decrease in volume and consequently generate an internal pressure decreasing (refer to appendix 9). If temperature increases, silicone oil contained in the sensing element enclosure will not be able to expand correctly and will consequently generate internal pressure increase (refer to appendix 9 and 1.16.4 tests at Esterline-Auxitrol) Once the ice

³ These schematics are the property of Auxitrol S.A. and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol S.A. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol S.A. and is considered proprietary of Auxitrol S.A.

thaws, the metallic membrane can expand normally releasing the internal pressure and sensor functions normally.

1.16.3 Pressure transducer and pressure regulating valve inspections

OH-LTO

Inspections at Kuopio airport

The technical personnel of Finnair Technical Services Ltd (FTS) arrived at Kuopio airport on the day of the occurrence. Troubleshooting was commenced by reading the recorded fault messages and by talking with the flight crew. Following this, the CVR and the FDR were replaced and cabin overpressure valves were visually inspected. Nothing out of the ordinary was found in the inspection.

The technical personnel checked the condition of the right engine's pressure transducers and connectors and cleaned the opened sense lines with pressurised air from the APU. No irregularities were found in this inspection, either. Then the right engine's bleed air system was tested with the engine running. The values were normal and the system worked properly.

The same checks were made to the left engine. Nothing abnormal was discovered. Then, on the basis of previous fault messages, the pressure regulating valve (PRV) of the left engine was replaced. Following this, the functioning of engine bleed air system was tested with both engines running. The left engine worked properly. However, the right bleed air system triggered an AIR ENG 2 BLEED FAULT ECAM warning which was entered into the journey logbook. Later tests in France determined that the left engine's PRV operated normally.

The following day the aircraft was ferried to Helsinki-Vantaa airport with the right engine's bleed air system turned off, as per A330 MEL (Minimum Equipment List).

Inspections at Helsinki-Vantaa airport

Both pressure transducers of the right engine were replaced at Helsinki-Vantaa airport on 12 Dec 2010. A couple of small water droplets were found at the Pr pressure port area. No similar water signs was observed at the Pt pressure port area. After the transducers had been replaced the engines' bleed air system was checked during an engine test run. The system worked perfectly.

On the next flight, 12 Dec 2010, the flight crew received a transient AIR ENG 1 BLEED FAULT ECAM warning. Upon arrival at Helsinki-Vantaa airport on 13 Dec 2010 both of the left engine's pressure transducers were replaced. Figure 16 shows that the pressure transducer Pr which had been removed contained several water droplets. Pressure transducer Pt was dry. After the transducers had been replaced the engines' bleed air system worked flawlessly during an engine test run.



Figure 16. Pressure transducer Pr that was removed from the left engine's bleed air system on 13 Dec 2010. A large drop of water is visible at seven o'clock inside the pressure port. Source: Finnair Technical Services Ltd.

OH-LTS

Inspections at Helsinki-Vantaa airport

When the aircraft arrived at Helsinki-Vantaa airport on 22 Dec 2010 each of the four pressure transducers were replaced. Moisture condensation was detected in the transducers of the left engine. No moisture was discovered in the sense lines leading to the pressure transducers. The right engine's transducers were dry. No water was discovered in the sense line leading to the Pr. On the other hand, there was water in the sense line leading to the Pt.

The sense lines that led to both engines' pressure transducers were cleaned. The bleed air system worked faultlessly during an engine test run.

1.16.4 Additional pressure transducer inspections

When pressure transducers fail they are tested as per the ESTERLINE Abbreviated Component Maintenance Manual (ACMM) 36-11-08 Rev. No 2 approved by Airbus.

To begin with, the condition of the pressure transducer's electrical connections and pressure ports are visually inspected from the outside. After this, an output signal stability test is carried out as per ACMM subtask 36-11-08-750-002-A01. This test will detect moisture condensation, if any, inside the pressure transducer.

A 28 V direct current is connected to the pressure transducer in the stability test. The transducer's temperature is lowered from room temperature to -55 °C, where it is allowed to stabilise for a while. After this, its temperature is returned to room temperature.



One temperature cycle takes about an hour to complete. A graphic plotter records the pressure transducer's output signal on paper. The output signal must remain constant throughout the test.

If any voltage fluctuations and/or spikes are detected, the pressure transducer is kept in a 100 °C oven for at least four hours. After this, the aforementioned stability test is repeated. If the transducer passes the test, this confirms the presence of water inside the pressure transducer. However, if the repeated stability test fails, the pressure transducer must be discarded.

Action completed by Finnair Technical Services Ltd

At the time of the occurrence flights Finnair Plc operated eight A330 aircraft. They contained altogether 32 bleed air pressure transducers. From 23–24 Dec 2010 FTS tested or replaced all Pr transducers.

Tests at Esterline-Auxitrol

After the occurrence flights FTS sent the five pressure transducers that were removed from OH-LTO and OH-LTS to Esterline-Auxitrol, France, for further testing. These tests were conducted on 9 Feb 2011 in the presence of BEA representatives. The final tests and checks were made from 22–23 March 2011.

First the pressure transducers were visually inspected. Inspection revealed that the pressure transducers were properly packaged for transportation and that the appropriate cover plugs were installed. All pressure transducers were clean, with no signs of corrosion. Pressure transducer s/n ASA14074 had 'scrap' written in red on it. During the visual inspection a significant amount of water was detected in one of the OH-LTO's transducers, s/n ASA12735 (Fig. 17). This was the very same transducer in which water was discovered at Helsinki-Vantaa airport on 13 Dec 2010 (Fig. 16). Esterline-Auxitrol's visual inspections did not detect any water in the other pressure transducers. Appendix 9 contains photographs of each of the five pressure transducers.

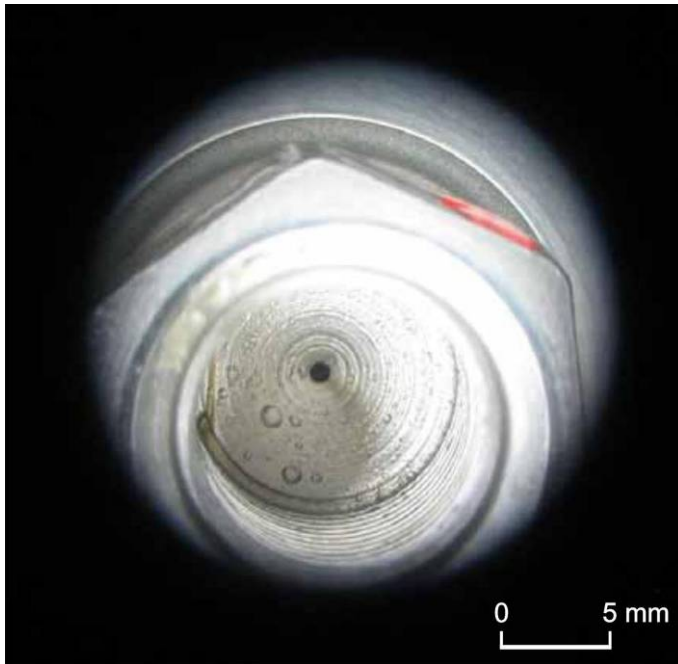


Figure 17. Pressure transducer s/n ASA12735 of OH-LTO. Source: Esterline-Auxitrol⁴.

Following the visual inspection all pressure transducers were subjected to the output signal stability test. Test arrangements are explained in figure 18. Tests detected water in three transducers. The clearest indication of this came from OH-LTO's transducer s/n ASA12571. The output signals of OH-LTO's transducers s/n ASA12736 and ASA12735 were inconstant during temperature changes. This is why they, too, were determined to contain water. Nonetheless, the presence of water in them was not as evident as in pressure transducer s/n ASA12571. Some of the water may have disappeared during removal and/or transportation. One of OH-LTO's pressure transducers, s/n 188, was of the first version manufactured. It passed the stability test. The ACMM does not require stability testing for first version pressure transducers.

Pressure transducer s/n ASA14074, removed from OH-LTS (marked as 'scrap'), had an electrical fault and, therefore, the output signal stability test could not determine the possible presence of water inside the transducer.

Output signal stability test result graphs and their salient points are included in appendix 9.

⁴ These schematics are the property of Auxitrol S.A. and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol S.A. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol S.A. and is considered proprietary of Auxitrol S.A.



Figure 18. Pressure transducer output signal stability test arrangements in the test chamber. Source: Esterline-Auxitrol⁵.

Three pressure transducers that contained water on the basis of output signal stability test results were put into a 100 °C oven for two hours. After this, the stability test was repeated. Throughout the test the output signal of each pressure transducer remained constant. In other words, they passed the test. The result graphs of this test are also shown in appendix 9.

Following the drying in climatic chamber the output signal stability test results confirmed that three pressure transducers had contained water before they were put into the oven. Finally, all four transducers that were removed from OH-LTO were functionally tested as per the ACMM. All transducers passed the test. After the final tests and checks the pressure transducers were accepted as ready for reinstalling.

Pressure transducer s/n ASA14074, removed from OH-LTS, had an electric fault. This had already been detected during the FTS test conducted at Helsinki-Vantaa airport. When Esterline-Auxitrol detected the electric fault during the output signal stability test the transducer was separated from the others for further inspections.

Further testing was conducted at Esterline-Auxitrol on 9 May 2011 in the presence of BEA's representatives. During this inspection the pressure transducer was opened. It

⁵ These schematics are the property of Auxitrol S.A. and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol S.A. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol S.A. and is considered proprietary of Auxitrol S.A.

was noted that resistor R2 was burned out and that the protective diode T2 was burned out and broken. No other damage was detected. The damage had been caused by inadvertent application of the voltage supply on outputs. According to Esterline-Auxitrol's test report the misapplication of voltage had occurred during prior testing at FTS when the voltage supply to connector pin 1 (+) was cross-connected with the output signal of pin 3 (+) following removal from the aircraft.

Table 3. Esterline-Auxitrol's output signal stability test results regarding pressure transducers removed from OH-LTO and OH-LTS.

Aircraft	Pressure transducer A/C position	Pressure transducer p/n	Pressure transducer s/n	Output signal stability test		Presence of water
				Before the oven treatment	After the oven treatment	
OH-LTO	8HA1 (Pr)	ZRA380-00	ASA12735	Fail	Pass	Yes
OH-LTO	9HA1 (Pt)	ZRA1990030	188	Pass	Not done	No
OH-LTO	8HA2 (Pr)	ZRA380-00	ASA12571	Fail	Pass	Yes
OH-LTO	9HA2 (Pt)	ZRA380-00	ASA12736	Fail	Pass	Yes
OH-LTS	8HA1 (Pr)	ZRA380-00	ASA14074	Fail	Not done	No information

1.16.5 Tests conducted by Airbus

Troubleshooting

FTS sent OH-LTO's BMC 1 and BMC 2 troubleshooting files to Airbus. The files revealed that when the right engine's bleed air system failed the erroneous pressure indication of pressure transducer Pr was 63 psi and the correct one provided by Pt was 37 psi. When the left engine's bleed air system failed the erroneous indication of pressure transducer Pr was 64 psi and the correct one provided by Pt was 36 psi. Following the right engine's bleed air fault the incorrect indication of the Pr transducer peaked at 233 psi.

FTS did not send OH-LTS's BMC 1 and BMC 2 troubleshooting files to Airbus. This being the case the investigation commission did not have access to pressure transducer fault data.

A330 pylon temperature

The engines' bleed air pressure transducers are situated in the A330's pylons. Airbus conducted test flights on several A330 aircraft in June 2010 in order to allow progress in the understanding of transducers freezing phenomenon and develop improvements. The test flights used a dedicated pylon temperature measuring system.

Flight test results on the GE engine established that pylon temperature decreased by 1°C/min during the climb. During the approximately four and a half hour-long cruise

phase of the flight at 40000 ft (ca. 12200 m) ambient temperature dropped from -50 °C to -60 °C. During that time the pylon temperature continued to decrease, albeit at a slower rate compared to the climb, reaching nearly 0 °C at its lowest. Appendix 10 shows the test flight result graphs. The marking "Pylon 2 temperature 1" denotes the pylon temperature curve.

1.16.6 Pressure transducer check intervals

The Airbus A330 Maintenance Program does not provide any maintenance or check intervals for engines' bleed air pressure transducers (Pr and Pt). On 16 Dec 2010, following the occurrence flight of OH-LTO, Airbus recommended that Finnair Plc inspect the Pr pressure transducers and drain the sense lines connecting the Pr and the PRV during the 3A check (2400 FH) of its A330 fleet. On 28 Dec 2010 Finnair Plc decided to inspect pressure transducers Pr and Pt and dry their sense lines during the 1A checks (800 FH).

According to a FTS test report which was also sent to the investigation commission, they tested in all 58 pressure transducers from 28 Dec 2010 – 5 Aug 2011. During this interval all pressure transducers completed at least two 1A check intervals. The total number of pressure transducer checks during this time was 142. Moisture was found in a few transducers.

In an OIT dated on 25 Aug 2011 (appendix 11) Airbus recommended that all operators of GE CF6-80E1 in their A330 aircraft periodically inspect Pr pressure transducers p/n ZRA380-00 and drain the sense lines during 1A, 2A or 3A checks. On 27 Sep 2011 Finnair Plc decided to continue checking pressure transducers p/n ZRA380-00 and draining their sense lines during the 1A check until further notice.

In September 2011 Airbus published service bulletin SB A330-36-3039 (appendix 12) which applies to all A330 aircraft fitted with GE CF6-80E1 engines. The Service Bulletin recommended removing the previous bleed regulated pressure transducers (Pr) from the engine 1 pylon and installing new ones, p/n ZRA691-00, by the beginning of December 2011. Following the recommendation Finnair Plc retrofitted all engine 1 pylon Pr transducers on the A330 fleet. Finnair Plc has only decided to inspect and drain the sense lines connecting pressure transducers p/n ZRA691-00 in the 1A check; the pressure transducers themselves will not be inspected or dried.

1.16.7 Cockpit Voice Recorder recording time

Provisions concerning the CVR recording

1. Pursuant to Regulation (EU) 996/2010 of the European Parliament, Article 14: A CVR recording *shall not be made available or used for purposes other than safety investigation, or other purposes aiming at the improvement of aviation safety.*
2. Pursuant to Annex 6, paragraph 11.6 of the Convention on International Civil Aviation: *An operator shall ensure... in the event the aeroplane becomes involved in an accident or incident, the preservation of ... the associated flight recorders, and their retention in safe custody pending their disposition in accordance with Annex 13.*

3. Pursuant to Annex 6, paragraph 6.3.4.2: *Flight recorders shall not be switched off during flight time.*
4. Pursuant to Annex 6: *Airliners' CVRs must be capable of retaining the information recorded during at least the last two hours of their operation.*

Examples of losing CVR information:

1. Despite instructions, the flight crew of OH-LTO did not manage to retain the CVR recording for this safety investigation. Therefore, the recording did not provide any information regarding the flight crew's action on the occurrence flight.
2. Safety Investigation Authority, Finland (SIA) launched investigation C9/2010L for an incident which occurred at Oslo Gardermoen airport, Norway on 23 Oct 2010. The incident involved an Embraer 190 aircraft which collided with runway edge lights during takeoff and continued on to its destination. Since the CVR recording was automatically over-recorded, the investigation commission did not have access to that information.
3. SIA launched investigation L2012-01 regarding a serious incident on 29 Dec 2011 at Helsinki-Vantaa airport. A Saab-340 aircraft taxied onto the runway in front of a landing ATR-72 aircraft. The Saab-340's CVR recording was not retrieved because the flight was continued and the CVR recording was automatically over-recorded. The CVR recording time of the Saab-340 was 30 minutes.
4. The Accident Investigation Division of Hong Kong's Civil Aviation Department (HKCAD) launched an investigation into a serious incident involving an A340 aircraft prior to takeoff at the Hong Kong International Airport on 26 Nov 2010. Following the incident the aircraft's engines were not turned off. Instead, the flight, which took more than eight hours, was continued to Helsinki-Vantaa airport. Because of the short recording time the investigation commission did not have access to the over-recorded CVR information at the time of the incident. The identifier of the HKCAD's investigation is Serious incident report 1/2011.
5. The Greek Accident Investigation and Aviation Safety Board investigated an accident which occurred on 14 Aug 2005 to a Boeing 737 aircraft near Athens airport. Due to the short recording time, the CVR recording from the early phase of the flight was lost. The investigation identifier is Accident investigation report 11/2006. The investigation commission issued safety recommendation GREC-2006-045 to the ICAO and EASA/JAA to require aircraft manufacturers to evaluate the feasibility of installing a CVR that records the entire flight. In 2006 the EASA replied to the recommendation as follows: *The Agency, after consulting its advisory bodies, considers that recording the entire flight is not expected to bring significant safety benefit, while it would induce high costs for operators.*

ETOPS

ETOPS (Extended-range Twin-engine Operational Performance Standards) is an ICAO Standard and Recommended Practice (SARP), permitting twin-engine airliners to fly routes with a diversion time of more than 60 minutes to the nearest suitable aerodrome.

Following certain emergencies, among other things, it must be possible to complete an ETOPS flight at a one-engine-inoperative cruise speed from the most critical point along the route to an adequate airport within the time frame approved for the aircraft type as per ETOPS. For example, an A330 which is ETOPS-180 rated must be able to reach a suitable diversion airport within three hours from the most critical point along the route, allowing for prevailing weather conditions.

Nowadays some aircraft are ETOPS-rated for more than five hours. If the flying time from the most critical point along the route to the nearest adequate airport is over two hours, the CVR recording only covers the final two hours of the flight.

1.17 Organizational and management information

1.17.1 Flow of information from Airbus to operators

Airbus publishes several kinds of bulletins for operators through various media. Among other ways, they are separately or jointly directed to the operators' engineering or operations divisions. The operators can read these publications in Airbus information portals, such as the Airbus World.

Bulletins intended for operators' engineering divisions include the Technical Follow-Up (TFU) and the Operator Information Telex (OIT). TFUs also contain a segment for operations divisions (OPS ADVICE).

Bulletins for operations divisions include, among others, the Flight Operations Telex (FOT) and the Operations Engineering Bulletin (OEB).

The technical representatives of Finnair Plc mainly read the Airbus bulletins that are intended for the engineering division. Correspondingly, operations personnel mainly peruse through bulletins intended for operations divisions.

According to Airbus, in all 58 Dual Bleed Loss (DBL) failures had occurred to A330 aircraft from the beginning of 1997 to the end of 2010 (appendix 13). 16 of these were caused by overpressure during the cruise or descent (failure mode for OH-LTO and OH-LTS). This failure mode first appeared in 2008. Airbus identified the cause of this failure mode by the end of 2009. The first Airbus TFU for operators regarding DBLs was published in October 2009 (appendix 14). TFU 36.11.00.065 issue 2 dated Feb 2010 is sharing the preliminary investigation outcomes and action plan.

Airbus published the first OIT for operators' engineering divisions regarding dual bleed air losses in February 2011.

1.17.2 Manuals and procedures

Flight crew procedures and abnormal procedures are included, among other things, in the Operation Manual A (OM-A) and the Flight Crew Operating Manual (FCOM) as well as the Quick Reference Handbook (QRH). In addition, during the flight the ECAM, a part of the aircraft's monitoring system, displays procedures to the flight crew. Some procedures are also printed on the hardcopy QRH.

1.18 Additional information

1.18.1 Reference material

In addition to the occurrence flights, reference material was collected from two other flights. Due to identical flying weather conditions the investigation used measured ambient temperatures as reference material. Figure 19 shows the measured ambient temperatures of all four flights as a function of time for the final five hours before the first bleed air loss. The aircraft used for reference were A330s and the engines were type GE CF6-80E1.

The first reference flight: An hour after OH-LTO another A330 (OH-LTN) experienced a similar single engine bleed air loss in identical temperature conditions and nearly at the same geographical location.

Second reference flight: On 29 Dec 2010 a serious incident occurred over the Black Sea when an A330, registration B-16312, experienced a dual bleed air loss, forcing the aircraft to make an emergency landing. Regarding this serious incident the Taiwanese Aviation Safety Council (ASC) provided some investigation material to this commission. ASC final report is available with reference ASC-AOR-12-04-001.

In figures 19 and 20 the graphs of all reference flights meet the zero of the time axis at the point where the first bleed air losses occurred. The second bleed air loss points are marked on the graphs.

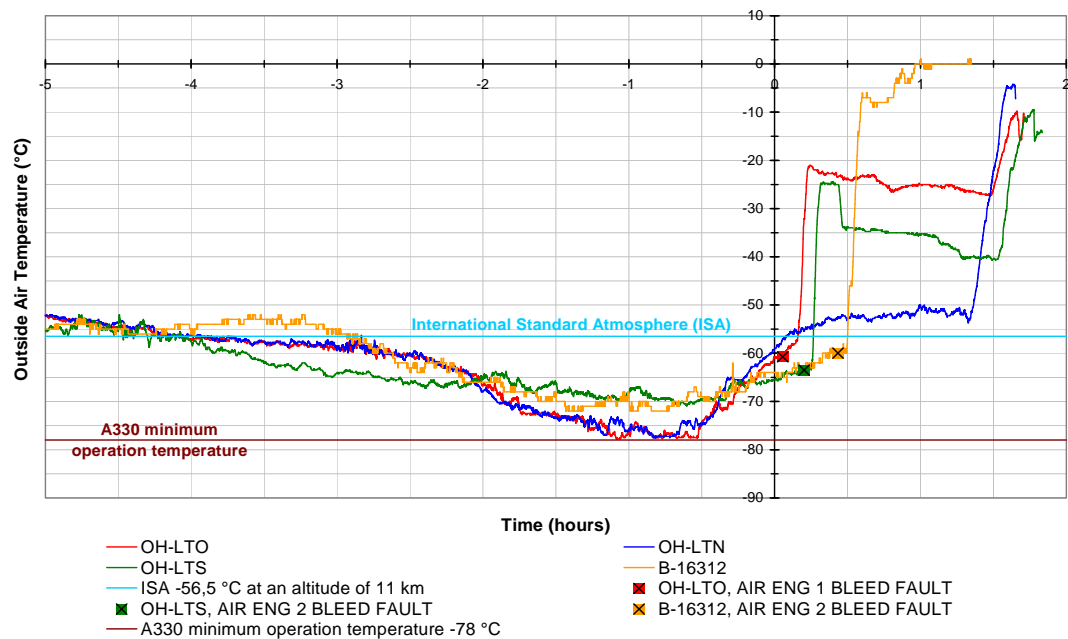


Figure 19. Ambient air temperatures on the reference flights as a function of time.

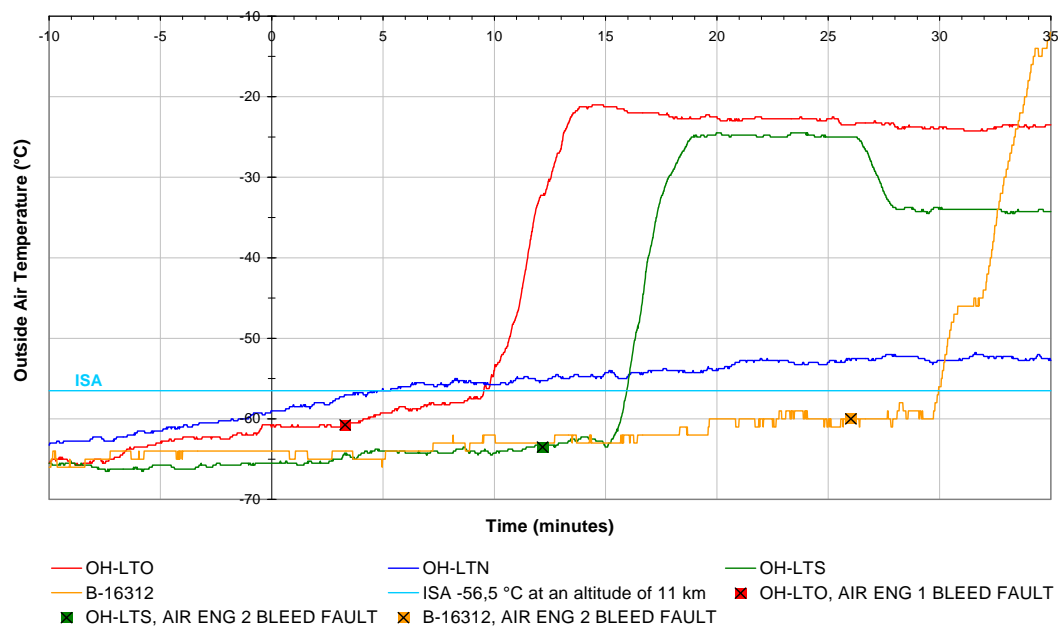


Figure 20. Enlargement of figure 19.

The following table presents the reference flights' information: Registration, duration of the cold ($< -60^{\circ}\text{C}$) temperature, minimum temperature, time from temperature increase to first bleed air loss, temperature increase and time from first bleed air loss to the second bleed air loss.

Table 4. Occurrence and reference flight information.

Registra- tion	Duration of the cold ($< -60^{\circ}\text{C}$) tempera- ture	Minimum tempera- ture	Time from temperature increase to the first bleed air loss	Tempera- ture in- crease	Time from first bleed air loss to the second one
OH-LTO	ca. 2.5 h	-77°C	ca. 35 min	17°C	3 min
OH-LTS	ca. 3.5 h	-71°C	ca. 40 min	8°C	12 min
OH-LTN	ca. 2.5 h	-77°C	ca. 35 min	17°C	
B-16312	ca. 3 h	-73°C	ca. 40 min	9°C	26 min

2 ANALYSIS

2.1. The functioning of the A330-302 engines' bleed air system and pressure transducers

During the flight it is impossible for engine bleed air pressure to rise to the high value noted by the flight crew on the first occurrence flight. The engines' bleed air system is not designed to use the information provided by the transferred pressure transducer (Pt) during the flight. In the opinion of the investigation commission it would probably have been possible to avert false alarms and a dual bleed loss situation if Pt information could be utilised in monitoring the system.

The investigation commission believes that all Pr pressure cell rooms contained water on the occurrence flights. In the course of time, moisture built up inside the pressure transducers in pylons. The tests conducted by Airbus, Auxitrol and FTS support this view. In addition, FTS has found moisture also in the sense lines of the bleed air system.

All Pr transducers on the occurrence flights were of version two, which is the most prone to malfunctioning caused by freezing of water due to its confined pressure cell room. Moreover, the transducers are situated in a place where they can freeze and are not fitted with any heating systems. The investigation commission considers that the extremely low ambient temperature contributed to water freezing inside the pressure cell rooms of the transducers, situated in the pylons. The relatively rapid rise in temperature prior to the engines' bleed air system fault could have contributed to this.

2.2 Pressure transducer check intervals

Airbus informed SIA that the third, i.e. newest, pressure transducer version is designed to better tolerate freezing inside the pressure cell room compared to the previous versions. The investigation commission regards it possible that, even in the newest version, water can condensate in the pressure cell room and when it freezes it impacts pressure measurement.

2.3 Flight crew action

2.3.1 OH-LTO

The investigation commission considers that the flight crew acted as per instructions and properly completed ECAM instructions after the first bleed air warning (AIR ENG 2 BLEED FAULT).

Following the second bleed air system fault the flight crew maintained the cruising altitude and continued to monitor the increasing cabin altitude from ECAM. The investigation commission considers that, upon receiving the second warning, they should have followed QRH procedures by rapidly descending to a lower flight level, instead of continuing to deliberate the possible causes of the high pressure value. Even if the cause of the abnormal situation may seem logical, it can only be based on the flight crew's own

estimation. It is the opinion of the investigation commission that flight crews should always and, especially in emergencies, fall back on the aircraft's pre-planned procedures. The actual cause of the fault can be obscured by an unexpected chain of events.

Cabin altitude exceeded 14000 ft during the emergency descent and, as a result of this, the emergency oxygen masks inside the cabin deployed. ACC Petrozavodsk asked the flight crew whether they intended to declare an emergency. In his interview the captain said that he decided that this would not be necessary at that phase since they had already told the air traffic control that they were in an emergency descent due to the engine bleed air fault. Furthermore, the captain thought the aircraft was not damaged and they had no passengers.

The captain used his discretion by deciding against declaring an emergency. His thought process could have been influenced by the facts that the aircraft seemed intact and that they did not have any cabin crew or passengers onboard. The investigation commission believes that the flight crew should have announced their emergency descent with the international distress signal (Mayday, Mayday, Mayday). Air traffic control may not always interpret the mere reporting of an emergency descent as an emergency, *per se*. If the declaration of an emergency proves to be disproportionate to the situation, it can always be cancelled. It is also important to declare an emergency so as to better enable the ATC to prepare for maintaining minimum separation between aircraft and for raising rescue readiness.

2.3.2 OH-LTS

The flight crew had read Finnair Plc Airbus fleet chief's bulletin on the Crew Information System regarding the serious incident that had occurred to OH-LTO. Because of this, after the first bleed air loss, the flight crew prepared for the possible second bleed air system malfunctioning by deciding on the procedures to be followed ahead of time. It is the opinion of the investigation commission that the proactive planning and the flight crew's immediate action as per procedure made it possible that the cabin pressure altitude increased only until 10800 ft.

Investigation revealed that the relief co-pilot was not summoned back to the cockpit during the serious incident. Instead, he was resting in the crew resting compartment. The investigation commission believes that the full potential of the crew should be available during emergencies so as to cope, for example, with unexpected situations and the increased workloads.

2.4 Weather conditions

2.4.1 The effect of the prevailing weather to the occurrence

Due to similarities in flight weather-related temperature profiles the investigation used data from reference flights as reference material. The weather phenomenon that was analysed involved an extremely cold weather type which prevailed for a long time en-route as well as the relatively rapid rise in ambient temperature that preceded the dual bleed air loss.



On the basis of reference data the investigation commission estimates that the above-mentioned weather type contributed to water freezing inside the pressure transducers' pressure cell rooms on both occurrence flights.

2.4.2 Weather briefing information

The flight crews received sufficient weather briefing material. Nonetheless, the investigation commission believes that weather charts should be made more informative and easier to decipher, among other things, through the use of different colours in the depiction of temperatures.

2.5 Communication

2.5.1 Flow of information

According to Airbus, in all 58 Dual Bleed Loss (DBL) failures had occurred to A330 aircraft from the beginning of 1997 to the end of 2010 (appendix 13). 16 of these were caused by overpressure during the cruise or descent (failure mode for OH-LTO and OHLTS). This failure mode first appeared in 2008. Airbus identified the cause of this failure mode by the end of 2009. The first Airbus TFU for operators regarding DBLs was published in October 2009 (appendix 14). TFU 36.11.00.065 issue 2 dated Feb 2010 is sharing the preliminary investigation outcomes and action plan.

The TFU also contains the OPS ADVICE segment which informs of possible occurrence-related action for operations. Still, since the TFU is primarily intended for engineering divisions, the investigation commission regards that TFUs are not necessarily the correct media for the distribution of operational bulletins. Rather, they should be promulgated via communications channels intended for operational divisions. By doing so, they would better reach their intended targets in operators' organisations.

2.5.2 Engine bleed air system abnormal procedures

Abnormal procedures related to a single engine bleed air fault are displayed on the ECAM, whereas dual bleed loss-related (DBL) abnormal procedures are only printed in the Quick Reference Handbook (QRH), which is available as a hardcopy in the cockpit.

This arrangement may increase flight crews' workload in DBL situations. It is the opinion of the investigation commission that both bleed air loss-related abnormal procedures should be displayed on the ECAM as well.

2.6 CVR recording time

Prompt and efficient safety investigation in civil aviation improves the safety of aviation and helps prevent accidents and incidents. Investigators in many countries consider the CVR recording to be a valuable and essential instrument in investigating flight crew action and crew cooperation related to accidents and incidents. Unfortunately, however, pertinent CVR recording was lost in several investigations due to its short recording time.

Nowadays some aircraft are ETOPS-rated for more than five hours. By and large, in practice the CVR recording only covers the final two hours of the flight. The investigation commission regards the extension of ETOPS-ratings over two hours without corresponding CVR recording time requirements illogical.

The investigation commission holds that by extending the CVR recording time to cover at least the duration of the flight it is possible to reduce the need for instructions to flight crews and technical personnel. This would minimise the possibility of human error in securing the recording for safety investigation.

With a CVR recording that would cover at least the duration of the flight, it would also be possible to clarify any possible discrepancies that arise in crew interviews because the recording would provide complementary information from the cockpit regarding the course of events.

A CVR recording that would cover the duration of the flight might also save operator costs because, after an incident, it would be possible to wait until returning to the operator's home base before removing the CVR device.

Annex 6 to the Convention on International Civil Aviation stipulates that a cockpit voice recorder in an airliner *shall be capable of retaining the information recorded during at least the last two hours of its operation*. The investigation commission regards paragraphs 6.3.4.2 and 11.6 in Annex 6 to be contradictory, namely, because as per para 6.3.4.2 *Flight recorders shall not be switched off during flight time*, and pursuant to para 11.6 *An operator shall ensure...the preservation of all related flight recorder records... pending their disposition as determined in accordance with Annex 13 (Aircraft Accident and Incident Investigation)*. In practice, it is impossible for the operator to comply with the abovementioned paragraphs on long flights. This being the case, the over-recording of recorded data is highly likely.

In 2006 the EASA replied to safety recommendation GREC-2006-045 as follows: *The Agency, after consulting its advisory bodies, considers that recording the entire flight is not expected to bring significant safety benefit, while it would induce high costs for operators*. The investigation commission regards that the CVR is an important element of safety investigation, making it possible to establish the course of events in the cockpit. The retention of the CVR recording is invaluable and essential from the standpoint of safety investigation when flight crew action is being evaluated. It is the view of the investigation commission that modern technology does not prevent the extension of the recording time.

Safety investigation authorities investigate incidents in aviation more often than accidents, as incidents occur more frequently. Incidents can provide lessons similar to accidents, without the serious casualties. The investigation commission believes that the present CVR recording time requirement primarily serves the purpose of accident investigation rather than incident investigation.

3 CONCLUSIONS

3.1 Findings

3.1.1 OH-LTO

1. The airworthiness certificate and certificate of registration were valid.
2. The flight crew had valid licences and the required ratings.
3. The flight was a scheduled passenger flight. However, there were no passengers or cabin crew onboard the aircraft.
4. Water had accumulated in both engines' bleed air systems and pressure transducers.
5. An extremely cold ambient temperature prevailed enroute. The temperature rose relatively rapidly before the engine bleed air system faults.
6. The water froze inside the pressure cell rooms of the engines bleed air system's regulated pressure transducers (Pr).
7. The frozen water in the pressure cell rooms caused the regulated pressure transducers (Pr) to malfunction, generating faulty pressure information to the Bleed Monitoring Computers (BMC).
8. The bleed air system of the right engine failed and the flight crew tried to reset it, to no avail. The bleed air system on this engine closed.
9. Approximately four minutes after the first malfunctioning the left engine's bleed air system failed as well. The bleed air system on this engine closed.
10. Despite the Quick Reference Handbook's procedures the flight crew maintained their cruising altitude.
11. In the cockpit ECAM cabin pressure page was displayed due to change in cabin pressurisation.
12. An Excessive Cabin Altitude warning appeared on ECAM because the threshold value (9550 ft) of the cabin pressure altitude was exceeded.
13. The flight crew had to use their emergency oxygen system.
14. The flight crew initiated an emergency descent about two minutes after the excessive cabin altitude warning.
15. The third member of the flight crew ended his rest period and returned to the cockpit.

16. Cabin pressure decreased and cabin altitude exceeded 14000 ft.
17. The emergency oxygen masks in the cabin deployed.
18. Despite their emergency descent the flight crew did not declare an emergency to the air traffic control.
19. They continued the flight at a lower altitude, which burned more fuel than planned.
20. First, the flight crew selected Rovaniemi as their diversion airport. After reconsidering, they selected Kuopio airport as their diversion airport instead.
21. Kuopio TWR issued an air accident alarm.
22. The aircraft landed normally at Kuopio airport. There was no need for rescue operations.
23. Following the failure to retain CVR data, the CVR recording was lost.
24. The flight crew unanimously decided against organising a defusing session.
25. The first time Airbus issued a TFU to operators regarding several previous A330-engine Dual Bleed Losses was in October of 2009.
26. Pursuant to ICAO Annex 13 severity classification this occurrence was a serious incident.

3.1.2 OH-LTS

1. The airworthiness certificate and certificate of registration were valid.
2. The flight crew had valid licences and the required ratings.
3. The flight was a scheduled chartered flight with passengers onboard.
4. Water had accumulated in both engines' bleed air systems and pressure transducers.
5. An extremely cold ambient temperature prevailed enroute. The temperature rose relatively rapidly before the engines' bleed air system fault.
6. The water froze inside the pressure cell rooms of the engines bleed air system's regulated pressure transducers (Pr).
7. The frozen water in the pressure cell rooms caused the regulated pressure transducers (Pr) to malfunction, generating faulty pressure information to the Bleed Monitoring Computers (BMC).



8. The bleed air system of the left engine failed. The bleed air system on this engine closed.
9. The flight crew started the APU.
10. Approximately 12 minutes after the first malfunctioning the right engine's bleed air system failed as well. The bleed air system on this engine closed as well.
11. In the cockpit ECAM cabin pressure page was displayed due to increase in cabin air pressure altitude.
12. The flight crew had to use their emergency oxygen system.
13. The flight crew initiated a descent rapidly to a lower altitude.
14. The third member of the flight crew was not summoned to the cockpit.
15. An Excessive Cabin Altitude warning appeared on ECAM because the threshold value (9550 ft) of the cabin air pressure altitude was exceeded, which requires an emergency descent.
16. Cabin pressure decreased and, simultaneously, cabin pressure altitude rapidly rose to approximately 10800 ft at the highest.
17. The APU's bleed air system was selected at flight altitude 6900 m.
18. The flight was continued at a lower cruising altitude.
19. The third member of the flight crew who had been resting returned to the cockpit.
20. The flight crew managed to reset the engines' bleed air system for the remainder of the flight.
21. The aircraft landed normally at Helsinki-Vantaa airport.
22. The flight crew unanimously decided against organising a defusing session.
23. The first time Airbus issued a TFU to operators regarding several previous A330-engine Dual Bleed Losses was in October of 2009.
24. Pursuant to Annex 13 severity classification this occurrence was a serious incident.

3.2 Probable causes and contributing factors

Both serious incidents were caused by malfunctioning of the engines' bleed regulated pressure transducers' (Pr). The malfunctioning was caused by freezing of water that had accumulated in the bleed regulated pressure transducers' pressure cell rooms, extremely confined by design.

Due to malfunctioning the transducers provided faulty pressure information to Bleed Monitoring Computers (BMC). Due to the erroneous information the BMCs closed both engines' bleed air systems which resulted in loss of pressurisation in cabin, i.e. a increase in cabin air pressure altitude.

The extremely cold air mass enroute during a long time period contributed to the fact that the water froze in the pressure cell rooms.

Furthermore, the relatively rapidly increasing ambient temperatures enroute may have contributed to the engines' bleed air system faults.

4 SAFETY RECOMMENDATIONS

4.1 Safety actions already implemented

On 16 Dec 2010 Airbus recommended that Finnair Plc inspect the engines' bleed air Pr pressure transducers and drain the sense lines during the 3A check (2400 FH) of A330 fleet operated by Finnair Plc.

Finnair Plc reported having replaced all of the engine bleed air system pressure transducers p/n ZRA380-00 on the A330 fleet by 25 Dec 2010. The installed pressure transducers were of the same version (p/n ZRA380-00) as the removed transducers.

On 28 Dec 2010 Finnair Plc decided to start inspecting all engine bleed air system pressure transducers on the A330 fleet and to dry their sense lines during the 1A checks (800 FH).

In September 2011 Airbus published service bulletin SB A330-36-3039, which applies to all A330 aircraft fitted with GE CF6-80E1 engines. The Service Bulletin recommended removing the previous bleed regulated pressure transducers (Pr) from the engine 1 (left) pylon and installing new ones, p/n ZRA691-00, by the beginning of December 2011.

By 1 Dec 2011 Finnair Plc had retrofitted all engine 1 pylon Pr transducers p/n ZRA691-00 on the A330 fleet operated by Finnair Plc.

On 4 Jan 2011 the Finnish Transport Safety Agency requested Finnair Plc to report, concerning the A330 aircraft pressurisation problems, the implemented and planned actions due to the serious incidents that had occurred. The reporting process also included written reports and meetings between the management and persons in charge of Finnair Plc and representatives of the Finnish Transport Safety Agency.

In addition, in a company check performed on 27 Jan 2012, the Finnish Transport Safety Agency checked the implemented and documented actions that were included in Finnair Plc's accident prevention and flight safety programme (OPS 1.037). The actions were mainly found satisfactory.

4.2 Safety recommendations

1. Investigation revealed that while the A330 occurrence flights were flown well within their permitted temperature range, pressure transducers p/n ZRA380-00 of A330 aircraft equipped with GE CF6-80E1 engines provided faulty information in these conditions.

It is recommended that EASA require Airbus S.A.S. to replace the pressure transducers ZRA380-00 by pressure transducers (p/n ZRA691-00 or equivalent) of A330 aircraft equipped with GE CF6-80E1 engines with such that function in conditions approved for the A330 fleet.

2. A330 abnormal procedures related to a single engine bleed air fault are displayed on the Electronic Centralized Aircraft Monitor (ECAM). Whereas, dual bleed loss-related (DBL) abnormal procedures are only printed in the Quick Reference Handbook (QRH). It is illogical to have to locate one system's abnormal procedures from two unconnected sources. Moreover, it may also make it more difficult to locate the correct abnormal procedure.

It is recommended that EASA require Airbus S.A.S. to also include Dual Bleed Loss abnormal procedures in the A330 ECAM action.

3. From the standpoint of safety investigation, the Cockpit Voice Recorder (CVR) recording is a valuable and essential instrument in investigating flight crew action and crew cooperation related to accidents and incidents. If the flight lasts longer than the CVR's recording capacity, the CVR recording from the early phase of the flight is over-recorded; cf. 1.16.8.

It is recommended that EASA and ICAO sufficiently lengthen the time recording requirement of CVRs so as to cover the entire routing of the flight.

4. Since Airbus TFUs are primarily intended for engineering divisions, the OPS ADVICE segments therein are not necessarily the correct media for the distribution of operational bulletins. Rather, they should be promulgated via communications channels intended for operational divisions.

It is recommended that Airbus S.A.S. improve the procedures of promulgating its operational bulletins by distributing them via communications channels intended for operational divisions.

4.3 Other observations and proposals

4.3.1 Proposals

On the occurrence flight of OH-LTO the flight crew did not follow the abnormal procedure promptly enough. In its flight crew training Finnair Plc should emphasise the importance of abnormal procedures and sufficiently rapid action regarding instructions therein.

On the occurrence flight of OH-LTS the third member of the flight crew was not summoned back to the cockpit during the serious incident. The investigation commission believes that the full potential of the crew should be available during emergencies so as to cope, for example, with unexpected situations and the increased workloads.

The investigation commission believes that the flight crew should have announced their emergency descent with the international distress signal (Mayday, Mayday, Mayday). In its flight crew training Finnair Plc should emphasise the importance of using the distress signal in situations when it is needed.

4.3.2 Observations

Airbus has informed SIA that the DBL procedures have been simplified and that they will be published in the QRH in 2012. The new ECAM action regarding a DBL situation will be introduced by beginning 2013.

The flight crews received sufficient weather briefing material for the occurrence flights. The operator should make enroute weather charts, and also possibly other material, more informative and easier to decipher, among other things, through the use of different colours in the depiction of temperatures.

The pressure transducer is tested as per ESTERLINE Abbreviated Component Maintenance Manual (ACMM) 36-11-08 Rev. No 2, approved by Airbus. If voltage fluctuations or surges are encountered during testing, the pressure transducer is put into a 100 °C oven for at least four hours. Investigation revealed that, contrary to the manual, Esterline-Auxitrol tested the pressure transducers that had been removed from the occurrence aircraft by only heating them for two hours instead of the four hours specified by the maintenance manual.

Helsinki, 24.7.2012

Timo Heikkilä

Pertti Kalttonen

Risto Timgren

Erja Savela

SUMMARY OF THE COMMENTS RECEIVED ON THE DRAFT FINAL REPORT

FINNISH TRANSPORT SAFETY AGENCY

The Finnish Transport Safety Agency suggested that company's actions from the OPS 1.037 viewpoint related to company's flight safety program would be examined in the investigation.

FINNAIR PLC

Finnair Plc suggested that the decisions made and actions taken by the Finnair Technical Services Ltd right after OH-LTS's event flight concerning replacing all the engines' bleed air systems' pressure transducers of the A330 aircraft operated by Finnair Plc would be added in the chapter 4.1 of the investigation report.

FINNISH METEOROLOGICAL INSTITUTE

According to the Finnish Meteorological Institute the occurrence of an extremely cold air mass, such as the one that prevailed on OH-LTO's flight, is exceptional. The air mass on OH-LTS's flight was cold but not exceptional.

BEA, AIRBUS AND ESTERLINE-AUXITROL

BEA sent their comments on the draft Final Report of the investigation report. The comments also included comments from Airbus and Esterline-Auxitrol.

BEA considered that the operational aspects had not been sufficiently addressed in the report. To complete the operational aspects BEA suggested adding the following into the report: Summary of flight crews' statements, ECAM instructions related to the event, detailed history of flights based on FDR data description (made by BEA) and Finnair Plc's technical info on the company's Crew Information System (CIS) made by the company's Airbus fleet chief after OH-LTO's event flight. BEA emphasized the significance of the Excessive Cabin Altitude warning on the event flights and suggested that it would be raised more in the parts of the investigation report that deal with the history of the flights as well as in the summary and the synopsis.

According to BEA OH-LTO's and OH-LTS's serious incidents are not the same from an operational perspective. OH-LTO's flight crew did not initiate the descent from cruise level at the time required by operational procedures. The start of descent was initiated more than five minutes after the loss of pressurization (DBL) and more than two minutes after the Excessive Cabin Altitude warning had come ON. OH-LTS's flight crew in turn initiated the descent from cruise level about two minutes after the loss of pressurization (DBL). Excessive Cabin Altitude warning came ON during the descent.

In the summary and the chapters 1.17.1 and 2.5.1 of the investigation report BEA defined matters and added facts related to previous dual bleed losses on A330 aircraft, due to overpressure in engines' bleed air system during cruise/descent.

On OH-LTO's history of flight (chapter 1.1.1) BEA commented that according to the FDR data, the high pressure value, approximately 220 psi at the highest, observed by the flight crew was reached only about 10 minutes after the loss of the second engine's bleed air system.

Appendix 1

In the chapter 1.11 BEA and Airbus specified A330 aircraft CVR operation and stopping logic, for example that recording on the ground always provides that electrical supply is maintained.

Concerning the start of APU bleed (chapter 1.16.1) BEA stated that in case the flight crew sets the APU bleed to ON, the BMC commands the closure of the PRVs. If conditions allow, BMC opens the cross bleed valve to enable the supply of the two air conditioning packs. In addition to this BEA mentioned that flight crew can manually close the PRV from the cockpit.

In chapter 1.16.2 BEA specified that according to the manufacturer of the pressure transducer, in case of presence of moisture in the pressure cell, the second version has been more sensitive to the subject freezing related failures than the other versions. In the same chapter BEA specified also the description of the pressure transducer's operation.

Related to the chapter 1.16.3 of the investigation report, Airbus indicated that the actions performed by the technical personnel at Kuopio airport after OH-LTO's event flight are not mentioned in Airbus published maintenance procedures.

In the chapter 1.1.6.3 it is also mentioned that a couple of small water droplets were found at the pressure port area of OH-LTO's right engine bleed air system's pressure transducer Pr. BEA emphasized on its comments that the water droplets were found inside the Pr at the pressure port area, not in the pressure cell room, which is not externally visible.

In the chapter 2.1 of the investigation report BEA commented that comparison of pressure transducers' Pt and Pr values cannot allow BMC to choose which value is correct. In addition BEA commented that the tests performed by Airbus and Esterline-Auxitrol have concluded on the root cause being at pressure transducer Pr level and that no link was established between water condensation in the sense lines and the subject occurrence.

In the chapter 2.2. of the investigation report BEA commented that the tests performed by Airbus and Esterline-Auxitrol have concluded on the root cause linked to the necessary presence of water between the grid and the metallic membrane, freezing conditions and a temperature increase below freezing conditions. Due to the necessary contributors mentioned above, moisture condensation on its own may not lead to the observed faults. According to Airbus following the change of the grid, the pressure port redesign, and thanks to the attitude of the pressure transducers, when installed on the aircraft condensed water will be naturally drained from the third pressure transducer version.

Related to the chapter 2.3.2 of the investigation report BEA commented that the Excessive cabin altitude warning came on during the descent. This is an emergency situation, which requires an emergency descent. In addition BEA mentioned that A330 aircraft is certified to be operated by two pilots.

In the chapter 2.5.1 of the investigation report BEA stated that according to TFU it appears that Airbus reported DBL issue as soon as they had some hypothesis on the root cause of the failure mode. In addition, according to BEA the relatively low number of DBL with this failure mode compared to fleet flight hours could explain the timeframe to deal with such issue.

Appendix 1

BEA also mentioned that it is not the purpose of a safety investigation authority to suggest solutions but to identify issues to be solved by civil aviation authority or manufacturer to improve overall safety.

In the conclusions BEA specified the same subjects as elsewhere in the investigation report.

Concerning the first safety recommendation BEA commented that DBL is classified as Major according to EASA CS25.1309. The occurrence frequency of DBL seems consistent with this classification and DBL occurrences have not lead to any more serious safety issues. In addition actions already taken by Airbus mitigate the risk of DBL.

EUROPEAN AVIATION SAFETY AGENCY

European Aviation Safety Agency suggested a small change and more accuracy in the first safety recommendation so that the engines' bleed air system's pressure transducers' part numbers (p/n) and the engine type, to which the recommendation applies, would be mentioned in the recommendation.

FINAVIA CORPORATION

Finavia Corporation had no comments.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

International Civil Aviation Organization had no comments.

All the received comments have been taken into account in the final investigation report.

HISTORY OF OH-LTO'S FLIGHT BASED ON FDR DATA**Source: BEA**

A330-300 Finnair OH-LTO
History of flight from FDR - 12/11/2010

UTC time	Standard altitude (ft) Indicated airspeed (kt) or Mach	Static Air Temperature (°C)	Events			
10 h 34 min 23	39700 0.80	-61	AP1, FD1, FD2, ATHR are engaged. <table><tr><td>MACH</td><td>ALT CRZ</td><td>NAV</td></tr></table> Engine 2 PRV is closed. Engine 2 Pr is 61 psi, increasing.	MACH	ALT CRZ	NAV
MACH	ALT CRZ	NAV				
10 h 34 min 26	39700 0.80	-61	Engine 2 Bleed Fault ON. ECAM Bleed page is displayed.			
10 h 34 min 43	39700 0.80	-61	Engine 2 Bleed P/B OFF.			
10 h 37 min 37	39700 0.80	-61	Engine 1 PRV is closed. Engine 1 Pr is 63 psi, increasing.			
10 h 37 min 45	39700 0.80	-61	Engine 1 Bleed Fault ON. ECAM Bleed page is displayed.			
10 h 38 min 39	39700 0.80	-60	Engine 2 Bleed P/B ON.			
10 h 39 min 55	39700 0.80	-59	ECAM Cabin Pressure page is displayed.			
10 h 40 min 23	39700 0.80	-58.5	Excess Cabin Altitude warning ON.			
10 h 43 min 03	39700 0.80	-58	Emergency descent is initiated. Selected altitude is 10800 ft. Selected speed is 310 kt. <table><tr><td>THR IDLE</td><td>OP DES</td><td>HDG</td></tr></table>	THR IDLE	OP DES	HDG
THR IDLE	OP DES	HDG				
10 h 43 min 36	38550 0.80	-57.5	Speed brakes are commanded.			
10 h 43 min 39	38400 0.80	-57.5	Engine 2 Bleed P/B OFF.			
10 h 43 min 41	38250 0.80	-57.5	Engine 1 Bleed P/B OFF.			
10 h 44 min 35	31700 0.83	-53.5	Vertical speed reaches a minimum of -9650 ft/min.			
10 h 47 min 25	13450 310	-27	<table><tr><td>SPEED</td><td>ALT*</td><td>HDG</td></tr></table>	SPEED	ALT*	HDG
SPEED	ALT*	HDG				
10 h 47 min 34	12550 314	-24.5	Speed brakes are not commanded.			
10 h 47 min 39	12100 315	-24	Selected speed is 299 kt.			
10 h 47 min 44	11800 319	-23.5	Indicated airspeed reaches a maximum of 319 kt.			
10 h 48 min 32	10850 298	-21.5	<table><tr><td>SPEED</td><td>ALT</td><td>HDG</td></tr></table>	SPEED	ALT	HDG
SPEED	ALT	HDG				

Appendix 2

10 h 48 min 45	10800 299	-21.5	Selected speed is 270 kt.		
10 h 51 min 29	10800 270	-22	Selected speed is 260 kt.		
10 h 52 min 03	10800 261	-22.5			
10 h 53 min 43	10800 260	-22.5	Engine 1 Pr reaches a maximum of 240 psi.		
10 h 56 min 08	10800 260	-23	Engine 1 Pr is 0 psi.		
10 h 56 min 30	10800 260	-23	Engine 2 Pr reaches a maximum of 233 psi.		
11 h 01 min 21	10800 260	-23.5	Engine 2 Pr is 0 psi.		
11 h 58 min 48	11000 270	-27	Engine 1 Pr increases up to 10 psi, and then up to 14 psi till the end of the flight.		
12 h 06 min 56	8550 250	-21	Excess Cabin Altitude warning OFF.		
12 h 15 min 35			Landing.		

HISTORY OF OH-LTS'S FLIGHT BASED ON FDR DATA

Source: BEA

A330-300 Finnair OH-LTS History of flight from FDR – 12/22/2010

UTC time	Standard altitude (ft) Indicated airspeed (kt) or Mach	Static Air Temperature (°C)	Events		
18 h 25 min 57	38100 0.81	-65.5	AP1, FD1, FD2, ATHR are engaged.		
			MACH	ALT CRZ	NAV
			Engine 1 PRV is closed. Engine 1 Pr is 54 psi, increasing.		
18 h 26 min 01	38100 0.81	-65.5	Engine 1 Bleed Fault ON. ECAM Bleed page is displayed.		
18 h 26 min 16	38100 0.81	-65.5	Engine 1 Bleed P/B OFF.		
18 h 26 min 31	38100 0.81	-65.5	X Bleed Valve is opened.		
18 h 26 min 36	38100 0.81	-65.5	Engine 1 Pr reaches 60 psi.		
18 h 38 min 05	38100 0.81	-63.5	Engine 2 PRV is closed. Engine 2 Pr is 57 psi, increasing.		
18 h 38 min 09	38100 0.81	-63.5	Engine 2 Bleed Fault ON. ECAM Bleed page is displayed.		
18 h 38 min 47	38100 0.81	-63.5	X Bleed Valve is closed.		

Appendix 2

18 h 38 min 49	38100 0.81	-63.5	Engine 1 Bleed P/B ON.		
18 h 39 min 05	38100 0.81	-63	Engine 1 Bleed P/B OFF.		
18 h 39 min 29	38100 0.82	-62.5	ECAM Cabin Pressure page is displayed.		
18 h 40 min 16	38100 0.81	-62.5	Descent is initiated. Selected altitude is 14000 ft. Airspeed is managed.		
			MACH	DES	NAV
18 h 40 min 24	38000 0.81	-62.5	Selected Altitude is 17700 ft.		
18 h 40 min 41	37750 0.81	-63	Speed brakes are commanded.		
18 h 40 min 42	37750 0.81	-63	Selected altitude is 17700 ft. Airspeed is managed.		
			THR IDLE	OP DES	NAV
18 h 40 min 59	37050 0.81	-63.5	Airspeed is selected. The value is set to 272 kt, and then increases progressively.		
18 h 41 min 28	34150 0.82	-62	Excess Cabin Altitude warning ON.		
18 h 42 min 16	28800 0.78	-51	Selected speed is 319 kt.		
18 h 42 min 34	26600 0.76	-47	Vertical speed reaches a minimum of - 8750 ft/min.		
18 h 43 min 10	22600 321	-37	Speed brakes are not commanded.		
18 h 43 min 15	22100 321	-35.5	APU Bleed P/B ON.		
18 h 43 min 22	21550 322	-34	APU Bleed Valve is opened.		
18 h 43 min 24	21400 323	-33.5	Indicated airspeed reaches a maximum of 323 kt.		
18 h 43 min 33	20950 323	-32	X Bleed Valve is opened.		
18 h 44 min 34	18450 319	-26.5	SPEEDALT*NAV		
18 h 45 min 06	17700 317	-25	SPEEDALTNAV		
18 h 45 min 35	17700 319	-25	Excess Cabin Altitude warning OFF.		
18 h 48 min 06	17700 319	-25	Engine 1 Pr reaches a maximum of 236 psi.		
18 h 49 min 03	17700 319	-25	Airspeed is managed. The value is set to 271 kt.		
18 h 49 min 37	17700 296	-24.5	Engine 2 Pr reaches a maximum of 229 psi.		
18 h 50 min 21	17700 271	-25	X Bleed Valve is closed.		

Appendix 2

18 h 50 min 24	17700 271	-25	Engine 1 Pr drops to 18 psi.		
18 h 52 min 01	17700 272	-25	Engine 2 Pr drops to 0 psi.		
18 h 52 min 07	17700 272	-25	Selected altitude is 21700 ft. Airspeed is managed to 271 kt.		
			THR CLB	OP CLB	NAV
18 h 53 min 30	20900 272	-32			
			SPEED	ALT*	NAV
18 h 54 min 04	21650 272	-34			
			SPEED	ALT	NAV
19 h 37 min 21	21700 273	-37.5	Engine 2 Bleed P/B OFF.		
19 h 38 min 02	21700 270	-38	Engine 1 Bleed P/B ON.		
19 h 38 min 04	21700 273	-38	Engine 1 Bleed Fault OFF.		
19 h 38 min 41	21700 268	-38	Engine 2 Bleed P/B ON.		
19 h 38 min 42	21700 268	-38	Engine 2 Bleed Fault OFF.		
19 h 38 min 45	21700 268	-38	Engine 2 PRV is opened. Engine 2 Pr increases up to 45 psi.		
19 h 39 min 06	21700 265	-38.5	APU Bleed P/B OFF.		
19 h 39 min 13	21700 265	-38.5	APU Bleed Valve is closed. Engine 1 PRV is opened. Engine 1 Pr increases up to 47 psi.		
20 h 13 min 53			Landing.		

QRH ABNORMAL PROCEDURES AIR DUAL BLEED FAULT

A330 	ABNORMAL PROCEDURES	REV 26	2.24
		SEQ 200	

AIR DUAL BLEED FAULT■ **If ENG 1 BLEED was lost due to a :**

LEAK on side 1

ENG 1 FIRE

Start Air Valve 1 failed open.

Overpressure with bleed valve 1 failed open

APU BLEED LEAK FED BY ENGINE

– DESCENT TO FL100/MEA INITIATE

Descend rapidly to FL100/MEA, with full speedbrakes, to prevent excessive cabin altitude.

AVOID ICING CONDITIONS

● **IF ICE ACCRETION :**

– APPR SPD VLS + 10 KT

– LDG DIST PROC APPLY

Refer to the QRH Part 2.■ **If ENG 2 BLEED was lost due to a :**

LEAK on side 2

ENG 2 FIRE

Start Air Valve 2 failed open.

Overpressure with bleed valve 2 failed open

– X BLEED CHECK CLOSED

– DESCENT TO FL220/MEA INITIATE

Descend rapidly to FL220, with full speedbrakes, to recover the bleed supply from the APU.

– APU START

Start the APU during the descent.● **AT, OR BELOW, FL220 :**

– WING A.ICE OFF

APU BLEED must not be used for wing anti-ice.

– APU BLEED ON

MAX FL220

AVOID ICING CONDITIONS

● **IF ICE ACCRETION :**

– APPR SPD VLS + 10 KT

– LDG DIST PROC APPLY

Refer to the QRH Part 2.

A330 FINNAIR 	ABNORMAL PROCEDURES	REV 26	2.25
		SEQ 001	

AIR DUAL BLEED FAULT (CONT'D)

■ **In all other cases :**

- DESCENT INITIATE
Descend rapidly to FL220, with full speedbrakes, so that the bleed supply may be supplied by the APU, if the bleed system recovery is not successful.

● **If both packs are available :**

If both packs are operative, it can be suspected that the second bleed system failed due to excessive demand. Recovery of the second failed engine bleed may be attempted.

■ **If ENG 1 BLEED is lost first :**

- PACK 1 OFF
- ENGINE 2 BLEED ON

■ **If ENG 2 BLEED is lost first :**

- PACK 2 OFF
- ENGINE 1 BLEED ON

● **If engine bleed recovery was not successful, or if one pack is inoperative :**

- X BLEED CHECK OPEN
- DESCENT TO FL220/MEA CONTINUE
Descend rapidly to FL220, with full speedbrakes, to recover the bleed supply from the APU.
- APU START
Start the APU during the descent.

● **AT, OR BELOW, FL220 :**

- WING A.ICE OFF
APU BLEED must not be used for wing anti-ice.
 - APU BLEED ON
- MAX FL220

AVOID ICING CONDITIONS

● **IF ICE ACCRETION :**

- APPR SPD VLS + 10 KT
- LDG DIST PROC APPLY

Refer to the QRH Part 2.

R
R
R
R
R

ECAM PROCEDURE AIR ENG 1(2) BLEED FAULT**AIR ENG 1(2) BLEED FAULT**

This Topic is relevant to the whole fleet

This caution appears in case of overheat, overpressure or low pressure.

-ENG BLEED affected (if not automatically closed)

OFF

The ENG BLEED is not automatically closed in case of LO PR.

The FAULT It extinguishes when the failure disappears (overheat or overpressure).

PACK FLOW is limited to 80 %.

STATUS

INOP SYS

ENG 1 (2) BLEED

AIR ABNORM BLEED CONFIG

Refer to associated procedure.

Appendix 4

ECAM PROCEDURE AIR ABNORMAL BLEED CONFIG

<u>AIR</u> ABNORM BLEED CONFIG

This Topic is relevant to the following aircraft: 994, 1007, 1013, 1023, 1067, 1078

At least one BLEED system is faulty, off, or not supplied.

- If BLEED is abnormally selected off :

ENG 1(2) BLEED OFF

- IF BLEED NOT RECOVERED

-X BLEED

CLOSE or OPEN

CLOSE, if :

- LEAK, or
- ENG FIRE (detected, or FIRE pushbutton pressed), or
- Engine start valve failed open, or
- Overpressure with bleed valve failed open.

OPEN in all other cases.

- X BLEED OPEN

- If WING A. ICE off, and no engine failed :

-PACK FLOW

LO

Pack flow is limited to 80 %

-FWD CRG COOLING

OFF

- If WING A. ICE on or one engine failed :

-PACK (affected side if opposite pack healthy)

OFF

Note : If the pack is switched off following an engine shutdown, it may be recovered, provided performance permits and wing anti-ice is selected off.

STATUS

INOP SYS

ONE PACK ONLY IF WAI ON

ENG 1 (2) BLEED
FWD CRG TEMP

PACK 1 (2)
(if selected off)

■ X BLEED CLOSE

-WING A. ICE

OFF

AVOID ICING CONDITIONS

Note : APU BLEED must not be used for wing anti-ice purposes, or after ENG 1 FIRE.

STATUS

● IF ICE ACCRETION :

INOP SYS

-APPR SPD VLS + 10 KT

-LDG DIST PROC APPLY

Refer to the QRH Part 2, or to the

FCOM 3.02.80.

WING A. ICE
ENG 1 (2) BLEED
FWD CRG TEMP
PACK 1(2)

Appendix 4

ECAM PROCEDURE CAB PR EXCESS CAB ALT

	<u>CAB PR</u> EXCESS CAB ALT	
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This Topic is relevant to the whole fleet

Rely on the

CAB PR

EXCESS CAB ALT warning even if not confirmed on the CAB PRESS page. This warning can be triggered by a cabin pressure sensor different from the one used to control the pressure and display the cabin altitude on the SD.

-CREW OXY MASK (if above FL 100) ON

- If above FL 100, and under FL 160 :

-DESCENT INITIATE

-MAX FL 100/MEA

- If above FL 160 :

-SIGNS ON

EMER DESCENT

-DESCENT INITIATE

-THR LEVERS (if A/THR not engaged) IDLE

-SPD BRK FULL

-SPD MAX/APPROPRIATE

Descend at maximum appropriate speed. However, if structural damage is suspected, use the flight controls with care and reduce speed as appropriate.

Landing gear may be extended below 21 000 feet. In this case, speed must be reduced to VLO/VLE.

-ENG START SEL IGN

-ATC NOTIFY

Notify ATC of the nature of the emergency and state intentions.

If ATC cannot be contacted, select ATC code A7700, or transmit a distress message on one of the following frequencies :

(VHF) 121.5 MHz, or (HF) 2182 KHz, or 8364 kHz.

Note : To save oxygen, set the oxygen diluter selector to the N position. With the

oxygen diluter selector set to 100 %, oxygen quantity may not be sufficient for the entire descent profile. Ensure that the flight crew can communicate wearing oxygen masks. Avoid continuous use of the interphone to minimize the interference from the noise of the oxygen mask. When descent is established and if time permits, check that the OUTFLOW VALVES are closed on the CAB PRESS ECAM page. If they are not closed and ΔP is positive, select manual control and the V/S CTL switch to full down.

-MAX FL

100/MEA

- IF CAB ALT > 14 000 FT :

-PAX OXY MASKS

MAN ON

This action confirms that the passenger oxygen masks are released.

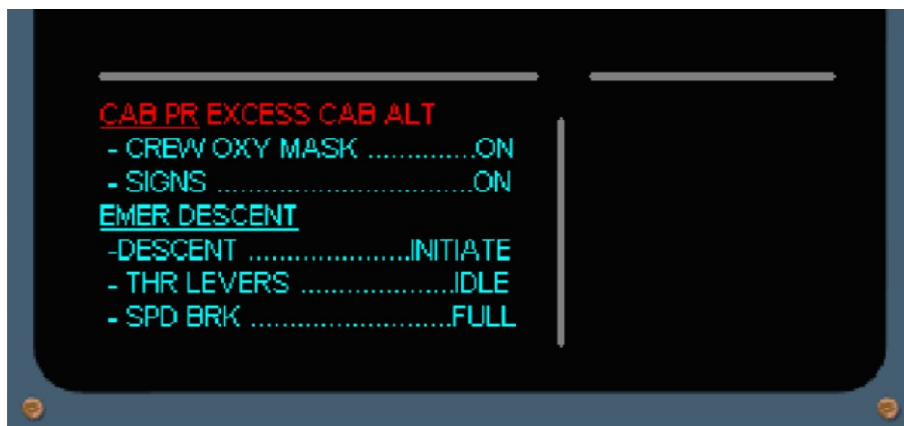
Note : Notify the cabin crew, when the aircraft reaches a safe flight level, and when cabin oxygen is no more necessary.

STATUS

MAX FL

100/MEA

ECAM DISPLAY CAB PR EXCESS CAB ALT



FINNAIR'S CREW INFORMATION SYSTEM (CIS) TECHNICAL INFO CONCERNING OH-LTO'S DUAL BLEED LOSS. (TRANSLATION OF THE ORIGINAL FINNISH INFO)

OH-LTS's flight crew had the information given by this CIS technical info on their flight.

Here is Technical Services' short description of the event and an initial analysis of the reasons that lead to the event. OH-LTO lost both engines' bleed air systems due to a fault. It is very highly likely that the fault was caused by moisture that had accumulated in the bleed air system's pressure transducer and had frozen during the flight at high altitude. As moisture froze the pressure transducer indicated too high pressure value. As a consequence, BMC closes the system's pressure regulating valve (PRV) and BLEED # FAULT appears on ECAM. In OH-LTO's case the pressure values on SD were 120–230 psi. If pressure was actually this high, system's overpressure valve (OPV) would close as well. OPV is fully pneumatically controlled and not influenced by the operation of the BMC. The system has also another similar pressure transducer (transferred pressure transducer) which measures the pressure between high pressure valve (HPV) and PRV.

All the four pressure transducers of OH-LTO have been replaced. After that similar problems have not occurred. Visible moisture was found in the removed regulated pressure transducers.

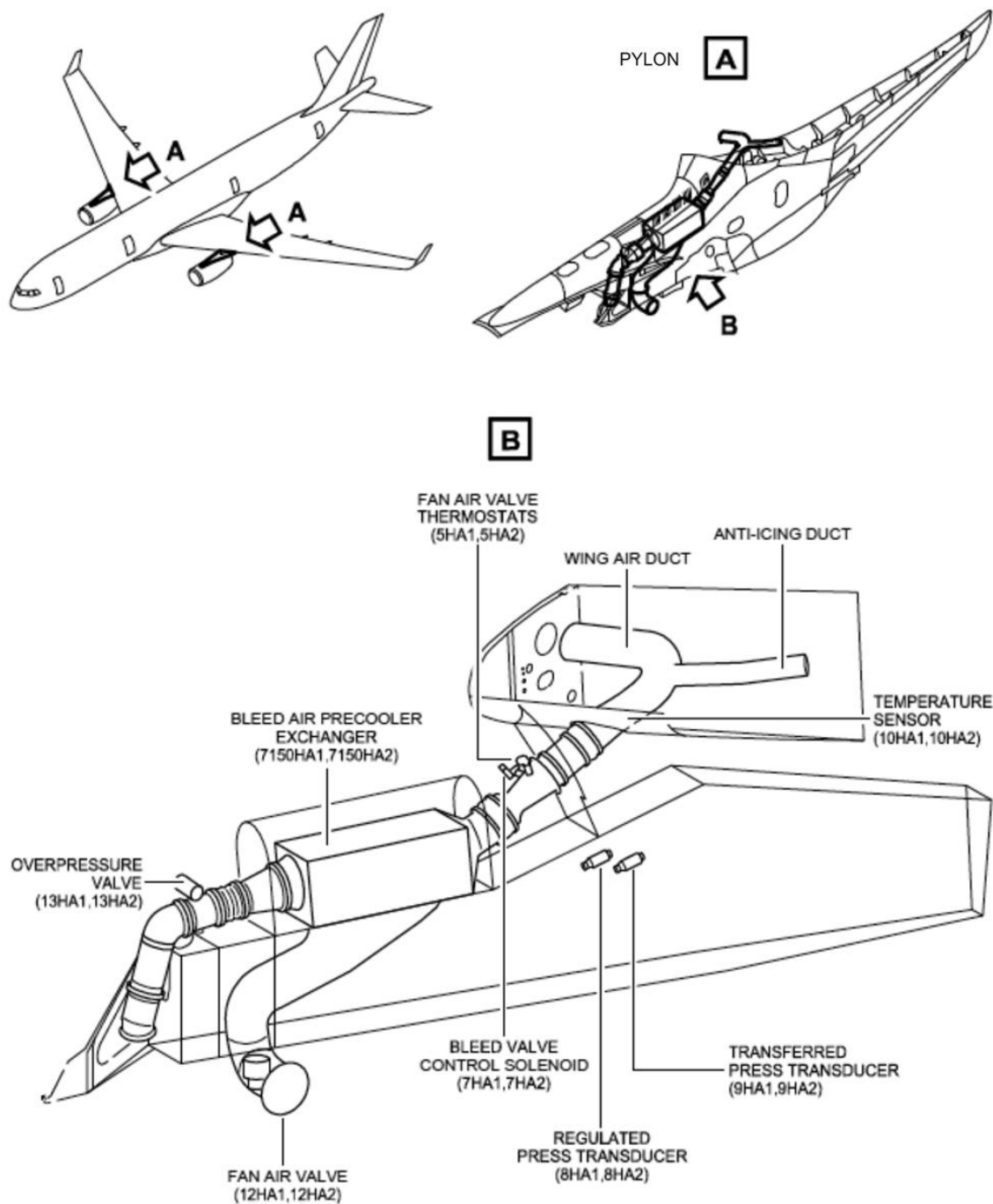
Similar occurrences have been experienced by other A330 operators as well. There is no need to be especially concerned because of this issue, but however be alert.

Technical Services will check all the pressure transducers of the A330 aircraft during the next few days.

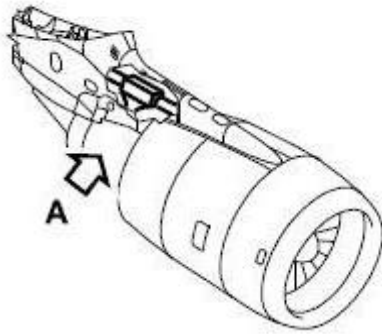
16.12.2010 18:43

A330 ENGINE BLEED AIR SYSTEM COMPONENTS

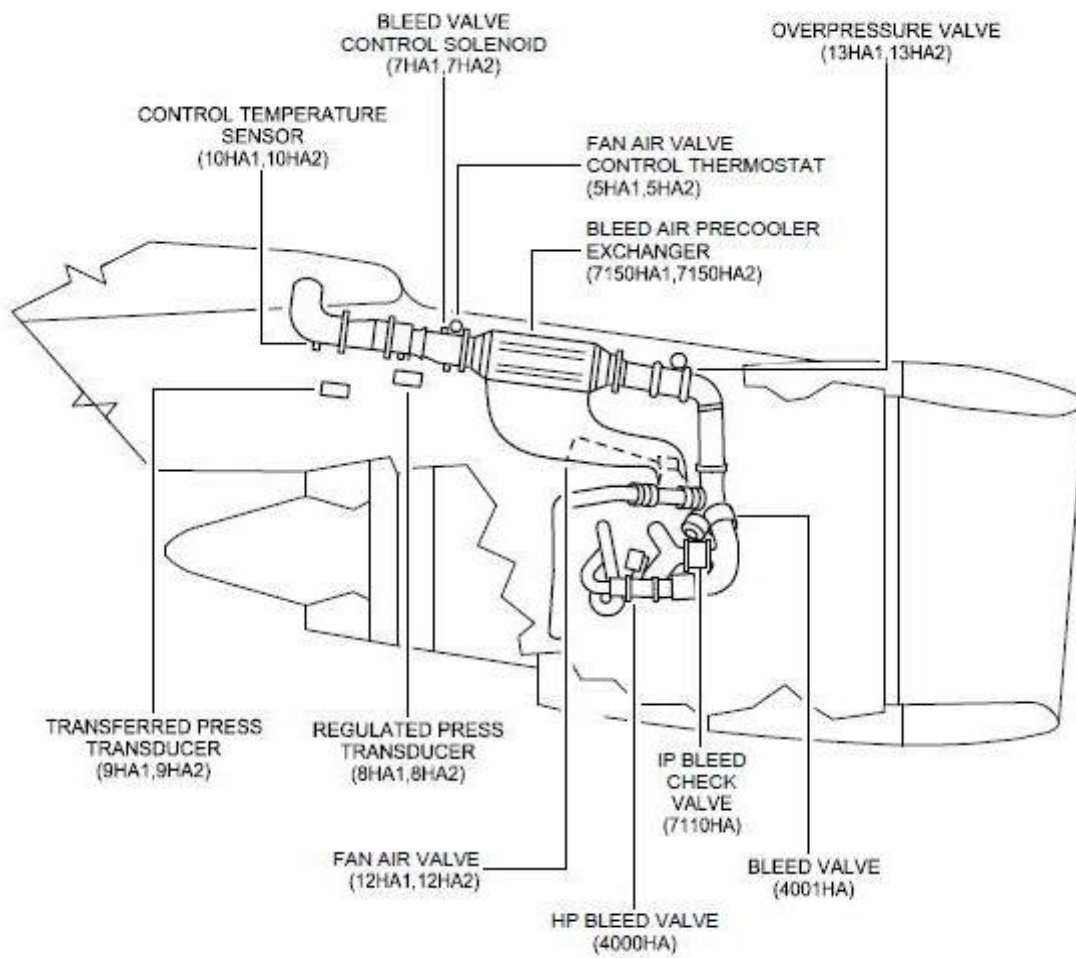
Source: Aircraft Maintenance Manual



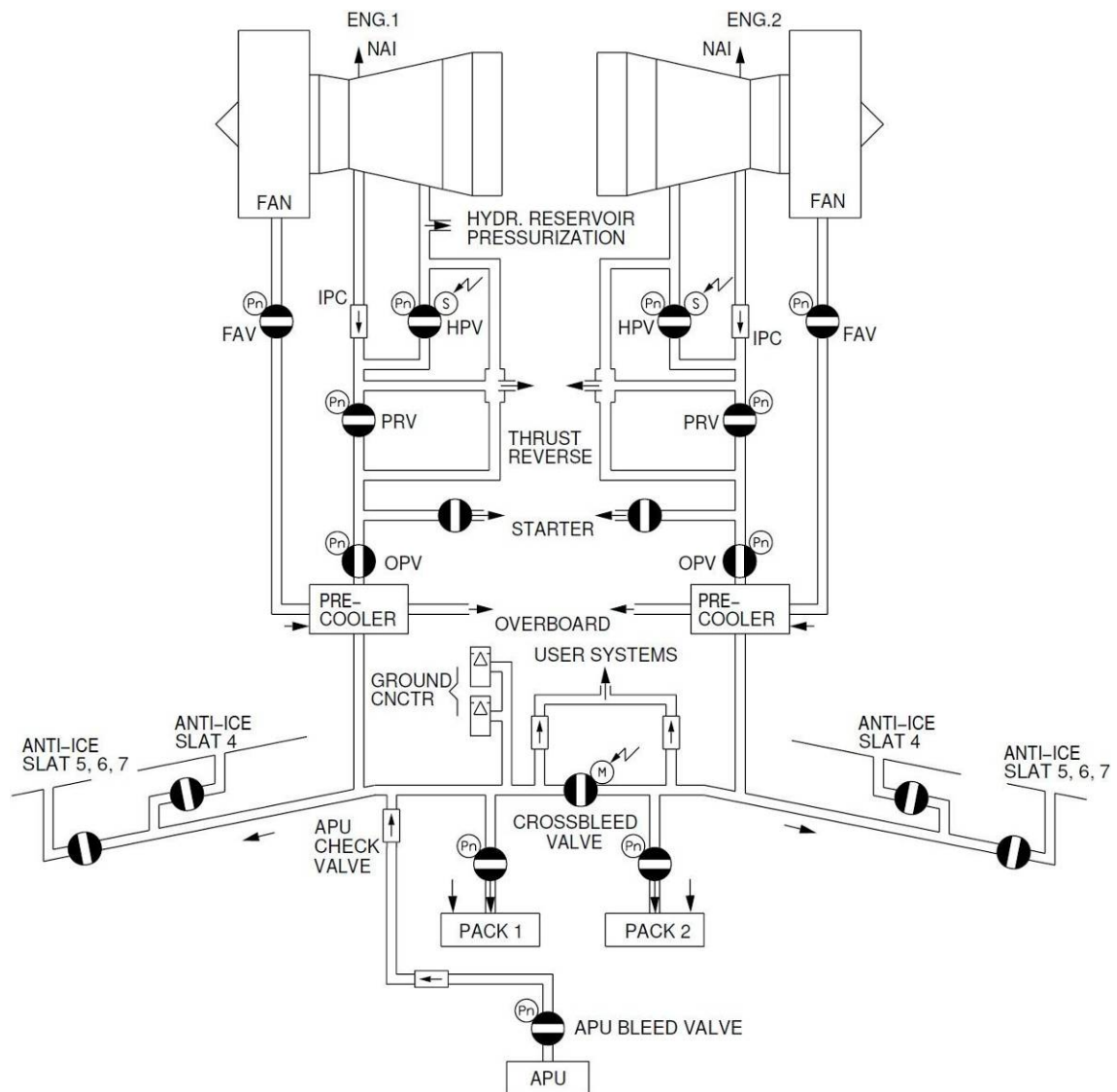
Appendix 6



A

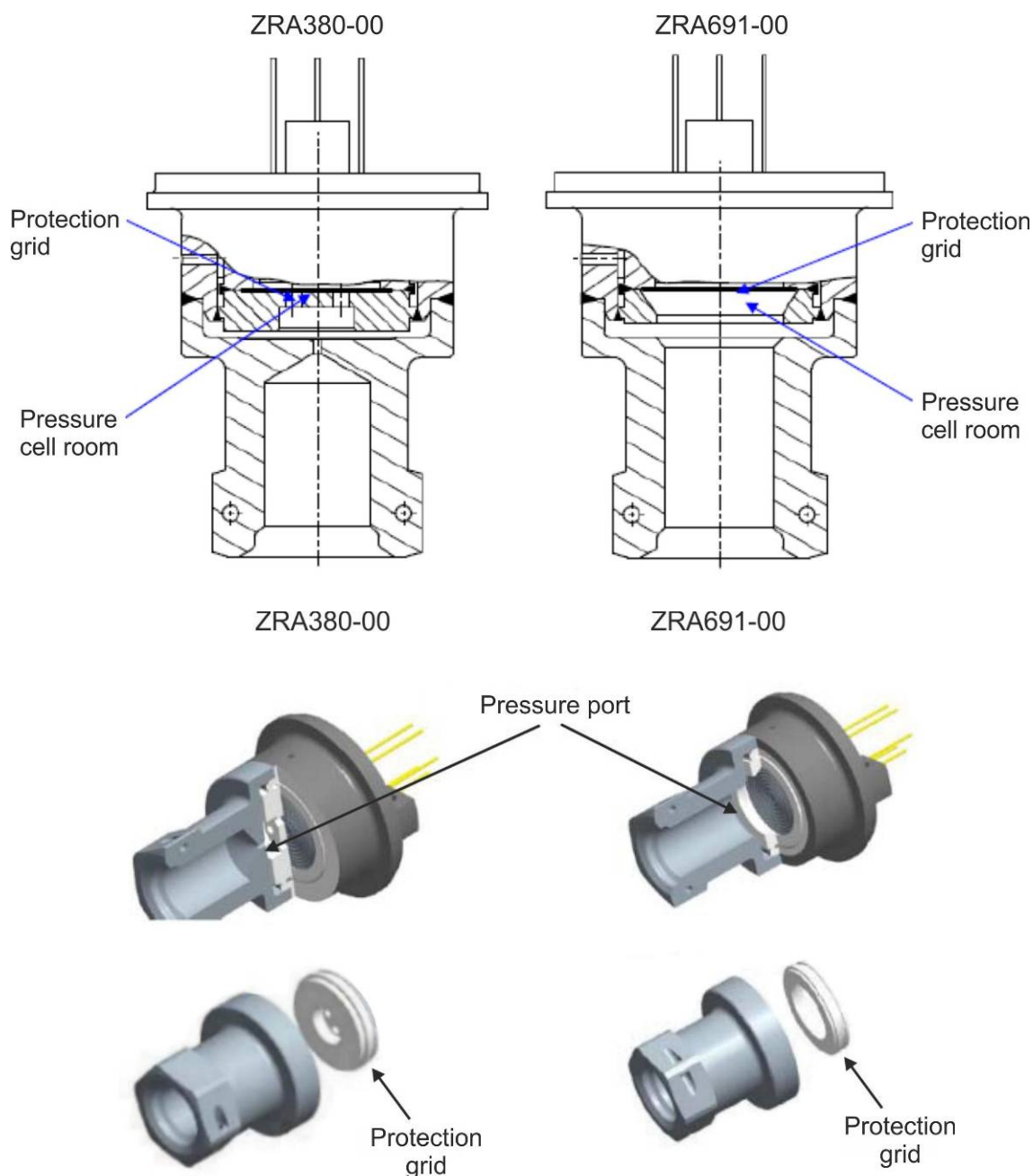


THE SCHEMATIC OF THE A330 BLEED AIR SYSTEM



STRUCTURAL DIFFERENCES BETWEEN PRESSURE TRANSDUCERS P/N ZRA380-00 AND ZRA691-00

The third pressure transducer version, p/n ZRA691-00, was designed and manufactured by modifying p/n ZRA380-00, the second version. Their essential differences lie in the protection grid as well as the pressure cell room between the grid and the metallic membrane. In order to avert blockage caused by ice build-up, the four small holes in version no. 2 are no longer present in the third version. They are replaced by one large hole. Whereas the height of the second version's pressure cell room is 0.17 mm, it is 5.2 mm in the third version.



These schematics are the property of Auxitrol SA and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol SA. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol SA and is considered proprietary of Auxitrol SA.

PHOTOGRAPHS OF THE PRESSURE TRANSDUCERS TESTED AT ESTERLINE-AUXITROL



Pressure transducers removed from OH-LTO's left engine; s/n ASA12735 on the left and s/n 188 on the right.



Pressure transducers removed from OH-LTO's right engine; s/n ASA12571 on the left and s/n ASA12736 on the right.



Pressure transducer s/n ASA14074 removed from OH-LTS's left engine.

These schematics are the property of Auxitrol SA and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol SA. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol SA and is considered proprietary of Auxitrol SA.

Appendix 9

OUTPUT SIGNAL STABILITY TESTS AT ESTERLINE-AUXITROL

The figures⁶ presenting Esterline-Auxitrol's output signal stability test results are on the following page. The vertical axis (T,U) represents temperature and voltage. The longitudinal axis (t) represents time. The figure on the left shows the results of a test before the oven treatment and the figure on the right after the oven treatment.

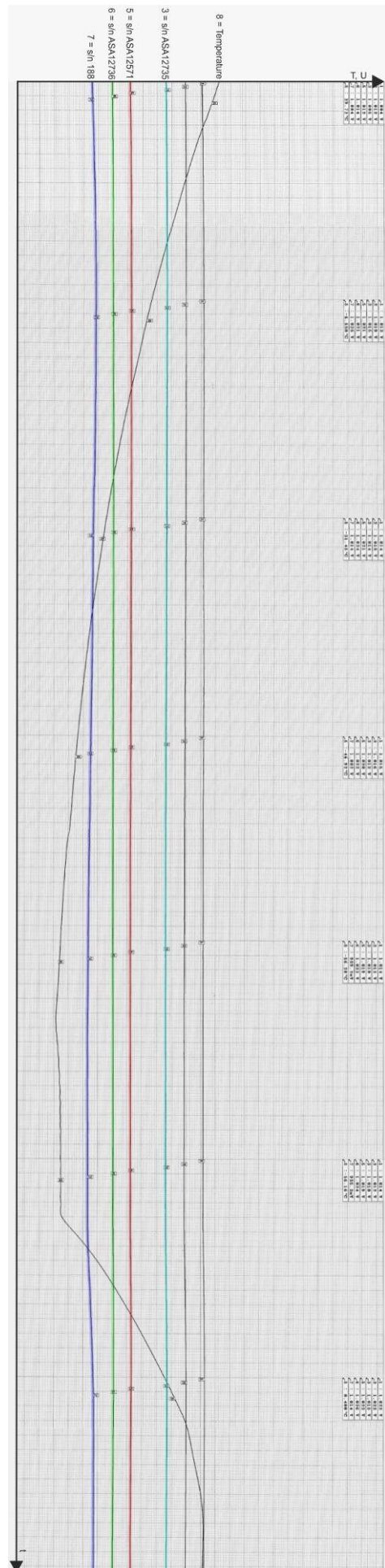
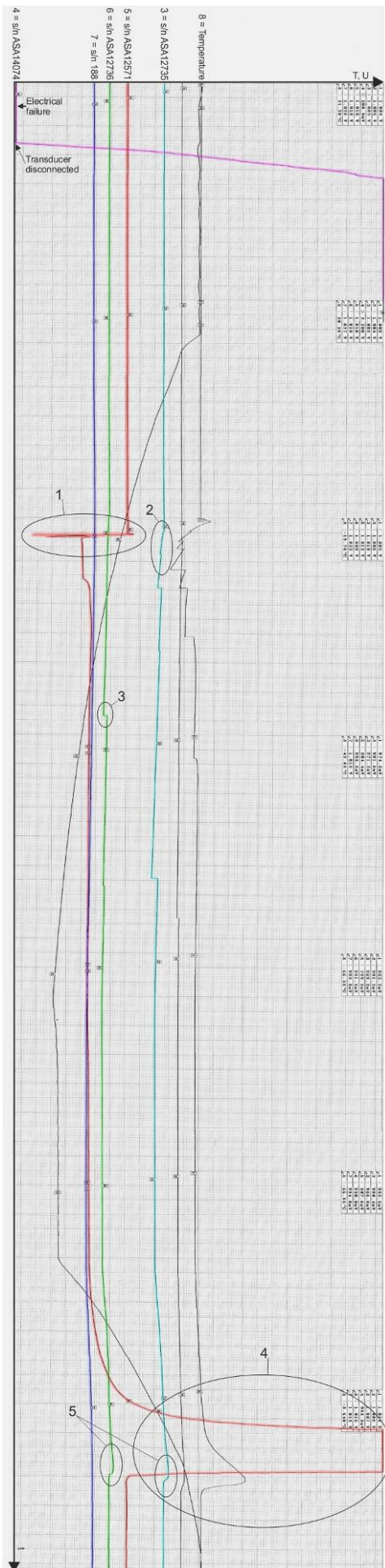
The figure on the left contains eight curves whereas the right one contains seven curves. The curves are numbered. Curves 1 and 2 are not related to this investigation. Curves 3-7 are associated with the pressure transducers in this investigation as follows: 3 = s/n ASA12735, 4 = s/n ASA14074, 5 = s/n ASA12571, 6 = s/n ASA12736 and 7 = s/n 188 (first version). Curve 8 shows the temperature of the testing chamber. Since pressure transducer s/n ASA14074 had an electric fault and, hence, was excluded from the test, its curve is not shown on the figure on the right.

The following is a detailed explanation of the circled spots 1-5 on the left graph as per Esterline-Auxitrol's report, taking into account the output signal stability test after the oven treatment:

1. Bubble (1) ASA12571: When the test chamber is around -20 °C, the water inside the pressure port freezes which affects the output signal. In this case the output signal was typical with a small peak followed by several saw tooth-shaped dips. Then, during the exposure at low temperature the output signal was not compliant due to its negative offset around 200 mV.
2. Bubbles (2) ASA12735: At the same temperature we can also note an output signal variation, albeit less than in s/n ASA12571. At any rate, the behaviour was not normal indicating the presence of water inside the pressure port. During the exposure at low temperature the output signal was still within tolerances.
3. Bubbles (3) ASA12736: At the same temperature we can note a very small drop in the output signal and at around -40 °C the variation is more important, even if it is less than that of the other transducer. Nonetheless, the behaviour was not normal, indicating the presence of water inside the pressure port. During the exposure at low temperature the output signal was still within tolerances.
4. Bubble (4) ASA12571: When the test chamber was around -8 °C, the water inside the pressure port was frozen (blocking the metallic membrane displacement) and the pressure cell generated a self pressure (due to the different expansion coefficients of the materials composing the pressure cell), which very quickly exceeded the alarm threshold fixed at 60 psi (4.13 bar), continuing for at least 15 seconds. The onset of this phenomenon occurred around -30 °C but with a very slight ramp up. Then when the chamber temperature reached +14 °C, the temperature of the pressure cell increased to approximately 0 °C (thermal inertia between chamber and transducer), reaching the melting point of water and resulting in the release of the previously generated self pressure. Therefore, the transducer's output signal returned to normal.
5. Bubble (5) ASA12735 & ASA12736: Regarding these transducers only a small increase in the output signal was noted, followed by a small and rapid drop below the threshold. This confirms the presence of water inside the pressure port, however, not enough to generate a warning in the aircraft. As described above, perhaps the water had partially disappeared during the removal and/or transportation of the transducers.

⁶ These schematics are the property of Auxitrol SA and may not be copied, used or disclosed for any Purpose other than the A330 Bleed Transducer redesign presentation, without the prior written approval of Auxitrol SA. The information contained within these schematics is subject to patents and possible patent applications in the name of Auxitrol SA and is considered proprietary of Auxitrol SA.

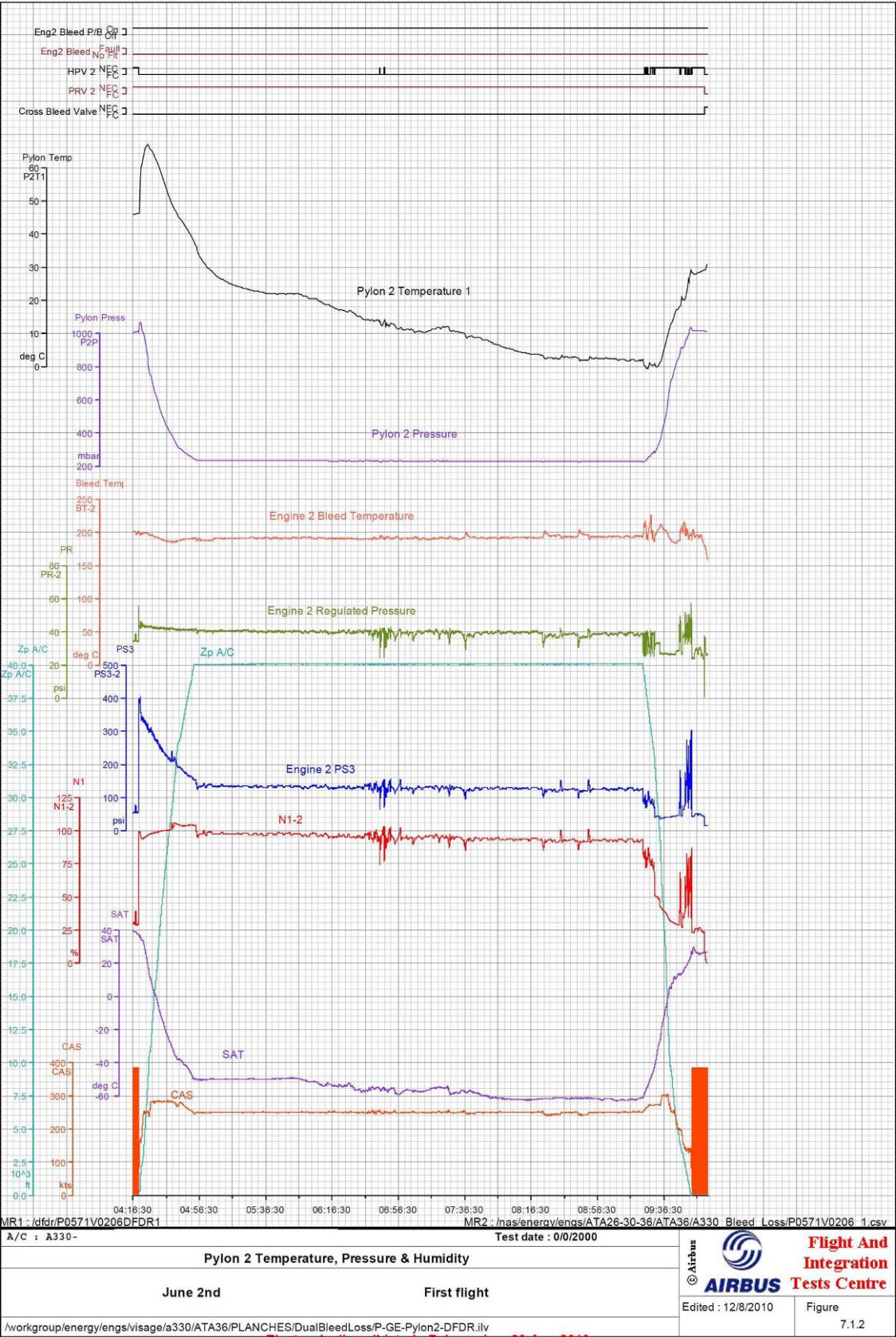
Appendix 9



AIRBUS TEST FLIGHT RESULT GRAPHS

A330 - ATA 36 - Dual Bleed Loss Investigation

G3600TRA101938



OPERATOR INFORMATION TELEX, REF: SE 999.0015/11 REV 01, 25.8.2011

Subject: DUAL BLEED LOSS (DBL) ACTION PLAN

FROM : AIRBUS CUSTOMER SERVICES TOULOUSE

OPERATOR INFORMATION TELEX - OPERATOR INFORMATION TELEX

TO: ALL A330 OPERATORS

SUBJECT: ATA36 - Dual Bleed Loss (DBL) action plan.

OUR REF.: SE 999.0015/11 REV 01 dated 25 Aug 2011, OUR PREVIOUS REF.: SE 999.0015/11 dated 16 Feb 2011.

OIT Classification: MAINTENANCE ADVICE

REFERENCED DOCUMENTS:

REF.1: TFU 36.11.00.065 DUAL BLEED LOSS OVER TEMPERATURE

REF.2: TFU 36.11.00.069 DUAL BLEED LOSS OVER PRESSURE

REF.3: 2010 A330/A340 Technical Symposium, ATA36 presentation

REF.4: IPC 36-11-06-10 and 36-11-06-10A transducer 8HA1 (2)

REF.5: Auxitrol ACMM 36-11-08

REF.6: Airbus SIL 36-051 ENGINE BLEED AIR SYSTEM COMPONENTS EVOLUTION & INTERCHANGEABILITY

****BEG REV****

REF.7: Airbus SB A330-36-3039

REF.8: RIL G36M11020430

****END REV****

Ø. REASON FOR REVISION

The original issue of this OIT described reported Dual Bleed Loss (DBL) events and their impact on flight operations. It also informed operators of the actions launched in the fleet and provided recommendations to prevent DBL occurrence.

This revision provides feedback on root cause and informs of actions that can be taken on aircraft with pressure transducer PN ZRA380-00 supplied by Auxitrol and alternate pressure transducer PN APTE-182-1000- 30barg supplied by Kulite (mod 42266).

This revision also provides information (REF.7 and REF.8) concerning new Auxitrol pressure transducer PN ZRA691-00 that addresses DBL occurrences.

THE UPDATED PARAGRAPHS ARE INDICATED BETWEEN ****BEG REV**** and ****END REV****

1. PURPOSE

Dual Bleed Loss (DBL) events have been reported to Airbus. These events have an impact on flight operations, with subsequent rapid descent and potential exposure to emergency descent and use of oxygen masks. In 2007 Airbus implemented a specific Liebherr / Airbus task force to tackle the technical issues (Ref.3), also involving Auxitrol since 2009.

Appendix 11

Although the number of events had remained stable since 2008, in 2010 a total of 12 events were reported, 7 of which in December. Subject OIT is released to advise operators of the latest developments and provide recommendations to prevent DBL re-occurrence.

2. DESCRIPTION

Two main failure modes are driving DBL events:

- Over-temperature faults
- Over-pressure faults

For over temperature faults, a number of improvements have already been defined and are available to customers as per TFU REF.1 and presentation (REF.3). In service experience has shown that incorporation of these actions has significantly reduced the number of cases of dual bleed loss over the last 2 years.

Airbus therefore recommends all operators to complete the implementation of the solutions described in TFU 36.11.00.065.

For over-pressure faults, two different scenarios have been identified:

1/ Over-pressure at take-off due to pressure overshoot at engine thrust increase (faults triggered up to 1500ft), 2/ Faulty indication of the regulated pressure transducer (8HA1 (2)) during cruise/descent.

With regards to scenario 1/ at take-off, the following actions have proven to reduce exposure:

- Apply a 2-step engine thrust increase as per FCOM 3.03.12
 - Consider performing take-off with air conditioning packs selected ON.
- This will avoid the configuration where engine bleed is used with no bleed demand, which may cause transitory pressure overshoots.

With regards to scenario 2/ in cruise/descent, investigation has confirmed that the significant increase of DBL occurrences in December 2010 was due to over-pressure erroneous indications.

Note: all Dec10 DBL events were reported on GE CF6-80E1 powered A330 aircraft. The reason for this specific fleet only being affected is linked to environmental conditions for the pressure transducer PN ZRA380-00 in the aircraft pylon area (IPC REF.4).

DFDR analyses and laboratory investigations have confirmed that the erroneous indication of the regulated pressure is linked to the combination of the following contributing factors:

- Moisture condensation in the sensing chamber of the pressure transducer 8HA1 (2).
- Negative environmental temperatures at transducer level, leading to freezing of the water contained in the sensing chamber.

As a consequence, the indicated regulated pressure is erroneous.

When the indicated regulated pressure exceeds 60 psig for 15 seconds, an over-pressure fault triggers the AIR ENG BLEED FAULT ECAM warning associated with fault message PRESS REG-V (Ei-4001HA) and also in some cases OVERPRESS-V (13HAi)/ PRESS XDCR (8HAi).

In-service experience has shown that the erroneous indication scenario is more likely to be seen during the winter period and all on A330 with GE engine. It is also to be noted that a sampling for single bleed faults shows that approximately 30% of the A330 GE fleet has been affected by such faults. Some cases of single bleed faults have also been identified on the PW & RR A330 fleet.

3. MITIGATING ACTIONS FOR THE A330/GE CF6-80 FLEET

In order to mitigate exposure to potential DBL occurrences, Airbus would like to make A330/GE CF6-80 operators aware of additional recurrent maintenance actions listed below:

****BEG REV****

3.1. Periodic maintenance actions

3.1.1 Airbus recommends to periodically (1A check to 3A check, ie 900FH or 150 days to 2700FH or 450 days) drain any water contained in the sense line connected between pressure transducer 8HA1(2) and the Pressure Regulating Valve (PRV). This sense line cleaning procedure is documented in AMM 36-11-16 PB06.

3.1.2 Airbus also recommends to periodically (1A check to 3A check, ie 900FH or 150 days to 2700FH or 450 days) remove pressure transducer 8HA1(2) with PN ZRA380-00 (supplied by AUXITROL) and carry out transducer drying, as per Auxitrol ACMM 36-11-08.

3.1.3. If available in their stock, operators can install non affected Auxitrol pressure transducer PN ZRA1990030 (MOD41862). However, please note this transducer is no longer manufactured.

3.2. Single bleed fault monitoring

Malfunction of regulated pressure transducer PN ZRA380-00 or PN APTE- 182-1000-30BARG can be suspected in the event of class 1 fault messages PRESS REG-V (Ei-4001HA) and/or OVERPRESS-V (13HAi)/ PRESS XDCR(8HAi) being triggered during phase 6, particularly if the event occurs after at least 1 hour into the flight. These fault messages can be monitored via the PFR or via Airman when available. In case of triggering of these faults, Airbus recommends to apply the maintenance actions in paragraph 3.1 as soon as possible for PN ZRA380-000. Airbus recommends timely transducer removal for PN APTE-182-1000-30BARG.

****END REV****

4. FINAL FIX

****BEG REV****

Auxitrol have designed a modified pressure transducer PN ZRA691-00 to replace PN ZRA380-00. Availability of first serial units is planned for September 2011.

An Airbus modification will be opened to identify the change. It will be applicable to CF6-80E1 powered A330 aircraft only. The corresponding SB A330-36-3039 (REF.7) will address A330/CF6-80E1 in-service aircraft. Target date for SB release is beginning of September 2011.

Appendix 11

An urgent Airbus monitored retrofit campaign will be launched for SB A330-36-3039 (REF.7). The objective of this campaign is to expedite introduction of PN ZRA691-00 on one engine (position 8HA1) of all GE CF6-80E1 powered A330 aircraft before the 2011/2012 winter (northern hemisphere) starts, in order to decrease fleet exposure to DBL events. This campaign is scheduled to begin in September 2011. A dedicated Retrofit Information Letter G36M11020430 (REF.8) will be dispatched beginning of September 2011 to the affected operators. The logistics aspects have been agreed with Auxitrol to ensure delivery of PN ZRA691- 00 to the operators starting in September 2011. Airbus objective is to have all parts to cover replacement of 8HA1 on all A330/CF6-80E1 aircraft delivered by the beginning of December 2011.

Airbus requests that affected operators respond timely to the forthcoming RIL.
END REV

5. A330/PW4000 and A330/Trent700 FLEETS

BEG REV

Airbus does not recommend any retrofit nor specific mitigating actions for the A330/PW4000 and A330/Trent700 fleets. For these fleets, single bleed fault monitoring as described in paragraph 3.2. can be done. In case of repetitive triggering of class 1 fault messages PRESS REG-V (Ei-4001HA) and/or OVERPRESS-V (13HAi)/ PRESS XDCR (8HAi) during flight phase 6, Airbus recommends timely removal of transducer PN ZRA380-000 or PN APTE-182-1000-30BARG, as applicable.

END REV

6. FOLLOW-UP

No follow-up to this OIT is planned.
Questions about the technical content of this OIT are to be addressed to:

Jerome REAL
Phone +33 (0) 5 61 93 71 85
Fax +33 (0) 5 61 93 36 14
E-mail: jerome.real@airbus.com

Best Regards,

P. GLAPA
VICE PRESIDENT
ENGINEERING SUPPORT
CUSTOMER SERVICES

**RETROFIT INFORMATION LETTER SB A330-36-3039 PNEUMATIC – ENGINE BLEED
AIR SUPPLY SYSTEM – CHANGE THE BLEED REGULATED PRESSURE TRANSDU-
CER ON ENGINE 1**



RETROFIT INFORMATION LETTER (RIL)

TO

A330 Operators equipped with GE engines

FROM

Claire HAREL

COPY

AIRBUS Programs Support
AIRBUS Support Engineering
AIRBUS Service Bulletins
AIRBUS Warranty
AIRBUS Support Procurement
AIRBUS Supplier Monitoring
Customer Support Directors
Field Service Stations & Representatives
AIRBUS Retrofit Department
Auxitrol Retrofit Department

DATE

12 Sep 2011

PHONE

+33 (0)5 62 11 02 87

E-MAIL

claire.harel@airbus.com

REFERENCE

SEOT2 G36M11020430

SB A330-36-3039

**Pneumatic – Engine Bleed Air Supply System – Change the Bleed Regulated
Pressure Transducer on Engine 1**

Dear Customers,

Please be advised that AIRBUS has launched a monitored retrofit campaign for the change of Pressure Transducer on the Engine 1 pylon on A330 aircraft equipped with General Electric (GE) engines.

The purpose of this letter is to provide logistical advice to complete the retrofit. Please note that exact installation and embodiment instructions must be taken from relevant Service Bulletin.

Please note also that all AIRBUS Monitored Retrofit Information Letters can also be viewed in **Airbus World** portal (Maintenance & Engineering, Access Retrofit Campaigns).

Best regards,

Claire HAREL

Director Retrofit Operations - SEOT2
Aircraft Embodiment Operations
AIRBUS Customer Services
Phone: +33 (0)5 62 11 02 87
Mobile: +33 (0)6 08 94 02 36
Fax: +33 (0)5 61 93 27 45
Mailto: claire.harel@airbus.com

Generic eMail address:
Mailto:monitored.retrofit@airbus.com



1. REASONS

Some operators have reported dual bleed loss events during cruise or descent flight phase. These events occurred because regulated pressure transducer FIN 8HA1 – 8HA2 P/N ZRA380-00 provided an incorrect output pressure signal. This was due to water / condensation ingress within sensitive part of pressure transducer associated to negative temperature surrounding the pressure transducer (freezing effect). All reported cases were on aircraft with General Electric (GE) CF6-80 engines.

The Service Bulletin A330-36-3039 is issued to remove the previous Bleed regulated Pressure Transducer PN ZRA380-00 from the Engine 1 pylon (FIN 8HA1) and install a new Pressure Transducer PN ZRA691-00.

2. TECHNICAL DOCUMENTATION

- AIRBUS SB A330-36-3039 REV00, dated 07 Sep 2011
- MOD. N°201968 C10871 (MOD 202028 for aircraft in production line)
- TFU 36.11.00.069
- OIT SE 999.0015/11 rev01 dated 25 Aug 2011

3. AFFECTED FLEET

This AIRBUS monitored retrofit campaign applies to A330 aircraft equipped with GE engines

4. PART NUMBER EVOLUTION

EQUIPMENT	PRE-MOD P/N	POST-MOD P/N	INTERCHANGEABILITY	MIXABILITY
Pressure Transducer	ZRA380-00	ZRA691-00	352	N/A

If a Pressure Transducer with a different Part Number is found in the position 8HA1, the modification can also be performed.

5. SERVICE BULLETIN ACCOMPLISHMENT MANPOWER

The man-hours (MH) and elapsed time (ET) to accomplish the retrofit are (as per SB):

MH : 5.50 hrs

ET : 5.50 hrs

6. RETROFIT ORGANIZATION AND FOLLOW-UP

Aircraft will be upgraded by Operator using Auxitrol PN ZRA691-00, quantity 1ea per A/C, in position 8HA1.

Spare units are not covered by the retrofit campaign.

- 1) Operators are requested to return the RIL Appendix completed with tentative planning for the replacement of Pressure Transducer. Availability of parts & planning will then be agreed with AIRBUS Retrofit Department.



- 2) Upon parts & planning agreement with AIRBUS Retrofit Department, Operators will place a Purchase Order to Auxitrol for the material.
- 3) Parts transportation from Auxitrol will be FCA.
- 4) Pre-mod ZRA380-00 units can be used on other aircraft types (e.g. A320 family) after return to Auxitrol for re-certification. Parts to be sent to below contact at Auxitrol
- 5) After accomplishment of the modification on impacted aircraft, Operators are requested to report aircraft embodiment status to AIRBUS SB Reporting (sb.reporting@airbus.com).

7. RETROFIT POLICY

The Airbus monitored retrofit campaign is launched to support the embodiment of SB A330-36-3039 before the 2011/2012 winter (northern hemisphere) starts. The objective is to complete the installation on all affected aircraft before the end of year 2011.

Parts PN ZRA691-00 will be provided to Operators on a Free of Charge basis, for orders placed before 30 Nov 2011.

The man hours indicated in Airbus SB A330-36-3039 remain at Operator's costs.

From 01 Dec 2011, commercial conditions and industry support described in Airbus SB A330-36-3039 will then apply.

8. ADMINISTRATION

AIRBUS Retrofit Department is responsible for overall retrofit organization.

Focal point is:

Claire HAREL

Director Retrofit Operations - SEOT2

Aircraft Embodiment Operations

AIRBUS Customer Services

Phone: +33 (0)5 62 11 02 87

Mobile: +33 (0)6 08 94 02 36

Fax: +33 (0)5 61 93 27 45

Mailto: claire.harel@airbus.com

Auxitrol Retrofit Department is responsible for logistics and parts shipment.

Focal point is:

Marguerite AVERENKOVA

Aftermarket Customer Service Manager

Sensors Services Europe

ESTERLINE Advanced Sensors

5, allée Charles Pathé

18941 BOURGES Cedex 9

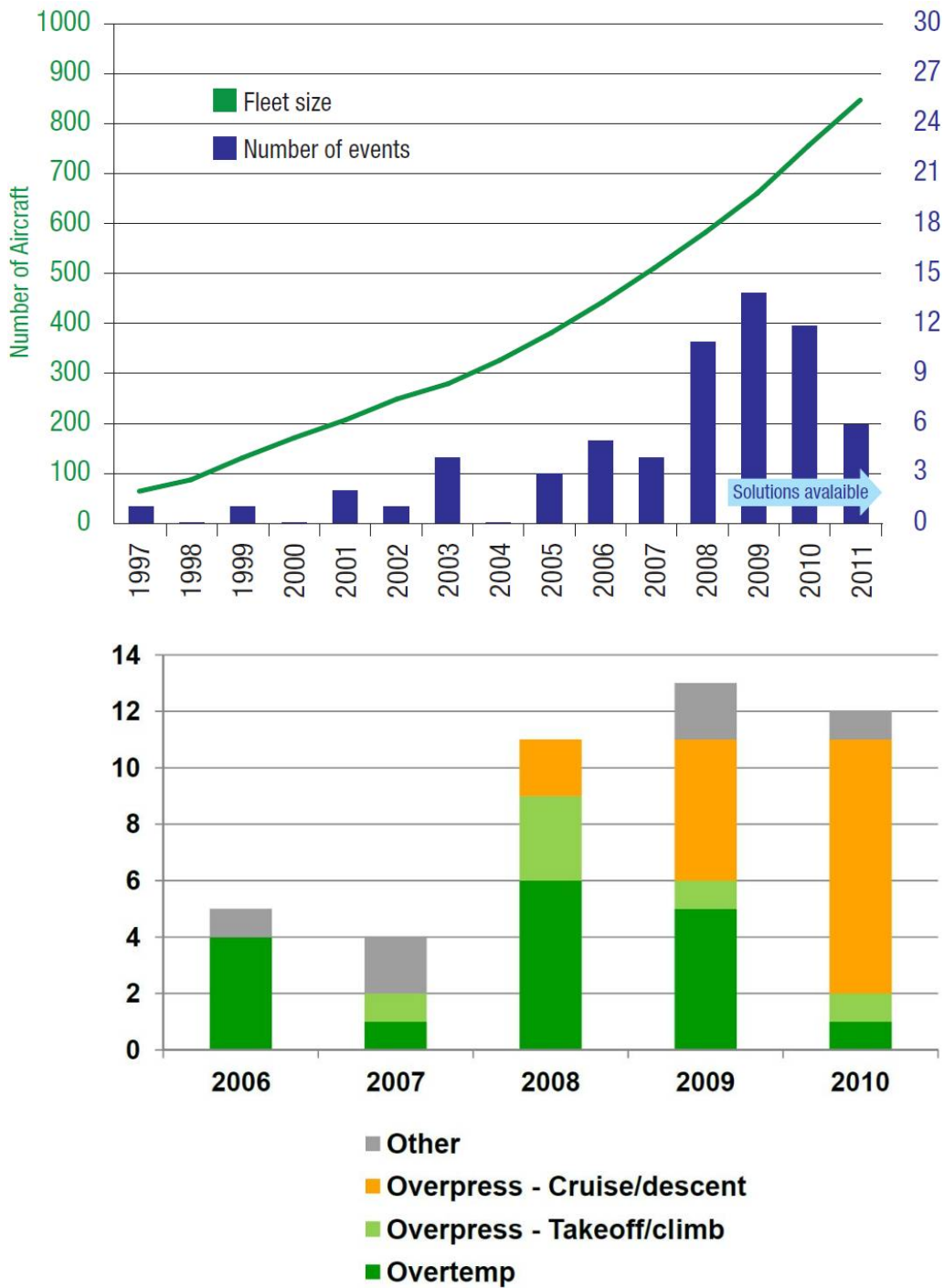
FRANCE

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AIRBUS STATISTICS OF A330 DUAL BLEED LOSS OCCURRENCES



AIRBUS TECHNICAL FOLLOW-UP TFU REF: 36.11.00.065 OCTOBER 2009



Technical Follow-Up

PAGE 1/2

TFU REF : 36.11.00.065	Dual Bleed Loss	TFU STATUS : OPEN
OWNER/EXT : J. REAL Tel : +33 561937185 E-Mail : JEROME.REAL@airbus.com	A/C Affected : A330 Engine Affected : CF6-80E1, PW4100, TRENT-700 PAIR-ISP Item : 08.0191	TFU ISSUE DATE : OCT 2009 TFU FIRST ISSUE DATE : OCT 2009 TFU NEXT ISSUE DATE : JAN 2010 ISSUE NB : 01
DESCRIPTION : Several A330 operators reported cases of Dual Bleed Loss (DBL) failures. Since beginning of year 2006, 25 cases of DBL events have been reported to Airbus. This kind of events could lead to In Flight Turn Back or Emergency descent.		
CONSEQUENCE : Due to both engine bleed systems inoperative, cabin pressurisation can not be maintained and an aircraft emergency descent is then required.		
INVESTIGATION STATUS : A joint Airbus and Liebherr team is working on improvements to further reduce DBL events. This team analysed Dual Bleed Loss events and identified two mains failure modes. The first failure mode is Pressure regulation issue (48%) and the second one is Over Temperature issue (52%). The working team identified following potential improvements : <ul style="list-style-type: none"> 1- Pressure regulation issue (Over pressure or Low pressure) : This issue is mainly due to a premature closure of OPV (FIN 13HA) during take off or cruise flight phase. <ul style="list-style-type: none"> - A resetting of OPV closure is reviewed in the aim to change the specification of the ATP closing pressure of the valve from 75-85psig (static) to 82-85psig. - An improvement of Functional test of OPV (AMM task 36-11-53-720-808-1(-2)) is reviewed in the aim to add a masse flow parameter. This masse flow parameter associated to a pressure parameter will ensure the behaviour of OPV considering the OPV actuator leakage. 2- Over temperature issue: <p>This issue is mainly due to a loss of muscle pressure to open Fan Air Valve (FIN 12HA) during take off or cruise or top of descent flight phase:</p> <ul style="list-style-type: none"> - An improvement of Functional test of FAV (AMM task 36-11-54-720-806(-1)) is reviewed in the aim to add a masse flow parameter. This masse flow parameter associated to a pressure parameter will ensure the behaviour of FAV considering the FAV actuator leakage. - MPD task 36361143-01-1 associated to ThC filter cleaning at each 6000FH will become mandatory, referring to MRB. Indeed, for the time being, this MPD task refers to the SIL 36-055. - A ThC improvement is already available. This modification consist to modify the ThC mesh filter . ThC Modification consists in replacing mesh filter by a pollution cover avoiding to reduce muscle pressure sent to the FAV . This modification is covered by Liebherr VSB 398-36-04. 		
IMPACTS CLASSIFICATION Impact on flight OPS : Medium Impact on line maintenance : Medium Impact on shop maintenance : Low Impact on environment : None Effect on flight : Medium Category : Economic Visibility on PAX : High		
RELEVANT DOCUMENTATION Airbus OPS documentation Airbus Maintenance documentation Doc. Ref. Date SIL 36-055 01 15-NOV-2006 (A318, A319, A320, A321, A330, A340)		
Other documentation VENDOR and PN affected HONEYWELL INTERNATIONAL INC 6743A010000 LIEBHERR AEROSPACE TOULOUSE SAS 398E020000 SERVICE BULLETIN Airbus Vendor Ref. Date 398-36-04 00 Iss 25-SEP-2009 (A330) VENDOR and PN solution LIEBHERR AEROSPACE TOULOUSE SAS 398E050000 398E020000		



Technical Follow-Up

PAGE 2 / 2

TFU REF : 36.11.00.065	Dual Bleed Loss	TFU STATUS : OPEN
OWNER/EXT : J. REAL Tel : +33 561937185 E-Mail : JEROME.REAL@airbus.com	A/C Affected : A330 Engine Affected : CF6-80E1, PW4100, TRENT-700 PAIR-ISP Item : 08.0191	TFU ISSUE DATE : OCT 2009 TFU FIRST ISSUE DATE : OCT 2009 TFU NEXT ISSUE DATE : JAN 2010 ISSUE NB : 01
<p><u>MITIGATION / INTERIM PLAN :</u> Over temperature issue:</p> <p>Airbus recommends to A330 operators to adjust interval frame of Temperature Control Thermostat (ThC 5HA) Filter cleaning given by MPD task 361143-01-1. In reference to SIL 36-055, the ThC filter cleaning interval customisation could be applied for each operator depending on the operating environment (highly polluted or sandy area).</p> <p><u>MAINTENANCE ADVICE :</u> N/A</p> <p><u>OPS ADVICE :</u> Airbus recommends to A330 operators to follow FCOM procedure 3.03.12 associated to take off. Indeed, through this procedure it is requested to adjust engine thrust in two steps. This will avoid to encounter potential Engine bleed air system pressure overshoot (over pressure) during take off phase.</p> <p><u>REPERCUSSION ON A/C DISPATCH :</u> N/A</p> <p><u>PERMANENT OR FINAL SOLUTION :</u> A - Over temperature:</p> <p>A-1 Airbus informs A330 operators that modified ThC is available and covered by Liebherr VSB 398-36-04: Through this modification, the ThC mesh filter has been modified. ThC Modification consists in replacing mesh filter by a pollution cover avoiding to reduce muscle pressure sent to FAV. This modification is applied on ThCs, From SN 1830 for PN 398B050000 and from SN 1826 for PN 398E020000</p> <p>A2- THC filter cleaning MPD task 361143-01-1 update: - As of date this MPD task 361143-01-1 refers to SIL 36-055. From first quarter of year 2011, MPD task 361143-01-1 will become Mandatory as the MPD task update will refer MRB.</p>		