Havarikommissionen
Accident Investigation Board Denmark

FINAL REPORT

Serious incident

3-12-2016

involving

ATR72 202

OY-LHA

Certain report data are generated via the EC common aviation database

FOREWORD

This report reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the safety investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The safety investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents and serious incidents.

Consequently, any use of this report for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

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FINAL REPORT

General

File number:	HCLJ510-2016-320
UTC date:	3-12-2016
UTC time:	05:12
Occurrence class:	Serious incident
Location:	3 nautical miles (nm) northwest of Bornholm/Roenne (EKRN)
Injury level:	None

Aircraft

Aircraft registration:	OY-LHA
Aircraft make/model:	ATR ATR72 202
Current flight rules:	Instrument Flight Rules (IFR)
Operation type:	Commercial Air Transport Passenger Airline
Flight phase:	Take-off
Aircraft category:	Fixed Wing Aeroplane Large Aeroplane
Last departure point:	Denmark EKRN (RNN): Bornholm/Roenne
Planned destination:	Denmark EKCH (CPH): Kobenhavn/Kastrup
Aircraft damage:	None
Engine make/model:	PRATT & WHITNEY (CANADA) PW100 FAMILY (PW 124B)

SYNOPSIS

Notification

All times in this report are UTC.

The Aviation Unit of the Danish Accident Investigation Board (AIB) was notified of the serious incident by the Area Control Centre (ACC) at Copenhagen, Kastrup (EKCH) on 3-12-2016 at 05:27 hours.

The AIB notified the Danish Transport and Construction Agency (DTCA), the French Accident Investigation Board (Le Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA)), the European Aviation Safety Agency (EASA), the Directorate-General for Mobility and Transport (DG MOVE), the Transportation Safety Board of Canada (TSB) and the International Civil Aviation Organization (ICAO) on 5-12-2016.

For unknown reasons, the TSB did not receive the notification from the AIB on 5-12-2016. The AIB notified the TSB once more on 27-3-2017. However, the AIB safety investigation was not affected by the time lapse in the notification process, because the necessary communication between the AIB and the TSB was established in the period between 5-12-2016 and 27-3-2017.

The BEA and TSB appointed non-travelling accredited representatives to the AIB safety investigation.

Summary

A failure of the no. 2 bearing in the no. 1 engine most likely caused an engine seizure.

Consequently, smoke entered the aircraft through the air conditioning system.

During the serious incident:

- The senior cabin attendant (CA 1) attempted without success to extract her protective breathing equipment (PBE) from the protective bag.
- Neither cabin crew nor passengers heard the passenger address (PA) announcements made by the left hand seated pilot.

The serious incident occurred in dark night and under visual meteorological condition (VMC).

Scope of the safety investigation

It is the position of the AIB that the engine seizure was caused by a failure to the no. 2 bearing. In addition, the limited available parts for the safety investigation did not make it possible to determine the root cause of this bearing failure.

For that reason, the aspects pertaining to the engine seizure deemed to be a continued airworthiness issue and were not investigated further by the AIB.

This safety investigation report focuses on the survivability aspects related to the presence of smoke in the aircraft, because of the failure to the no. 2 bearing.

1 FACTUAL INFORMATION

1.1 History of the flight

The serious incident flight was a commercial IFR domestic passenger flight from Bornholm/Roenne (EKRN) to Copenhagen, Kastrup (EKCH).

The serious incident flight was a commander upgrade qualification line training flight for the first officer sitting in the left hand pilot seat (LH pilot). The first officer performed the duties of a commander and was the pilot flying (PF).

The pilot seated in the right hand pilot seat (RH pilot) was the commander (CMDR). The CMDR performed the duties of a first officer and was the pilot monitoring (PM).

At 05:09:31 hours, the flight crew received take off clearance (runway 29) from the air traffic controller (ATCO) at EKRN Tower (118.325 MHz).

At 05:10:25 hours, the aircraft departed EKRN and upon reaching an altitude of 500 feet mean sea level (msl), the aircraft according to the standard noise abatement procedure turned left and intercepted radial 277° MAG (R-277) outbound ROE VOR (112.000 MHz).

At 05:11:31 hours, climbing through 1800 feet altitude msl, the flight crew smelled a metallic odour.

At 05:11:30 - 05:11:32 hours, the engine no. 1 torque decreased from 101% to 98% and then increased to 100%.

At 05:11:34 hours, the engine no. 1 torque started decreasing below 100%.

At 05:11:36 - 05:11:39 hours, the master warning lights and continuous repetitive chime (CRC) aural warnings were triggered and the “ENG 1 OIL” warning illuminated on the crew alerting panel (CAP). Simultaneously, the flight crew noticed an engine no. 1 torque indication of approximately 65%, and retarded the engine no. 1 power lever to flight idle.

Smoke started entering the cockpit and the cabin through the air conditioning system outlets.

At 05:11:44 hours, the LH pilot ordered the flight crew to don their oxygen masks.

At 05:11:47 - 05:12:14 hours, the master warning lights and CRC aural warning were triggered, and the “ELEC SMK” illuminated on the CAP.

Having identified the engine no. 1 as the source of the smoke, the flight crew decided to shut down the engine and perform the emergency checklist “Smoke”.

See appendix 5.1

The RH pilot retarded the engine no. 1 condition lever to feather and then to fuel shut off, and set both recirculation fan switches to the “OFF” position.

At 05:13:00 - 05:13:18 hours, the RH pilot declared an emergency (mayday call) to EKRN Tower stating the presence of smoke in cockpit and cabin and the aircraft returning to EKRN.

The ATCO at EKRN Tower acknowledged the emergency and asked which runway the flight crew preferred.

The RH pilot opted for a visual approach to runway 11, which the ATCO acknowledged.

At 05:13:05 hours, the LH pilot initiated a right descending turn toward EKRN.

Due to the presence of smoke in the cabin, the CA 1 decided to don her PBE. She tried without success to open the PBE protective bag.

As the smoke ingress seemed to have stopped following the engine shutdown, and since there were no indications of engine fire or fire anywhere else, the flight crew assessed the operational conditions to be stable and prioritised landing as soon as possible and not performing further in-flight emergency checklists.

At 05:13:52 - 05:14:18 hours, the CA 1 called the cockpit via the aft service station interphone and informed the RH pilot that there was smoke in the cabin.

The RH pilot acknowledged the situation, and informed the CA 1 that they were returning to EKRN expecting to land within two to three minutes.

At 05:14:39 hours, the CA 1 made a PA announcement, informing the passengers that the aircraft was returning to EKRN, would shortly land and that they should keep their seat belts fastened.

After the PA announcement, the CA 1 signalled to the forward cabin attendant (CA 2) “one minute to landing”, and both cabin attendants returned to their respective seats.

The flight crew prepared for the approach to runway 11 and configured the aircraft for landing. At 05:15:29 hours, the flight crew completed the “Before landing” checklist.

At 05:15:43 hours, the ATCO at EKRN Tower cleared the aircraft to land on runway 11.

At 05:16:47 hours, the aircraft landed and stopped on the runway.

At 05:17:01 hours, the ATCO at EKRN Tower asked the flight crew, if the intention was to evacuate the aircraft on the runway, which the RH pilot confirmed.

Shortly after, the airport fire and rescue services were in position next to the aircraft.

By memory, the LH pilot performed the "On Ground Emergency Evacuation" checklist items, except setting the battery switch to the off position.

See appendix 5.2

At 05:17:17 hours, the LH pilot issued an announcement directed to the cabin crew: "*Cabin crew standby, cabin crew standby"*.

At 05:18:05 hours, the LH pilot issued an announcement directed to the cabin crew: "*Cabin crew evacuate the aircraft, evacuate the aircraft"*.

At 05:18:32 hours, the RH pilot initiated reading the "On Ground Emergency Evacuation" checklist.

At 05:18:52 hours, the CA 1 called the cockpit via the interphone and informed the RH pilot that smoke was still present in the cabin and that they needed to evacuate the aircraft.

The RH pilot instructed the CA 1 to evacuate the aircraft by means of the passenger entrance door.

At 05:19:29 hours, the LH pilot issued an announcement directed to the cabin crew: "*Cabin crew, you may open doors and get out"*.

The passengers and the cabin crew left the aircraft through the passenger entrance door and met in front of the aircraft together with personnel from the airport fire and rescue services.

At 05:19:34 hours, the RH pilot continued reading the "On Ground Emergency Evacuation" checklist.

All checklist items were completed except setting the battery switch to the off position.

At 05:21:00 hours, the RH pilot removed his oxygen mask and evacuated the aircraft through the passenger entrance door.

At 05:21:26 hours, the LH pilot removed his oxygen mask and evacuated the aircraft through the passenger entrance door.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal			
Serious			
None	4	14	

1.3 Damage to aircraft

Engine no. 1 was severely damaged because of engine internal distress.

1.4 Other damage

There were no other damages.

1.5 Personnel information

1.5.1 The commander

1.5.1.1 License and medical certificate

The commander (male - 38 years) was the holder of a valid Danish Airline Transport Pilot License (ATPL) (A)).

The ATPL contained the following type rating: ATR42/72/IR. The type rating was valid until 31-10-2017.

The PART-FCL medical certificate class 1 was valid until 15-6-2017.

1.5.1.2 Operator training

- On 22-10-2016, a combined ATR42/72 Operator Proficiency Check (OPC)/License Proficiency Check (LPC) was performed.
- On 27-9-2016, the latest Crew Resource Management (CRM) training was performed.

1.5.1.3 Flying experience

	Last 24 hours	Last 90 days	Total
All types	1	122	7215
This type	1	122	4368
Landings (This type)	0	72	-

1.5.2 The first officer

1.5.2.1 License and medical certificate

The first officer (male - 40 years) was a holder of a valid Danish Airline Transport Pilot License (ATPL) (A)).

The ATPL contained the following type rating: ATR42/72/IR. The type rating was valid until 30-11-2017.

The PART-FCL medical certificate class 1 was valid until 28-1-2017.

1.5.2.2 Operator training

- On 31-8-2016, a combined ATR42/72 Operator Proficiency Check (OPC)/License Proficiency Check (LPC) was performed.
- On 18-11-2016 a skill test (commander upgrade) for ATPL(A) was performed.
- On 24-5-2016, the latest Crew Resource Management (CRM) training was performed.

1.5.2.3 Flying experience

	Last 24 hours	Last 90 days	Total
All types	1	120	3874
This type	1	120	2108
Landings (This type)	1	78	-

1.5.3 The senior cabin attendant

1.5.3.1 Operator training

- On 9-3-2016, the latest Crew Resource Management (CRM) training was performed.
- On 29-11-2016, the latest Emergency and Safety Equipment training (including use of PBE) was performed.

1.5.4 The cabin attendant

1.5.4.1 Operator training

- On 26-1-2016, the latest Crew Resource Management (CRM) training was performed.
- On 29-11-2016, the latest Emergency and Safety Equipment training (including use of PBE) was performed.

1.6 Aircraft information

1.6.1 General

Registration:	OY-LHA
Type:	ATR72
Model:	202
Manufacturer:	ATR - GIE Avions de Transport Régional
Serial number:	508
Year of manufacture:	1996
Engine manufacturer:	Pratt & Whitney Canada Inc.
Engine type:	PW124B
Propellers:	Hamilton Standard Division, 14 SF-11E
Aircraft total flight hours:	23 749
Aircraft total flight cycles:	38 278
Airworthiness review certificate:	Valid until 12-8-2017

1.6.1.1 Engine information

Nomenclatures:

ESN	Engine serial number
HSI	Hot section inspection
RGB	Reduction gearbox
SN	Serial number
TMM	Turbomachinery module
TSN	Time since new (hours)
TSO	Time since overhaul (hours)
CYC	Cycles (number)
CSN	Cycles since new (number)
TSLSV	Time since last shop visit (hours)
CSLSV	Cycles since last shop visit (number)
LLP	Life limited part
OH	Overhaul
NA	Not applicable

Engine no. 1:

ESN:	AH0021	
RGB SN:	AH0021	
TMM TSN:	13 801,3	
TMM CSN:	21 069	
RGB TSN:	13 801,3	
RGB CSN:	21 069	
TSLSV:	3 907,6	HSI and LLP replacement

CSLSV:	6 657	HSI and LLP replacement
TSO:	NA	
CSO:	NA	
LLP limiter CYC	8 343	Compressor and turbine

Engine no. 2:		
ESN:	124417	
RGB SN:	124273	
TMM TSN:	34 195,6	
TMM CSN:	46 789	
RGB TSN:	35 622,6	
RGB CSN:	48 290	
TSLSV:	1 039,6	TMM and RGB OH with LLP replacement
CSLSV:	1 848	TMM and RGB OH with LLP replacement
TSO:	1 039,6	
CSO:	1 848	
LLP limiter CYC:	15 000	Compressor and turbine

1.6.1.2 Pneumatic and air conditioning system

Confer the ATR 72-200 Flight Crew Operating Manual (FCOM) 1.03 (in extract):

Pneumatic system – 20.1 Description:
"Compressed air is bled from the engine compressors at the low pressure (LP) or high pressure (HP) stages."
" It supplies under pressure air for air conditioning, pressurization and ice protection system."

Isolation:
"Downstream of the junction of the LP and HP ducting, air is admitted into the duct by a pneumatically operated, electrically controlled butterfly bleed valve which acts as a shut off valve."
"In the absence of air pressure, the valve is spring-loaded closed regardless of electrical power supply."

Air conditioning – 30.1 Description
Air production:
"The air conditioning system is supplied by air processed through two packs which regulate air flow and temperature as required."
"Hot air from the engines is admitted through pack valves and conditioned (cooled, dried, compressed) into the packs."
"The pack valve is pneumatically operated and electrically controlled. This butterfly valve has two functions:

- *Pack shut off*

- *Pressure control and hence flow control.*

Without air pressure and regardless of electrical command, the pack is spring-loaded closed. It will also close without electrical supply."

Air ventilation:
"Conditioned air is blown into the cabin by outlet ramps located under the hot racks. It is then evacuated through guides along the cabin side of the walls at floor level. A part of it is recirculated by the fans, the other part being evacuated overboard through the outflow valves installed in the rear under the floor."

For a schematic of the general air system – see appendix 5.3

According to the aircraft solid state flight data recorder (SSFDR) readout, the position of the LH HP Air flow valve (HP valve) and the LH Pack Air Flow valve (Pack valve) was:

Time UTC	LH HP valve	LH Pack valve
05:02:11 - 05:04:07	Closed	Closed
05:04:09 - 05:10:03	Opened	Opened
05:10:05 - 05:11:43	Closed	Opened
05:11:45 - 05:12:11	Opened	Opened
05:12:13 - 05:19:12	Closed	Closed

1.6.2 Operational flight plan

The AIB has erased the names of the crew members and the name of the operator.

See appendix 5.4

1.6.3 Mass and balance

The AIB has erased the names of the crew members and the name of the operator.

See appendix 5.5

1.7 Meteorological information

1.7.1 Terminal aerodrome forecast (TAF)

ekrn 030520z 0306/0315 33012kt cavok=

1.7.2 Aviation routine weather report (METAR)

ekrn 030520z auto 31005kt 9999ndv ncd 02/m03 q1022=

ekrn 030450z auto 32004kt 9999ndv ncd 01/m03 q1022=

1.8 Aids to navigation

1.8.1 Notices to airmen (NOTAM) EKRN.

See appendix 5.6

1.9 Communication

1.9.1 General

The flight crew was in radio contact with EKRN Tower (118.325 MHz).

1.9.2 ATC voice recording

The AIB obtained the involved ATC voice recording. The recordings were of good quality and useful to the AIB safety investigation.

1.9.3 Flight crew headset

As standard, the operator had installed David Clark model H10-13.1 headsets (boomset) in the aircraft.

During the serious incident flight, the LH pilot used a Lightspeed model PFX headset and the RH pilot used a Lightspeed model Zulu headset instead of the installed operator headset.

1.9.4 Internal crew communication

Because smoke entered the cockpit and cabin, both flight crew members donned their oxygen mask and established internal pilot communication (interphone) by the use of their oxygen mask microphone and their headset speakers.

The FCOM 1.05.10 Communications (in extract) described the activation of the oxygen mask microphone:

Note: A switch located in the oxygen mask box when in released position (oxygen mask out), automatically transfer transmissions from the boom set mike to the oxygen mask mike. Radio reception is not affected by the transfer switch position.

1.9.4.1 ACP INT/RAD selector switch

Like stated in the flight crew interview and in order to avoid continuous transmission of oxygen mask breathing noise, the flight crew set their Audio Control Panel (ACP) Interphone/Radio (INT/RAD) selector switch to Neutral position (mid position = no transmission).

See appendix 5.7

1.9.4.2 Control wheel PTT selector switch

Like stated in the flight crew interview and to activate their oxygen mask microphone the flight crew used the Push To Talk (PTT) selector switch on their control wheel for the remaining part of the flight.

See appendix 5.8

1.9.5 Interphone audio

According to the RH pilot, there was a lot of ambient noise (including pilot breathing) in the cockpit, and internal pilot communication was not easy while using the oxygen masks. The RH pilot did not remember if breathing noise continuously was audible in the cockpit or only audible when the LH pilot transmitted.

According to the LH pilot, the internal pilot communication worked without problems, but it was "*impossible to talk when you breathed*". The LH pilot only heard the RH pilot breathing noise when the RH pilot transmitted, but the LH pilot continuously heard his own breathing noise as ambient noise.

According to the CA 1, it was almost impossible to understand the RH pilot via the interphone due to pilot breathing noise.

The CA 1 and the RH pilot applied closed loop communication technique in order to secure mutual understanding.

Most of the communication between the flight crew and the CA 1 was in their mother tongue (Swedish and Danish).

1.9.6 Passenger Address

During the sequence of events, four verbal announcements (announcements no. 1 - 4) intended as PA announcements were given.

Announcement no.:	1	2	3	4
Time (hours):	05:14:39	05:17:17	05:18:05	05:19:29
Given by:	CA 1	LH pilot	LH pilot	LH pilot
Heard by:	Passengers and cabin crew	Both pilots	Both pilots	Both pilots
Recorded on the solid state cockpit voice recorder (SSCVR) track no.:	5	2, 3 and 5	2, 3 and 5	2, 3 and 5

1.10 Aerodrome information

1.10.1 EKRN aerodrome

Airport position (ARP):	55 03 47.76N 014 45 34.41E
Elevation:	52 feet
Magnetic variation:	3.3°E (November 2012)
Runway identifications:	11 and 29
Direction of runway 11:	113.7° (GEO) 110.4° (MAG)
Direction of runway 29:	293.7° (GEO) and 290.4° (MAG)
Surface:	Asphalt/concrete
Runway dimensions:	2002 x 45 meters
Main landing aids:	Instrument landing system (ILS) CAT I
Rescue and fire fighting services:	CAT 5 and boats available for scheduled traffic

1.11 Flight recorders

1.11.1 Solid state flight data recorder (SSFDR)

Manufacturer: L-3 Aviation Communications, Part Number 2100-4043-00 (Serial Number 000357085).

The recovered flight data were useful to the AIB safety investigation.

1.11.2 Solid state cockpit voice recorder (SSCVR)

Manufacturer: L-3 Aviation Communications, Part Number 2100-1020-02 (Serial Number 000238506).

The SSCVR data provided six different audio tracks with recordings containing:

- Track no. 1 (30 minutes high quality) passenger address (PA) and CVR time code.
- Track no. 2 (30 minutes high quality) RH pilot microphone signal and radio communication.
- Track no. 3 (30 minutes high quality) LH pilot microphone signal and radio communication.
- Track no. 4 (30 minutes high quality) Cockpit Area Microphone (CAM) signal.
- Track no. 5 (120 minutes standard quality) a mix of track no. 1, no. 2 and no. 3.
- Track no. 6 (120 minutes standard quality) Cockpit Area Microphone (CAM) signal.

The SSCVR recorded approximately 25 minutes of recordings after the LH pilot had left the aircraft at 05:21:26 hours. The reason for this was not positively identified by the AIB, but most likely due to a non-technical unintentional omission or action performed by either the flight crew before leaving the aircraft, or by external personnel entering the aircraft after the flight crew had left the aircraft.

Data covering the entire event were recorded on track no. 5 and no. 6, while data covering the period from touchdown and until after the evacuation (05:16:47 hours until 05:21:26 hours) were recorded on track no. 1, no. 2, no. 3, and no. 4.

This hampered to a certain degree the AIB safety investigation.

The SSCVR recorded according to The European Organisation for Civil Aviation Equipment (EUROCAE) Document 56A (ED-56A), version 1993, using the "HOT microphone" function:

The hot microphone ensures that, in addition to the recording of the radio transmissions to and from the aircraft, all sounds received by the crew's microphones are recorded continuously irrespective of the position of the audio selector switches.

1.11.3 Reference time UTC

In this safety investigation, the ATC voice recording was the time of reference. The AIB synchronized the UTC on the SSFDR/SSCVR with the UTC on the ATC voice recording.

The AIB used VHF keying parameters to synchronize the SSFDR with the identical radio transmissions recorded on the SSCVR.

1.12 AIB Safety investigation

1.12.1 No. 1 engine

An initial technical visual inspection of engine no. 1 discovered severe damage to the PT turbine blades.

An attempt to turn the propeller in both direction was not possible.

The inspection revealed no further external damage to the engine, the engine cowlings or the pylon.

The main oil filter and the scavenge oil filter were removed and both filters were found clogged with metal debris of different alloys.

1.12.1.1 Borescope inspection

The engine was removed from the aircraft and sent to the operator's maintenance facilities.
The AIB in cooperation with the operator performed a borescope inspection.

The borescope inspection revealed heavy roller bearing damages to no. 5, no. 6 and no.7 bearings. It also revealed compressor and turbine tip damages due to rotation contact with the compressor casing and the turbine inner casing.

The oil system was contaminated (the propeller gearbox and the core engine). The "last change screens" at no. 5, no. 6 and no. 7 bearings were clogged by metallic alloy debris.

1.12.1.2 Tear down examination

Following the borescope investigation, the engine was sent to one of the engine manufacturer's maintenance facilities.

The AIB in cooperation with the maintenance facility personnel performed a teardown examination.

The tear down examination revealed extensive engine damages and indicated failure of the engine no. 2 bearing most likely causing the engine seizure.

No. 2 bearing damages – see appendix 5.9

Engine investigation report (extract) – see appendix 5.10

1.12.1.3 Engineering investigation

The no. 2 bearing was common to all PW100 engine models.

Across the PW100 fleet, a total of 165 million (m) engine flight hours (EFH) and 175 m cycles were accumulated since the engine was introduced into service.

The historical event rate for the engine relating to the no. 2 bearing was one event for every 12.6 m EFH.

In 2016, the no. 2 bearing event rate increased to one event for every 2.3 m EFH.

The engine manufacturer initiated an engineering investigation to identify the root cause(s) for the 2016 rate.

The details of the engineering investigation and action plans (once identified) for the no. 2 bearing will be shared with the Continuing Airworthiness Department of the Canadian Civil Aviation Authority Transport Canada (TC), on a quarterly basis (as a minimum).

This will provide status on investigation findings, assessment of risk, any required mitigation action if necessary and associated scheduling. Reviews of these issues continue until closure is mutually agreed.

1.12.2 Interphone and PA

After the serious incident, the AIB tested the aircraft interphone and the PA system.

The test did not reveal any malfunctions of the ACP panels or the ACP functions, the steering wheel PTT selector switches, the installed operator flight crew headsets (speaker part), the oxygen mask microphones, the cabin loudspeakers or the cabin crew interphone handsets.

1.13 Medical and pathological information

After the serious incident, all four crew members went to hospital for medical examination of smoke and fumes contamination. All tests results were below allowed limits, and all four crew members left the hospital after the medical examination.

1.14 Fire and smoke

1.14.1 Smoke in cabin

The CA 1 seat (facing forward) was located in the aft part of the passenger cabin (galley) between the passenger entrance door and the service door. An interphone handset was located next to the seat.

The CA 2 seat (facing backward) was located in the front of the passenger cabin between the two emergency exits.

The CA 1 saw smoke entering the cabin from below the overhead bins and from the eyeball outlets (passenger adjustable air outlets) in the area below the wings. She called the cockpit via the interphone, but the pilots did not answer her call.

At the same time, the CA 2 saw smoke entering the cabin from the overhead panels beside her seat and from the ventilation outlets behind the overhead bins below the wings. Within a few seconds, smoke filled the cabin, and the CA 2 left her seat and went to the galley to talk with the CA 1.

When the CA 2 reached the galley, the CA 1 was trying to contact the flight crew via the interphone. The CA 1 pointed at the Halon fire extinguisher. The CA 2 took the fire extinguisher and walked toward the cabin area adjacent to the left wing in order to locate and extinguish the fire.

Approaching the area, passengers seated in the left hand window row informed the CA 2 that the smoke was coming from the engine no. 1 and not from a fire within the cabin. She walked back to the galley to inform the CA 1.

At the same time, the CA 1 had ended her interphone attempt without success. In order to extract and don her PBE, the CA 1 pulled her PBE from the storage box and tried to open the protective bag.

A passenger (who worked as an airport fire and rescue officer) sitting in the aft left hand side of the cabin informed the CA 1 that the smoke was coming from engine no. 1 and not from a fire within the cabin.

It was not possible for the CA 1 to open the protective bag; neither by using one hand holding the PBE tight and pulling the “rip tag” with her other hand nor by holding the PBE tight with her legs and pulling the “rip tag” with both her hands.

When the CA 2 saw the CA 1 with a PBE, she went to collect her own PBE, which was located in the forward part of the cabin, and she then returned to the galley.

Meanwhile, the CA 1 had called the cockpit again and was informed by the RH pilot that the aircraft was returning to EKRN and that they would land right away – in two to three minutes – which the CA 1 perceived as within one minute.

The CA 1 informed the CA 2 that they would land within one minute.

Then the CA 1 put her PBE away and returned to her seat.

The CA 2 assessed whether or not to put on her PBE, but decided it would take too long because of the remaining flight time of one minute. Instead, the CA 2 returned to her seat and chose to use her scarf as protection from the smoke for the remaining part of the flight.

1.14.2 Smoke intensity

The intensity of the smoke was perceived as covering the entire cabin, but it was possible to see from one end of the cabin to the other end with only a bit of blurriness. The smoke intensity did not hamper the visual communication between the cabin crew members.

1.15 Survival aspects

1.15.1 Evacuation

Because of the amount of smoke in the aircraft, the flight crew decided to evacuate the aircraft on the runway by use of the passenger entrance door.

The evacuation was carried out in calmness without any injuries.

1.16 Tests and research

The AIB performed an in-house test of the PBE unit, which the CA 1 unsuccessfully tried to use during the sequence of events.

The protective bag was a vacuum-sealed pouch type, with a “rip tag” protruding from one corner of the bag.

The “rip tag” was 6.5 x 2.5 centimetre in dimension and made of a nylon-like material.

The PBE with “rip tag” – see appendix 5.11

The test revealed that a pull of 19.03 kg was needed to open the protective bag when the PBE was fixated and a pulling force was applied to the “rip tag”.

1.17 Organizational and management information

1.17.1 Regulatory requirements

1.17.1.1 Design standards

The PBE was marked with the tag shown in the picture (Figure 1) below:

Figure 1

To the marking "Approved under TSO-C116", the Department of Transportation (US) Federal Aviation Administration (FAA) Aircraft Certification Service Technical Standard Order "TSO-C116", dated March 1, 1990, required minimum performance standards:

Appendix 1 to the TSO-C116 contained the following text (in extract):

2.0 Scope.
These standards apply to protective breathing equipment that provides any crewmember with the ability to locate and combat a fire within the airplane cabin or any other accessible compartment at normal cabin altitudes (up to 8000 feet equivalent).

3.0 Minimum Performance Standards.
3.12 The unit shall be capable of being easily donned and activated, after gaining access to the stowed unit within 15 seconds. It must be easy to doff.

4.4 Aerospace Standards (AS) 8031 and 8047 (Class 1) may be used as references, as applicable.

The corresponding EASA European Technical Standard Order "ETSO-C116" dated October 24, 2003, had identical phrasing to the FAA TSO extract above.

Subsequent revisions to the C116, i.e. FAA TSO-C116a dated July 30, 2009 and EASA TSO-C116a dated August 5, 2016, both referring to Aerospace Standard AS4087, incorporated the following phrasing (in extract):

3.2.11 Portable PBE must be easily put on and activated, after the user gains access to the stowed unit within 15 seconds.

The AIB asked EASA which – if any – requirements existed concerning opening of the protective bag of the PBE.

According to EASA:

- No requirements existed on prescription of a certain load to open the bag within E/TSO-C116. For information, in the successive Revision "a" of E/TSO referring to AS8047 standard, prescribes:
  3.2.11 Portable PBE must be easily put on and activated, after the user gains access to the stowed unit within 15 seconds.
- No specific mention is given to the accessibility, but the 15 seconds computation should include the bag opening time.
- Further, mention is given to the training unit:
  5. TRAINING:
  5.1 Requirements:

1. Any unit available for crew training shall simulate the characteristics of accessibility, donning, function and communication.

- Therefore "accessibility" should mean bag included.

1.17.1.2 PBE training requirements

The cabin crew initial and recurrent PBE training requirements were stated in:

- Commission Regulation (EU) No. 290/2012, Annex V, Subpart TRA "Training requirements for cabin crew attestation applicants and holders".
- Commission Regulation (EU) No. 965/2012, Annex III "Organisation Requirements for Air Operations" (PART-ORO) SUBPART CC.
- EASA "Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-ORO" (Consolidated version — Issue 2, 24 April 2014).

See appendix 5.12

According to EASA, the rules/regulations did not go into the level of detail that included the unpacking of the protective cover of the PBE. AMC1 ORO.CC.115(c) "Conduct of training courses and associated checking (TRAINING METHODS AND TRAINING DEVICES)" (in extract) stated:

(b) When assessing the representative training devices to be used, the operator should:

(2) ensure that those items relevant to the training and checking intended to be given accurately represent the aircraft or equipment in the following particulars:

(i) layout of the cabin in relation to doors/exits, galley areas and safety and emergency equipment stowage as relevant;

(iv) safety and emergency equipment of the type provided in the aircraft (such equipment may be 'training use only' items and, for oxygen and protective breathing equipment, units charged with or without oxygen may be used);

1.17.2 The operator

1.17.2.1 General

The operator provided a number of scheduled services as well as passenger charters and freight services.

The aircraft fleet consisted of twin-engine turboprop aircraft and medium-haul jet aircraft.

The area of operation (passengers, cargo and emergency medical service) were ICAO EUR, NAT, AFI, and MID/ASIA.

The operator's Air Operator Certificate (AOC) held an approved Operations Manual (OM) system containing operational documentation and limitations, and standard operating procedures (SOP).

1.17.2.2 Authority, duties and responsibilities of the commander

The operator's Operations Manual Part A, approved by the DTCA, described the authority, duties and responsibilities of the commander in chapter 1.4 (in extract):

The commander of each flight has authority to discharge all his statutory and company responsibilities for the operation, the disposition and safety of the Aeroplane and the safety of all persons on board. Nothing in the operations manual shall be construed as limiting or derogating from this authority.

The commander, in addition to complying with OM-A 1.5(1-3), shall:

8. Ensure that all operational procedures and checklists are complied with, in accordance with the Operations Manual;

24. In an emergency situation that requires immediate decision and action, take any action he considers necessary under the circumstances. In such cases he may deviate from rules, operational procedures, and methods in the interest of safety.

1.17.2.3 PBE training

The operator's Operations Manual Part D, approved by the DTCA, contained Cabin crew Initial, Conversion, Differences and Recurrent (12 and 36 months) training requirements.

See appendix 5.13

The PBEs used for training were normally extracted from the protective bag prior to training, i.e. as "training use only" items.

Both the CA 1 and the CA 2 had during their latest Emergency and Safety Equipment training session donned a PBE similar to the one that the CA 1 attempted to use during the sequence of events.

One other person participating in the same Emergency and Safety Equipment training session extracted a PBE from the protective bag as a demonstration. The duration of the demonstration by the other person lasted according to the CA 1 and CA 2 between 1½ to 2 minutes, although the person did not hurry.

Neither the CA 1 nor the CA 2 had ever tried to extract a PBE from a protective bag.

1.17.2.4 Language policy

The use of a common working language (English or Danish) was described in the operator's Operations Manual Part A and Part D.

See appendix 5.14

1.17.3 Other PBE opening issues events

1.17.3.1 Database search

The AIB looked for PBE bag opening issues in the EC Joint Research Centre Data Catalogue, DTCA, EASA, TSB and TC databases.

The data run did not reveal similar occurrences or any reported problems concerning the opening of a PBE protective bag.

1.17.3.2 Ongoing investigations

During the course of the safety investigation, the AIB became aware of an ongoing safety investigation that seemed to involve similar or related PBE issues.

On 3-8-2016, an accident involving a Boeing 777 occurred at Dubai International Airport (OMBD). During the evacuation of the aircraft, a number of cabin crew members experienced problems concerning their PBE equipment.

These problems were summarized in paragraph 1.15.3 of the preliminary report, (AAIS Case No.: AIFN/008/2016, published on 5-9-2016 by the Air Accident Investigation Sector (AAIS) of the United Arab Emirates (UAE) General Civil Aviation Authority (GCAA)):

1.15.3 Protective Breathing Equipment (PBE)
A total of five PBE units were used during the evacuation. Some of the cabin crewmembers reported that they had experienced difficulty in opening the PBE containers, or the PBE protective bags.

Because the AAIS safety investigation was ongoing at the time of publication of this report, the safety conclusions of the AAIS safety investigation were not available to the AIB.

1.18 Additional information

Not applicable

1.19 Useful or effective investigation techniques

None

2 ANALYSIS

General

The licenses and qualifications held by the flight crew and the cabin crew, the documented technical and known maintenance status of the aircraft, the aircraft mass and balance and the operational flight planning had, in the opinion of the AIB, no influence on the sequence of events.

2.1 Engine no. 1

To the AIB the engine no. 1 seizure was caused by a failure to the no. 2 bearing (contained engine failure ref. ICAO annex 13).

The engine seizure did not result in any aircraft controllability problems or any aircraft single system failures. Upon shutting down the engine, the flight crew operated the aircraft in a single engine configuration. This was within the certified operating envelope of any large commercially operated aircraft and within the training requirements of any commercial airline flight crew.

The borescope inspection and the teardown examination of engine no. 1 revealed that failure of the no. 2 bearing most likely caused the engine seizure.

Because the number of remaining parts of the no. 2 bearing was limited, the remaining parts were substantially damaged, and no serial numbers were identifiable, the AIB finds the decision of the manufacturer to open an engineering investigation into the possible cause(s) of the increased rate of distressed no. 2 bearings across the engine fleet to be appropriate.

The involvement of TC will in the opinion of the AIB, secure the progress and objectivity of the engineering investigation and support the dissemination of the safety outcome.

For that reason, the aspects pertaining to the engine seizure deemed to be a continued airworthiness issue and were not investigated further by the AIB.

2.2 Smoke

Because of the no. 2 bearing failure and the engine seizure, smoke mixed with compressed air was extracted via the LP stage – or via the HP stage and HP valve – into the aircraft pneumatic system.

The smoke contaminated air proceeded then via the Bleed valve and the Pack valve to the LH pack.

After the smoke contaminated air was processed in the LH pack, it was routed via the air conditioning supply duct to the cockpit and cabin outlets.

Below, the AIB has correlated various flight stages, flight crew actions and aircraft automatic system actions to the aircraft SSFDR readout position of the LH HP Air flow valve (HP valve) and the LH Pack Air Flow valve (Pack valve).

The position of the LH Bleed valve links with available air pressure. It will close if no air pressure is available – like the LH HP valve and the LH Pack valve – according to the FCOM 1.03.

Time UTC	LH HP valve	LH Pack valve	LH Bleed valve
05:02:11 - 05:04:07 Before engine start	Closed	Closed	Closed
05:04:09 - 05:10:03 Engine started	Opened	Opened	Opened
05:10:05 - 05:11:43 Take off and climb out. At 05:11:39 engine power lever retarded to flight idle	Closed	Opened	Opened
05:11:45 - 05:12:11 Engine condition lever retarded to feather and then set to fuel shut off	Opened	Opened	Opened
05:12:13 - End of recording Engine stopped	Closed	Closed	Closed

Smoke was thus able to enter the air conditioning system from 05:04:09 hours (after engine start) and until 05:12:13 hours (engine stopped).

In the period 05:11:31 – 05:11:39 hours, the flight crew smelled a metallic odour, the CRC aural warning triggered, the “ENG 1 OIL” warning illuminated, and the engine torque dropped. These were all indications of the impending engine seizure and when the power lever was retarded to flight idle, the engine air pressure changed. Immediately after, the flight crew observed smoke entering the cockpit.

The opening of the LH HP valve at 05:11:45 - 05:12:11 hours was most likely prompted by a demand for higher air pressure due to a combination of idle engine power setting and available air pressure due to the engine seizure.

It is the opinion of the AIB that smoke continued entering the pack and the air conditioning system until 05:12:13 hours when both the Bleed valve and the Pack valve closed. Following this, any further smoke from the engine seizure was isolated from the aircraft air conditioning system.

Any subsequent flight crew action – whether performed or not – would only have had an influence on the removal of smoke already present in the aircraft cockpit and cabin.

There was no specific checklist for cabin ventilation, but – according to the FCOM 1.03.30.1 Air Ventilation – with the recirculation fans stopped, the smoke contaminated cabin air was not recycled into the air conditioning system. The cabin was ventilated when uncontaminated air from the air conditioning system replaced smoke contaminated cabin air – which was expelled overboard through the cabin outflow valves.

The decision of the flight crew to limit the use of checklists to the "Smoke" (emergency), the "Before landing" (normal) and the "On Ground Emergency" (emergency), was based on their assessment of the aircraft technical status and their wish to minimize the remaining flight time. The flight crew decision was in accordance with the Operator's Operations Manual Part A, Chapter 1 part 1.4 item no. 24.

To the AIB, a combination of flight crew checklist actions, flight and cabin crew decision making and aircraft system automation mitigated the consequences of;

- the engine seizure
- the ingress of smoke into the aircraft
- smoke exposure to passenger and cabin crew.

2.3 Internal crew communication

After the flight crew had donned their oxygen masks, flight crew interphone communication was achieved with little or some difficulty according to the flight crew.

According to the CA 1, the interphone communication with the cockpit (RH pilot) was highly difficult.

All crew members stated that the oxygen mask breathing noise was the main source to communication difficulties.

The AIB has no firm explanation to the perceived low quality of the interphone audio by the CA 1.

The AIB test of the system revealed no faults. However, the following might have influenced the perceived audio quality:

- The quality of the oxygen mask microphone or the cabin handset.

- The ambient cockpit noise (including the breathing of the LH pilot) being relayed in the interphone system when the RH pilot spoke.
- The speaking/breathing technique used by the RH pilot.
- Other unusual inputs affecting the cognitive ability of CA 1, i.e. smoke in the cabin, worried passengers, and focus on own tasks etc.
- The LH pilot ACP INT/RAD selector set in the INT position (although the AIB finds this highly unlikely, as the internal flight crew communication most likely would have been hampered to a larger degree than perceived by the flight crew).

Although the operator's Operations Manual Part D stated that communication between crew members should be in a common language, both Danish and Swedish were used during the sequence of events.

In general, the AIB considers a mix of Danish and Swedish used between experienced crew members as a common language.

The recorded internal crew communication of the SSCVR supported this statement, and therefore the AIB does not consider the use of Danish and Swedish to have hampered the internal crew communication.

The applied SSCVR recording technique ("HOT microphone") meant that SSCVR track no. 2, no. 3 and no. 5 recordings contained continuous breathing noise from the flight crew, ambient cockpit noise in addition to internal crew communication, and ATC transmissions.

This made it difficult – and at times nearly impossible – to interpret the meaning of the recorded communication on track no. 2, no. 3 and especially on track no. 5.

The limited period of useable recording on track no. 1, no. 2 and no. 3 meant that the AIB mainly had to use the mixed channel recording of track no. 5 for the safety investigation.

Despite the above difficulties, the recordings gave the AIB an impression of a crew that:

- divided the workload according to the crew member roles
- maintained closed loop communication (internal flight crew, cockpit to CA 1, internal cabin crew and cockpit to ATC)
- performed required tasks, e.g. assessed the situation, prioritized, completed checklists and planned ahead.

This was mainly in line with the crew's own perception of their cooperation during the sequence of events.

Despite the delay in evacuating the passengers, the safety of the flight was in the opinion of the AIB not impaired.

2.4 Passenger address

During the sequence of events, the CA 1 and the LH pilot overall gave four announcements intended to be PA announcements.

The passengers and the cabin crew only heard announcement no. 1 given by CA 1.

The other three announcements (no. 2 - 4) all made by the LH pilot:

- were heard by the flight crew, but not by anyone in the cabin
- were recorded on SSCVR track no. 5 (Mix), but not on track no. 1 (PA and SSCVR time code).

Because the subsequent test of the PA system, performed by the AIB, did not reveal any malfunctions of the system, the AIB concludes that the announcements no. 2 - 4 were given via the interphone (INT) channel and not via the PA channel.

In order to perform a PA announcement from the LH pilot position using the oxygen mask microphone:

- The ACP PA transmission key must be selected, and
- either the ACP INT/RAD selector must be held to RAD, or
- the control wheel PTT selector must be held in the backward position (Radio).

Because the LH pilot stated use of the control wheel PTT selector switch during the flight, two scenarios seems plausible, which might explain how the announcements were given via the interphone channel:

- Either the INT transmission key was selected instead of the PA transmission key on the ACP, or
- the control wheel PTT selector switch was pushed to the forward position (Interphone) instead of held backward in the aft position (Radio).

The AIB finds it likely, that a combination of a relatively unfamiliar seat position, the role for the LH pilot, and an unfamiliar – and most likely stressful – environment led to one of the two above scenarios.

2.5 Use of PBE

The CA 1 was not able to open the protective bag containing her PBE during the sequence of events despite of the facts that:

- she had completed her annual recurrent Emergency and Safety Equipment training provided by the operator less than one week prior to the time of the event
- one other participant at the training session demonstrated how to open a similar PBE protective bag
- the operator's approved Operations Manual Part D included specific training requirements for PBE (and fire and smoke) which were consistent with the required European Commission regulations (EU) 290/2012 and 965/2012 and the EASA AMC & GM to Annex III – Part-ORO
- design specifications for the PBE required "*The unit shall be capable of being easily donned and activated, after gaining access to the stowed unit within 15 seconds.*" which was reflected in TSO-C116 and E/TSO-C116, both referring to AS8047.

In the opinion of the AIB, the following influenced the sequence of events:

- The CA 1 had never tried to open a PBE protective bag during her training.
- Extracting the PBE from the protective bag was not a specific training requirement.
- The length of the protective bag "rip tag" was insufficient to curl around your hand for a better grip.
- The duration of the PBE demonstration during the annual recurrent Emergency and Safety Equipment training session (1½ to 2 minutes) influenced the decision of the CA 2 not to don her PBE.

Possible explanations to the above might be:

The use of an already extracted PBE for training purposes seemed to be in contrast to the wording in the AMC1 ORO.CC.115 *"..accurately represent the aircraft or equipment."*
However, the same section opens up for the use of *"..training use only items."*.
This might suggest to a training organisation, that compliance was fulfilled by performing a demonstration of how to open a PBE protective bag followed by practical training on using an already extracted PBE.

There seems to be a significant gap between the perceived time required to don a PBE by operational personnel and the time stated in the TSO-C116 and E/TSO-C116. Numerous explanations for this gap might be "slow" demonstration, perceived complexity in the donning process or the influence of different environmental conditions.

3 CONCLUSIONS

3.1 Findings

1. The licenses and qualifications held by the flight crew and the cabin crew, the documented technical and known maintenance status of the aircraft and the weather conditions had no influence on the sequence of events.
2. Approximately 25 minutes of recordings, recorded after the sequence of events, were recorded on the SSCVR.
3. It was a commander qualification upgrade line training flight.
4. The flight crew were seated according to a "commander upgrade" seating, i.e. in a more unfamiliar pilot seat environment.
5. Engine no. 1 seized approximately one minute after take-off, most likely due to the failure of bearing no. 2.
6. Smoke entered the cockpit and cabin through the air conditioning system following the engine seizure.
7. The flight crew limited the use of emergency checklists to the "Smoke" and the "On Ground Emergency Evacuation" checklist.
8. The operator's approved Operations Manual Part A authorised the commander – to in an emergency – to deviate from rules, operational procedures, and methods in the interest of safety.
9. The LH pilot PA announcements were recorded on SSCVR track no .2, no. 3 and no. 5 but not on track no. 1.
10. The CA 1 PA announcement was recorded on SSCVR track no. 5. The period of the CA 1 PA announcement was not included in the recordings on SSCVR track no. 1.
11. Neither passengers nor cabin crew heard any PA announcements from the flight crew.
12. Both passengers and cabin crew heard the CA 1 PA announcement.
13. The subsequent test of the Interphone/PA system did not reveal any faults.
14. The internal crew communication was effective albeit hampered by the flight crew's use of oxygen masks.
15. During the sequence of events, the crew internally communicated in Danish and Swedish.
16. The operator's approved Operations Manual Part A and Part D described the use of a common working language.
17. Closed loop communication technique was used to mitigate the consequences of perceived inferior interphone audio quality.
18. The CA 1 was unable to open her PBE protective bag.
19. Neither of the two cabin crew members had opened a PBE protective bag during training or line flying.
20. Opening of a PBE protective bag was not directly specified as a requirement in neither initial nor recurrent cabin crew PBE training requirements.

21. According to the EASA AMC, the training provider must "ensure that those items relevant to the training and checking intended to be given accurately represent the aircraft or the equipment".
22. The use of "training use only" equipment was described in the EASA AMC.
23. The operator's cabin crew PBE training syllabus – described in the Operations Manual Part D – reflected the EU cabin crew PBE training requirements, and was approved by the DTCA.
24. The AIB pull test of the PBE revealed that 19.03 kg of pull was needed to tear open the protective bag.
25. An AIB data search in different international databases did not reveal crew PBE protective bag opening issues.
26. The aircraft on ground evacuation was – albeit delayed due to missing PA announcements in the cabin – effective.

3.2 Factors

1. Engine no. 1 seized approximately one minute after take-off, most likely due to the failure of the bearing no. 2.
2. The CA 1 was unable to open her PBE protective bag.

3.3 Summary

A failure of the no. 2 bearing in the no. 1 engine most likely caused an engine seizure.

Consequently, smoke entered the aircraft through the air conditioning system.

During the serious incident:

- The senior cabin attendant (CA 1) attempted without success to extract her protective breathing equipment (PBE) from the protective bag.
- Neither cabin crew nor passengers heard the passenger address (PA) announcements made by the left hand seated pilot.

The serious incident occurred in dark night and under visual meteorological condition (VMC).

4 AREA OF SAFETY CONCERN

4.1 Area of safety concern

The AIB safety investigation in combination with the AIB data search for similar PBE handling occurrences did not reveal direct organisational flight safety lapses.

However, at an individual level the AIB safety investigation did reveal flight safety indicators of potential flight safety issues like:

- Certification of PBE on design versus crew user-friendliness at an individual level.
- Certification of PBE versus regulation on crew training in use of PBE.
- Regulation on crew training in use of PBE versus crew training effectiveness at an individual level.

Aside from this safety investigation, the AIB has no academic substance for the presented flight safety indicators.

For that reason, the AIB encourages EASA to:

1. Trend monitoring of future similar PBE handling occurrences.
2. Take into consideration the potential flight safety outcome of the GCAA AAIS Case No: AIFN/0008/2016 safety investigation.

4.2 Preventive actions

Due to this serious incident, the operator recognized the PBE opening issue and replaced all their PBE's similar to the one installed on this serious incident flight (part number 110093-11) with an updated version of the PBE (part number 110093-21).

The updated version incorporated a cut in the seam between the rip-tag and the vacuum protective bag, which should enable an easier opening of the PBE protective bag.

Additionally, the operator is considering implementing changes to their future PBE training of cabin crews.

5 APPENDICES

5.1 Smoke checklist – the operator
5.2 On ground emergency evacuation checklist – the operator
5.3 Air system schematic
5.4 Operational flight plan
5.5 Mass and balance
5.6 Notam
5.7 ATR 72 FCOM Audio Control Panel (extract)
5.8 ATR 72 FCOM PTT Selector
5.9 No. 2 bearing damages
5.10 Engine manufacturer's teardown investigation report (in extract)
5.11 PBE with tag
5.12 PBE training requirements (in extract)
5.13 Operators Operations Manual Part D (in extract)
5.14 Operators Operations Manual Part A and D (in extract)

5.1 Smoke checklist – the operator

Return to history of the flight

SMOKE

CREW OXY MASKS..... ON / 100%
GOGGLES .....SET
CREW COMMUNICATIONS .....ESTABLISH
RECIRC FANS 1 + 2 ..... OFF
AP ..... ON

SMOKE SOURCE..... IDENTIFY

■ **If source not identified or electrical smoke suspected**
Note: ELEC light may be activated by an air conditioning smoke source
ELECTRICAL SMOKE procedure (1.05A) .....APPLY

■ **If air conditioning smoke identified**
AIR COND SMOKE procedure (1.05A) .....APPLY

■ **If FWD SMK illuminated or smoke in FWD zone of aircraft**
FWD SMOKE procedure (1.06).....APPLY

■ **If AFT SMK illuminated or smoke in AFT zone of aircraft**
AFT SMOKE procedure (1.06) .....APPLY

■ **If AUX AFT COMPT SMK illuminated (depending on models)**
AUX AFT COMPT SMK procedure (1.06).....APPLY

5.2 On ground emergency evacuation checklist – the operator

Return to history of the flight

ON GROUND EMER EVACUATION

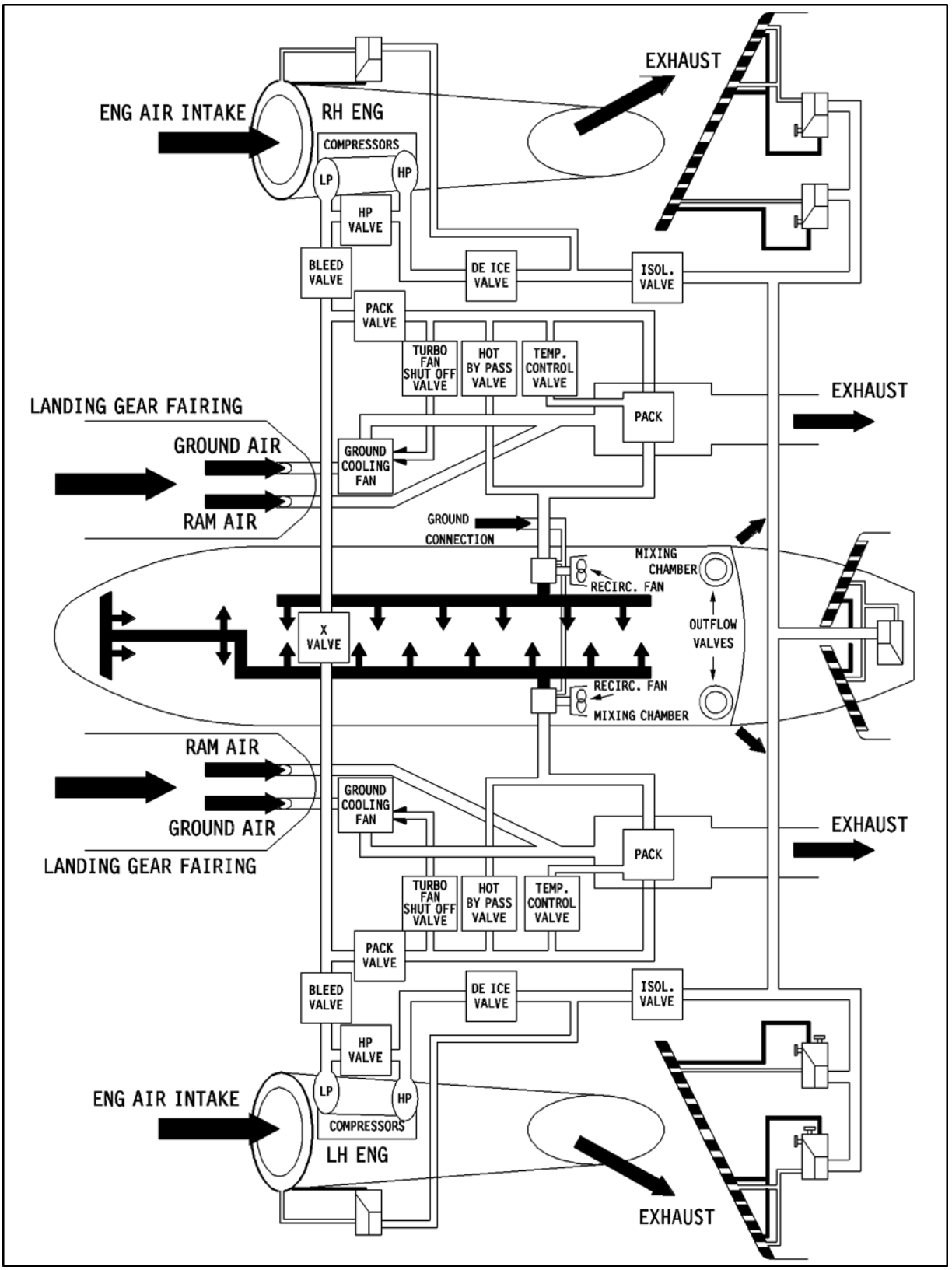
AIRCRAFT / PARKING BRAKE ..... STOP / ENGAGE
AUTO PRESS..... DUMP
ATC (VHF 1) ..... NOTIFY
CL 1 + 2 ..... FTR THEN FUEL SO
MIN CAB LIGHT ..... ON
CABIN CREW (PA)..... NOTIFY
FIRE HANDLES 1 + 2.....PULL
AGENTS .....AS RQD
ENG START ROTARY SELECTOR..... OFF / START ABORT
FUEL PUMPS 1 + 2..... OFF
EVACUATION (PA) .....INITIATE

- **Before leaving aircraft**

  BAT ..... OFF

5.3 Air system schematic

Return to pneumatic and air conditioning system



5.4 Operational flight plan

Return to operational flight plan

```
Log Nr.: 7783 Page  1                                     EKRN-EKCH
TYPE OF FLIGHT: IFR COMMERCIAL - 9 PREFIX IN FLIGHT NO. INDICATES FERRY FLIGHT

FLT ID :          DOF 03/12-2016  | PIC:     | ATIS/WX DEP                         INFO :
REG/AC :  OYLHA/AT72              | F/O:     |                                     QNH  :
DEP    :  EKRN RNN BORNHOLM/RONNE | CA1:     |                                     HANDL:131.55
DEST   :  EKCH CPH COPENHAGEN/KAST| CA2:     | ATIS/WX ARR                         INFO :
ALT1   :  ESMS MMX MALMO          | CA3:     |                                     QNH  :
ALT2   :                          |          |                                     HANDL:130,275
T/O ALT: ________________

ATC Routing: ROE M743 ALM          <<<ENGINE OUT DP>>>                STD: 05:15 STA: 05:50
                                                                      ETD:  5:15 ETA:  5:45
                                                                      OFF:        ON :
                                   ACCELERATION ALTITUDE : ______     AIR:        LND:

ATC Clearance:                  MLM:_________   PIC SIGN: ______________   REMAINING FUEL:______
XPDR:                                                                      ACT FUEL BURN :______

------------ FUEL--------------  ---- WEIGHTS (info only) ----  ----------- INFO ---------------- ---------- Corrections ----------
             TIME    Kg    LMC                        MAX
Trip         0:30   379  ______                Kg      Kg   Avg. WC          :  22 KTS HEAD   FL    WC    TIME   FUEL   COST
Alt1 (ESMS)  0:14   260  ______   DOM       13509            Avg. ISA         :  -11C
Alt2 (    )  0:00     0  ______   EZFM      14994    19700   GC dist     NM   :   79          160   -39   33.0    367      9
MCF  (    )  0:05    45  ______   ETOM      16414    22000   Total dist  NM   :  104          140   -35   31.7    369      4
Final Res    0:30   269  ______   ELDM      16035    21350   Total dist  KM   :  193          120   -31   30.7    370      0
Cong. Airs   0:00     0  ______   ERAMP     16444    22030   WINDDATA M/D/H   : 12030515     |100   -22   29.7    377      0|
Min T/O      1:19   953  ______                              A/C CONFIG       : PAX            80   -19   29.2    387      3
Taxi                 30  ______   PAX:  15 HOLD LOAD:   225 Kg CRUISE PROFILE : NORMAL NP 86%  60   -18   29.1    403     12
Ramp min            983  ______   TOTAL PLANNED LOAD:  1485 Kg 20kt HW COR.   : 0:02    27 Kg  40   -23   28.3    404      9
Extra        0:55   467  ______   Underload          :  4706 Kg                                 20     0   N/A       0    ---
Ramp         2:14  1450  ______   Underload factor   :  MZFM
```

WPT	IDENT	T	FREQ	AIR WAY	FL	MA	MT	DIST Leg	DIST 104	TIME INT	TIME ACC	ETO	ATO	GS	W/V	ISA	FUEL FLOW	-- FUEL -- USED	-- FUEL -- MREQ	-- FUEL -- ACT / REMAIN	MREQ +/- DIF
	EKRN		52ft																		
RONNE	ROE	D	112.00	DCT	100	15	233	10	94	4	0:04			280	326/034	-14	867	83	855	/	
	-TOC-	A		M743	100	15	295	0	94	0	0:04	___	___	252	326/034	-14	867	83	855	___ / ___	
ROXUB	ROXUB	A		M743	100	15	295	26	68	6	0:10			252	326/034	-14	867	172	765	/	
ALMA	ALM	V	116.40	M743	100	25	293	20	48	5	0:15	___	___	260	328/027	-11	867	239	699	___ / ___	
	-TOD-			DCT	100	26	289	28	20	6	0:21			261	328/027	-11	867	332	606	/	
	EKCH		17ft	DCT		26	289	20	0	9	0:30	___	___	156	328/027	-11	867	409	529	___ / ___	

5.5 Mass and balance

Return to mass and balance

ID 164307 BY ON 03-12-2016 05:00:27 STANDARD DCS LDM

```
LOADSHEET                    DATE
ALL WEIGHTS IN KILOS         2016-12-03T05:15:00Z

FROM                TO       FLIGHT      A/C REG      VARIATION      CONFIG
EKRN                EKCH                 OYLHA        66 PAX         11

                             WEIGHT      DISTRIBUTION
LOAD IN COMPARTMENTS         55          -1551-1-1-1010
PASSENGERS / CABIN BAG       1176                                    TTL 14
TOTAL TRAFFIC LOAD           1231
DRY OPERATING WEIGHT         13521
ZERO FUEL WEIGHT             14752       MAX 19700
TAKE OFF FUEL                1461
TAKE OFF WEIGHT              16213       MAX 22000
TRIP FUEL                    379
LANDING WEIGHT               15834       MAX 21350
**********************************************************************
BALANCE AND SEATING CONDITIONS
DOI                          -16.7
LIZFW                        0.46
LITOW                        2.89
LILW                         2.26
MACZFW                       25.20
MACTOW                       26.16
MACLW                        25.93
THS
PAX                 0|0|8|6
UNDERLOAD BEFORE LMC         4948
**********************************************************************
NOTOC                        NO
```

5.6 NOTAM

Return to notices to airmen (NOTAM)

Notams

DEPARTURE AIRPORT

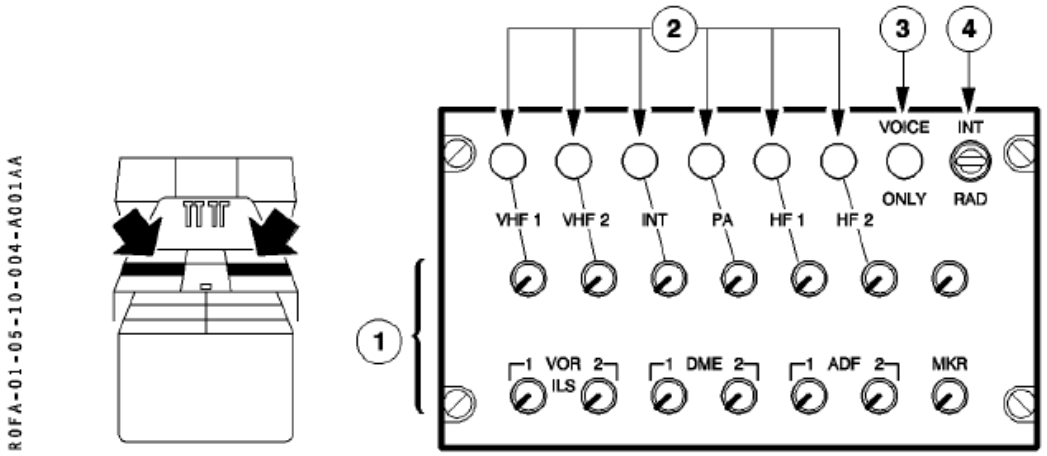
dep
RWY 11 29
EKRN - RNN - BORNHOLM/RONNE

	NOTAM NUMBER	START	END	
1 DAY	B2749 ANEMOMETER RWY 29 U/S	dec 01, 2016 - 17:10	dec 09, 2016 - 15:00	ICAO
4 DAYS	D1525 ROE MAST OBST LIGHTS LIH FLG W OUT OF SERVICE. PSN 550936N 0145313E, ELEV 1415FT HGT AGL 1036FT.	nov 29, 2016 - 09:19	PERMANENT	ICAO
7 DAYS	D1508 OBST LIGHTS AARSBALLE MAST OUT OF SERVICE. PSN 550855N0145248E ELEV 965FT HGT AGL 575FT LIH FLG W.	nov 25, 2016 - 11:14	PERMANENT	ICAO
16 DAYS	B2593 ROENNE VOR ROE FREQ 112.0 MHZ MAGNETIC VARIATION CHANGED TO 4E. REF AIP ENR 4.1-1.	nov 16, 2016 - 13:06	dec 31, 2099 - 00:00	ICAO

5.7 ATR 72 FCOM audio control panel (extract)

Return to ACP INT/RAD selector switch

AUDIO CONTROL PANEL



(1) *Volume control knob*
To control reception volume for associated communication or navigation facilities.

(2) *Transmission keys*
To select the individual communication facilities for transmission, six interlocked keys are provided. Only one key can be engaged at a time. It illuminates white when selected.

(3) *VOICE ONLY key*
When depressed, it inhibits NAV receivers station identification by activating a band cut off filter above 1020 HZ. Light illuminates amber.

(4) *INT/RAD selector*
Provides selection of transmission mode when using OXY MASK or BOOM SET mike.

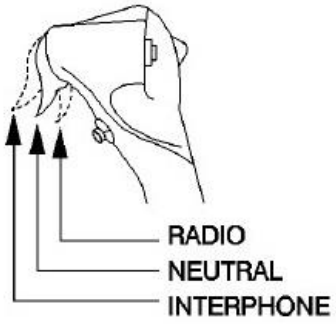
INT	Hot mike position. Interphone is always operative between crew stations. Other transmissions require to select a transmission key and use a PTT pb.
NEUTRAL	Only handmike is usable as long as one transmission key is selected.
RAD	This position is required to automatically connect for transmissions BOOM SET and OXY MASK mikes without using a PTT pb.

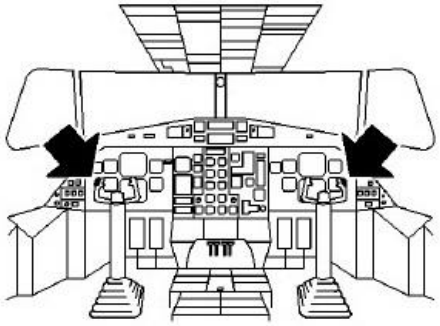
Note : Recovering boomset/micro function when the oxygen mask is out of its container : cf 1.07.20.

5.8 ATR 72 FCOM PTT selector

Return to control wheel PTT selector switch

PTT SELECTOR





The outboard horn of both control wheels is provided with a PTT selector controlling the transmission mode and effective only when BOOM SET or OXY MASK mike is used for transmission.

Interphone	Forward position springloaded to neutral. transmission on flight interphone selected. INT transmission key has not to be used to communicate between cockpit crew stations.
Neutral	Center position. Transmission is not possible. Reception is normal. Hand microphones are connected for transmission when keyed.
Radio	Backward position springloaded to neutral. BOOM SET or OXY MASK is connected for transmission over the selected communication facility.

5.9 No. 2 bearing damages

Return to tear down examination

No. 2 bearing housing distress

Remains of no. 2 bearing

Remaining of no. 2 roller bearing, no. 2 bearing airseal, and no. 2 bearing nuts

5.10 Engine manufacturer's teardown investigation report (in extract)

Return to engine investigation report

ENGINE INVESTIGATION REPORT

Historical Facts:

Service order:	*6107388875*	*TIME SINCE NEW :*	*13,801.3 hrs*
Engine model:	*PW124B*	*TIME SINCE O/H :*	*N/A hrs*
Turbomachinery s/n:	*AH0021*	*CYCLES SINCE NEW :*	*21,069*
Reduction gearbox s/n:	*AH0021*	*CYCLES SINCE O/H :*	*N/A hrs*
Customer:	*Erased by the AIB*		
Date of engine removal:	*13-Dec-2016*		
Previous shop visit:	*At P&WC (SEA) in Nov 2013 for H.S.I / LCF under S.O: 6105676598*		
Reason for engine removal:	*In-Flight Shutdown (IFSD)*		

Summary:

Subject engine was removed from aircraft OY-LHA, #1 position (MSN: 508) and input to P&WC (SEA) for IFSD investigation.

This teardown report summarizes the hardware status removed from the engine. It describes defects and anomalies that were discovered during the engine disassembly.

Findings at Incoming Inspection:

HP rotor grinding noise, LP rotor rotate with grinding noise, PT shaft disengaged.

RGB chip detectors: Metal debris collected.

TBM chip detectors: Metal debris collected.

Recommended Investigations:

Modular disassemble TBM and RGB to determine the root cause for the reported In-Flight Shutdown (IFSD).

Workscope performed:

Performed disassembly of turbomachinery (TBM) module i.a.w. PW124B Overhaul and approved DAA data.

Performed disassembly of Reduction Gearbox (RGB) module i.a.w. PW124B Overhaul and approved DAA data.

Findings:

TBM

Disassembly of the TBM observed the following damages:

•Metal debris collected on Turbomachinery magnetic chip detector (MCD);

•The #1 bearing housing was observed with metal debris inside the strainer element.

•As-received oil flow check on No. 2 bearing orifice revealed partial blockage of the orifice;

•The front inlet case was found with impact damage;

•The PT rotor shaft found sheared;

•The fracture end of PT shaft was observed with solidified molten metal;

•The #1 bearing was observed fracture at the outer ring;

•The #2 bearing found distressed (Part and serial number not visible), no rollers retrieved during disassembly;

•The RIC was found with metal deposits at the bottom tank and impact damage at the No.1 bearing mating area;

•The #2 bearing housing was found distressed

•The LP impeller was observed with solidified molten metal at the balancing flange area and heavy rubbing at the full vane leading edges tips.

•The LP rotor shaft was observed fracture and seized with HP impeller.

•The ICC oil pressure strainer was observed with metal debris as indicated.

•The HP impeller housing showed rubbing as at the gas path area.

•The HP impeller observed fracture at location aft of the #5 bearing air-oil seal snap diameter.

•All rotor shafts were found fused together.

•The GCC showed coked oil at # 5 bearing cover area and metal debris was found at the ICC-GGC oil pressure transfer tube.

•The outer liner was observed with crack, erosion and ceramic coating loss at cooling rings and circumferential crack on the outer wrapper.

•The inner liner was found with burnt hole, crack, erosion and ceramic coating loss at cooling ring.

•The HP vane segments were observed with cracking and rubbing at the trailing edge and the inner shroud area.

•The HP turbines blades were found with heavy rubbing at the blades tips and blades platform area.

•The HP shroud segments were noted with rubbing on the gas path surface.

•The LPT disk were found rubbed at the balancing flange and adjacent radii area and fir tree area.

•The PT1 stator was observed with impact damage at the trailing edge.

•The #6&7 bearing pressure transfer tube was observed with metal debris.

•The PT first stage blades were observed rubbing and damage at the tip, leading edge and disk surfaces.

•The PT second stage stator was observed impact damage at the leading edge, trailing edge and airfoil surfaces, rubbing at the inner shroud area.

•The PT second stage blades were observed with rubbing and damage at the leading edge and blade tip.

•The PT second stage disk was observed with rubbing at the disk surfaces.

•Solidified molten material was observed within the PT shaft upon disassembly.

RGB

Disassembly of the RGB observed the following damages:

•Metal debris collected on Reduction Gearbox magnetic chip detector (MCD);

•The RGB input shaft assembly was observed rubbing deposits at the No.9 bearing retaining nuts area;

•The RGB rear housing was observed metal deposits at the bottom of the housing and rubbing at #9 bearing outer area.

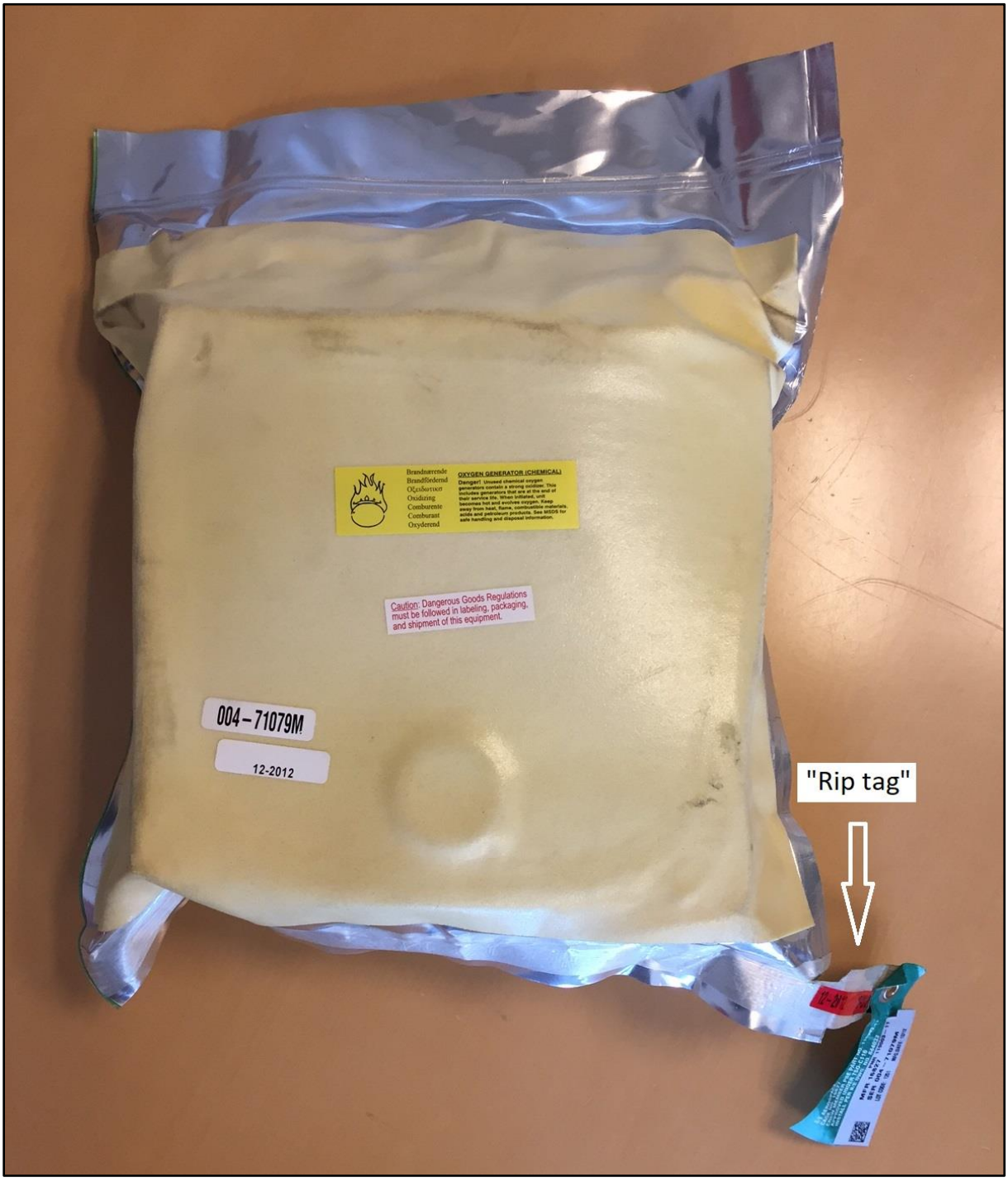
Conclusion:

Engine was input for In-Flight Shut Down and during disassembly, multiple part distress were observed. Disassembly also observed seal housing strainer element with debris and lab analysis of the debris shows that they belong largely to high temperature bearing grade steel M50 or AMS6491.

During the investigation, although the #2 bearing oil nozzles were found partially blocked during the oil flow test, the blockage of the oil nozzle was likely caused by secondary contamination of the oil passage as a result of the event. Post discussion with Service Investigation concluded that the cause of the event is attributable to the distressed no.2 bearing. However, due to the amount of damage sustained, evidence of the causes have been destroyed and therefore the root cause of the bearing distress cannot be determined at this shop visit.

5.11 PBE with “rip tag”

Return to tests and research



5.12 PBE training requirements (in extract)

Return to PBE training requirement

Commission Regulation (EU) No. 290/2012.

General cabin crew initial training requirements were described in Commission Regulation (EU) No. 290/2012, Annex V, Subpart TRA "Training requirements for cabin crew attestation applicants and holders", section CC.TRA.220 "Initial training course and examination".

Appendix 1 to the Annex provided a more detailed training programme.
PBE training was described in section 8 "Fire and smoke training":

8.5. "the techniques of application of extinguishing agents; the consequences of misapplication; and of use in a confined space including practical training in fire-fighting and in donning and use of smoke protection equipment used in aviation"

Aircraft type or variant qualifications were according to section CC.TRA.225:
(a) Holders of a valid cabin crew attestation shall only operate on an aircraft if they are qualified in accordance with the applicable requirements of Part-ORO.

Commission Regulation (EU) No. 965/2012.

Annex III "Organisation Requirements for Air Operations" (PART-ORO)
SUBPART CC – Cabin Crew described training requirements for (extract):

ORO.CC.120 Initial training course

(a) Each new entrant who does not already hold a valid cabin crew attestation issued in accordance with Annex V (Part-CC) to Regulation (EU) No 290/2012:
(1) shall be provided with an initial training course as specified in CC.TRA.220 of that Annex; and
(2) shall successfully undergo the associated examination before undertaking other training required by this Subpart.

ORO.CC.125 Aircraft type specific training and operator conversion training

c) The aircraft type specific training programme shall:
(2) cover at least the following aircraft type specific training elements:
(ii) all safety equipment and systems installed relevant to cabin crew duties;
(v) fire and smoke protection equipment where installed;

(d) The operator conversion training programme for each aircraft type to be operated shall:

(3) cover at least the following operator specific training elements as relevant to the aircraft type to be operated:
(ii) location, removal and use of all portable safety and emergency equipment carried on-board;
(v) fire and smoke training including the use of all related fire-fighting and protective equipment representative of that carried on-board;

ORO.CC.140 Recurrent training

Recurrent training shall include annually:
(i) by each cabin crew member:
(B) the donning of life-jackets, portable oxygen and protective breathing equipment (PBE);

(2) Recurrent training shall also include at intervals not exceeding three years:
(iv) by each cabin crew member:
(B) donning and use of PBE in an enclosed simulated smoke-filled environment.

EASA "Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-ORO" (Consolidated version — Issue 2, 24 April 2014)

GM1 ORO.CC.115 Conduct of training courses and associated checking
EQUIPMENT AND PROCEDURES

The following definitions apply for the purpose of training programmes, syllabi and the conduct of training and checking on equipment and procedures:
(a) 'Safety equipment' means equipment installed/carried to be used during day-to-day normal operations for the safe conduct of the flight and protection of occupants (e.g. seat belts, child restraint devices, safety card, safety demonstration kit).
(b) 'Emergency equipment' means equipment installed/carried to be used in case of abnormal and emergency situations that demand immediate action for the safe conduct of the flight and protection of occupants, including life preservation (e.g. drop-out oxygen, crash axe, fire extinguisher, protective breathing equipment, manual release tool, slide-raft).

AMC1 ORO.CC.115(c) Conduct of training courses and associated checking
TRAINING METHODS AND TRAINING DEVICES

(a) The operator should establish training methods that take into account the following:
(b) When assessing the representative training devices to be used, the operator should:
(1) take into account that a representative training device may be used to train cabin crew as an alternative to the use of the actual aircraft or required equipment;
(2) ensure that those items relevant to the training and checking intended to be given

accurately represent the aircraft or equipment in the following particulars:
(iv) safety and emergency equipment of the type provided in the aircraft (such equipment may be 'training use only' items and, for oxygen and protective breathing equipment, units charged with or without oxygen may be used);

AMC1 ORO.CC.125(c) Aircraft type specific training and operator conversion training
TRAINING PROGRAMME — AIRCRAFT TYPE SPECIFIC TRAINING

The following aircraft type specific training elements should be covered as relevant to the aircraft type:
d) Fire and smoke protection equipment
Each cabin crew member should be trained in using fire and/or smoke protection equipment where fitted.

AMC1 ORO.CC.125(d) Aircraft type specific training and operator conversion training
TRAINING PROGRAMME— OPERATOR CONVERSION TRAINING

The following training elements should be covered as relevant to the aircraft type and the related operator's specifics:

(b) Safety and emergency equipment
Each cabin crew member should receive realistic training on and demonstration of the location and use of all safety and emergency equipment carried, including:
(3) fire extinguishers and protective breathing equipment (PBE);

(c) Normal and emergency procedures
Each cabin crew member should be trained on the operator's normal and emergency procedures as applicable, with emphasis on the following:

(e) Fire and smoke training
(1) Each cabin crew member should receive realistic and practical training in the use of all fire-fighting equipment, including protective clothing representative of that carried in the aircraft.
(2) Each cabin crew member should:
(i) extinguish an actual fire characteristic of an aircraft interior fire except that, in the case of halon extinguishers, an alternative extinguishing agent may be used; and
(ii) exercise the donning and use of PBE in an enclosed simulated smoke-filled environment with particular emphasis on identifying the actual source of fire and smoke.

5.13 Operator's Operations Manual Part D (in extract)

Return to PBE training

2.2 Cabin Crew training (extracts)

2.2.1.3 Initial safety training

The Cabin Attendant's Initial Course shall include:

n) Fire and Smoke Training
s) Depressurization, location and handling of emergency equipment, including oxygen systems, and the donning of life vest, portable oxygen and protective breathing equipment.

2.2.1.21 Location and handling of emergency equipment

The student shall receive lectures in location and handling of emergency equipment, this training shall cover exercise in a classroom, cabin mock-up or actual aircraft.

Further emphasis must be on emergency equipment location, the use of life vest (donning), oxygen system on board, portable and protective breathing equipment. Special attention on procedures and techniques.

2.2.3.2 Conversion training

A Conversion Course must be completed before being:

- *First assigned by the operator to operate as a cabin crew member; or*
- *Assigned to operate another Aircraft type.*

2.2.3.3 Differences training

Differences Training must be completed before operating:

- *On a variant of an Aircraft type currently operated; or*
- *With different safety equipment, safety equipment location, or normal and emergency procedures on currently operated Aircraft types or variants.*

2.2.3.4 Syllabus (diff. conversion training) CAB 2.2.4.

Conversion and Differences Training must be given on the location, removal and use of all safety and survival equipment carried on the Aircraft as well as all normal and emergency procedures related to the Aircraft type, variant and configuration to be operated.

2.2.3.6 Subjects

The following subjects must be covered, all appropriate requirements must be included:

- *Fire and smoke training*

2.2.3.7 Fire and Smoke training

Each cabin crew member must either:

- *Be given realistic and practical training in the use of all fire fighting equipment including protective clothing representative of that carried in the Aircraft. This training must include:*

Extinguishing a fire characteristic of an Aircraft interior fire except that, in the case of Halon extinguishers, an alternative extinguishing agent may be used, and Donning and use of protective breathing equipment by each cabin crew member in an enclosed, simulated smoke-filled environment, or;

- *Fulfil the recurrent training requirements of paragraph 2.2.4.4 of this manual*

2.2.4.3 Recurrent training (12 calendar months)

- *The location and handling of emergency equipment, including oxygen systems, and the donning by each cabin crew member of life-jackets, portable oxygen and protective breathing equipment (PBE);*

2.2.4.4 Recurrent training (36 calendar months) CAB 2.2.5.

An operator shall ensure that, at intervals not exceeding three years, recurrent training also includes:

3. Each cabin crew member being given realistic and practical training in the use of all fire-fighting equipment, including protective clothing, representative of that carried in the aircraft.

This training must include:
(ii) the donning and use of protective breathing equipment by each cabin crew member in an enclosed, simulated smoke-filled environment;

2.2.4.9 Fire and Smoke Training.

Each cabin crew member must receive realistic and practical training in the use of all fire-fighting equipment, including protective clothing, representative of that carried in the aircraft.

This training must as a minimum include:

- *The donning and use of protective breathing equipment (PBE) by each cabin crew member in an enclosed, simulated smoke-filled environment.*

5.14 Operator's Operations Manual Part A and D (in extract)

Return to language policy

Operations Manual Part A:

1.8 Company's policy's.

Common language in the company is English. In situations where all crew on duty understand Danish, communication is accepted to be in Danish. [FLT1.4.1and 3.1.1] This is to be used in following situations:

- *On the flight deck during line operations;*
- *Between the flight crew and cabin crew during line operations;*
- *During flight crew training and evaluation activities.*

Operations Manual Part D:

2.2.1.24 Communication.

During training, emphasis shall be placed on the importance of effective communication between cabin crew and flight crew including technique, common language and terminology.