THE DANISH
ACCIDENT INVESTIGATION BOARD
The Aviation Unit

FINAL REPORT

HCLJ510-2011-11

Serious incident to Avions de Transport Régional ATR72-212A
Registration OY-CIM
Copenhagen Airport, Kastrup (EKCH), Denmark
On 13 September 2011

The report will be available at the Danish AIB web site: http://www.hclj.dk

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FOREWORD

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

In accordance with the provisions of EU Regulation No 996/2010 and pursuant to Annex 13 of the International Civil Aviation Convention, the investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability. The investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than that of 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.

Parallel with the investigation by the Danish Accident Investigation Board, similar investigations were going on in Italy and Hungary respectively and cooperation across national borders was initiated.

Ref.: Tri-National Interim Report, see this report paragraph 1.18.1 and enclosure 18.

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FINAL REPORT

HCLJ510-2011-11	**Serious incident**		
Aircraft:	ATR72-212A	Registration:	OY-CIM
Engines:	2 – P & W 127F	Flight:	Scheduled flight, IFR
Crew:	4 – no injuries	Passengers:	47 - no injuries
Place:	Copenhagen Airport Kastrup (EKCH)	Date & Time:	13.9.2011 at 17:45 UTC

All times in this report is UTC.

Synopsis

The Aviation Unit of the Danish Accident Investigation Board (AIB-DK) was notified of the serious incident by the Area Control Centre at Copenhagen Airport, Kastrup (EKCH) on 13.9.2011 at 17:54 hrs.

The International Civil Aviation Organization (ICAO), Le Bureau d'Enquêtes et d'Analyses (BEA), the Transportation Safety Board of Canada (TSB) and the European Aviation Safety Agency (EASA) were notified on 14.9.2011 at 08:41 hrs. The BEA and the TSB appointed accredited representatives to the investigation.

The serious incident occurred during a scheduled flight from Copenhagen Airport, Kastrup (EKCH) to Aalborg Airport (EKYT). Shortly after take-off from runway 22R, a Master Warning for the left engine low oil pressure was triggered and subsequently a Master Caution for the left engine high Inter Turbine Temperature (ITT) was triggered. The flight crew decided to shut down the left engine (IFSD). While climbing through approximately 750 feet Radio Altitude (RA), a Master Warning for the left engine on fire was triggered. Sequentially, both engine fire agents were discharged and the flight crew decided to land on runway 30. The total airborne time was five minutes and two seconds.

The serious incident occurred in twilight and under visual meteorological conditions (VMC).

Summary

The root cause of the engine failure and engine fire was found to be fatigue crack propagation caused by casting defects (shrinkage porosities) of one of the Power Turbine (PT) stage 1 blades, which led to fracture. The fractured blade caused a lot of fractured PT stage 2 blades and the PT Rotor came in unbalance and broke the bolts holding the Rotor shaft Bearing Housing No 6 & 7 and this caused the housing to rotate. As a result of the rotating bearing housing, all the force was put on the Bearing Housing oil transfer tubes and caused them to break, subsequently leading to an oil leak. The internal oil leak caused a fire. The leaking oil continued out to the bottom of the nacelle and the internal oil fire then spread outside to the nacelle area.

The technical investigation revealed that this event was not an isolated event. The AIB-DK concluded that at the time of the serious incident, there were unidentified PT1 blades from the same Batch (Heat) in circulation around the world as the fractured PT1 blade - with micro shrinkage porosity.

As a consequence of a Tri-National investigation, five safety recommendations have been made and forwarded to EASA and Transport Canada (TC).

1. Factual information

1.1 History of the flight

The incident occurred during a scheduled flight from Copenhagen Airport, Kastrup (EKCH) to Aalborg Airport (EKYT). The commander was Pilot Non Flying (PNF) and the first officer was Pilot Flying (PF).

Shortly after take-off from runway 22R while climbing through approximately 134 feet Radio Altitude (RA), a cockpit Master Warning was triggered referring to left engine low oil pressure. The cockpit Master Warning was silenced. Subsequently, a cockpit Master Caution was triggered referring to left engine high ITT. Smoke was present in the cockpit and in the passenger cabin. The flight crew decided to shut down the left engine (memory items). While climbing through approximately 750 feet RA, a cockpit Master Warning was triggered referring to left engine fire. The cockpit Master Warning was silenced.

A Mayday call to Kastrup Tower was made and the Rescue and Fire Fighting Services of the airport were activated.

The commander took over the control of the aircraft (PF) and initiated a left hand visual circling to runway 22L. The flight crew noted a left engine fire warning light (red light in the left fire handle). Sequentially, both engine fire agents were discharged and the flight crew decided to land on runway 30.

On final to runway 30, the flight crew advised Kastrup Tower of an impending emergency evacuation of the aircraft on runway 30.

Descending through approximately 486 feet RA, a cockpit Master Warning was triggered. The Master Warning was silenced.

A single engine landing was performed.

On runway 30, the flight crew observed that the fire had extinguished and they cancelled the emergency evacuation of the aircraft. The passengers were instructed to calmly disembark the aircraft through the passenger entrance door.

The total Digital Flight Data Recorder (DFDR) recorded airborne time was five minutes and two seconds. Throughout the flight, the flight crew did not make use of the autopilot.

The table below presents the operational sequence of events.

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:42:07 On ground	The cabin crew reported “cabin clear” to the flight crew.	
17:43:08 On ground		After crossing runway 30 and taxiing on taxiway A, OY-CIM was instructed to line up on runway 22R and cleared for take-off. The wind was reported to be 250° 17 knots.
	The flight crew completed the before take-off checklist	
17:44:48 On ground	The first officer initiated the take-off roll on runway 22R. Take-off power and instruments were checked without remarks.	
17:45:13 Departure time See enclosure 1 - marking 1	OY-CIM was airborne. The landing gear was selected up and the yaw damper was engaged.	
17:45:19 App. 136 feet RA See enclosure 1 - marking 2	A cockpit Master Warning (continuous repetitive chime) was triggered referring to left engine low oil pressure. The cockpit Master Warning was silenced.	

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:45:23 App. 256 feet RA See enclosure 1 - marking 3	A cockpit Master Caution (single chime) was triggered referring to left engine high ITT. The flight crew sensed a bad smell and observed smoke in the cockpit and they decided to shut down the left engine (memory items).	
17:45:32 App. 564 feet RA See enclosure 1 - marking 4	By performing memory checklist items, the flight crew initiated a shutdown of the left engine.	
17:45:35 App. 638 feet RA See enclosure 1 - marking 5	By interphone, the cabin crew tried to establish contact with the flight crew. The cabin crew was instructed to be on standby.	
17:45:40 App. 750 feet RA See enclosure 1 - marking 6	A cockpit Master Warning (continuous repetitive chime) was triggered referring to left engine fire. The cockpit Master warning was silenced. Simultaneously by the interphone, the cabin crew reported smoke in the passenger cabin.	
17:45:44 App. 821feet RA See enclosure 1 - marking 7	The flight crew agreed on the aircraft flying without difficulties on the right engine.	The commander reported “Mayday Mayday Mayday” to Kastrup Tower. Kastrup Tower offered the flight crew a teardrop for runway 04R. The wind was reported to be 260° 15 knots or the flight crew could choose any other runway.
17:45:46 App. 850 feet RA	The first officer closed the High Pressure Bleed Valve engine no 1 (memory item).	

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:46:19 App. 1080 feet RA See enclosure 1 - marking 8	The flight crew agreed on changing control of the aircraft from the first officer to the commander. Furthermore, they agreed on returning for landing on runway 22.	
17:46:24 App. 1090 feet RA See enclosure 1 - marking 9		To Kastrup Tower, the flight crew reported their intention of a left turn and returning for landing. Kastrup Tower offered the flight crew a left turn for runway 04R with a tailwind component of 15 knots. The wind was reported to be 260° and 15 knots. The flight crew reported that the aircraft was flying on one engine only and they would like to land on runway 22. Kastrup Tower confirmed landing on runway 22L.
17:46:30 App. 1103 feet RA See enclosure 1 - marking 10	The change of control of the aircraft from the first officer to the commander took place.	
17:47:02 App. 1211 feet RA See enclosure 1 - marking 11		The flight crew of a succeeding departing aircraft in take-off position on runway 22R reported that they could see smoke and a bright light from the left side of OY-CIM.
17:47:11 App. 1242 feet RA See enclosure 1 - marking 12	The flight crew noted a left engine fire warning light (red light in the left fire handle) and by performing memory checklist items, they discharged the engine fire agent number one.	

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:47:28 App. 1270 feet RA See enclosure 1 - marking 13	By the passenger address system, the commander in Danish and English briefed the passengers of the problem with the left engine and that the aircraft would return for landing.	
17:47:41 App. 1305 feet RA See enclosure 1 - marking 14	The flight crew started talking about using runway 30 for landing.	
17:47:48 App. 1351 feet RA See enclosure 1 - marking 15	The flight crew noted that the fire in the left engine was still present and they discharged the engine fire agent number two.	
17:47.54 App. 1315 feet RA See enclosure 1 - marking 16		The flight crew requested information on whether Kastrup Tower from the ground could see fire. Kastrup Tower replied that they would take a closer look and call back.
17:48:11 App. 1284 feet RA See enclosure 1 - marking 17	By the interphone, the flight crew called the cabin crew in order to know if the cabin crew could see fire on the left side of the aircraft. The cabin crew replied that there was no longer any sign of fire.	
17:48:15 App. 1254 feet RA See enclosure 1 - marking 18		Kastrup Tower requested information on persons onboard and fuel upon landing.

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:48:24 App. 1093 feet RA See enclosure 1 - marking 19		Kastrup Tower requested information on whether it was the left of the right engine. The flight crew replied that it was the left engine. Kastrup Tower reported that they could not see any fire on the left side of the aircraft.
17:48:33 App. 1017 feet RA See enclosure 1 - marking 20		The flight crew requested wind information. Kastrup Tower reported that landing on runway 30 would give a crosswind component of 22 knots. The flight crew replied that it would be a landing on runway 30.
17:48:50 App. 704 feet RA See enclosure 1 - marking 21	The landing gear was selected down.	
17.48:57 App. 525 feet RA See enclosure 1 - marking 22	The flaps were extended from flap position 15° to flap position 30°.	
17:48:59 App. 486 feet RA See enclosure 1 - marking 23	A cockpit Master Warning (continuous repetitive chime) was triggered. The cockpit Master Warning was silenced.	
17:49:00 App. 466 feet RA See enclosure 1 - marking 24	The flight crew agreed on a coming on ground emergency evacuation of the aircraft on runway 30.	

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17.49:08 App. 421 feet RA See enclosure 1 - marking 25		The flight crew reported that an evacuation of the aircraft would take place on runway 30. OY-CIM was cleared to land and the wind was reported to be 250° 17 knots gusting to 27 knots.
17.49:16 App. 350 feet RA See enclosure 1 - marking 26	By the interphone, the flight crew informed the cabin crew of the coming on ground emergency and that the evacuation of the aircraft would take place from the aircraft right hand side emergency exits. Furthermore, the cabin crew was instructed to be on standby until further instructions were given from the flight crew.	
17:49:51 App. 144 feet RA See enclosure 1 - marking 27	The flight crew noted that the aircraft was stabilized.	The wind was reported to be 250° and 17 knots.
17:50:15 Arrival time See enclosure 2 - marking 28	OY-CIM landed on runway 30.	
17:50:23 On ground See enclosure 2 - marking 29		The flight crew reported that they would turnaround the aircraft on the runway.

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:50:33 On ground See enclosure 2 - marking 30	By the passenger address system, the commander ordered “Standby Standby Standby” to the cabin crew.	
17:50:37 On ground See enclosure 2 - marking 31	The flight crew noted that the fire had extinguished and they agreed on cancelling the evacuation of the aircraft.	
17:50:39 On ground See enclosure 2 - marking 32	By the interphone, the flight crew informed the cabin crew on the cancellation of the evacuation and that the passengers could disembark the aircraft by the passenger entrance door. The passengers would be informed by the commander.	Kastrup Tower informed the flight crew of the position of the fire brigade. The flight crew informed Kastrup Tower on the extinguished fire and that the evacuation of the aircraft had been cancelled.
17:51:03 On ground See enclosure 2 - marking 33	The first officer performed the on ground emergency checklist. In Danish, the commander briefed the passengers on the extinguished engine fire and instructed the passengers to calmly disembark the aircraft through the passenger entrance door.	
17:52:08 On ground	The commander observed that smoke was still present in the passenger cabin and by the use of the passenger addresses system (cabin crew station number 2), the commander in Danish instructed the passengers to disembark the aircraft and leave their hand luggage behind.	

Time (hh:mm:ss) Radio Altitude (RA)	Crew actions	ATC VHF radio communication (119,350 MHz)
17:52:40 On ground	By the use of the passenger address system, the cabin crew informed the passengers on awaiting assistance outside the aircraft.	

1.2 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal			
Serious			
Minor/None	4	47	

1.3 Damage to aircraft

Only the engine was damaged during the engine malfunction and emergency landing. A small amount of soot could be seen from the outside the left engine nacelle. The engine suffered severe internal damage due to the turbine failure (fig. 1). The external section of the engine from the rear inlet case to the exhaust had sooty appearance. Parts of the wiring harness and connectors were melted due to fire and heat (fig. 2).

Fig. 1. Power Turbine (PT) stage 2.

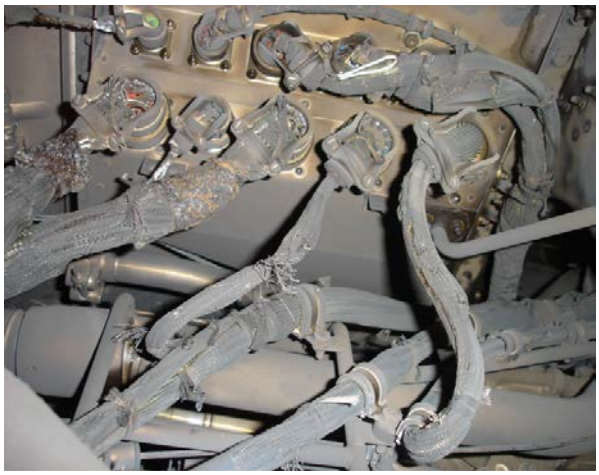


Fig. 2. Visible signs of fire and heat could be seen on the outside of the engine.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Statement of the commander's flying time

	Previous 24 hours	Previous 90 days	Total
All types:	3.1 hours	128 hours	3874 hours
This class/type:	3.1 hours	113.8 hours	3108.5 hours
Number of landings (this class/type)	1	147	-

1.5.2 License held by the commander

The commander – male 32 years old – was in possession of a valid Airline Transport Pilot License (ATPL (A)) with appurtenant valid medical certificate. The commander's JAR-FCL ATR 42/72 rating was valid until 29.2.2012.

1.5.3 Statement of the first officer's flying time

	Previous 24 hours	Previous 90 days	Total
All types:	-	-	2613.2 hours
This class/type:	-	-	-
Number of landings (this class/type)	-	-	-

1.5.4 License held by the first officer

The first officer – male 34 years old – was in possession of a valid Airline Transport Pilot License (ATPL (A)) with appurtenant valid medical certificate. The first officer's JAR-FCL ATR 42/72 CO-PILOT rating was valid until 31.5.2012.

1.5.5 Operator training held by cabin crew member number 1 (CA1)

- ATR 72 training was completed on 1.8.2009.
- Cabin crew medical certificate was valid until 4.1.2013.
- Senior cabin crew course was completed on 14.2.2009.
- Crew resource management recurrent training was valid until 29.2 2012.
- Cabin crew first aid training was valid until 31.1.2012.
- Door training was valid until 28.2.2013.
- Emergency brush up training was valid until 29.2.2012.
- Cabin crew line check was valid until 25.7.2013.

1.5.6 Operator training held by cabin crew member number 2 (CA2)

- ATR 72 training was completed issued on 18.12.2010.
- Cabin crew medical certificate was valid until 18.6.2013.
- Crew resource management recurrent training was valid until 31.12.2011.
- Cabin crew first aid training was valid until 31.12.2011
- Door training was valid until 31.12.2013.
- Emergency brush up training was valid until 31.12.2011.
- Cabin crew line check was valid until 31.12.2011.

1.5.7 The flight and duty time of the pilots (data selected by the AIB-DK)

1.5.7.1 The commander.

Period (year/month)	Block Hrs
2011/01	41:25
2011/02	29:49
2011/03	75:45
2011/04	67:28
2011/05	40:29
2011/06	32:25
2011/07	30:17
2011/08	44:47
2011/09	22:22

On the day of the serious incident, the commander checked in for flight at 1205 hrs. It was the second flight of the day.

1.5.7.2 The first officer.

Period (year/month)	Block Hrs
2011/05	29:48
2011/06	58:54
2011/07	28:58
2011/08	48:58
2011/09	18:11

On the day of the serious incident, the first officer checked in for flight at 1205 hrs. It was the second flight of the day.

1.6 Aircraft information

1.6.1 General aircraft information

Registration:	OY-CIM
Type:	ATR72
Model:	212A
Manufacturer:	Aérospatiale, France
Serial number:	468
Year of manufacture:	1996
Engine manufacturer:	Pratt & Witney Canada
Engines type:	PW127F
Propellers:	Hamilton Standard 568-1
Aircraft total flight hours:	20554:10 hrs.
Aircraft total flight cycles:	31168 CSN
MTOM:	22.800 kg
Airworthiness Review Certificate:	Valid until 15.09.2012

1.6.2 General engine information

The engine (TM) is a three-spool, twin radial compressor. A single stage axial turbine (rotor) powers each of the compressors, and a two stage axial turbine provides power to the propeller through a reduction gear box.

On the 7th of May 1999, the engine was new and had at the time of the serious incident a total of 16018:29 flight hours.
In February 2006 at engine overhaul thirty-seven (37), PT stage 1 (PT1) blades failed the Fluorescent Penetrant Inspection (Non-Destructive Test (NDT)) due to cracked airfoils in the leading and trailing edge and were for that reason replaced with new ones.

On the 5th of February 2011, the latest engine shop visit (Hot Section (HS) repair) took place and it did not reveal any failed PT1 blades.

A schematic of the engine layout is shown in fig. 3.

Removal Date	TSN	CSN	Workscope	Shop Info
TM AV0098				
05 Feb 2011	15832:07	23937	HS repair	w/o WT772345
02 Mar 2010	14830:31	22219	HSI	w/o WT772185
18 Jul 2008	13392:22	19200	Repair	w/o, WT589147
17 Feb 2006	10078:33	13608	TM overhaul	w/o WT983534
07 May 1999	0:00	0	New build PW127F	P&WC

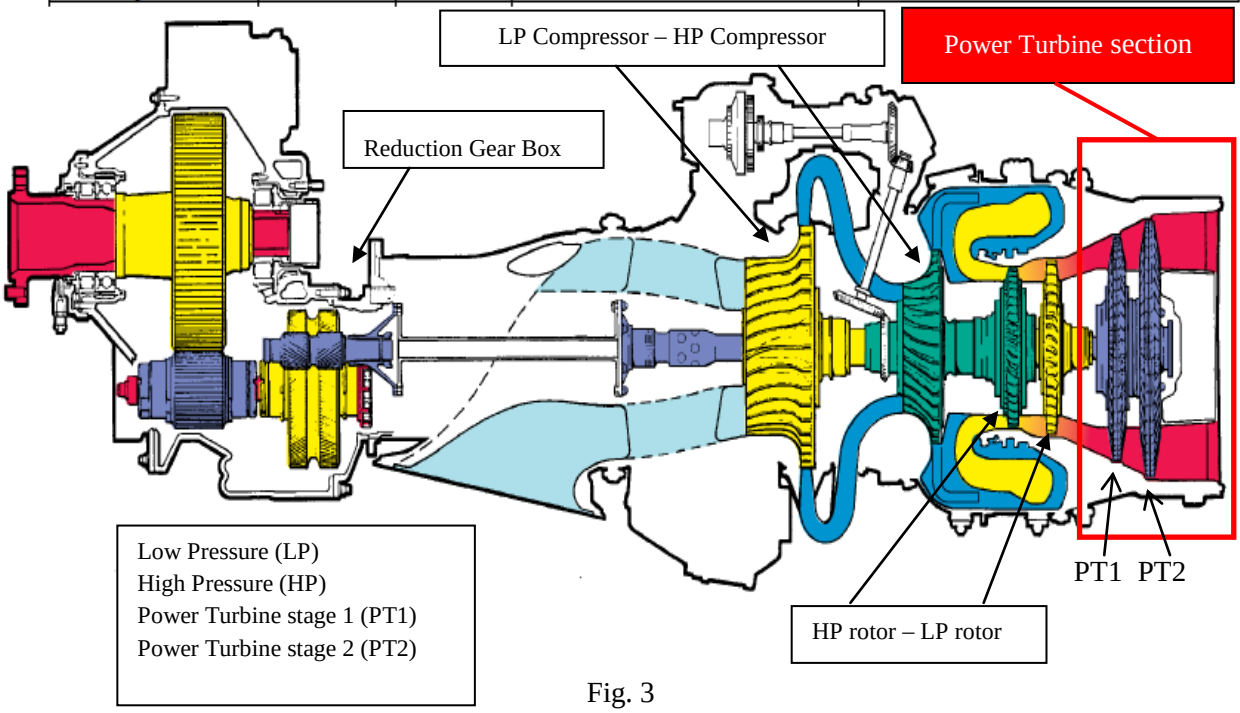


Fig. 3

1.6.3 Power plant fire protection system

1.6.3.1 General

To prevent the spread of fire in the engine nacelle area, there were two fire shut-off valves that could be activated from the cockpit with a Fire Handle. The purpose of the fire shut-off valves was to isolate a fire. Activating the Fire T-Handle in the cockpit closed off the supply of fuel to the engine and air supply from the engine to the cabin and cockpit.

The power plant fire protection system was certified in accordance to EASA Certification Specifications for Large Aeroplanes CS-25.1181 to 25.1203.

Below in italics are extracts from EASA Certification Specifications for Large Aeroplanes CS-25.1181 to 25.1203:

"Compliance with CS 25.1189(a) has typically been shown by installation of shut-off means for flammable fluids that could contribute to the hazards associated with an engine fire, except for lines fittings, and components forming an integral part of an engine and/or fireproof oil system components, which are not required to have a shut-off means per CS 25.1189(a)(1) and (a)(2).
Flammable fluids that have been considered include fuel supplied to the engine/APU, fuel that may enter the fire zone from engine recirculation systems and hydraulic fluids entering the fire zone. Oil that may be supplied from outside the fire zone, deicing fluid, and other fluids would require similar consideration; however these are not typically incorporated in modern CS-25 aircraft engine installations.

Although shut-off means are typically incorporated, CS 25.1189(a) allows the option of otherwise preventing flow of hazardous quantities of flammable fluids. A shut-off means is, therefore, not required if no possible scenario will result in the flow of hazardous quantities of flammable fluid.
Factors to be considered in determination of whether this compliance means is acceptable include the following:

A. Considerations

1. *Leakage rates and characteristics, including massive leakage caused by component failure or fire damage, and slow leakage, which may be a spray or mist if the source is under pressure, caused by failures such as cracks or pinholes.*
2. *The amount of fluid in the system that is subject to leakage.*
3. *Combining A.1), and A.2), the range of potential duration of leakage.*
4. *Scenarios in which the analysed system leakage is subject to ignition and is the initial fire source.*
5. *Scenarios in which the initial fire source is a different system, and fire damage to theanalysed system can result in leakage which contributes to the magnitude or duration of the fire.*

B. Compliance
Considering the above factors and service experience of oil systems without shut-off means, it is acceptable to not install a shut-off means for specific systems which contain flammable fluid if the following conditions are met:

1. *All components of the analysed system within the fire zone are fireproof, and*
2. *The quantity of fluid which can flow into the fire zone is not greater than the fluid quantity of the engine or APU oil system for an engine or APU fire zone, and*
3. *Accomplishment of AFM Emergency Procedures will preclude continuation of a pressurized spray or mist.*

The meeting of conditions (1)-(3) are considered acceptable in precluding a hazardous quantity of flammable fluids from flowing into, within or through any designated fire zone.

1.6.3.2 Engine fire detection system

The engine fire detection is achieved by thermo sensing loops which trigger the warning by means of an electronic control unit in case of a temperature rise in the engine nacelle. A temperature rise causes the following:

- Illuminate the engine fire warning light on T-handle, fig. 4 A and B.
- Illuminate the fire warning light on the Crew Alerting Panel, fig. 4 C.
- Illuminate master warning light on captain's main instrument panel, fig. 4 D.
- Illuminate fuel shut-off warning light on the condition lever, fig. 4 E.
- Trigger the aural warning.

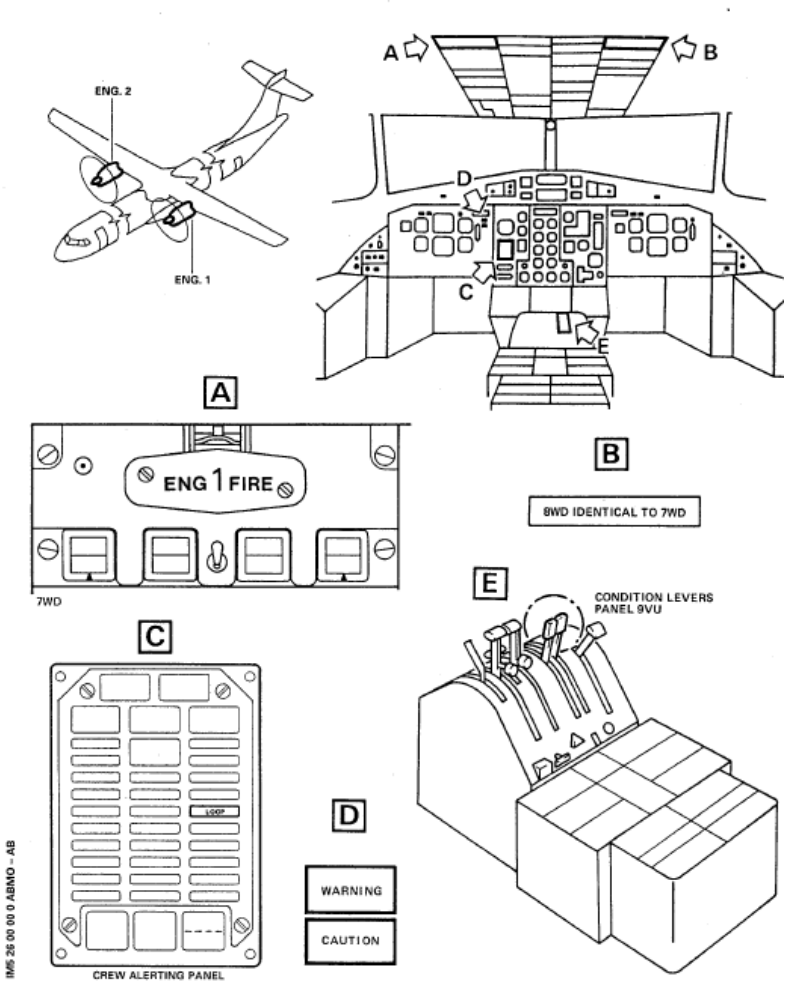
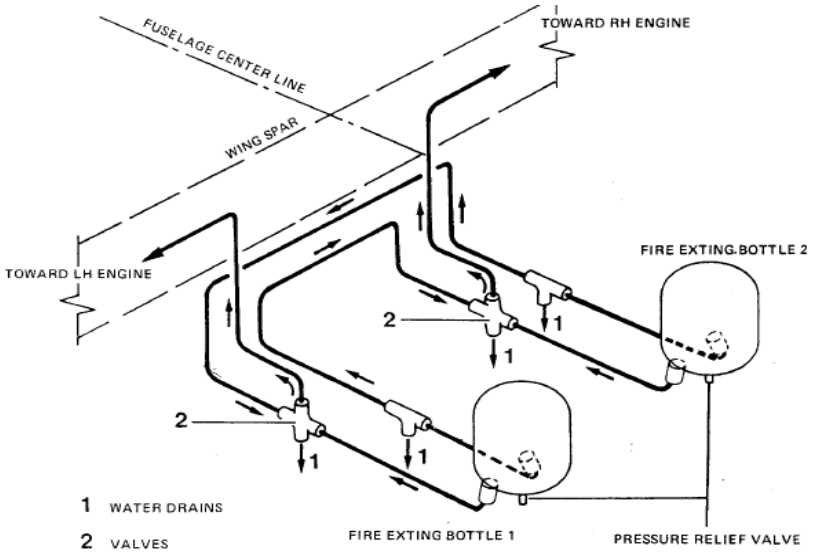


Fig. 4

1.6.3.3 Engine fire extinguisher system

The engine fire extinguisher system consists of two fire extinguisher bottles, which are used to extinguish any fire breaking out in the engine nacelle zone. Two percussion panels located in the cockpit overhead panel enable control of the fire extinguisher agent discharge on the engine concerned, fig. 4 A & B and fig. 5.



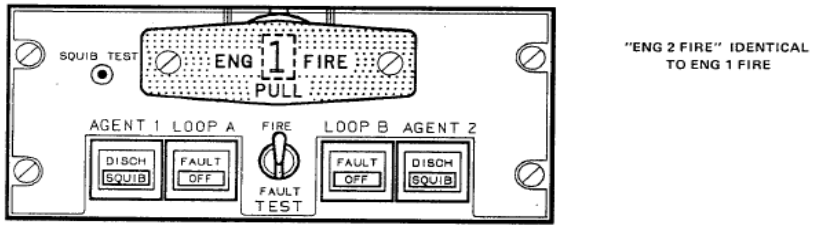


Fig. 5

1.6.4 Aircraft log and documents

1.6.4.1 Discrepancy/comment on 8.9.2011

"ENG 2 BLEED FAULT/BLEED LEAK"

1.6.4.2 Action on 8.9.2011

"MEL IN USE 36.22.1.C TRANSF TO DDL ENG #2 BLEED VALVE AND X-FEED VALVE DEACTIVATED".

1.6.4.3 Deferred Defect List (DDL)

Type: **DE**	#: **104363**	Date: 08/09/2011	Melref:	36221	Cat:	C	Deadline: **18/09/2011**
A/C: 468	**OY-CIM**	PlanDate:		Log#:	16542	Pos:	ENG #2 BLEED LEAK
	ENG #2 bleed leak during climb.						
	ENG #2 bleed valve & Ground X bleed valve deactivated.						

1.6.4.4 Minimum Equipment List (MEL) (extract)

The AIB-DK has removed the operator's name.

	ATR 42 / 72 MINIMUM EQUIPMENT LIST			Section: 2.36 Page : 1 Issue: 0808
ATA CHAPTER: 36 PNEUMATIC SYSTEM	2 - REPAIR INTERVAL CATEGORY	3 - NUMBER INSTALLED	4 - NUMBER REQUIRED FOR FLIGHT	5 - REMARKS OR CONDITIONS
11-1 HP valve	C	2	1	* (m) One may be inoperative provided it is deactivated
11-2 BLEED valve	C	2	1	In case of BLEED LEAK a maintenance action is due to close X-BLEED: **refer to item 11-4** * (o)(m) One may be inoperative provided: a) It is secured closed, and b) Flight Level is limited to FL 170
11-3 Bleed FAULT alert	C C	2 2	1 1	* One may be inoperative provided associated pack FAULT alert is operative - OR - * One may be inoperative provided associated bleed valve is considered inoperative and selected OFF: **refer to item 11-2**
11-4 Ground X feed valve	C	1	0	* (m) May be inoperative provided it is secured closed
11-5 Ground X FEED VALVE OPEN alert	C	1	0	* (m) May be inoperative provided X-feed valve is checked closed
11-6 OVHT alert	C	2	1	* One may be inoperative provided associated bleed valve is considered inoperative and selected OFF **refer to item 11-2**
22-1 LEAK alert	C	2	1	* One may be inoperative provided associated bleed valve is considered inoperative and selected OFF: **refer to item 11-2**
70-1 Indications and controls on maintenance panels	C	-	0	

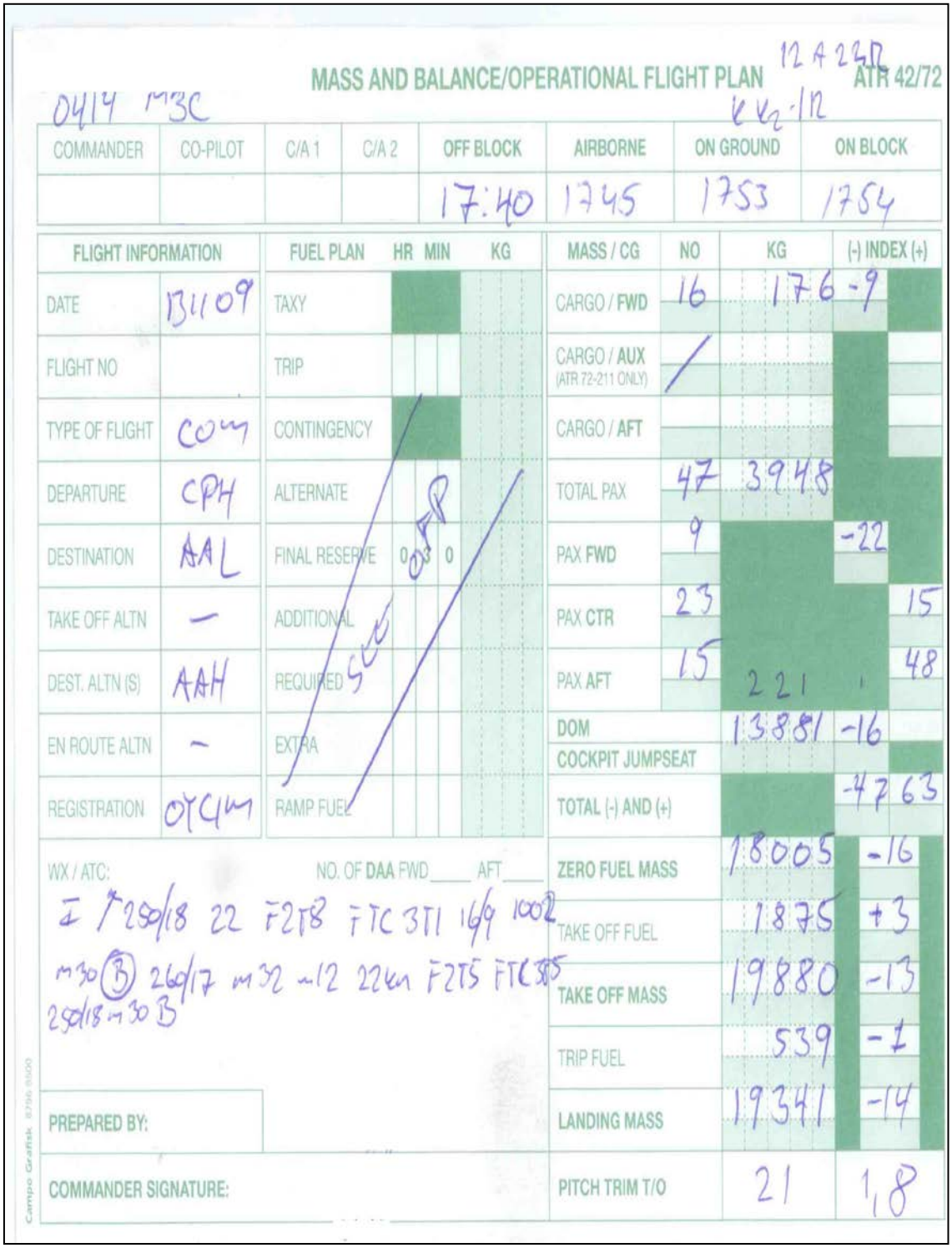
1.6.5 Recirculation fans

The recirculation fans were found in the on position.

1.6.6 Mass and balance

1.6.6.1 Mass and balance sheet.

The mass and balance sheet below was prepared by the pilots prior to starting at EKCH. The AIB-DK has removed the operator's name, the aircraft's call sign and personal information.



MASS AND BALANCE/OPERATIONAL FLIGHT PLAN ATR 42/72

0414 M3C 12 A 24R

COMMANDER	CO-PILOT	C/A 1	C/A 2	OFF BLOCK	AIRBORNE	ON GROUND	ON BLOCK
				17:40	1745	1753	1754

FLIGHT INFORMATION		FUEL PLAN	HR	MIN	KG
DATE	13/10/09	TAXY			
FLIGHT NO		TRIP			
TYPE OF FLIGHT	COM	CONTINGENCY			
DEPARTURE	CPH	ALTERNATE			
DESTINATION	AAL	FINAL RESERVE	0	30	0
TAKE OFF ALTN	–	ADDITIONAL			
DEST. ALTN (S)	AAH	REQUIRED			
EN ROUTE ALTN	–	EXTRA			
REGISTRATION	OYCKM	RAMP FUEL			

MASS / CG	NO	KG	(-) INDEX (+)
CARGO / FWD	16	176	-9
CARGO / AUX (ATR 72-211 ONLY)	/		
CARGO / AFT			
TOTAL PAX	47	3948	
PAX FWD	9		-22
PAX CTR	23		15
PAX AFT	15	221	48
DOM		13881	-16
COCKPIT JUMPSEAT			
TOTAL (-) AND (+)			-7 63
ZERO FUEL MASS		18005	-16
TAKE OFF FUEL		1875	+3
TAKE OFF MASS		19880	-13
TRIP FUEL		539	-1
LANDING MASS		19341	-14
PITCH TRIM T/O		21	1,8

WX / ATC: NO. OF DAA FWD____ AFT____

I F250/18 22 F278 FTC 371 169 1002

M30 (B) 260/17 M32 -12 22kn F275 FTC385

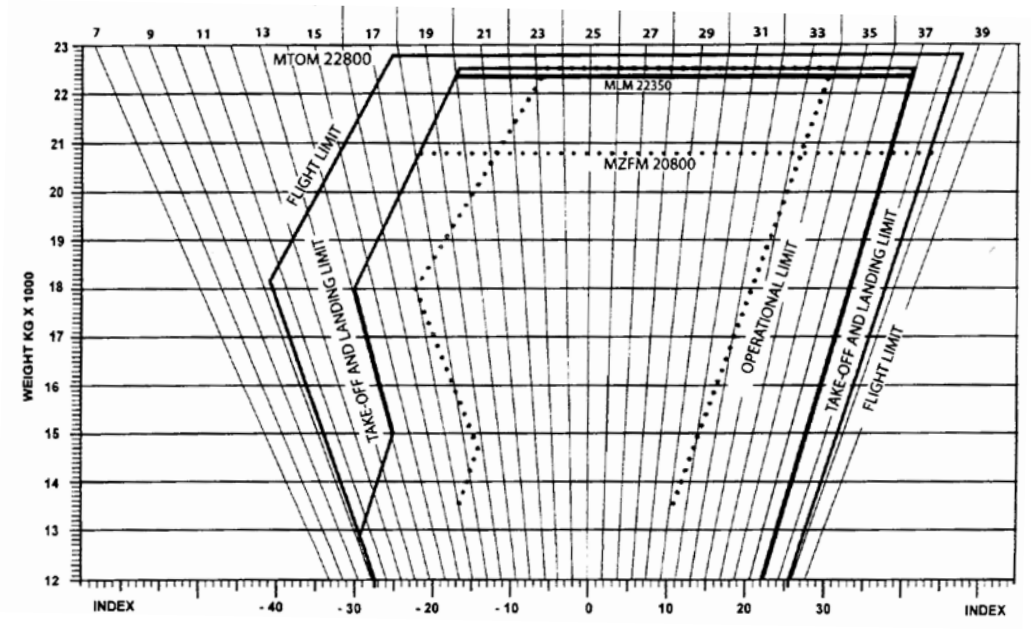
250/18 M30 B

PREPARED BY:

COMMANDER SIGNATURE:

Campo Grafisk 8796 8500

1.6.6.2 Centre of gravity limitations



1.6.7 Operational flight plan (extract)

The AIB-DK has removed the aircraft's call sign and personal information.

FLT/DAY	ORG /DEST	TTL NAM	ROUTE	AVG WIND /AVG.ISA TEMP
/110913	EKCH/EKYT	177	CPH-AAL	23 KTS HEAD -1

	E.FUEL Kg	A.FUEL	E.TIME	NM	NAM	FL
TRIP EKYT	539	... ..	0:47	158	177	160
CONT MCF	50	... ..	0:05			
ALT EKAH	315	... ..	0:21	83		30
FINAL RESERVE	300	... ..	0:30			
COMPANY FUEL	0	... ..	0:00			
TAXI	25	CORR.	+ / -			
REQUIRED	1229	... ..	1:43			
EXTRA	409	240	~~0:52~~ 116			
BLOCK FUEL	1639	1900	2:35			

FCN:

CAPT SIGN:

FUEL BURN ADJUSTMENT FOR 1000KGS INCREASE/DECREASE IN TO : 4

	E.M Kg	CORR.	OP. LIMIT	STRUC. REASON FOR OP.LIMIT
DOM DOM DOI/-23	13924	... ..		
PAX(43)	4085	... ..		
EZFM	18009	... ..	OZFM	20800 /. . . . .
TOF	1614	... ..		
ETOM	19623	... ..	OTOM	22800 /. . . . .
TRIP	539	... ..		
ELAM	19084	... ..	OLAM	22350 /. . . . .

1.7 Meteorological information

1.7.1 TAF

131400 TAF-FT ekch 131440z 1315/1415 24020g35kt 9999 bkn030 tempo 1315/1410 -shra sct020tcu tempo 1410/1415 6000 shra sct020cb=

131700 TAF-FT ekch 131740z 1318/1418 24018g32kt 9999 bkn030 tempo 1318/1410 -shra sct020tcu tempo 1410/1418 6000 shra sct020cb=

132000 TAF-FT ekch 132040z 1321/1421 25018g30kt 9999 sct030 tempo 1321/1410 -shra sct020tcu tempo 1410/1418 6000 shra sct020cb=

1.7.2 METAR

131650 METAR ekch 131650z 25020kt 9999 few028 few031tcu bkn075 16/09 q1002 tempo 25018g30kt=

131720 METAR ekch 131720z 26016kt 220v280 9999 few025 few035tcu bkn080 15/10 q1002 tempo 25018g30kt=

131750 METAR ekch 131750z 25019kt 9999 few025 sct080 15/10 q1002 tempo 25018g30kt=

131820 METAR ekch 131820z 25024g37kt 9999 few025 sct080 15/08 q1002 tempo 25018g30kt=

1.8 Aids to navigation

All aids to navigation on board the aircraft and on the ground were available and there were no remarks in this regard.

1.9 Communication

A transcript of the VHF voice communication for Kastrup control tower (119.350 MHz) was prepared. The VHF voice communication was of a good quality and was used in the investigation.

1.10 Aerodrome information

1.10.1 Overview of EKCH Airport

See enclosure 3.

1.10.2 NOTAM

No NOTAM was issued for EKCH that was of any relevance to the sequence of events.

1.11 Flight recorders

Data from the aircraft's DFDR and Cockpit Voice Recorder (CVR) was read out. The data was of a good quality and was used in the investigation.

Extract of DFDR data, see enclosure 4 – DFDR plots A and B.

The AIB-DK has chosen the ATC time as the reference time. On the basis of the ATC voice communication, the AIB-DK has corrected the times indicated from DFDR time to ATC time. The DFDR touch-down time was 02:53:16. The ATC-corrected touch-down time was 17:50:15.

1.12 Engine tear down and inspection

1.12.1 General

After the aircraft was removed from runway 30 to the hangar area, the engine was inspected. The inspection confirmed that there had been a fire in the engine nacelle. The Power Turbine (PT) stage 2 blades were severely damaged. The scavenge oil line from bearing number 6 and 7 was found loose and leaking at 6 o'clock position at the PT support case. The Engine oil tank in the rear inlet case had about 2 liters left when drained. The capacity of the oil tank was about 22 liters.
Both engine fire extinguishers were found emptied.

The engine was removed from the aircraft and sent to an independent overhaul facility for tear down and further investigation.

1.12.2 Engine tear down and inspection

The tear down and investigation was conducted in cooperation with an overhaul facility and an accredited representative from the engine manufacturer and led by the AIB-DK.

The complete tear down report is attached as enclosure 5.

1.12.3 Boroscope inspection

The boroscope inspection revealed that the High Pressure (HP) impeller and LP impeller were heavily rubbed. The HP blades were eroded at the leading edges (fig. 6 and 7). Both the LP and HP turbine shrouds were heavily rubbed.

Fig. 6. HP impeller

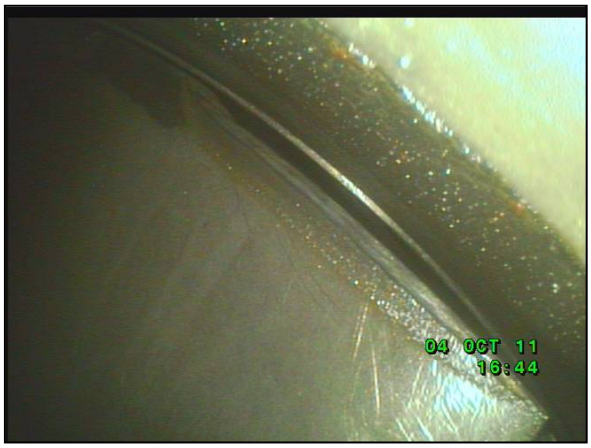


Fig. 7. LP impeller

1.12.4 Power Turbine stage 2 (PT2)

Before removal of the PT2, it was obvious that all blades were heavily damaged and had several fractured blades (fig. 8).

The PT2 was removed and the blades were inspected (fig. 9).

Fig. 8. PT2 blades

Fig. 9. PT2 after removal

After removal of the PT2 it could be seen that PT2 stator and shroud was heavily damaged (fig. 10). A large piece of outer shroud was missing (fig. 11).

Fig. 10. PT2 stator

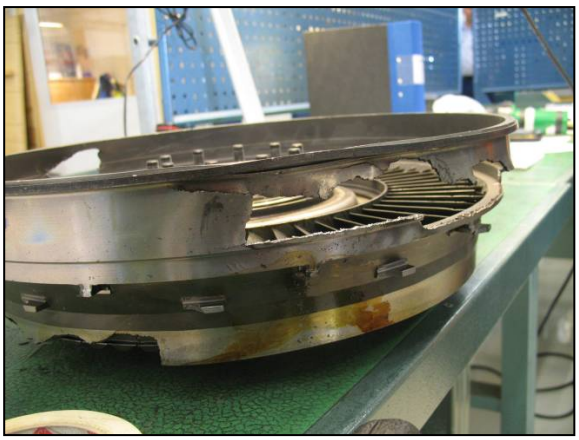


Fig. 11. Outer shroud

1.12.5 Power Turbine stage 1(PT1)

The PT1 was removed from the engine (fig. 12). The blades were heavily damaged and two blades were fractured almost at the root platform (fig. 13). All the PT1 blades had evidence sign of overheat. This was seen on the fracture surface and on the coating on all other blades.

Fig. 12

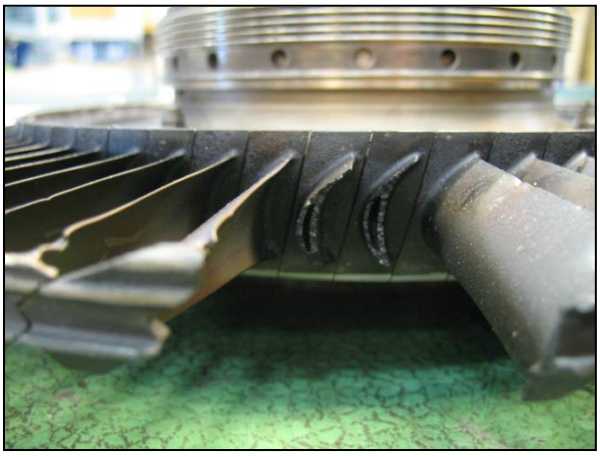


Fig. 13

1.12.6 PT1 stator and No 6 & 7 bearing housing

After removal of PT1 it was observed that the bearing baffle for No 6 & 7 bearings were damaged and the three (3) attaching bolts holding the baffle and bearing housing in place were sheared off (fig. 14 & 15). Before the bearing no. 6 & 7 housing assy with interstage Case and PT1 stator were removed it was possible to rotate/turn the bearing housing. This indicating that the remaining nine (9) bolts below the baffle and the three (3) bearings oil transfer tubes (scavenge, pressure and breather) had been be sheared off.

When removing the baffle and PT1 stator, the remaining nine (9) bolts holding the bearing housing in place were found sheared off, fig. 17. When the Turbine Inlet Case (TIC) was removed it was observed that it was wet from oil inside between 6 and 10 o'clock.

When removing the bearing housing assy with the interstage case, the three (3) oil transfer tubes for bearing No 6 and 7 were found sheared off almost in flush with the bearing housing (fig.16 & 17). There was no damage observed on the T6 probes.

It was observed that the scavenge tube was wet from oil on the outside. The pressure- and breather tubes were dry from oil on the outside.

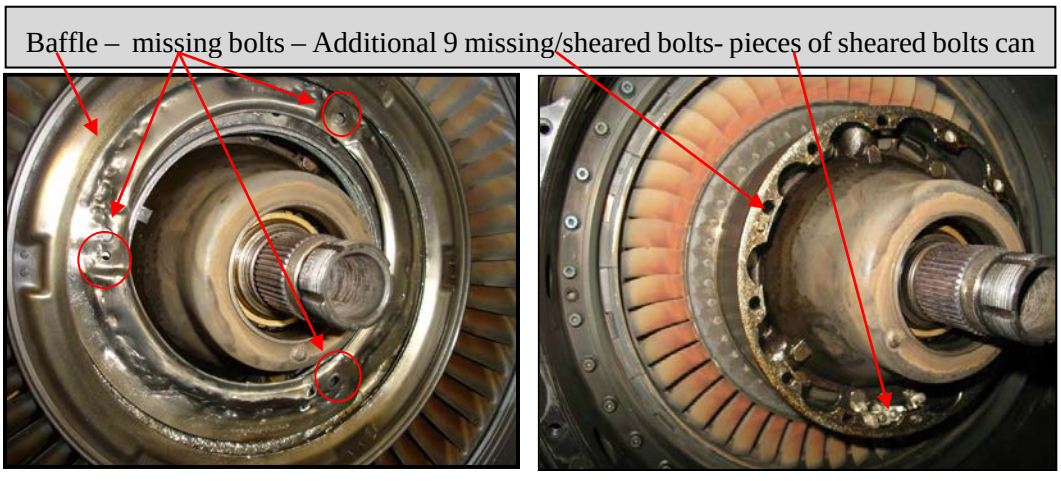


Fig. 14. Bearing baffle and PT1 stator

Fig. 15. Bearing housing and LP rotor

In all of the three oil tube connections to the bearing housing the remaining of sheared oil tubes could be seen, fig 16.
The three (3) sheared oil tubes can be seen in figure 17. The outer right oil tube was a new one compared to a sheared one. On the magnification it can be seen that the oil transfer tubes were sheared just above the threads.

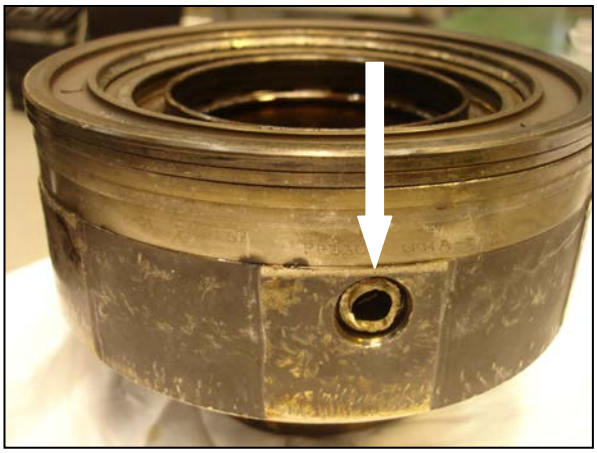


Fig. 16. No 6 & 7 bearing housing.

Fig. 17. Oil transfer tubes.

There could be seen heavy rubbing between PT and LP rotor especially the PT rotor air seal (fig. 18) (Labyrinth Seal) and the bearing no. 6 rotor nut (fig. 19). The seal and nut were both heavily rubbed and the seal was distorted.

The bearing no. 6 seal assy in the bearing no. 6 & 7 housing, fig.20 were heavily rubbed and was observed broken.

Fig. 18. Labyrinth Seal

Fig. 19. Bearing no. 6 rotor nut

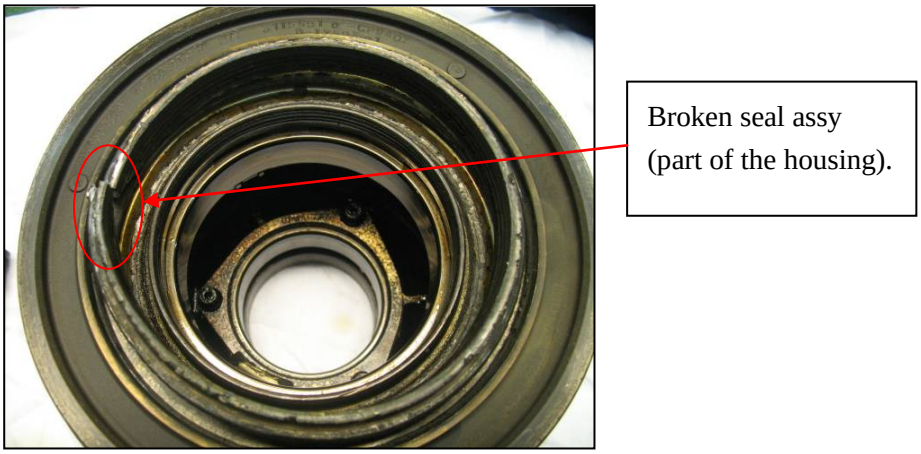


Fig. 20. Bearing no. 6 and 7 housing

1.12.7 Laboratory analysis

The following parts were sent to a laboratory for further analysis and investigation:

- The two fractured PT1 blades,
  - P/N 3120983-01, Serial Number (S/N) HMC34146, TSN: 16018 hrs.
  - P/N 3120983-01, S/N HMM31295, TSN: 5939 hrs.
- The PT2 Assy.
- Reduction Gear Box (RGB) chip detector.
- Engine chip detector.

The analysis revealed that the parts from the engine, showed tensile overload fractures in all blades but one. PT1 blade S/N HMM31295 had fractured about 8 mm above the root platform (core pocket area) as a result of fatigue crack propagation caused by casting defects (shrinkage porosities). The complete analysis is attached as enclosure 6.

1.12.8 PT blades stage 1

The PT1 consisted of 66 blades with Part Number (P/N) 3120983-01.
In February 2006, the engine underwent an overhaul (OH). Thirty-seven (37) PT1 blades failed the NDT inspection (Fluorescent Penetrant Inspection) due to cracked airfoil in the leading- and trailing edge, and for that reason replaced with new ones.

The new 37 blades started with the letter HMM in the Serial Number (S/N) and the remaining 29 of the blades started with HMC in the S/N. The blades were unevenly distributed across the disc. The blade configuration was controlled at P/N level and various S/N combinations were approved on the same disc. It was approved to install blades that had difference cycles.

- Blades with HMC in the serial number had a Time Since New (TSN) of 16018:29 hrs.
- Blades with HMM in the serial number (the new blades) were installed in February 1996 and had a TSN of 5939:56 hrs.

All blades were made by a subcontractor and released by the engine manufacturer:

- Three (3) of the HMM blades were released on Authorized Release Certificate TCCA 24-0078 Work Order 2117141–331989 dated 12th of December 2005.
- The remaining (34) HMM blades - which include the failed one – were released on Authorized Release Certificate TCCA 24—0078 Work Order: 2117009-331880 dated 8th of December 2005.
  See enclosure 7.

The blades were constructed to shearer of at the blades core pocket in case of an overspeed of 120% to prevent a runaway disc in case of an engine failure (fig. 20).

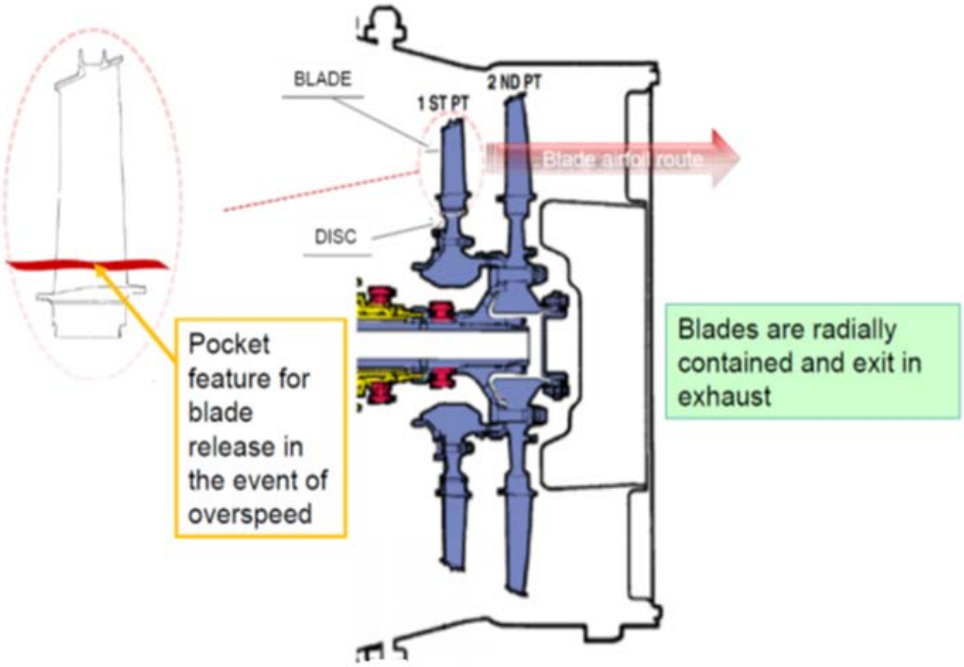


Fig. 20

1.12.9 The failed blade S/N HMM31295

The Engine manufacturer used a subcontractor for the manufacture of blades.
The engine manufacturer informed the AIB-DK that the failed blade S/N HMM31295 came from a Heat (Batch) #MWA0706. This "Heat" had a total quantity of 6587 blades. Serial number ranged between HMM24614 to HMM77770 and was manufactured on the 29th of October 2005.

The engine manufacturer informed that there was no indication of any production problems recorded during manufacturing. However, the engine manufacturer informed that they from manufacturing date to the 7th of February 2012 had 4 blades from Heat MWA0706 that were confirmed fractured due to micro shrinkage porosity. Blades from other prior and subsequent heats were similarly affected. No clear correlation to individual heats was established.

Furthermore, there were 8 confirmed porosity-related fracture events for blades installed in 2004 and 2005 (21 total since 2004). A number of blades were re-inspected and found serviceable (i.e. not included in SB21766) subsequently fractured in micro shrinkage porosity, pre-2008 x-ray inspection process.

1.12.10 Service Bulletin 21766.

In the time frame 2005 - 2011 with a peak in 2008 a recurrent failure of Fatigue failure of PT1 blades P/N 3120983-01 was found with a total of at least 28 similar events due to this root cause.

In 2008, the manufacturer of the PT1 blades P/N 3120983-01 made a survey of blade events. The manufacturer reviewed the past 2 years x-ray films from 2007 and 2008.

- 90,000 blades were reviewed
- 68 blades were identified with porosity exceeding x-ray limits.
- Approx. 12 – 16 engines were recalled prior to next HSI.

As a consequence to the result of the survey, the manufacturer improved the inspection on new blades by introducing an additional X-ray inspection in 2008, with a specifically view in the core pocket area of the blades. Relating thereto was issued a Service Bulletin 21766 (see enclosure 8) in March 2008 to remove identified suspect blades manufactured year 2007 and 2008.
The engine S/N AV0098 and blade S/N HMM31295 was not covered by this Service Bulletin.

1.12.11 Power turbine Assembly
In accordance to the Engine Manufacturer Inspection Requirement, the blades had no specified life (scrap) in terms of flight-hours or cycles. In other terms the blades were discarded "on condition" only.

The Inspection Requirement for the blades at Hot Section Inspection (HSI) consists of a detailed borescope inspection without disassembly the PT.

The Inspection Requirement for the blades at OH included the above inspection and a dimensional inspection and on top on that a High Sensitivity (level 3) Fluorescent Penetrant Inspection.

1.12.12 Reported engine malfunction in Denmark year 2006
In year 2006, the same operator as in this serious incident had an IFSD with an ATR 42-500 with PW127 engines installed. The circumstances were identical with this serious incident and the engine turbine failures were similar. The report number HCLJ510-000314 (in Danish) can be downloaded from AIB-DK web site: HCLJ510-000314

1.12.13 Reported IFSD in European Countries year 2011
From June to September 2011, three (3) IFSD during take-off and climb (including OY-CIM) were reported, one in Hungary and one in Italy. Both the other reported aircraft were ATR types and had PW127 engines installed. The circumstances were identical with this serious incident and the engine turbine failures were similar.

1.13 Medical and pathological information
None.

1.14 Fire
A fire in the left engine occurred shortly after take-off and an emergency landing was initiated. The fire was out before the firefighting services arrived at the scene on runway 30. Neither passengers nor crew members were injured. Both passengers and crew members disembark the aircraft through the passenger entrance door.

1.15 Survival aspects

There were no injuries to persons or damage to structures.

1.16 Tests and research

None

1.17 Organizational and management information

1.17.1 Operations Manual Part A (extract)

"*1.4 Authority, Duties and responsibilities of the Commander.*

Notwithstanding any of the following the Commander shall 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 Flight Crew Operating Manual (FCOM) (extract)

1.17.2.1 Operational parameters

ATR 72 F.C.O.M.	LIMITATIONS	2.01.03		
		P 5	050	
	AIRSPEED AND OPERATIONAL PARAMETERS			SEP 07

AA

TAKE-OFF AND LANDING

TAIL WIND LIMIT : 10 KT

The maximum demonstrated cross wind on dry runway is 35 kt

1.17.2.2 Checklists

Engine oil low pressure, engine over limit, inflight engine fire, singe engine operation, smoke, air conditioning smoke and on ground emergency – see enclosure 9 to 15.

1.17.3 Crew Procedure Handbook (extract)

1.17.3.1 Equipment overview

See enclosure 16.

1.17.3.2 Unprepared emergency

See enclosure 17.

1.17.4 Cabin Attendant Manual – announcement (extract in English)

"ENGINE PROBLEMS
Ladies and Gentlemen.
For safety reasons we had to shut down one of the engines. Please do not worry; we can operate safely on one engine only.
Thank you!"

1.18 Additional information

1.18.1 Tri-National Interim Report

During the investigation process, the event was considered similar to two other serious incidents, which occurred on the 17th of June 2011 at Budapest Airport, Hungary (LHBP) and on the 3rd October 2011 at Firenze Airport, Italy (LIRQ).

Due to the similarities, arrangements were made for cooperation across national borders (Hungary, Italia and Denmark). A joint venture investigation group was established.

As a result of the joint meeting held at Agenzia Nazionale per la Sicurezza del Volo (ANSV) premises in Rome, Italy on the 7-9th February 2012, following common findings were revealed:

- all events occurred at initial climb
- the events were all due to the initial distress of a PT1 rotor blade causing subsequent damages
- heavy unbalance of the whole PT assembly, further unbalance of the LP rotor through No. 6 & 7 bearing housing, and final oil leakage due to breaking of No. 6 & 7 bearing compartment retaining bolts and distress of the radial transfer tubes. Fire was then originated by such a leakage in presence of hot parts
- in all these serious incidents distress of the PT1 rotor blade was due to a crack propagated from an internal casting defect (shrinkage porosity) in the vicinity of the blade core pocket. Propagation was in accordance with a low cycle Fatigue mechanism.

The above common findings led to two joint recommendations DENM-2012-01 and DENM2012-02 concerning the PT 1 Blades.

In continuation of the national investigations, three additional findings (smoke removal procedure, harmonization of procedures and memory items) led to three joint recommendations DENM-2012-03, DENM-2012-04 and DENM-2012-05

The Safety Investigation Authorities addressed two recommendations to Transport Canada and three recommendations to EASA, respectively (see this report paragraph 4.1 and 4.2 and enclosure 18).

The investigation that led to the recommendations DENM-2012-01, DENM2012-02 and DENM-2012-03 are featured in this investigation report.

The investigation that led to the recommendations DENM-2012-04 and DENM-2012-05 are to be found in the national investigation reports of Italy and Hungary.

1.18.2 MEL release versus smoke removal.
The AIB-DK requested information from the manufacturer on how smoke was removed from the aircraft if under the prevailing conditions aircraft system redundancy was downgraded by a MEL release.

The manufacturer replied:
"The aircraft being already under MMEL (No bleed #2 and cross bleed valve closed) upon an engine fire warning on Engine #1, the procedure application leads to pull the related engine fire that isolates the engine and close the bleed valve #1.

There is no dedicated procedure (in the FCOM or QRH) covering this configuration. The only way to evacuate smoke would the differential pressure but in this event it was close to zero.

It should be noted that most probably the smoke quantity was limited as its origin was closed as soon as the crew pulled the fire handle."

1.18.3 Smoke removal emergency procedures – similar aircraft types (extracts)
1.18.3.1 Saab 340 - see enclosure 19.

1.18.3.2 Fokker 50 - see enclosure 20.

1.18.3.3 Dash 8 - see enclosure 21.

1.19 Useful or effective investigation techniques
None.

2. Analysis
2.1 Technical investigation
2.1.1 The cause of the engine failure and oil fire
In accordance with the DFDR readout, the engine neither was exposed to an overspeed nor had the engine been over torqued. See enclosure 4 - DFDR plot B. The built in overspeed (120%) feature on the blade core pocket was not a contributing factor.

The root cause of the engine failure and engine fire was found to be fatigue crack propagation caused by casting defects (shrinkage porosities) of one of the PT1blades. The fracture of the PT1blade caused a lot of fractured PT stage 2 blades and the PT rotor came in unbalance. The unbalance PT rotor resulted in heavy rubbing between the PT and the LP rotor.

The LP rotor rubbed against the bearing No 6 & 7 housing and most likely by its force causing the housing to rotate. This led to the attaching bolts to shear off, which did put all the force on the oil transfer tubes causing them to break and leading to an internal engine oil fire.
The broken oil transfer tubes most likely caused both the pressure and in the beginning also the scavenge oil to pour down at the 6 o'clock position. The leaking oil continued out to the bottom of the nacelle and the internal oil fire then spread outside to the nacelle area. The oil supply to the bearing No 6 & 7 housing was either cut off when the oil supply was depleted or when HP rotor stopped after the engine was stopped.

To support this, the flight crew of a succeeding departing aircraft in take-off position on runway 22R reported that they could see smoke and a bright light from the left side of OY-CIM. This observation and the observed signs of excessive high temperature on the PT1 blades stated that an internal oil fire in the engine and its tail pipe occurred. Leaking oil caused a fire in the engine nacelle area.

2.1.2 Engine nacelle fire

The engine oil tank in the rear inlet case had about 2 liters left when drained. The capacity of the oil tank was about 22 liters. Approximately 18 liter of oil was leaked/pumped out and burned off due to an internal fire in the turbine and in the nacelle area

In accordance with EASA CS-25.1181 to 125.1203, the engine internal oil fire and subsequent outside fire occurred in a designated fire zone and for that reason the fire extinguisher system should have extinguished the fire.

There seemed to be only one explanation for the fire extinguishing system not being capable of extinguishing the oil fire. After the first fire bottle was discharged, the fire in the nacelle area went out. However, due to the internal fire in the engine - and the continuous leakage - the oil was re-ignited in the nacelle area. This probably happened again after number two fire extinguishing bottle was discharged. The fire eventually went out by itself, since the oil tank was nearly emptied and for this reason did not provided more oil to the nacelle area.

Under other circumstances; the capacity of the fire extinguisher bottles would have extinguished the fire. But in this serious incident, the extinguishing system was not optimal. However, in this type of engine failure, a big proportion of oil will always be burned off as an internal fire in the turbine. Therefore, only a relatively small amount of oil will come out to the nacelle area. This amount was acceptable and happened in a in a designated fire zone.
After the two fire extinguisher bottles were discharged, there was only a small amount of remaining oil. The fire went out by itself since this amount was consumed.

2.1.3 PT1 blades P/N 3120983-01 inspection

The manufacturer approved the combinations of blades with HMM and HMC in the serial number as well as different TSN on the same disc. The AIB-DK did not consider this combination of blades as a contributing factor and for that reason further investigation into this matter was not regarded as a necessity.

The inspection of the PT1 blades P/N 3120983-01 manufactured in 2007 and 2008 were covered in SB 21766. Blades manufactured after 2008 did undergo the manufacturers new inspection and X-ray inspection methods.

PT1 blades P/N 3120983-01 manufactured before year 2007 was not subject of an inspection of casting defects (shrinkage porosities). Nor were blades subject of a survey of events before this serious incident. The affected PT1 blade was manufactured in 2005.

The purpose of the inspection requirements at HSI was to reveal minor surface irregularities in the blades airfoil, such as nicks, dents and visible cracks. The purpose of the High Sensitivity (level 3) Fluorescent Penetrant Inspection (FPI) at OH was to detect any cracks in the coating of the blades.

The FPI could not detect shrinkage porosities.

The shrinkage porosities could only be detected by X-ray inspection. The only time a blade did undergo an x-ray inspection was during the manufacturing process.

There were no life limits on the blades.

An operator, engine shop or an O/H facility did not have any possibility to detect micro shrinkage porosity in PT1 blades. There were no X-ray procedures except for those done at the manufacturer.

From June to September 2011 three (3) IFSD were reported. In all three events, the PT1 blade fractured shortly after take-off during initially climb. During take-off roll and initial climb the engine operated at its maximum power setting, which may explain why all three events happened during this phase of the flight.

A fractured PT1 blade during engine operation will always result in a severe turbine failure and an IFSD.

The AIB-DK concluded that this serious incident with the PW127 engine S/N AV0098 was not an isolated event. This conclusion was based on the three reported incidents in year 2011 and the one reported in Denmark 2006. Furthermore, there were 4 blades in the same Heat (MWA0706) as blade S/N HMM31295, which were confirmed, fractured due to micro shrinkage porosity.

Furthermore, the AIB-DK concluded that on the time of the serious incident, there probably still were unidentified PT1 blades in circulation around the world with micro shrinkage porosity. This was based on that Heat HWA0706 had a total quantity of 6587. Blades at this time could be installed in an engine, or perhaps lie in stock. The conclusion was also based on 21 reported and confirmed PT1 blades that were identified as being related to porosity, and a number of blades that were re-inspected and found serviceable, subsequently fractured due to micro shrinkage porosity.

2.2 Operational investigation

2.2.1 General

The licenses held by the flight crew, the flight and duty times of the flight crew, the cabin crew operator training and the aircraft mass and balance had, in the AIB-DK's opinion, no influence on the sequence of events.

2.2.2 Flight planning and actual weather

The pilots planned the flight from EKCH to EKYT with one destination alternate (EKAH).

It is the AIB-DK's view that the flight planning, including fuel calculations, had no bearing on the sequence of events.

In terms of reported weather, the actual weather conditions made it possible for the flight crew to make a left hand visual approach to runway 30 rather than an instrument procedure to runway 30, an instrument procedure to runway 22L or a visual approach to runway 22L. The flight crew decision on landing on runway 30 instead of landing on runway 04R (tailwind component of more than 10 knots) or a visual

approach to runway 22L was in the AIB-DK's opinion an optimum compromise between operational flight safety on one hand and reduction of the total airborne time on the other.

By a reduction of the total airborne time, the severity of this incident (inflight fire) and the total risk were lessened.

2.2.3 Blade fracture and cockpit warnings

Immediately upon take-off from runway 22R, the left engine suffered from a Power PT1 blade fracture, which led to an oil fire in the nacelle section.

Consequently, three significant warnings were presented to the flight crew:

1. A cockpit Master Warning was triggered referring to left engine low oil pressure (the oil pressure dropped below 40 psi)
2. A cockpit Master Caution was triggered referring to left engine high ITT (an excessive ITT in flight, maximum 800 degrees C)
3. A cockpit Master Warning was triggered referring to left engine fire (an oil fire sensed by the engine fire loop detection system)

Furthermore, a cockpit Master Warning (continuous repetitive chime) was triggered on final to runway 30. The AIB-DK finds it possible that this warning was a reactivation of the left engine fire warning.

2.2.4 Crew handling

Looking at the operational sequence of events, the flight crew workload was high.

For that reason, the AIB-DK supports the way of prioritising the inflight actions by the flight crew:

1. Fly the aircraft and keep it safe
2. Handle the emergency
3. Land as soon as possible

By declaring an emergency (mayday call), fire and rescue services were activated, all runways were available, VHF radio communication was conducted on only one ATC frequency and radio silence was present (preventing unnecessary clutter for the flight crew), which in all contributed to a reduction of the flight crew workload.

Change of controls from the first officer to the commander made it possible for the commander to keep continuous visual contact with runway 30, which contributed to a reduction of the total airborne time. In this regard and in the overall handling of the emergency, a way of further reducing the flight crew workload might have been use of the autopilot.

Taking the severity of this serious incident into consideration and in the interest of flight safety, the flight crew decision of overriding the operational procedures including checklists (six emergency checklists) and only perform memory items was - under the actual conditions - optimum. This decision also contributed to a reduction of the total airborne time and the flight crew workload.

Most likely, a high flight crew workload at a critical moment (the left engine fire warning at app. 750 feet RA) mentally blocked the flight crew's perception of the warning and delayed the appropriate emergency actions (delay of 1 minute and 31 seconds). However, though an engine fire extinguishing procedure was delayed, the AIB-DK believes that this finding did not have a crucial impact on the sequence of events.

The AIB-DK finds the crew interaction and communication valuable to a constructive handling of the emergency. The flight crew used available internal (commander and first officer / cabin crew) and external resources (ATC) in order to optimize the flight crew decision making, which had a positive bearing on the sequence of events.

The AIB-DK regards this incident as an unprepared emergency, which made time a crucial parameter. For that reason, crew interaction and communication had first priority rather than continuous information to and briefing of the passengers. However, the passengers were briefed in flight on the engine problems and again on ground on the disembarkation by the commander. Besides safety related cabin crew duties (securing the cabin), the AIB-DK finds it likely that a cabin crew announcement shortly before landing on the engine problems and on safety preparations (seatbelts) might have been supportive to the commander's briefing and thereby sustaining a positive passenger control.

2.2.5 Technical status of the aircraft and smoke removal

In accordance with the MEL, the engine number two bleed valve and the ground x-feed bleed valve was deactivated before flight. In flight, the deactivation of the two valves led to the presence of smoke in the cockpit and in the passenger cabin simultaneously.

In general, the source to and content of smoke might be unknown to the crew. For that reason and in the interest of flight safety, the AIB-DK strongly encourages crew to use the onboard crew breathing protection equipment (PBE/oxygen masks/goggles), whenever smoke is present.

By closing (memory item at app. 850 feet RA) the High Pressure Bleed Valve engine no 1, the flight crew limited the quantity of smoke in the cockpit and in the passenger cabin. However, the recirculation fans were found in the on position, which in an off position might have further reduced the passenger cabin contamination.

In the AIB-DK's view, the MEL release was an approved downgrade of aircraft system redundancy. The manufacturer stated that no dedicated procedure (neither in the Flight Crew Operating Manual (FCOM) nor in the Quick Reference Handbook (QRH)) covered the prevailing configuration (the aircraft being already under MMEL (No bleed #2 and cross bleed valve closed) upon an engine fire warning on Engine #1).

For that reason, the Danish AIB-DK finds that no efficient smoke removal method compensating the lack of aircraft system redundancy seemed to be at the disposal of the flight crew. Under the prevailing conditions, the smoke emergency procedure (air conditioning smoke) did not direct the flight crew's decision making on how to remove smoke from the cockpit and the passenger cabin, if cabin ventilation was required.

The AIB-DK noted differences (use of differential pressure) when comparing to similar aircraft types (Saab 340, Fokker 50 and Dash 8).

In this serious incident, the Danish AIB-DK does not consider this finding as a contributing factor. However, whether or not a similar serious incident (approved downgraded aircraft system redundancy before flight) takes place shortly after takeoff or at any altitude (in this case - flight level limited to FL 170 by MEL), appropriate and comprehensive flight crew procedures must be available. For that reason, the AIB-DK regards this finding as a flight safety issue, which needs further consideration.

3. Findings

3.1 Technical and operational findings

3.1.1 Technical findings

1. One PT1 blade had fractured.
2. Fatigue crack propagation caused by casting defects (shrinkage porosities) on one PT1 blade.
3. The PT failure led to an internal as well as an external engine oil fire.
4. All installed PT1 blades had an Authorized Release Certificate.
5. The combination of blades with different TSN and different letters in the serial number on the same disc was approved.
6. 37 PT1 blades were replaced with new ones in February 2006, included the failed one.
7. The PT1 blade came from production Heat Number MWA0706
8. The Heat Number had a quantity of 6587 blades.
9. Four (4) blades from Heat Number MWA0706 were found to have fractured due to micro shrinkage porosity.
10. Eight (8) confirmed porosity-related fracture events for PT1 blades installed in 2004 and 2005 (21 total since 2004) have been reported.
11. A number of blades were re-inspected and found serviceable (i.e. not included in SB21766) subsequently fractured due to micro shrinkage porosity (pre- 2008 X-ray inspection process).
12. The blade P/N 3120983-01 and S/N HMM31295 were manufactured in 2005.
13. Service Bulletin 21766 issued in 2008 to remove identified suspected PT1 blades manufactured in 2007 and 2008.
14. The manufacturer introduced a new inspection and X-ray procedure in 2008.
15. Service Bulletin 21766 did not cover PT1 blades manufactured before 2007.
16. There was no lifetime (scrap time) on the PT1 blades.
17. The PT1 blades were discarded (scraped) “on condition” only.
18. The Inspection Requirement for the PT1 blades dos not contains X-ray procedure.
19. The engine fire extinguishing system was certified and in complies with EASA CS 25.1181 to 25.1203.

For further findings during the engine tear down see enclosure 5.

3.1.2 Operational findings

1. The licenses held by the flight crew, the flight and duty times of the flight crew, the cabin crew operator training and the aircraft mass and balance had no influence on the sequence of events.
2. The flight planning including fuel calculations had no bearing on the sequence of events.
3. The actual weather conditions made it possible for the flight crew to make a left hand visual approach to runway 30.
4. By a reduction of the total airborne time, the total risk was lessened.

5. Immediately upon take-off from runway 22R, the left engine suffered from a PT1 blade fracture, which led to an oil fire in the nacelle section.
6. Consequently, three significant warnings were presented to the flight crew.
7. The flight crew workload was high.
8. By declaring an emergency, fire and rescue services were activated, all runways were available, VHF radio communication was conducted on only one ATC frequency and radio silence was present.
9. The flight crew decision of overriding the operational procedures including checklists (six emergency checklists) and only perform memory items was - under the actual conditions - optimum.
10. A high flight crew workload at a critical moment mentally blocked the flight crew's perception of the warning and delayed the appropriate emergency action.
11. The crew interaction and communication was valuable to a constructive handling of the emergency.
12. The flight crew used available internal and external resources in order to optimize the flight crew decision making.
13. The serious incident was an unprepared emergency, which made time a crucial parameter.
14. Crew interaction and communication had first priority rather than continuous information to and briefing of the passengers.
15. The passengers were briefed in flight on the engine problems and again on ground on the disembarkation by the commander.
16. A cabin crew announcement shortly before landing on the engine problems and on safety preparations might have been supportive to the commander's briefing and thereby sustaining a positive passenger control.
17. The engine number two bleed valve and the ground x-feed bleed valve was deactivated before flight.
18. The deactivation of the two valves led to the presence of smoke in the cockpit and in the passenger cabin simultaneously.
19. In the interest of flight safety, the use of the onboard crew breathing protection equipment was advisable.
20. By closing the High Pressure Bleed Valve engine no 1, the flight crew limited the quantity of smoke in the cockpit and in the passenger cabin.
21. The MEL release was an approved downgrade of redundancy.
22. An efficient smoke removal method was not at the disposal of the flight crew.
23. The ATR smoke emergency procedures seemed not to be sufficient if smoke was persisting and cockpit/passenger cabin ventilation was required.

3.2 Factors

There were two factors leading to the engine failure.

1. Fatigue crack propagation caused by casting defects (shrinkage porosities) on one PT1 blade.
2. Fracture of one of the PT1 blades.

3.3 Summery

The root cause of the engine failure and engine fire was found to be fatigue crack propagation caused by casting defects (shrinkage porosities) of one of the Power Turbine (PT) stage 1 blade, which led to fracture of one of the PT1 blades. The fractured blade caused a lot of fractured PT stage 2 blades and the PT Rotor came in unbalance and broke the bolts holding the Rotor shaft Bearing Housing No 6 & 7. This in turn put all the force on the Bearing Housing oil transfer tubes causing them to break, subsequently leading to an oil leak. The internal oil leak caused a fire. The leaking oil continued out to the bottom of the nacelle and the internal oil fire then spread outside to the nacelle area.

The technical investigation revealed that this event was not an isolated event. The AIB-DK concluded that at the time of the serious incident, there were unidentified PT1 blades from the same Batch (Heat) in circulation around the world as the fractured PT1 blade - with micro shrinkage porosity.

4. Safety recommendations

4.1 Transport Canada (TC)

Based on the information gathered and shared among the Safety Investigation Authorities, the Danish Accident Investigation Board (AIB-DK) addressed the following recommendations to TC:

REC DENM-2012-01

Motivation:

Fatigue failure of PT1 rotor blade was found a recurrent failure on this engine, with a total of at least 28 events already due to this root cause in the timeframe 2005-2011, with a peak in 2008-2009.
As a consequence, in April 2008 the engine manufacturer improved the X-Ray inspection on the new blades by introducing an additional view specifically to be taken in the area of interest (core pocket). In addition, all retained X-Ray films were reviewed and 68 blades were limited in terms of service life in accordance with SB 21766.
The recurrence of the failure in a wide range of accumulated cycles/flight hours shows that time to rupture can't be predicted and it is mainly dependent on the size of the original shrinkage porosity. So, all other blades currently in service could be potentially affected by the same kind of deferred fatigue failure when a defect, not revealed at the first and only check for blades manufactured before 2007 or not detected at the second check in case of blades manufactured between 2007 and 2008, is big enough to propagate a crack.

Text:

To consider the need to early withdraw from service the Power Turbine stage 1 blades manufactured before the introduction of NDT improvement or, alternatively, to urgently introduce a one shot X-Ray inspection on all those blades having accumulated a number of cycles beyond a limit to be established (e.g. 2000), specifically focused on the pocket area to exclude the presence of a fatigue crack.

REC DENM-2012-02

Motivation:

One more fatigue breakage was observed on new PT1 blades manufactured after implementing the improved X-Ray inspection, although at the moment they only have accumulated a limited number of cycles.
In effect, in absence of a robust POD (Probability of Detection) study and with no knowledge of the minimum casting defect able to promote the crack growth, it seems there is still some uncertainty on the effective improvement achieved in terms of reliability of the parts.
The significant increase in rejection rate at production, being only limited to 2011, at the moment can't be considered as a proof of the effectiveness of the modifications introduced since 2008.

Text:

Taking into account the high volume of Power Turbine stage 1 blades production, to consider the opportunity to introduce in production, at least as a temporary measure, an additional Computed Tomography check on a representative sample of blades in order to gain confidence on the effective improvement achieved through the review of the X-Ray methodology implemented in 2008.

4.2 European Aviation Safety Agency (EASA)

Based on the information gathered and shared among the Safety Investigation Authorities, the Danish Accident Investigation Board (AIB-DK) addressed the following recommendations to EASA:

REC DENM-2012-03

Motivation:

Investigations revealed that the emergency procedure (air conditioning smoke) did not direct the flight crew's decision making on how to remove smoke from the cockpit and cabin if smoke persisted.
Comparing to similar aircraft types (Saab 340, Fokker 50 and Dash 8), differences were noted and it was found that the A TR smoke emergency procedures seemed not to be sufficient if smoke was persisting and cockpit/passenger cabin ventilation was required.
Although in the serious incidents on subject this finding was not considered as a contributing factor, however, whether or not a similar incident takes place shortly after takeoff or at any altitude, no ATR smoke removal emergency procedure seemed to be at the disposal of a flight crew. For that reason, the signing investigation authorities regarded this finding as a flight safety issue, which needed further consideration.

Text:

To review the emergency procedures on ATR aircraft in order to ensure efficient removal of persisting smoke and appropriate cockpit/passenger cabin ventilation.

REC DENM-2012-04

Motivation:

All events were due to a severe mechanical damage and occurred at initial climb, although not necessarily immediately recognized as such by the crews and treated as an in-flight fire at a following stage.
The investigation highlighted an uncertainty on the emergency procedure in force at the time of the event, considering the several amendments issued and ongoing on this subject.
Examination of the existing documentation, namely the EU-OPS 1.130, seems not able to clarify in mandatory terms the timeframe and the procedures to achieve the effective operator compliance on this item when the AFM modification is not accompanied by a dedicated AD.

Text:

To consider the need to harmonize the procedures, or to review the existing documentation as necessary, in order to establish in all cases a time limit within which to make effective in the AFM owned by operators the amendments approved by EASA.

REC DENM-2012-05

Motivation:

ATR AFM Temporary Revision of the "engine fire at take-off' emergency procedure approved in Nov. 2011 introduced a large number of further memory items.
The increasing number of memory items seems to reflect a general trend in the implementation or review of the emergency procedures; however, it seems highly desirable that a careful consideration take place on the potential negative effects of the consequent build-up of the crew workload.
In this case, in addition to a delay of the shutoff action on the affected engine, it may potentially cause an area of hazard taking into consideration the criticality of the phase of flight.

Text:

To promote an internal debate (e.g.: dedicated working group, workshop, etc.) to carefully evaluate the pros and cons of a continuously increasing of memory items introduced in the implementation or review of the emergency procedure, mainly when to be applied in a critical phase of flight.

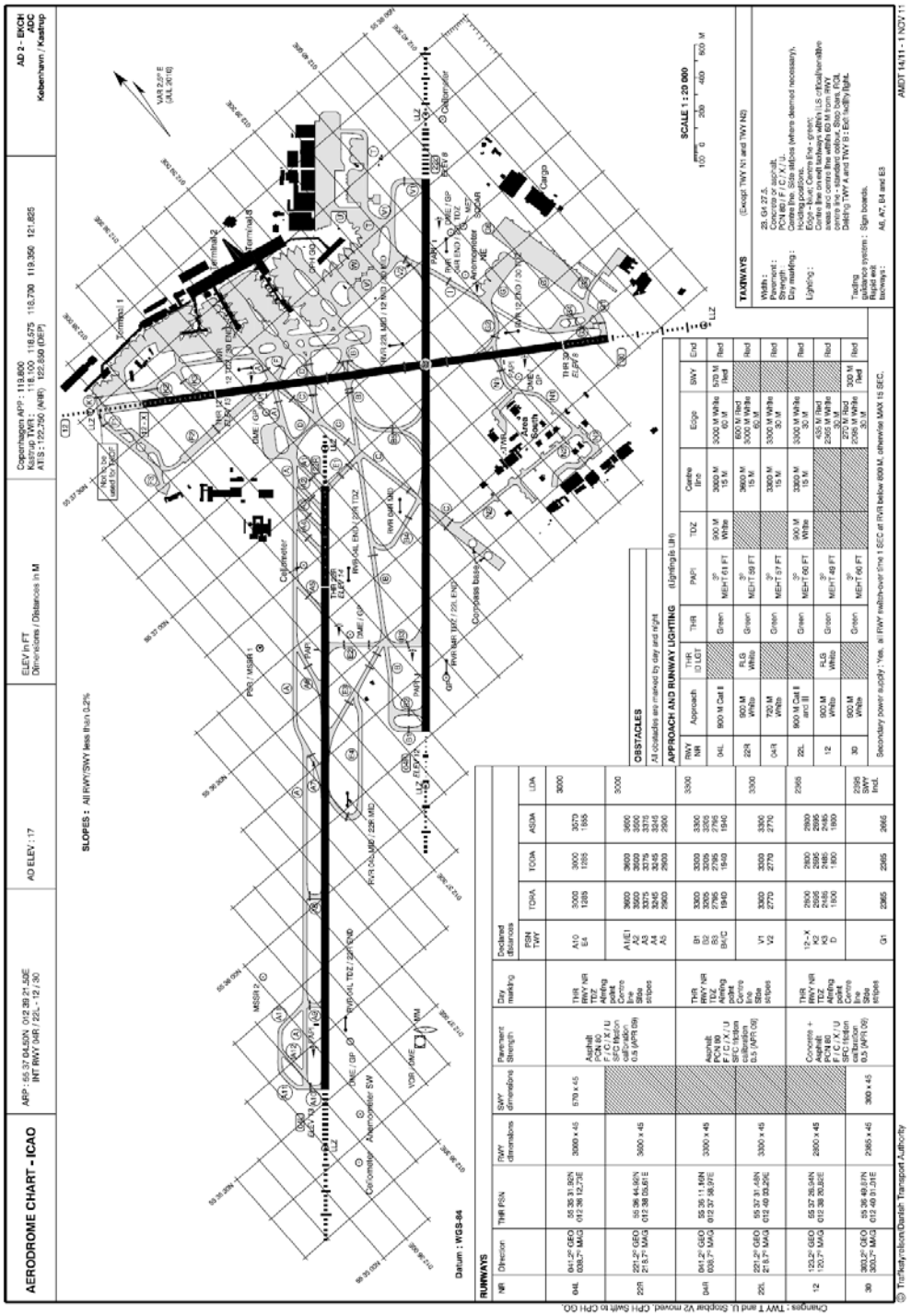
5. Enclosures

1. The operational sequence of events
2. The landing roll
3. Overview of EKCH Airport
4. DFDR plots
5. Engine tear down
6. Laboratory analysis
7. Blades form 8337
8. Service Bulletin 21766R3
9. Engine oil low pressure – checklist
10. Engine over limit – checklist
11. Inflight engine fire – checklist
12. Single engine operation – checklist
13. Smoke – checklist
14. Air conditioning smoke – checklist
15. On ground emergency – checklist
16. Equipment overview – Crew Procedure Handbook
17. Unprepared emergency – Crew Procedure Handbook
18. Tri-National interim report.
19. Smoke removal procedure – Saab 340
20. Smoke removal procedure – Fokker 50
21. Smoke removal procedure – Dash 8

Enclosure 1 - The operational sequence of events

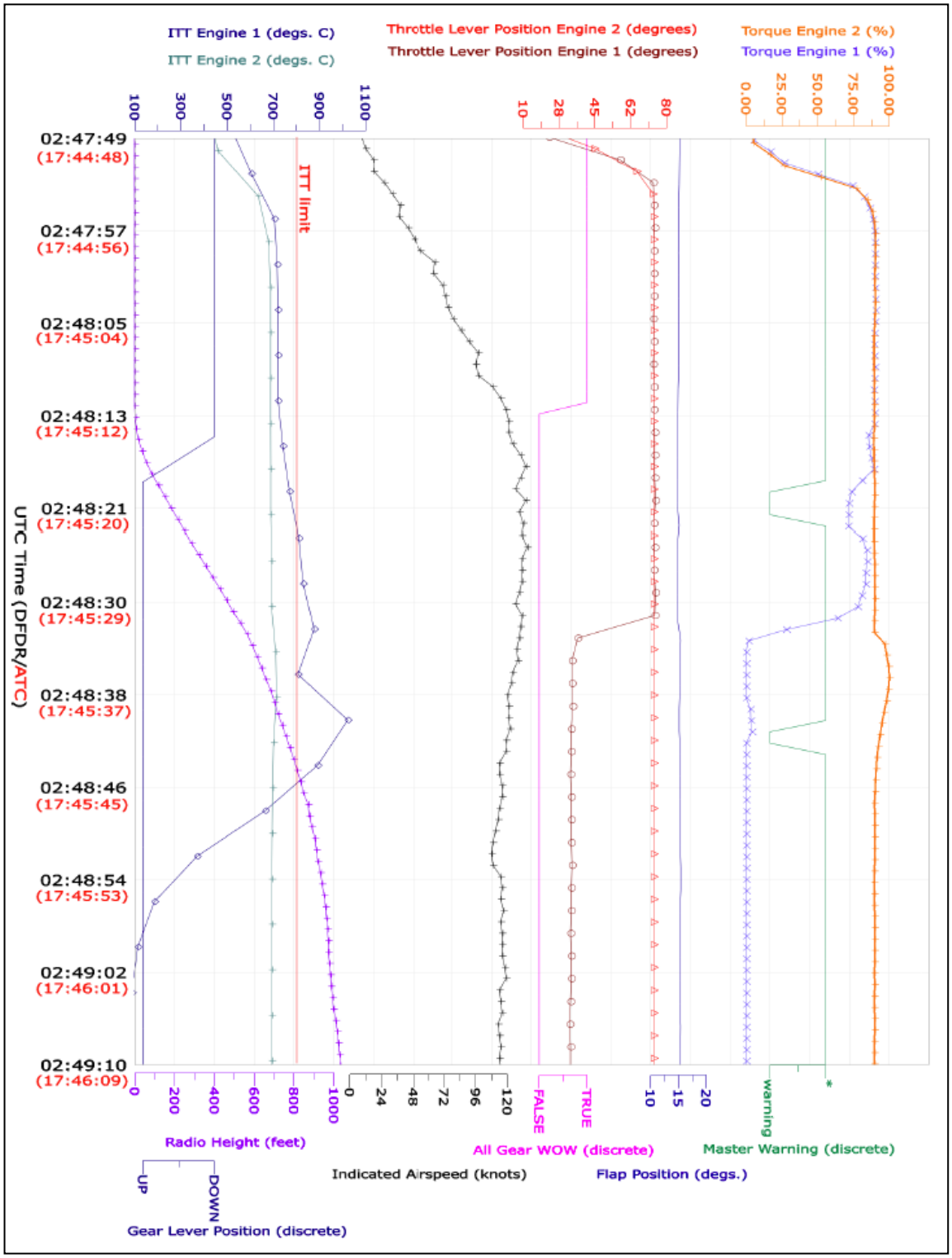
Enclosure 2 - The landing roll

Enclosure 3 - Overview of EKCH Airport

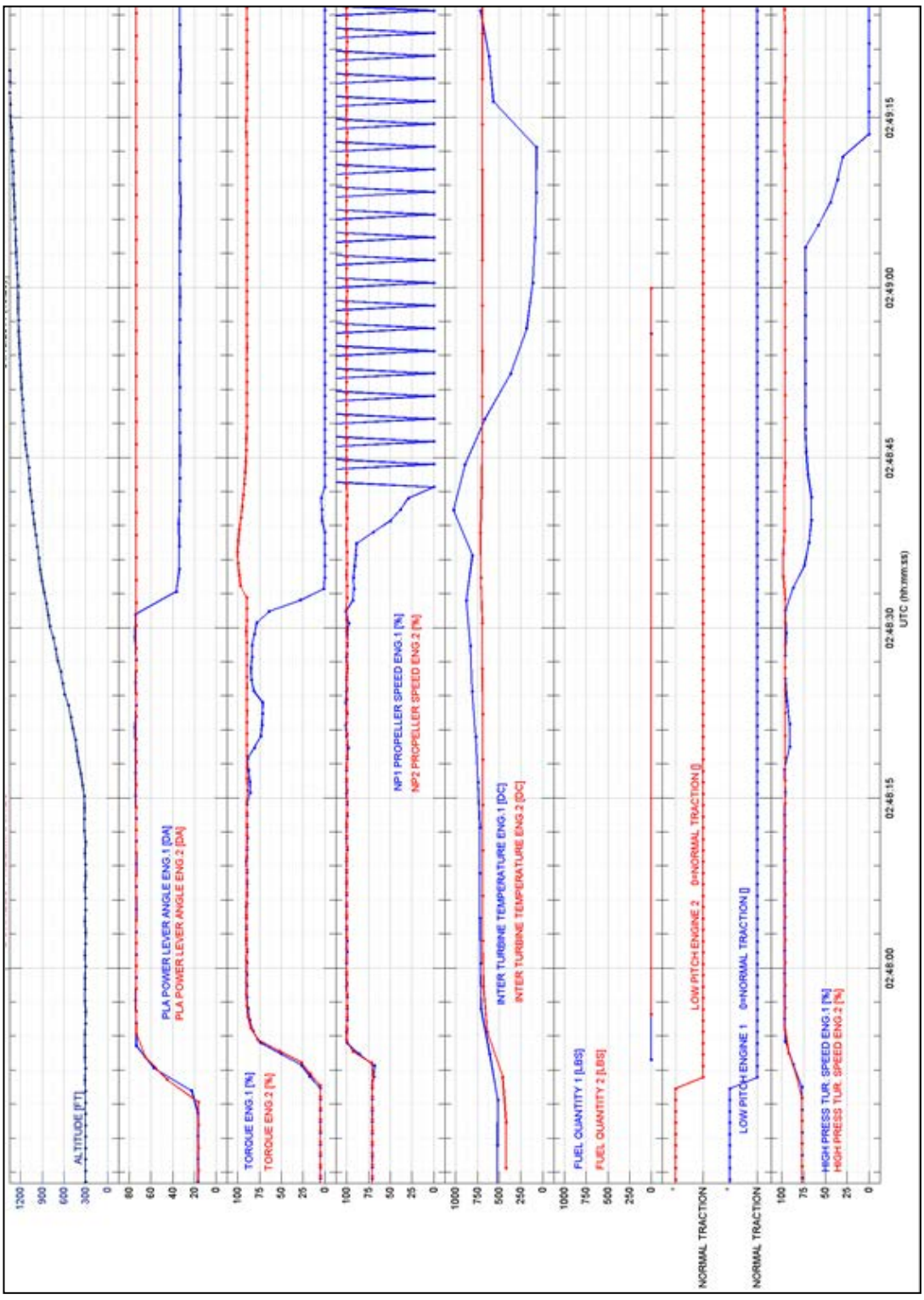


Enclosure 4 - DFDR plot A and B

Plot A



Plot B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PLA POWER LEVER ANGLE ENG.2 [DA]
TORQUE ENG.1 [%]
TORQUE ENG.2 [%]
NP1 PROPELLER SPEED ENG.1 [%]
NP2 PROPELLER SPEED ENG.2 [%]
INTER TURBINE TEMPERATURE ENG.1 [DC]
INTER TURBINE TEMPERATURE ENG.2 [DC]
FUEL QUANTITY 1 [LBS]
FUEL QUANTITY 2 [LBS]
LOW PITCH ENGINE 2 0=NORMAL TRACTION []
NORMAL TRACTION
LOW PITCH ENGINE 1 0=NORMAL TRACTION []
NORMAL TRACTION
HIGH PRESS TUR. SPEED ENG.1 [%]
HIGH PRESS TUR. SPEED ENG.2 [%]
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02:48:15
02:48:30
02:48:45
02:49:00
02:49:15
UTC (hh:mm:ss)

Enclosure 5 - Engine tear down

Engine Removal Data	
Engine Summary:	Engine was removed from A/C S/N 468, with Reg No OY-CIM L/H position due to in flight shut down and fire.
Workscope:	Investigation to find root cause to the in flight shut down and fire. The investigation has been requested by Accident Investigation Board, Denmark.

Engine modules as received

Type	S/N	TSN	CSN	TSO	CSO	TSHSI	CSHSI	TSLSV	CSLSV
T/M	AV0098	16018:29	24235	5939:56	10627	1187:59	2016	186:22	298
RGB	127197	23658:44	29079	186:22	298	N/A	N/A	186:22	298

Engine Serial Number: AV0098

Engine Receiving

General

- Engine received with ATR QEC installed.
- The external of the engine from the Rear Inlet Case back to the exhaust has a sooty appearance.
  See photo No 1 and 2
- Parts of the Wiring Harness and the connectors melted. See photo 3
- The exhaust of the engine showed damages to several PT2 blades and to PT Stator stage 2. See photo 4

Engine Receiving Photos

Photo No 1 **Right hand side of engine**

Photo No 2 **Left hand side of engine**

Photo No 3 **Melted HBV servo valve connector**

Photo No 4 **Broken PT2 Blades**

Receiving Inspection Report.

Findings at receiving inspection	HP- Rotor rotating freely. LP - Rotor had a rough running. PT- Rotor stuck.
RGB Chip Detector	Minor remark. See lab report attached. See photo No 5
TM Chip Detector	Some debris. See lab report attached. See photo No 6.
RGB Oil Filter	No remarks.
TM Oil Filter	No remarks.
Fuel Filter	No remarks.
RGB	No remarks.
LP Impeller	See borescope inspection.
HP Impeller	See borescope inspection.
Oil Sample from TM	See lab report, enclosure 6

Receiving Inspection Photos

Photo No 5 RGB Chip Detector

Photo No 6 TM Chip Detector

Borescope Inspection Report.

HP Impeller	Heavily rubbed. See photo No 7
LP Impeller	Heavily rubbed. See photo 8 and 9
HP Shrouds	Rubbed. See photo 10
HP Blades	Eroded leading edges. See photo 10.

Borescope Inspection Photos

Photo No 7 **HP Impeller rubbing**

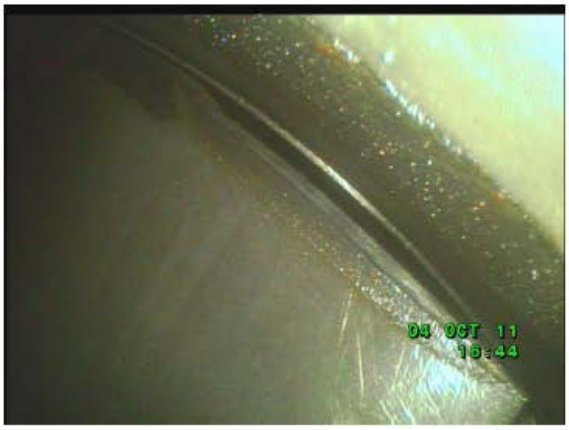


Photo No 8 **LP Impeller rubbing**

Photo No 9 **LP Impeller rubbing**

Photo No 10 **HP Shroud and blade rubbing**

Engine Disassembly

1.	**PT Rotor stage 2:**	Heavily damaged and fractured blades. See photo 11-14 and 17.
2.	**PT Stator stage 2:**	Heavily damaged. See photo 15-16
3.	**PT Rotor stage 1:**	Heavily damaged blades. 2 ea fractured. See photo 18-19.
4.	**Bearing No 6 & 7 Housing:**	Heavily damaged Baffle and sheared attachment bolts. See photo 20, 21 and 24. Heavily damaged seals with Housing in pieces. See photo 31 and 32
5.	**Bearing No 6 & 7 Transfer Tubes**	All three (3) Tubes sheared off right outside the Housing. Compare with the new tube to the right of the Vent Tube. See photo 22-23.
6.	**Bearing No 6**	No major remarks. See photo No 25 and 27.
7.	**Bearing No 7**	No major remarks. See photo No 25 and 26. Dried or coked oil on Bearing No 7 outer race. See photo. No 28.
8.	**Labyrinth Seal**	Damaged due to heavy rubbing mating Bearing No 6 Nut. See photo No 29.
9.	**Bearing No 6 Nut**	Damaged caused by heavy rubbing mating Labyrinth Seal. See Photo No 30.
10.	**LP Turbine Stator**	No major remarks. See photo No 33
11.	**LP Turbine Rotor**	Heavily damaged Bearing No 6 Rotor Air Seal and Disk. Heavily damaged Blade platform and heavy rubbing on blade tips. LP Blades loose. See photo No 34-38

Engine Disassembly Photos

Photo No 11 PT Blade stage 2

Photo No 12 PT Blade stage 2

Photo No 13 PT Blade stage 2

Photo No 14 PT Blade stage 2

Photo No 15 PT Stator stage 2

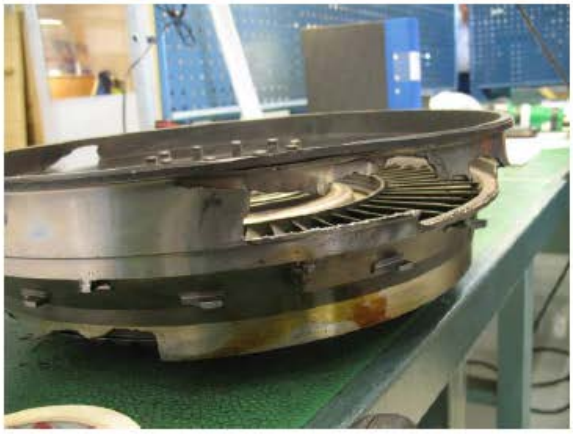


Photo No 16 PT Stator stage 2

Engine Disassembly Photos

Photo No 17 PT Disk and blade stage 2

Photo No 18 PT Disk and blade stage 1

Photo No 19 PT Disk and blade stage 1

Photo No 20 PT Stator stage 1 and Brg 6&7 Housing

Photo No 21 PT Stator stage 1 and Brg 6&7 Housing

Photo No 22 Brg 6&7 Transfer Tubes

Engine Disassembly Photos

Photo No 23 Transfer Tube compared to new

Photo No 24 Bearing No 6&7 Housing

Photo No 25 Bearing No 6 and 7

Photo No 26 Bearing No 7

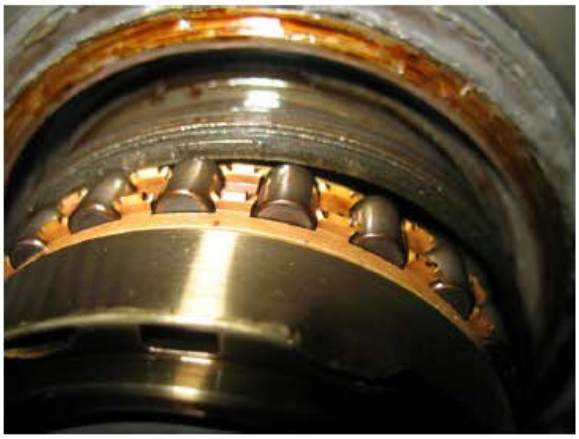


Photo No 27 Bearing No 6

Photo No 28 Bearing No 7 outer race.

Engine Disassembly Photos

Photo No 35 LP Rotor

Photo No 36 No 6 Bearing Rotor Air Seal Assy

Photo No 37 No 6 Bearing Rotor Air Seal Assy

Photo No 38 LP Turbine Blades trailing edge

Photo No 33 LP Stator

Photo No 34 LP Rotor

Investigation

The investigation has been performed together Accident Investigation Board, Denmark and Pratt & Whitney Canada.

Receiving Inspection:

- The engine was removed from the shipping container and put in a disassembly stand.
- The engine was sooty from the Rear Inlet Case and back. In addition the wiring harness with connectors was melted in some areas.
- In the exhaust of the engine there were several blade fractures visible in stage 2 of the Power Turbine.
- A normal receiving inspection was performed. This included a listing of LRUs and General condition. This included also a check of the chip detectors where the TM chip detector showed some debris.

Borescope Inspection:

- A Borescope Inspection was also performed which showed quite heavy rubbing on both LP and HP Impellers.
- Both the LP and HP Turbine Shrouds were also heavily rubbed.

Disassembly:

- PT module was removed.
    - Several PT stage 2 blades were fractured.
    - PT Stator stage 2 has a hole in outer shroud stage 2 at 11 o'clock about 7 cm long and another hole at 4:00 - 6:30 o'clock.
      Large pieces of outer shroud for stage 1 missing.
    - 2 ea PT Blade stage 1 were fractured.
- Before Bearing No 6 and 7 Housing Assy with Turbine Interstage Case and PT Stator stage 1 were removed the following could be observed.
    - The Baffle, P/N 3106409-02 was damaged and the three (3) attaching bolts were sheared off.
    - The Bearing No 6 & 7 Housing was possible to turn/rotate, indicating that the remaining nine (9) bolts and the three (3) Oil Transfer Tubes had to be sheared off.
- The three (3) Transfer Tubes for Bearing No 6 and 7 and the T6 probes were then removed.
    - No damage observed on the T6 probes.
    - The three (3) Oil Transfer Tubes and the nine (9) bolts were sheared off. The Transfer Tubes were sheared off just above the threads into the Brg No 6 & 7 Housing most likely caused by the torque put on the Bearing Housing and in turn caused by rubbing from the LP Rotor. All Tubes had heavy wear marks on the outer diameter.
    - It was observed that the scavenge tube was wet from oil on the outside and the remaining tubes were dry from oil on the outside.

Investigation

- The PT Stator stage 1 and Turbine Interstage Case were removed.
    - When the PT1 Stator and the TIC were removed it was observed that the TIC was wet from oil inside between 6 and 10 o'clock.
    - Also the Insulation Blanket was heavy and wet from oil between 6 and 10 o'clock.
    - The Bearing No 6 & 7 Housing was stuck together with the LP disk and wasn't possible to remove as it normally should be.
- The Bearing No 7, the Labyrinth Seal P/N 3113747-02 and the Bearing No 6 Rotor Nut P/N 3115907-01 were removed.
    - The Seal and the Nut were both heavily rubbed and the seal was also distorted.
    - The PT shaft, Labyrinth Seal mating face, was heavily distorted.
- The Bearing No 6 Air Seal Assy P/N 3115590-01 was removed.
    - The Brg No 6 Seal and the Bearing No 6 & 7 Seal Housing Assy (P/N 3116992-01 were heavily rubbed and had broken up in pieces.

The following parts were sent to Volvo Aero Laboratory for further analysis and investigation:

- The two 2 ea fractured PT Blades stage 1,
    - P/N 3120983-01, S/N HMC34146, TSN: 16018 hrs
    - P/N 3120983-01, S/N HMM31295, TSN: 5939 hrs
- The PT Disk and Blade stage 2 Assy.
- RGB Chip Detector
- TM Chip Detector.

All above are covered in laboratory report enclosure 6. An oil sample was taken from the engine and was analysed.

Conclusions

The root cause for the In Flight Shut Down and Fire was found to be fatigue of one of the fractured Power Turbine Blade stage 1 with P/N 3120983-01, S/N HMM31295 with TSN: 5939 hrs.
This fracture most likely caused the second PT Blade stage 1 to fracture which caused a lot of damages to the PT Stator stage 2 and in turn a lot of fractured PT Blade stage 2.

The unbalance of the PT Rotor has most likely caused a lot of secondary damages, such as:

- Heavy rubbing between PT and LP rotor especially the PT Rotor Air Seal (Labyrinth Seal) P/N 3113747-02 and the Bearing No 6 Rotor Nut P/N 3115907-01 and in turn caused heavy rubbing between the Brg No 6 Seal and the Bearing No 6 & 7 Seal Housing Assy (P/N 3116992-01).
- The LP rotor seals have rubbed against the Bearing No 6 & 7 Housing most likely causing the Housing to rotate and the attaching bolts to shear off which in turn put all force on the transfer tubes causing them to break.
- The broken Transfer Tubes have most likely caused both pressure and in the beginning also scavenge oil to poor down at 6 o'clock position and continue out to the bottom of the nacelle. The oil supply to the Bearing No 6 & 7 Housing was either cut off when the oil supply was depleted or when HP Rotor stopped after the engine shutdown. Normal HP Rotor spool down is about 3 minutes. The Turbo Machinery Oil Tank in the Rear Inlet Case had about 2 litres left when drained. The capacity of the oil tank is about 22 litres.
- There has most likely been an internal oil fire which could be seen on the PT Blades stage 1. All blades had after the fracture of the two blades been exposed to high temperature. This was seen in the fracture surfaces and on the coating on all other blades.
- The Borescope Inspection showed LP Impeller and Shroud, HP Impeller and Shroud and both LP and HP Turbine Shrouds, all to be heavily rubbed.

Enclosure 6 - Laboratory analysis

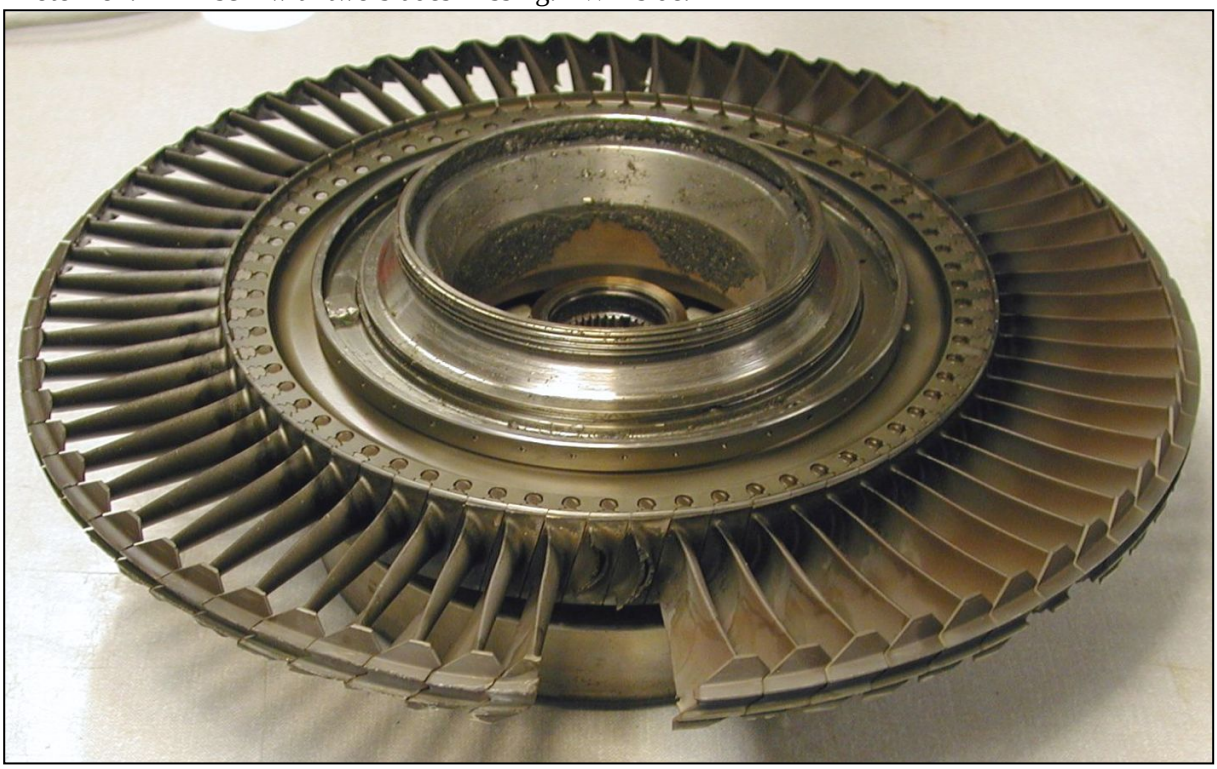
1. Result

Main chip detector: Among a large amount of debris was a few, up to 1.0 mm, chips of M50 bearing steel. The majority of the debris was of materials AMS 6414, 6415 and stainless steels like 17-4PH and 18-8.

RGB chip detector: A small amount of fine debris from material AMS 6260, 6265 and stainless steel 17-4PH, 18-8 and 410.

PT Disc stage 1.

Photo No1. PT Disc 1 with two blades missing. FWD side.



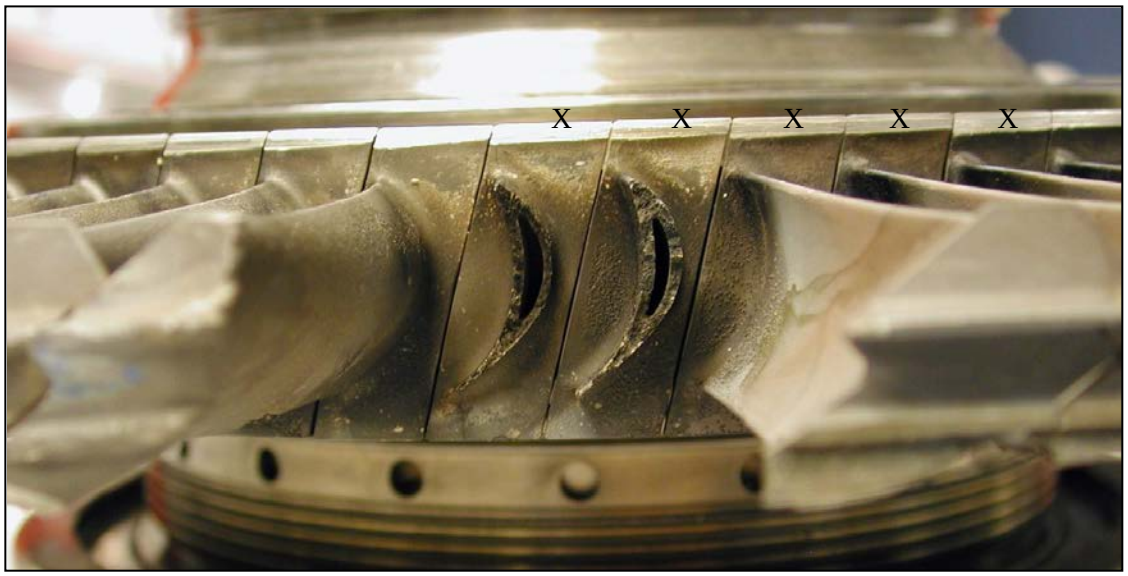


Photo No 2. A closer view of the fractured blades. The five (5) blades marked with X were removed from the disc for a closer investigation.

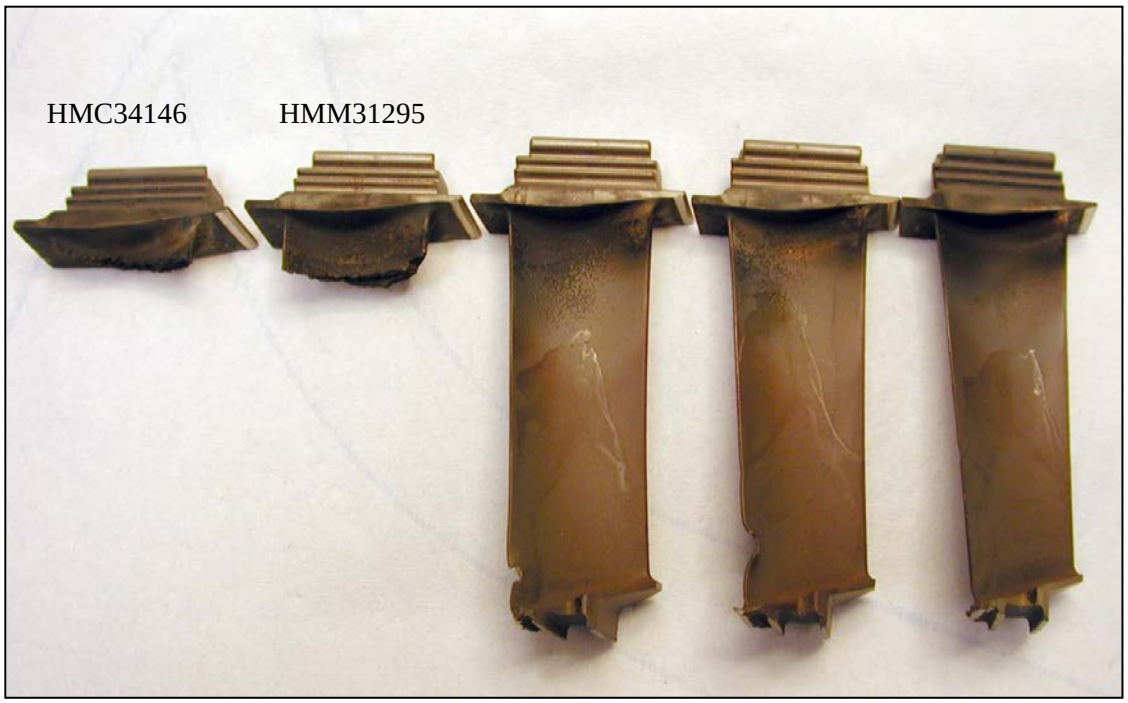


Photo No 3. The five blades after removal from disc. Visual inspection of the two fractured blades showed that S/N HMC34146 had a tensile overload fracture. Blade S/N HMM31295 was subjected to a fractographic investigation using a SEM. See page 69 to 72.

Photo No 4. blade S/N HMC34146 had a tensile overload fracture.

Photo No 5. All of the PT1 blades showed evidences of high temperature at the airfoil close to the root platform. This is probably a secondary damage since the two broken blades show evidences of high temperature on the fracture surfaces close to the leading edges.

Blade S/N HMM31295.

Photo No 6. The fracture surface of blade S/N HMM31295

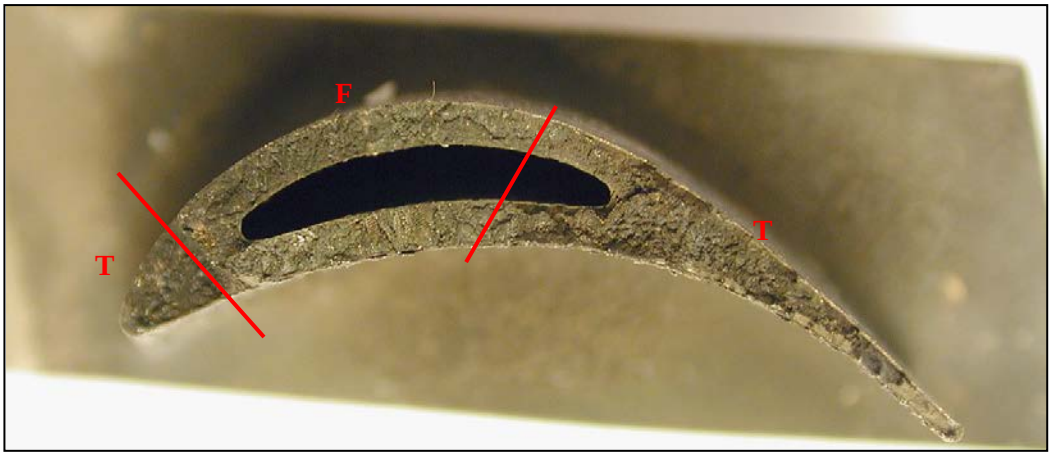


Photo No 7. S/N HMM31295. SEM-investigation (see the following pages) showed that area **F** is a fatigue surface, areas **T** are tensile fracture surfaces.

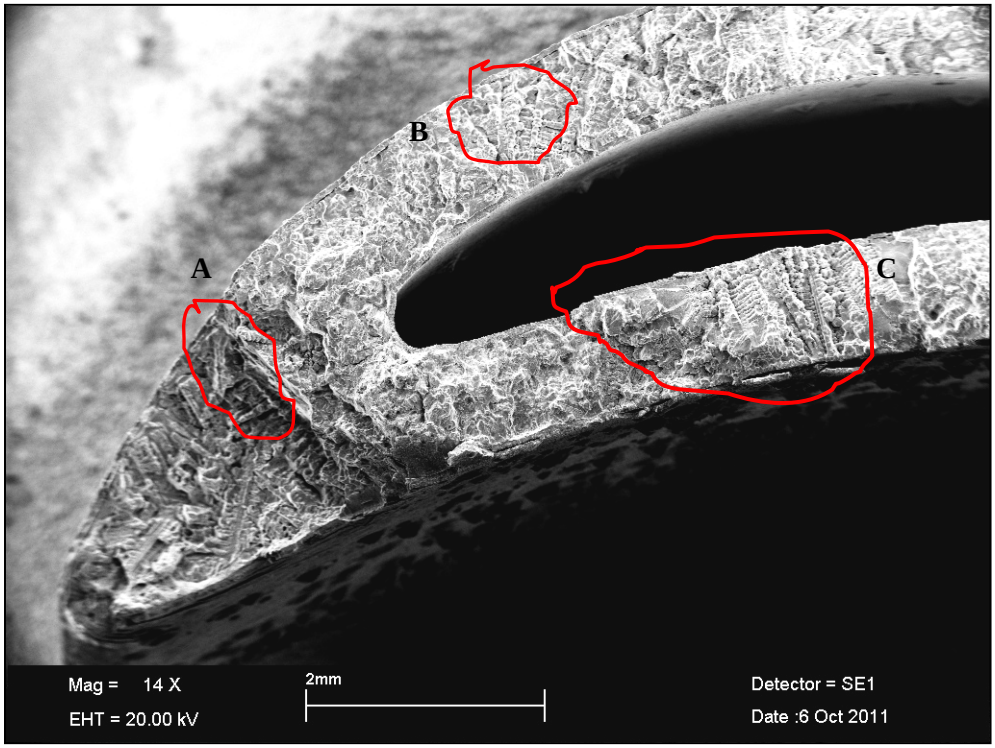


Photo No 8. Red lines show areas with shrinkage porosities where area **C** is the largest (photo no 10)

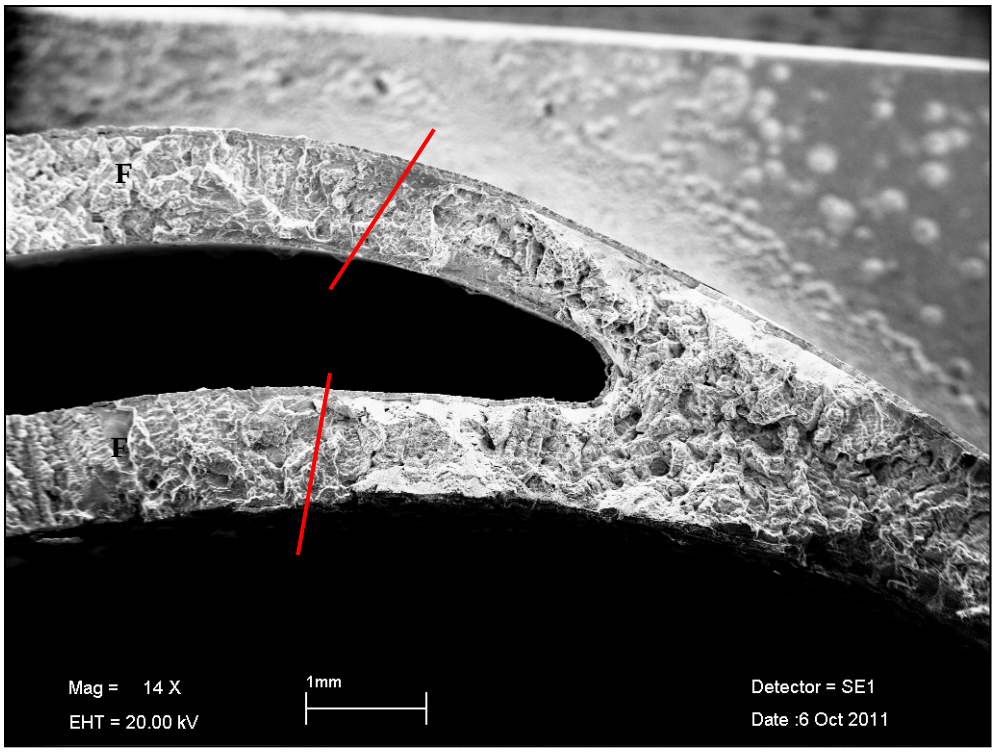


Photo No 9. Red lines show the limit between fatigue, **F**, and overload fracture.

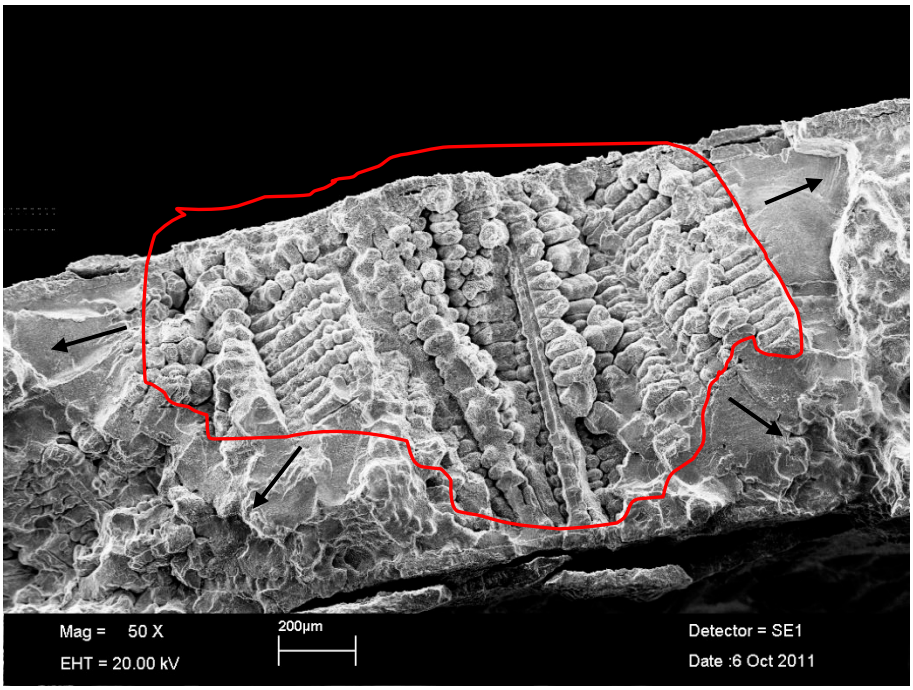


Photo No 10. Area **C** in photo no 8. The red line shows the extension of the shrinkage porosity. The arrows show the direction of fatigue propagation, away from the porosity.

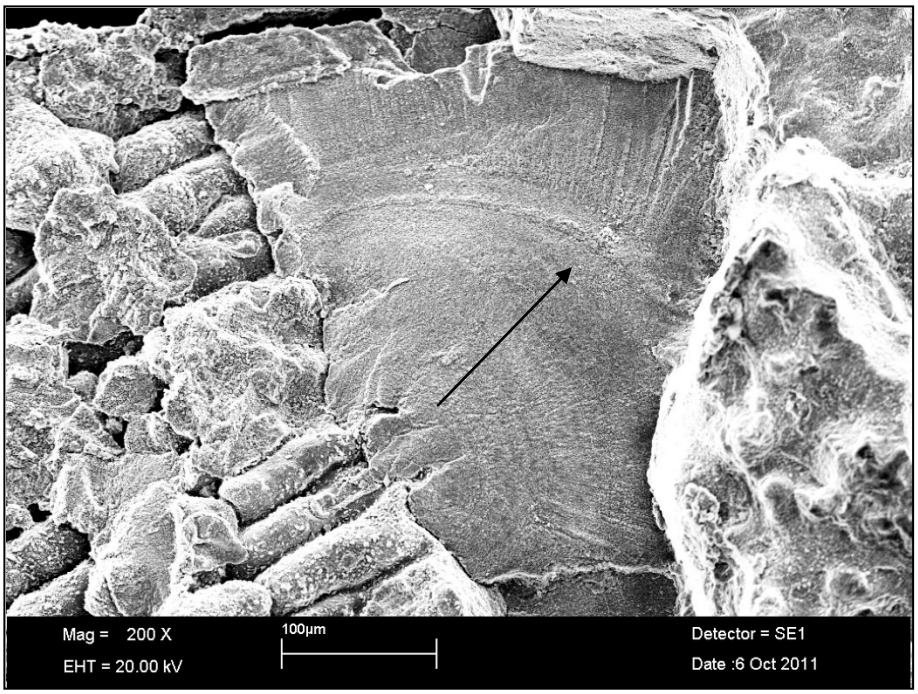


Photo No 11. Higher magnification of fatigue propagation initiated by the shrinkage in photo no 10.

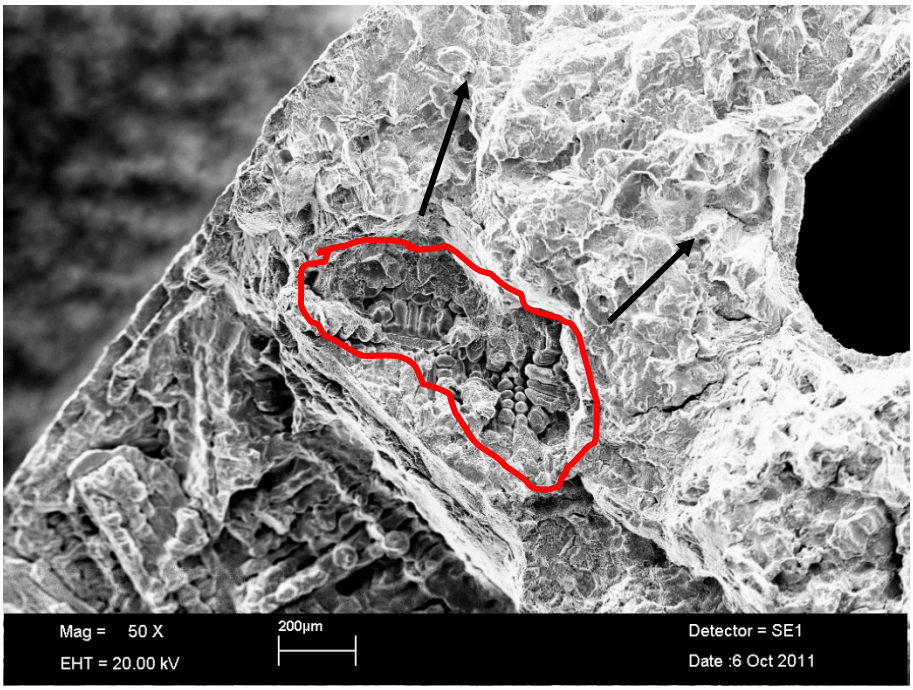


Photo No 12. Area **A** in photo no 8 with shrinkage porosity, from which fatigue propagates (arrows).

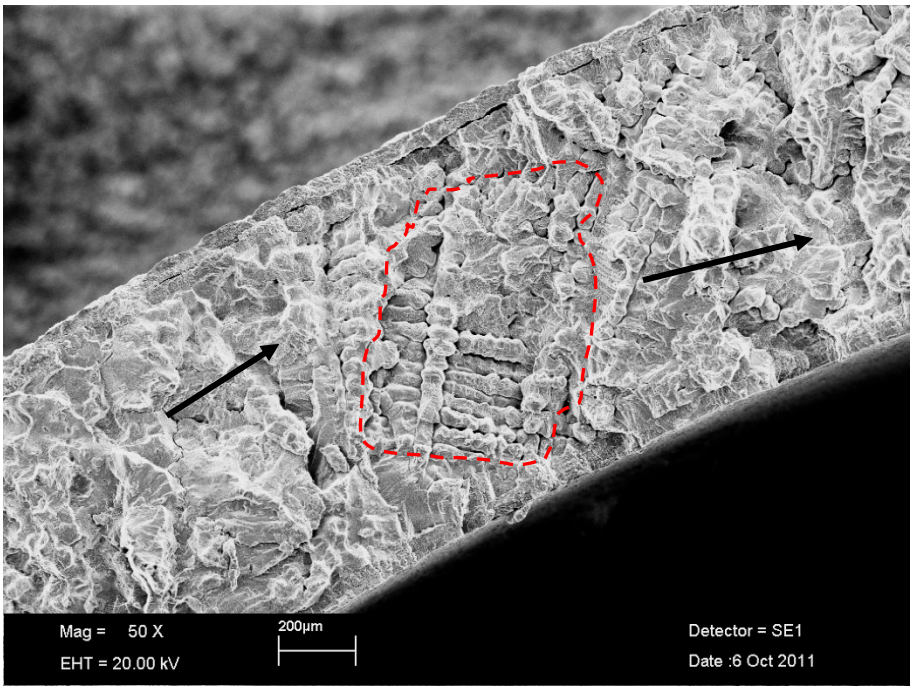


Photo No 13. Area **B** in photo no 8 with a porous structure in general. Arrows show direction of fatigue propagation.

PT Disc stage 2.

Photo No 14. PT Disc stage 2, AFT looking FWD.

Photo No 15. All fracture surfaces were closely inspected and found to be tensile overload fractures, which mean they are a secondary event.

2. Conclusion

The investigation of the parts from engine PW127F, S/N AV0098, showed tensile overload fractures in all blades but one.

PT blade stage 1, S/N HMM31295, had fractured about 8 mm above the root platform as a result of fatigue crack propagation caused by casting defects (shrinkage porosities).

1. Autorité de l'aviation du pays d'approbation / pays Approving national aviation authority/ country	2. B… DE SORTIE AUTORISÉE - AUTHORIZED RELEASE CE…IFICATE	3. Numéro de suivi du formulaire - Form Tracking No.
Transport Canada	**TCCA 24-0078**	80805629 - 000001 833707

4. Nom et adresse de l'organisme agréé - Approved Organization Name and Address	5. Bon de travail/contrat/facture - Work Order/Contract/Inv…
Pratt & Whitney Canada Une société de United Technologies / A United Technologies Company Pratt & Whitney Canada Cie. / Pratt & Whitney Canada Corp. 1000 boul. Marie-Victorin Longueuil, Quebec Canada J4G 1A1 (450) 677-9411	2117141 331989

6. Article - Item	7. Description	8. N° de la pièce - Part No.	9. Admissibilité - Eligibility *	10. Qté - Qty	11. N° de série/de lot - Serial/Batch No.	12. État / Travail - Status / Work
000001	BLADE-POWER TURBINE	3120983-01	VARIOUS	66 EA	SEE BLOCK 13	MANUFACTURED

13. Remarques - Remarks

Options	Détails - Details	N° de série - Serial No.			
N/A	N/A	HMM18316	HMM19173	HMM19175	HMM19184
		HMM20058	HMM20086	HMM20280	HMM20374
		HMM20376	HMM20404	HMM22602	HMM22635
		HMM22646	HMM22648	HMM22651	HMM22653
		HMM22663	HMM22664	HMM22665	HMM22676 ←
		HMM22700	HMM22722	HMM29005	HMM29028
		HMM29031	HMM29748	HMM29777	HMM30278
		HMM31027	HMM31028	HMM31047	HMM31049
		HMM31064	*HMM31069 ←	HMM31075	HMM31077
		HMM31078	HMM31084	HMM31158	HMM31183

Le cas échéant, la durée de stockage est précisée sur l'emballage de l'article - When applicable, shelf life is indicated on the item packaging.

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Approved design data and are in condition for safe operation.

☐ Des données de conception non approuvées indiquées à la case 13.
Non approved design data specified in block 13.

19. ☐ Certification après maintenance en vertu du RAC 571.10 - CAR 571.10 Maintenance Release

☐ Autre réglementation précisée à la case 13 - Other regulations specified in block 13.

Le présent bon certifie que, à moins d'indication contraire apparaissant à la case 13, le travail indiqué à la case 12 … décrit à la case 13 a été effectué conformément au RAC 571.
Certifies that, except where otherwise specified in block 13, the work identified in block 12 and described in block 13 was performed in accordance with CAR 571.

15. Signature autorisée - Authorized Signature	16. Ref.d'autorisation - Authorisation Ref. No.	20. Signature autorisée - Authorized Signature	21. Ref.d'autorisation - Authorisation Ref. …
	DOT APPROVAL 4 - 58		
17. Nom - Name	18. Date (JJ/MMM/AAAA- DD/MMM/YYYY)	22. Nom - Name	23. Date (JJ/MMM/AAAA- DD/MMM/YYYY)
	12/DEC/2005		

24-0078 (12-09-2001) - P&WC 5720 (2005-03) * Le monteur doit contre-vérifier l'admissibilité avec les données approuvées - *Installer must cross-check eligibility with approved data

1. Le présent document n'autorise aucunement le montage de la pièce.

2. Si le moteur se base sur la réglementation nationale d'une autorité de navigabilité autre que celle indiquée à la case 1, il doit s'assurer que l'autorité de navigabilité dont il relève accepte les produits ou les travaux de maintenance de l'autorité de navigabilité indiquée à la case 1.

3. Les énoncés des cases 14 et 19 ne constituent en aucune façon une certification du montage. Dans tous les cas, le dossier technique de l'aéronef doit renfermer une certification de montage délivrée conformément à la réglementation de l'État d'immatriculation, et ce, avant que tout vol puisse avoir lieu.

1. This document does not constitute authority to install the part.

2. Where the installer works in accordance with the national regulations of an airworthiness authority other than the authority specified block 1, the installer must ensure that his/her airworthiness authority accepts products or maintenance from the airworthiness autho… specified in block 1.

3. Statements 14 and 19 do not constitute installation certification. In all cases, the aircraft technical record must contain an installati… certification, issued in accordance with the national regulation of the state of registry, before the aircraft may be flown.

P&WC JR3-6836-E (2005-09)

1. Autorité de l'aviation du pays d'approbation / pays Approving national aviation authority/ country	2. B DE SORTIE AUTORISÉE - AUTHORIZED RELEASE CERTIFICATE	3. Numéro de suivi du formulaire - Form Tracking No.
Transport Canada	**TCCA 24-0078**	80805629 - 000001 833707

4. Nom et adresse de l'organisme agréé - Approved Organization Name and Address	5. Bon de travail/contrat/facture - Work Order/Contract/Inv
Pratt & Whitney Canada Une société de United Technologies / A United Technologies Company Pratt & Whitney Canada Cie. / Pratt & Whitney Canada Corp. 1000 boul. Marie-Victorin Longueuil, Quebec Canada J4G 1A1 (450) 677-9411	2117141 331989

6. Article - Item	7. Description	8. N° de la pièce - Part No.	9. Admissibilité - Eligibility *	10. Qté - Qty	11. N° de série/de lot - Serial/Batch No.	12. État / Travail - Status / Work
000001	BLADE-POWER TURBINE	3120983-01	VARIOUS	66 EA	SEE BLOCK 13	MANUFACTURED

13. Remarques - Remarks

HMM31301	HMM31304	HMM31309	HMM31316
HMM31331	HMM31337	HMM31348	HMM31972
HMM31973	HMM31974	HMM31976	HMM31986
HMM31993	HMM32009	HMM32283	HMM32290
HMM32291	HMM33397	HMM33434	HMM33450
HMM34186	HMM34300	HMM34311	HMM34317
HMM34319	HMM34322		

Le cas échéant, la durée de stockage est précisée sur l'emballage de l'article - When applicable, shelf life is indicated on the item packaging.

"Le numéro de pièce identifié sur la pièce peut inclure un suffixe alphabétique. Ce suffixe alphabétique dénote le niveau de revision de la pièce. Tous les niveaux de revision pour une pièce donnée sont parfaitement interchangeables. Le niveau de revision d'une pièce n'est pas requis pour ce certificat."

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Approved design data and are in condition for safe operation.

☐ Des données de conception non approuvées indiquées à la case 13.
Non approved design data specified in block 13.

19. ☐ Certification après maintenance en vertu du RAC 571.10 - CAR 571.10 Maintenance Release

☐ Autre réglementation précisée à la case 13 - Other regulations specified in block 13.

Le présent bon certifie que, à moins d'indication contraire apparaissant à la case 13, le travail indiqué à la case 12 décrit à la case 13 à été effectué conformément au RAC 571.
Certifies that, except where otherwise specified in block 13, the work identified in block 12 and described in block 1 was performed in accordance with CAR 571.

15. Signature autorisée - Authorized Signature	16. Ref.d'autorisation - Authorisation Ref. No	20. Signature autorisée - Authorized Signature	21. Ref.d'autorisation - Authorisation Ref.
	DOT APPROVAL 4 - 58		
17.Nom - Name	18. Date (JJ/MMM/AAAA- DD/MMM/YYYY)	22. Nom - Name	23. Date (JJ/MMM/AAAA- DD/MMM/YYYY)
	12/DEC/2005		

24-0078 (12-09-2001) - P&WC 5720 (2005-03) * Le monteur doit contre-vérifier l'admissibilité avec les données approuvées - *Installer must cross-check eligibility with approved data

1. Le présent document n'autorise aucunement le montage de la pièce.

2. Si le moteur se base sur la réglementation nationale d'une autorité de navigabilité autre que celle indiquée à la case 1, il doit s'assurer que l'autorité de navigabilité dont il relève accepte les produits ou les travaux de maintenance de l'autorité de navigabilité indiquée à la case 1.

3. Les énoncés des cases 14 et 19 ne constituent en aucune façon une certification du montage. Dans tous les cas, le dossier technique de l'aéronef doit renfermer une certification de montage délivrée conformément à la réglementation de l'État d'immatriculation, et ce, avant que tout vol puisse avoir lieu.

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3. Statements 14 and 19 do not constitute installation certification. In all cases, the aircraft technical record must contain an installa certification, issued in accordance with the national regulation of the state of registry, before the aircraft may be flown.

P&WC JR3-6836-E (2005-03)

1. Autorité de l'aviation du pays d'approbation / pays Approving national aviation authority/ country	2. FORME DE SORTIE AUTORISÉE - AUTHORIZED RELEASE CERTIFICATE	3. Numéro de suivi du formulaire - Form Tracking No.
Transport Canada	**TCCA 24-0078**	80804464 - 000001 832514

4. Nom et adresse de l'organisme agréé - Approved Organization Name and Address	5. Bon de travail/contrat/facture - Work Order/Contract/Invoi
Pratt & Whitney Canada Une société de United Technologies / A United Technologies Company Pratt & Whitney Canada Cie. / Pratt & Whitney Canada Corp. 1000 boul. Marie-Victorin Longueuil, Quebec Canada J4G 1A1 (450) 677-9411	2117009 331880

6. Article - Item	7. Description	8. N° de la pièce - Part No.	9. Admissibilité - Eligibility *	10. Qté - Qty	11. N° de série/de lot - Serial/Batch No.	12. État / Travail - Status / Work
000001	BLADE-POWER TURBINE	3120983-01	VARIOUS	66 EA	SEE BLOCK 13	MANUFACTURED

13. Remarques - Remarks

Options	Détails - Details	N° de série - Serial No.			
N/A	N/A	HMM18306	HMM19169	HMM19170	HMM19177
		HMM19179	HMM19189	HMM19192	HMM19248
		HMM20066	HMM20116	HMM20122	HMM20269
		HMM20270	HMM20273	HMM20274	HMM20277
		HMM20278	HMM20279	HMM20282	HMM20283
		HMM20286	HMM20292	HMM20293	HMM20299
		HMM20303	HMM20304	HMM20306	HMM20307
		HMM20309	HMM20310	HMM20379	HMM22638
		HMM22647	HMM22754	HMM22767	HMM29737
		HMM29741	HMM29744	HMM29749	HMM29754

Le cas échéant, la durée de stockage est précisée sur l'emballage de l'article - When applicable, shelf life is indicated on the item packaging.

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Non approved design data specified in block 13.

19. ☐ Certification après maintenance en vertu du RAC 571.10 - CAR 571.10 Maintenance Release

☐ Autre réglementation précisée à la case 13 - Other regulations specified in block 13.

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	DOT APPROVAL 4 - 58		
17. Nom - Name	18. Date (JJ/MMM/AAAA- DD/MMM/YYYY)	22. Nom - Name	23. Date (JJ/MMM/AAAA- DD/MMM/YYYY)
	08/DEC/2005		

24-0078 (12-09-2001) - P&WC 5720 (2005-03) * Le monteur doit contre-vérifier l'admissibilité avec les données approuvées - *Installer must cross-check eligibility with approved data

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2. Si le moteur se base sur la réglementation nationale d'une autorité de navigabilité autre que celle indiquée à la case 1, il doit s'assurer que l'autorité de navigabilité dont il relève accepte les produits ou les travaux de maintenance de l'autorité de navigabilité indiquée à la case 1.

3. Les énoncés des cases 14 et 19 ne constituent en aucune façon une certification du montage. Dans tous les cas, le dossier technique de l'aéronef doit renfermer une certification de montage délivrée conformément à la réglementation de l'État d'immatriculation, et ce, avant que tout vol puisse avoir lieu.

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P&WC JRJ-6836-E (2005-09)

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6. Article - Item	7. Description	8. N° de la pièce - Part No.	9. Admissibilité - Eligibility *	10. Qté - Qty	11. N° de série/de lot - Serial/Batch No.	12. État / Travail - Status / Work
000001	BLADE-POWER TURBINE	3120983-01	VARIOUS	66 EA	SEE BLOCK 13	MANUFACTURED

13. Remarques - Remarks

HMM29755	HMM29761	HMM29768	HMM29770
HMM29830	HMM31040	HMM31046	HMM31086
HMM31092	HMM31289	HMM31295 *	HMM31296
HMM31300	HMM31302	HMM31311	HMM31319
HMM31322	HMM31343	HMM31971	HMM31982
HMM31984	HMM32006	HMM32011	HMM32300
HMM34306	HMM51968		

*) FAILED BLADE

Le cas échéant, la durée de stockage est précisée sur l'emballage de l'article - When applicable, shelf life is indicated on the item packaging.

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	DOT APPROVAL 4 - 58		
17. Nom - Name	18. Date (JJ/MMM/AAAA- DD/MMM/YYYY)	22. Nom - Name	23. Date (JJ/MMM/AAAA- DD/MMM/YYYY)
	08/DEC/2005		

24-0078 (12-09-2001) - P&WC 5720 (2005-03) * Le monteur doit contre-vérifier l'admissibilité avec les données approuvées - *Installer must cross-check eligibility with approved data

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P&WC JR3-6836-E (2005-09)

Enclosure 8 - Service Bulletin 21766R3

PRATT & WHITNEY CANADA

SERVICE BULLETIN

P&WC S.B. No. 21766R3

TURBOPROP ENGINE
FIRST STAGE POWER TURBINE BLADE - INSPECTION OF

1. Planning Information

A. Effectivity

PW118, PW118A, PW118B, PW119B, PW119C, PW120, PW120A, PW121, PW121A, PW123, PW123B, PW123C, PW123D, PW123E, PW123AF, PW124B, PW125B, PW126, PW126A, PW127, PW127B, PW127D, PW127E, PW127F, PW127G, PW127H, PW127J and PW127M Engines that have a first stage power turbine blade with a serial number recorded in TABLE 1, 2 or 3 or the Appendix.

B. Concurrent Requirements

None.

C. Reason

A shrinkage porosity condition in excess of inspection limits has been identified on some first stage Power Turbine (PT) blades. P&WC has identified the potentially affected blades and recommends the replacement of these blades at different intervals based on the observed condition.

D. Description

Engines or PT Disk Balancing Assemblies are sent to an overhaul shop for the replacement of the identified first stage PT blades.

E. Compliance

Group 1 - For engines that have a PT blade with a serial number recorded in TABLE 1.

CATEGORY 3 - P&WC recommends to do this service bulletin before the PT Blades have TTSN 3000 flight hours.

Group 2 - For engines that have a PT blade with a serial number recorded in TABLE 2.

CATEGORY 3 - P&WC recommends to do this service bulletin at the engine next shop visit, or before the PT Blades have TTSN 5000 flight hours, whichever occurs first.

Group 3 - For engines that have a PT blade with a serial number recorded in TABLE 3.

CATEGORY 6 - P&WC recommends to do this service bulletin when the subassembly (i.e. module, accessories, components, or build groups) is disassembled and access is available to the necessary part. Do all spare subassemblies.

1. Planning Information (Cont'd)

   F. Approval

   D.O.T./D.A.A. approved.

   G. Weight and Balance

   None.

   H. Electrical Load Data

   Not changed.

   I. Software Accomplishment Summary

   Not changed.

   J. References

   Applicable PW100 Technical Manuals

   K. Publications Affected

   Applicable PW100 Technical Manuals

   L. Interchangeability and Intermixability of Parts

   Not applicable.

2. Material Information

   A. Industry Support Information

   Refer to Commercial Support Program Notification (CSPN) No.1003455.

   B. Material - Cost and Availability

   Not applicable.

   C. Manpower

   No more man-hours are necessary to include this service bulletin at overhaul.

   D. Material Necessary for Each Engine

   Not applicable.

2. Material Information (Cont'd)

E. Reidentified Parts

None.

F. Tooling - Price and Availability

Not applicable.

3. Accomplishment Instructions

A. **For an engine or a PT disk balancing assembly that was removed prematurely for the replacement of PT Blade(s) recorded in TABLE 1**:

NOTE: The removal of the Power Turbine (PT) blades can only be done at an authorized overhaul shop.

(1) Before the removal of the Engine or PT disk balancing assembly, make sure that the PT blade(s) serial number from TABLE 1 is recorded in the Engine Serialized Component Summary of the engine.

NOTE: 1. The Engine Serialized Component Summary form can be found in the log book of the turbomachinery module.

NOTE: 2. Any discrepancies between the Engine Serialized Component Summary and TABLE 1, 2 or 3 of this service bulletin, shall be reported to the PW100 service engineering group at pw100techsupp@pwc.ca

(2) Send the Engine or the PT disk balancing assy to an authorized overhaul shop that can do the replacement of the PT Blade(s).

(3) Disassemble the PT disk balancing assy to get access the first stage power turbine blades. Refer to the instructions in the applicable Overhaul or Engine Manual.

NOTE: Do not disassemble the PT blades of the second stage power turbine disk assembly. Only disassemble the necessary parts to have access to the first stage power turbine blades.

3. Accomplishment Instructions (Cont'd)

(4) Replace PT Blade(s) with a serial number that you can find in TABLE 1, and any other blade(s) with a serial number that you can find in TABLE 2 or 3. Return the blade(s) to the address that follows:

Pratt & Whitney Canada Corp.
NDT Technology Department Campus 1, Column SX33 (01MA3)
7007 de la Savane
St-Hubert, Quebec
Canada J3Y 3X7

Attention: Manager Warranty Admin

REF: P&WC S.B. No. 21766

(5) Do the inspection of the disassembled components of the PT disk balancing assembly per the Hot Section Borescope Inspection Criteria. Refer to the instructions in the applicable Maintenance Manual (Ref. 72-00-00, INSPECTION/CHECK).

(6) Assemble the PT disk balancing assembly. Refer to the instructions in the applicable Overhaul or Engine Manual.

(7) Install the PT disk balancing assembly. Refer to the instructions in the applicable maintenance manual (Ref. Chapter 72-03-00, Power Turbine Assembly - Installation).

B. **For Engines at a shop visit other than overhaul or major refurbishment, with PT Blade(s) recorded in TABLE 1 or 2:**

(1) Before the disassembly of the PT disk balancing assembly, make sure that the PT blade(s) serial number from TABLE 1 or 2 is recorded in the Engine Serialized Component Summary of the engine.

NOTE: Any discrepancies between the Engine Serialized Component Summary and TABLE 1, 2 or 3 of this service bulletin, shall be reported to the PW100 service engineering group at pw100techsupp@pwc.ca

(2) Disassemble the PT disk balancing assy to get access the first stage power turbine blades. Refer to the instructions in the applicable Overhaul or Engine Manual.

NOTE: Do not disassemble the PT blades of the second stage power turbine disk assembly, unless necessary (Ref. Hot Section Inspection Criteria (Ref. 72-03-00, TURBOMACHINERY - INSPECTION/CHECK). Only disassemble the necessary parts to have access to the first stage power turbine blades.

3. Accomplishment Instructions (Cont'd)

(3) Replace PT Blade(s) with a serial number that you can find in TABLE 1 or 2, and any other blade(s) with a serial number that you can find in TABLE 3. Return the blade(s) to the address that follows:

Pratt & Whitney Canada Corp.
NDT Technology Department Campus 1, Column SX33 (01MA3)
7007 de la Savane
St-Hubert, Quebec
Canada J3Y 3X7

Attention: Manager Warranty Admin

REF: P&WC S.B. No. 21766

(4) Do the inspection of the disassembled components of the PT disk balancing assembly per the Hot Section Inspection Criteria. Refer to the instructions in the applicable Maintenance Manual (Ref. 72-03-00, TURBOMACHINERY - INSPECTION/CHECK).

(5) Assemble the PT disk balancing assembly. Refer to the instructions in the applicable Overhaul or Engine Manual.

C. **For Engine at a shop visit for overhaul or major refurbishment:**

(1) Replace PT Blade(s) with a serial number that you can find in TABLE 3, and any other blade(s) with a serial number that you can find in TABLE 1 or 2. Return the blade(s) to the address that follows:

Pratt & Whitney Canada Corp.
NDT Technology Department Campus 1, Column SX33 (01MA3)
7007 de la Savane
St-Hubert, Quebec
Canada J3Y 3X7

Attention: Manager Warranty Admin

REF: P&WC S.B. No. 21766

NOTE: Any discrepancies between the Engine Serialized Component Summary and TABLE 1, 2 or 3 of this service bulletin, shall be reported to the PW100 service engineering group at pw100techsupp@pwc.ca

D. Write accomplishment of P&WC S.B. No. 21766 in the applicable engine module log book.

4. Appendix

A. Refer to TABLE 1, 2 and 3 for applicable Engines and PT blades serial numbers.

NOTE: TABLE 4 is a list of all PT Blades from TABLE 1, 2 and 3 but in order of PT blade part number and serial number.

4. Appendix (Cont'd)

TABLE 1, Group 1 – Applicable Engines and PT Blades Serial Numbers (by order of Engine Model)

Engine Model	Engine Serial Number	Blade Part Number	Blade Serial Number
PW118A	115674	3120963-01	HMM77391
PW123AF	AF0095	3120983-01	HMN29250
PW123D	AG0114	3120983-01	HMM74660
PW123E	AW0116	3120983-01	HMM55131
PW123E	AW0129	3120983-01	HMN49849
PW124B	AH0005	3120983-01	HMN78524
PW127E	EB0257	3120983-01	HMN46420
PW127F	AV0007	3120983-01	HMN46872
PW127F	EB0072	3120983-01	HMN51267
PW127F	EB0262	3120983-01	HMN50746
PW127F	EB0262	3120983-01	HMN49950
PW127F	EB0348	3120983-01	HWA26690
PW127G	AX0074	3120983-01	HMM23915
PW127G	AX0089	3120983-01	HMN44942
PW127J	EA0053	3120983-01	HMN99304
PW127M	ED0005	3120983-01	HMN34467

TABLE 2, Group 2 – Applicable Engines and PT Blades Serial Numbers (by order of Engine Model)

Engine Model	Engine Serial Number (PCE-)	Blade Part Number	Blade Serial Number
PW119C	AB0037	3120983-01	HMM59936
PW120	120064	3120963-01	HMM21047

4. Appendix (Cont'd)

TABLE 2, Group 2 – Applicable Engines and PT Blades Serial Numbers (by order of Engine Model) (Cont'd)

Engine Model	Engine Serial Number (PCE-)	Blade Part Number	Blade Serial Number
PW120	120182	3120963-01	HMN23742
PW120	120815	3120963-01	HMN28647
PW120	120601	3120963-01	HMN46066
PW121	AC0017	3120963-01	HMP52097
PW123AF	AF0024	3120983-01	HMN49848
PW123D	123331	3120983-01	HMP70816
PW123E	123228	3120983-01	HMN46354
PW123E	123228	3120983-01	HMN46722
PW123E	AW0127	3120983-01	HMN16282
PW124B	124609	3120983-01	HMM66664
PW125B	125097	3120973-01	HMM11400
PW125B	125138	3120983-01	HMP05480
PW126	124522	3120983-01	HMN98396
PW127E	EB0233	3120983-01	HMM76345
PW127F	EB0082	3120983-01	HMN95965
PW127F	EB0294	3120983-01	HMN62770
PW127J	EA0058	3120983-01	HMP14074

4. Appendix (Cont'd)

TABLE 3, Group 3 – Applicable Engines and PT Blades Serial Numbers (by order of Engine Model)

Engine Model	Engine Serial Number	Blade Part Number	Blade Serial Number
PW118A	115484	3120963-01	HMP07289
PW123	123243	3120983-01	HMP19354
PW123E	AW0024	3120983-01	HMM69658
PW124B	124358	3120983-01	HMN48001
PW124B	124571	3120983-01	HMN48209
PW124B	124599	3120983-01	HMN16661
PW125B	124046	3120983-01	HMN48244
PW125B	125007	3120983-01	HMN46915
PW125B	125007	3120983-01	HMN48556
PW125B	125157	3120983-01	HMN24233
PW127	127007	3120983-01	HMP09168
PW127	127149	3120983-01	HMM70343
PW127F	EB0012	3120983-01	HMN18734
PW127F	EB0262	3120983-01	HMN48724
PW127G	AX0092	3120983-01	HMN24164
PW127J	EA0049	3120983-01	HMN48440
PW127J	EA0049	3120983-01	HMN48703
PW127J	EA0068	3120983-01	HMP69832
Unknown		3054053-01	HWA46378

4. Appendix (Cont'd)

TABLE 4, PT Blades by order of Part Numbers and Serial Numbers

Blade Part Number	Blade Serial Number	Applicable Group Number
3054053-01	HWA46378	3
3120963-01	HMM21047	2
3120963-01	HMM77391	1
3120963-01	HMN23742	2
3120963-01	HMN28647	2
3120963-01	HMN46066	2
3120963-01	HMP07289	3
3120963-01	HMP52097	2
3120973-01	HMM11400	2
3120983-01	HMM23915	1
3120983-01	HMM55131	1
3120983-01	HMM59936	2
3120983-01	HMM66664	2
3120983-01	HMM69658	3
3120983-01	HMM70343	3
3120983-01	HMM74660	1
3120983-01	HMM76345	2
3120983-01	HMN16282	2
3120983-01	HMN16661	3
3120983-01	HMN18734	3
3120983-01	HMN24164	3

4. Appendix (Cont'd)

TABLE 4, PT Blades by order of Part Numbers and Serial Numbers (Cont'd)

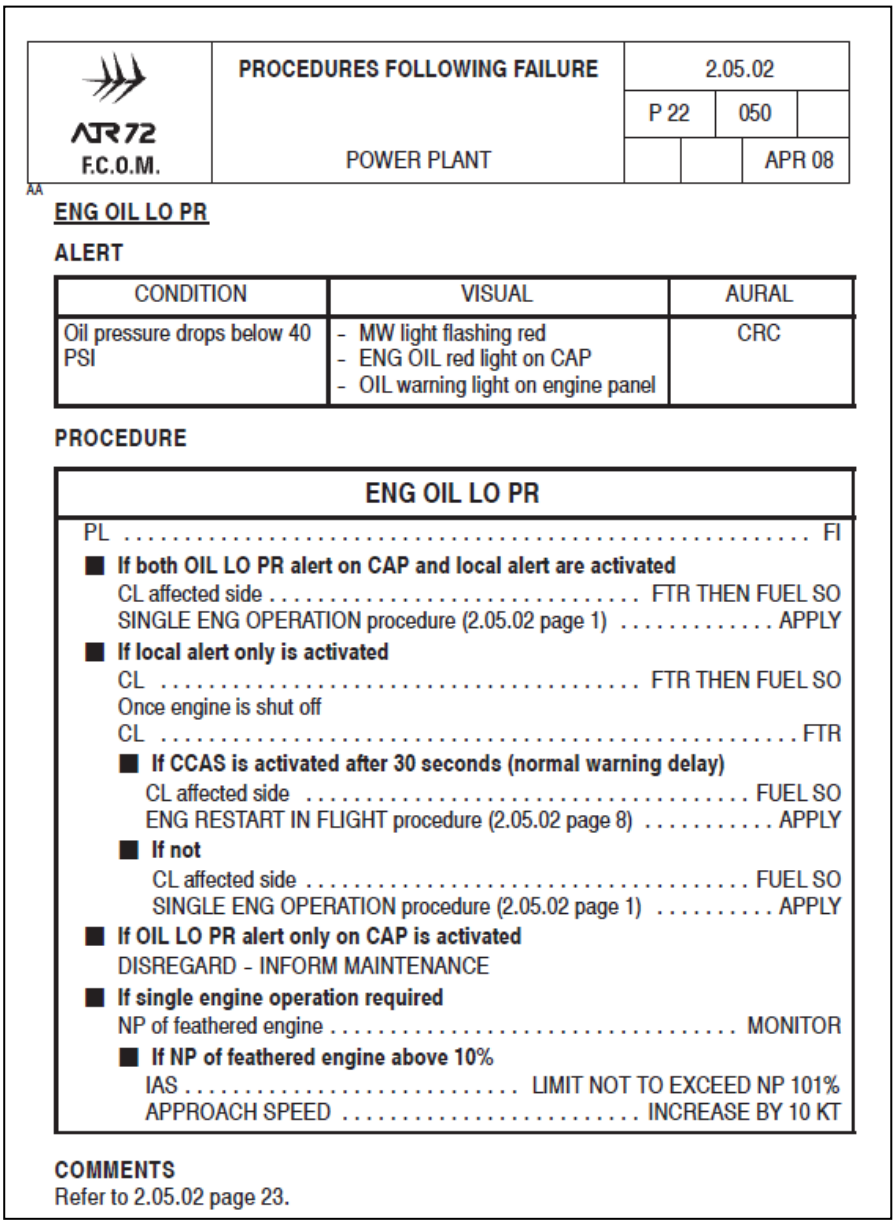
Blade Part Number	Blade Serial Number	Applicable Group Number
3120983-01	HMN24233	3
3120983-01	HMN29250	1
3120983-01	HMN34467	1
3120983-01	HMN44942	1
3120983-01	HMN46354	2
3120983-01	HMN46420	1
3120983-01	HMN46722	2
3120983-01	HMN46872	1
3120983-01	HMN46915	3
3120983-01	HMN48001	3
3120983-01	HMN48209	3
3120983-01	HMN48244	3
3120983-01	HMN48440	3
3120983-01	HMN48556	3
3120983-01	HMN48703	3
3120983-01	HMN48724	3
3120983-01	HMN49848	2
3120983-01	HMN49849	1
3120983-01	HMN49950	1
3120983-01	HMN50746	1
3120983-01	HMN51267	1

4. Appendix (Cont'd)

TABLE 4, PT Blades by order of Part Numbers and Serial Numbers (Cont'd)

Blade Part Number	Blade Serial Number	Applicable Group Number
3120983-01	HMN62770	2
3120983-01	HMN78524	1
3120983-01	HMN95965	2
3120983-01	HMN98396	2
3120983-01	HMN99304	1
3120983-01	HMP05480	2
3120983-01	HMP09168	3
3120983-01	HMP14074	2
3120983-01	HMP19354	3
3120983-01	HMP69832	3
3120983-01	HMP70816	2
3120983-01	HWA26690	1

Enclosure 9 - Engine oil low pressure



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		P 22	050	
	POWER PLANT			APR 08

AA

ENG OIL LO PR

ALERT

CONDITION	VISUAL	AURAL
Oil pressure drops below 40 PSI	- MW light flashing red - ENG OIL red light on CAP - OIL warning light on engine panel	CRC

PROCEDURE

ENG OIL LO PR

PL ..... FI

■ **If both OIL LO PR alert on CAP and local alert are activated**

CL affected side ..... FTR THEN FUEL SO

SINGLE ENG OPERATION procedure (2.05.02 page 1) ..... APPLY

■ **If local alert only is activated**

CL ..... FTR THEN FUEL SO

Once engine is shut off

CL ..... FTR

■ **If CCAS is activated after 30 seconds (normal warning delay)**

CL affected side ..... FUEL SO

ENG RESTART IN FLIGHT procedure (2.05.02 page 8) ..... APPLY

■ **If not**

CL affected side ..... FUEL SO

SINGLE ENG OPERATION procedure (2.05.02 page 1) ..... APPLY

■ **If OIL LO PR alert only on CAP is activated**

DISREGARD - INFORM MAINTENANCE

■ **If single engine operation required**

NP of feathered engine ..... MONITOR

■ **If NP of feathered engine above 10%**

IAS ..... LIMIT NOT TO EXCEED NP 101%

APPROACH SPEED ..... INCREASE BY 10 KT

COMMENTS

Refer to 2.05.02 page 23.

Enclosure 10 - Engine over limit

ENG OVER LIMIT

ALERT

CONDITION	VISUAL	AURAL
ITT above limit in flight or on ground except at start	- MC light flashing amber - ENG amber light on CAP - associated ITT caution light on engine panel	SC

PROCEDURE

ENG OVER LIMIT

PL affected side . . . . . RETARD TO RESTORE NORMAL VALUES

R Note: BLEED VALVE may be selected OFF in order to reduce ITT

■ **If TQ, NH, and/or ITT still over limit and if conditions permit**

PL affected side . . . . . FI

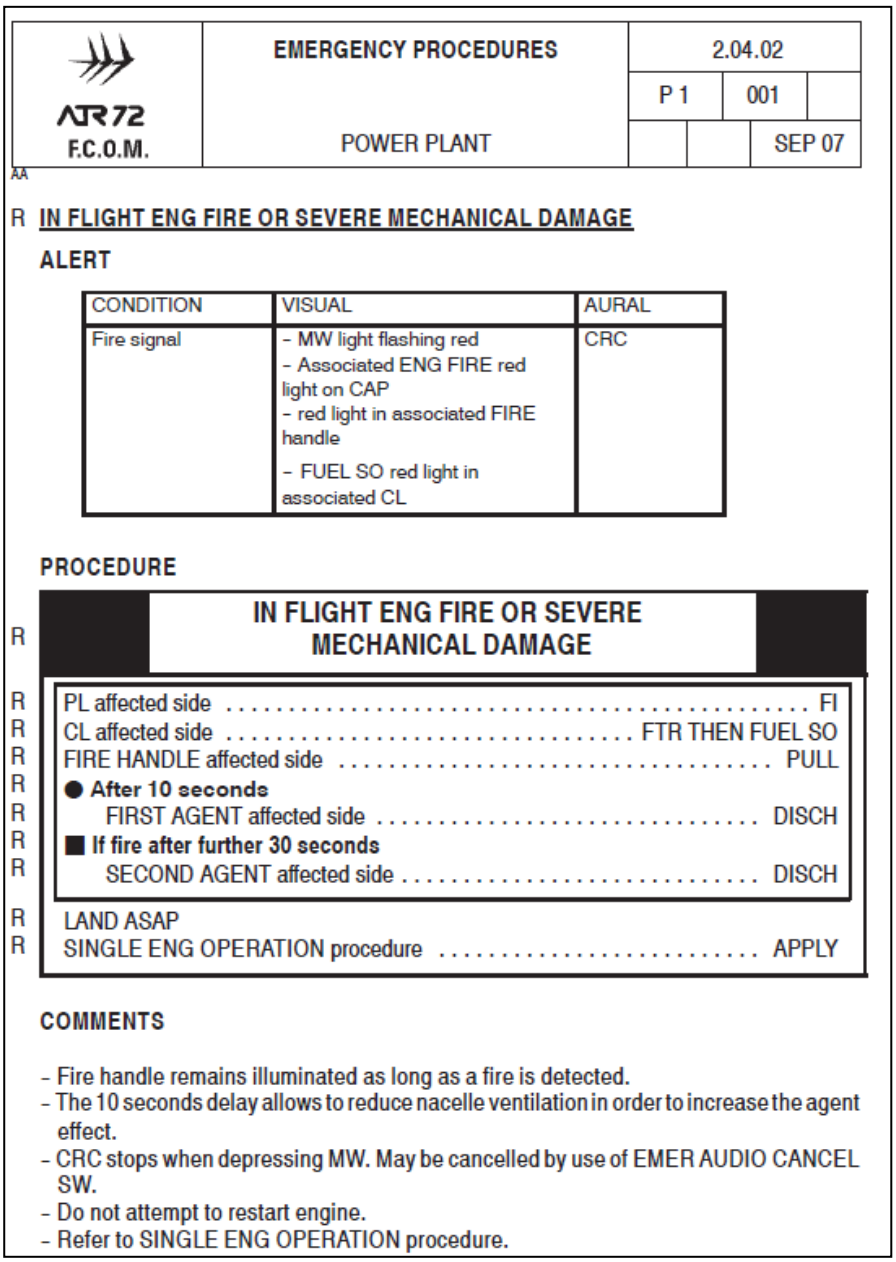
CL affected side . . . . . FTR THEN FUEL SO

SINGLE ENG OPERATION procedure (2.05.02 page 1) . . . . . APPLY

COMMENTS

- Red limits must not be deliberately exceeded.
- Check pointer and counter to determine limit exceedance and proceed accordingly.
- Over limit conditions and primary engine(s) parameters must be recorded for maintenance purposes.
- If conditions do not permit engine shut down, land as soon as possible using the minimum power required to sustain safe flight.

Enclosure 11 - Inflight engine fire



ATR72 F.C.O.M.	EMERGENCY PROCEDURES POWER PLANT	2.04.02 P 1 | 001 SEP 07

AA

R **IN FLIGHT ENG FIRE OR SEVERE MECHANICAL DAMAGE**

ALERT

CONDITION	VISUAL	AURAL
Fire signal	- MW light flashing red - Associated ENG FIRE red light on CAP - red light in associated FIRE handle - FUEL SO red light in associated CL	CRC

PROCEDURE

R **IN FLIGHT ENG FIRE OR SEVERE MECHANICAL DAMAGE**

R PL affected side ..... FI
R CL affected side ..... FTR THEN FUEL SO
R FIRE HANDLE affected side ..... PULL
R ● **After 10 seconds**
R FIRST AGENT affected side ..... DISCH
R ■ **If fire after further 30 seconds**
R SECOND AGENT affected side ..... DISCH

R LAND ASAP
R SINGLE ENG OPERATION procedure ..... APPLY

COMMENTS

- Fire handle remains illuminated as long as a fire is detected.
- The 10 seconds delay allows to reduce nacelle ventilation in order to increase the agent effect.
- CRC stops when depressing MW. May be cancelled by use of EMER AUDIO CANCEL SW.
- Do not attempt to restart engine.
- Refer to SINGLE ENG OPERATION procedure.

Enclosure 12 - Single engine operation

AA

SINGLE ENG OPERATION

PROCEDURE

SINGLE ENG OPERATION

LAND ASAP

R PWR MGT ..... TO if necessary then MCT
FUEL PUMP affected side ..... OFF
DC GEN affected side ..... OFF
ACW GEN affected side ..... OFF
PACK affected side ..... OFF
BLEED affected side ..... OFF
R APM (If installed) ..... OFF
TCAS (If installed) ..... TA ONLY
OIL PRESSURE ON FAILED ENGINE ..... MONITOR

Note: In icing conditions, FLAPS 15 will be selected to improve drift down performances and single engine ceiling.

Note: Refer to QRH pages (4.61) and (4.62) to determine single engine gross ceiling.

Note: If during the flight, a positive oil pressure has been noted on the failed engine for a noticeable period of time, maintenance must be informed.

Note: monitor fuel balance. Recommended operational maximum fuel unbalance is 200 kg (440 lb).

● **When FUEL CROSS FEED is required**

FUEL PUMP affected side ..... ON
FUEL X FEED ..... ON
FUEL PUMP on operating ENG ..... OFF

● **For approach**

MAX APPROACH SLOPE for Steep Slope Approach 5.5°
BLEED NOT AFFECTED ..... OFF
CL live engine ..... 100% OVRD
APPROACH SPEED ..... NOT LESS THAN 1.1VMCA

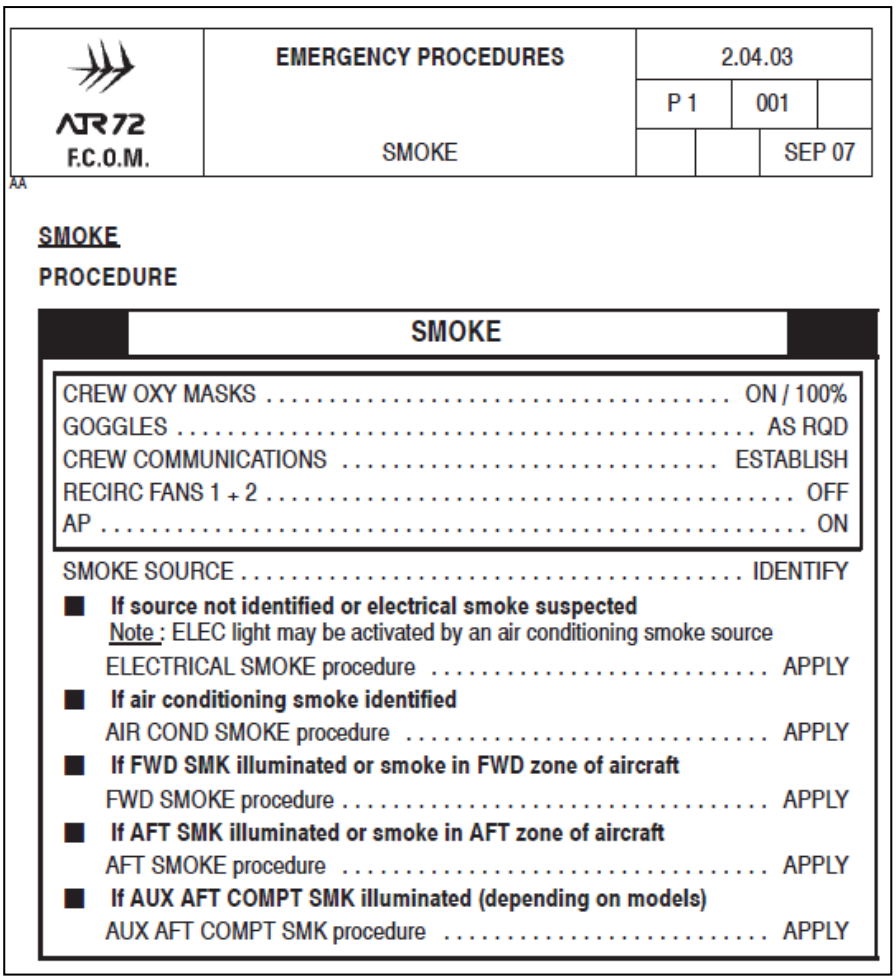
Note: Refer to QRH page 4.64 to determine 1.1VMCA.

Note: At touch down, do not reduce below FI before nose wheel is on the ground.

COMMENTS

- Refer to section Procedures and Techniques for fuel unbalance.
- For approach and landing, comply with Procedures and Techniques, Flight Patterns sub-section 2.02.10.

Enclosure 13 - Smoke



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AA

SMOKE

PROCEDURE

SMOKE

CREW OXY MASKS ..... ON / 100%
GOGGLES ..... AS RQD
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 ..... APPLY

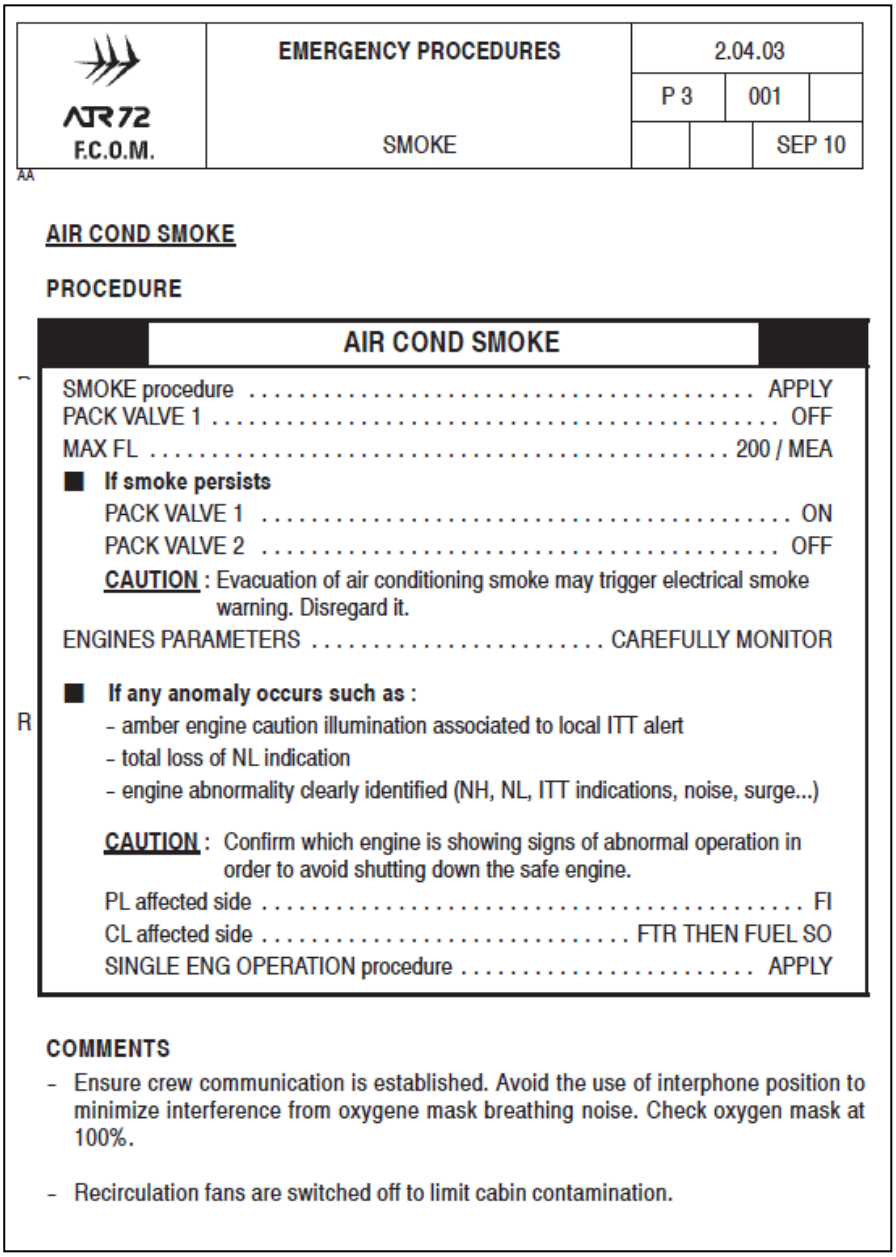
■ **If air conditioning smoke identified**
AIR COND SMOKE procedure ..... APPLY

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

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

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

Enclosure 14 - Air conditioning smoke



ATR 72 F.C.O.M.

EMERGENCY PROCEDURES | 2.04.03

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SMOKE | SEP 10

AA

AIR COND SMOKE

PROCEDURE

AIR COND SMOKE

SMOKE procedure ..... APPLY
PACK VALVE 1 ..... OFF
MAX FL ..... 200 / MEA

■ **If smoke persists**

PACK VALVE 1 ..... ON
PACK VALVE 2 ..... OFF

CAUTION : Evacuation of air conditioning smoke may trigger electrical smoke warning. Disregard it.

ENGINES PARAMETERS ..... CAREFULLY MONITOR

R ■ **If any anomaly occurs such as :**

- amber engine caution illumination associated to local ITT alert
- total loss of NL indication
- engine abnormality clearly identified (NH, NL, ITT indications, noise, surge...)

CAUTION : Confirm which engine is showing signs of abnormal operation in order to avoid shutting down the safe engine.

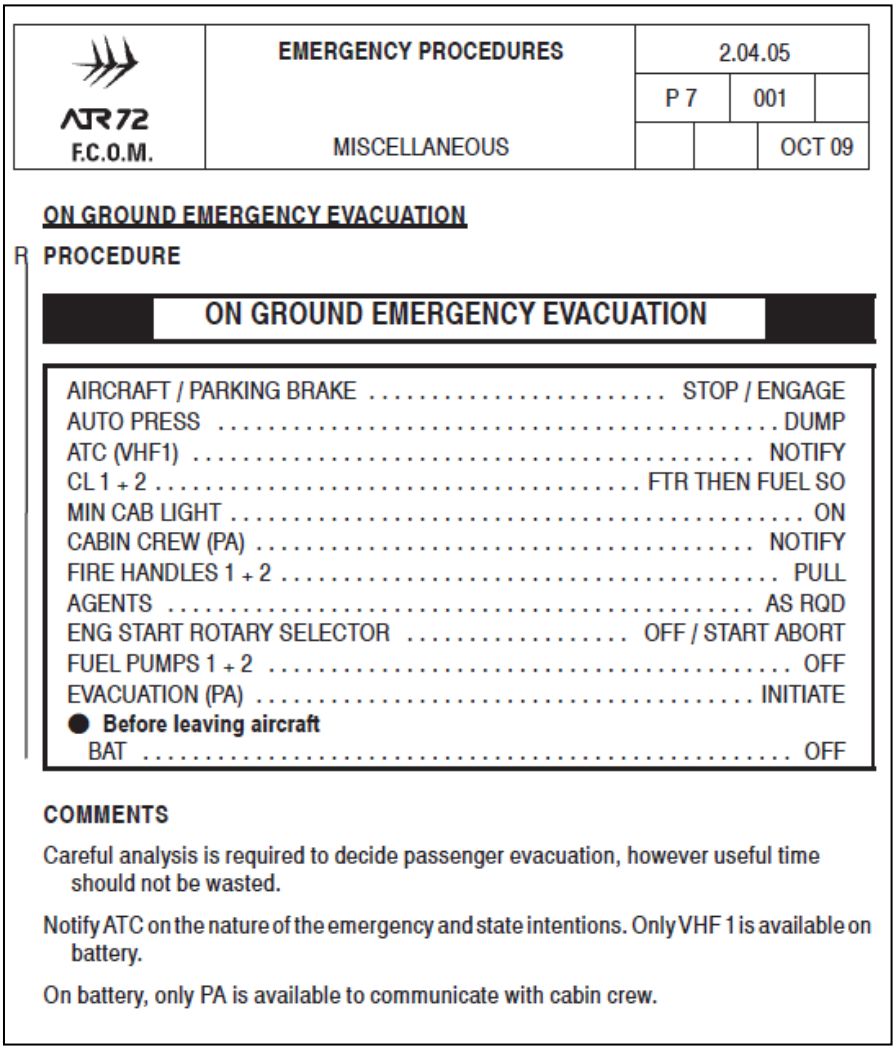
PL affected side ..... FI
CL affected side ..... FTR THEN FUEL SO
SINGLE ENG OPERATION procedure ..... APPLY

COMMENTS

- Ensure crew communication is established. Avoid the use of interphone position to minimize interference from oxygene mask breathing noise. Check oxygen mask at 100%.

- Recirculation fans are switched off to limit cabin contamination.

Enclosure 15 - On ground emergency



ON GROUND EMERGENCY EVACUATION

R **PROCEDURE**

ON GROUND EMERGENCY EVACUATION

AIRCRAFT / PARKING BRAKE	STOP / ENGAGE
AUTO PRESS	DUMP
ATC (VHF1)	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

COMMENTS

Careful analysis is required to decide passenger evacuation, however useful time should not be wasted.

Notify ATC on the nature of the emergency and state intentions. Only VHF 1 is available on battery.

On battery, only PA is available to communicate with cabin crew.

Enclosure 16 - Equipment overview

ATR 72-202

Cockpit F/C side
Quick donning mask
Smoke goggles
Flash light
Red crew life vest
Cabin emergency checklist
Fire gloves
Smoke detector floor/racks

Observer
Quick donning mask
Smoke goggles
Yellow life vest

Over C/A 2 seat stowed position
H2o Fire extinguisher

Under C/A 2 seat
Crew portable oxygen bottle
120L.,with 2 nose/mouth masks attached
Red crew lift vest
Flash light
Cabin emergency checklist
Key for fixed Oxygen/circuit breaker
Tool for loosening the hat rack

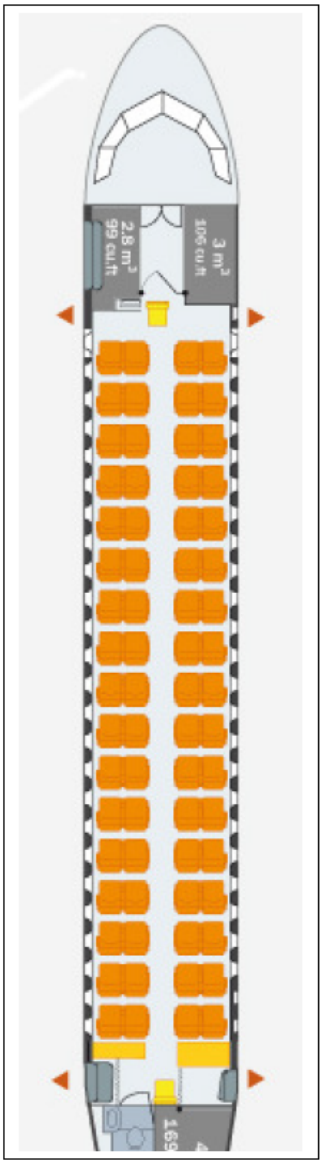
Hat rack aft LH
First aid kit (FAK)
Spare safety cards 0-10
H-Kit

Toilet
Automatic halon fire extinguisher over waste box
Smoke connector tube to smoke detector aft cargo

Ceiling over CA 1 seat
ELT

Smoke detector
In ceiling aft cargo compartment

Halon connector to aft cargo
On panel over C/A1 seat



Cockpit F/O side
Quick donning mask
Smoke goggles
Flash light
Red crew life vest
Halon/BCF fire extinguisher
Fire axe
Escape rope
Steps to the hatch

Ceiling fwd cargo compartment
Smoke detector

Locker fwd RH side
PBE (Puritan Bennett)
Demo kit

Exit Seating cards

Locker aft RH side
Megaphone
4 infant loops
4 infant life vest
2 extension belt
4 straps (2 open, 2 closed)

On locker aft RH
Halon/BCF fire extinguisher

Hat rack aft RH side
PBE (Puritan Bennett)
Halon/BCF fire extinguisher

On the wall behind last row RH
PBE (Puritan Bennett)

In locker Galley aft RH side
1-4 spare life vests (behind waste

Under C/A 1 seat
Crew portable oxygen bottle
120L.,with 2 nose/mouth masks attached
Red crew lift vest
Flash light
Cabin emergency checklist
Key for fixed oxygen/circuitbreaker
Tool for loosening the hat rack

The Oxygen system must be able to supply min. 10% of the passengers.
Outlets19 oxygen with nose/mouth.

Enclosure 17 - Unprepared emergency ATR72

Unprepared emergency

Definition

An unprepared emergency is a sudden emergency situation requiring immediate evacuation of the aircraft. This situation may arise in connection with taxiing, takeoff, descent and landing or even while the aircraft is stationary on the tarmac.

In the event of an unprepared emergency, cabin crew may only have enough time to give very short commands to prepare passengers for an imminent crash.

The instructions to take the brace for impact position will be the most important piece of information that the crew will give to the passengers in an unprepared emergency

Brace for impact signal given

When the brace for impact signal is given without previous warning, all C/A's must command:

"Heads down, heads down"
It must be realized that the brace for impact signal may not be given at all. However there are many clues that may warn the C/A's. The most obvious ones are:
Impact forces.
Unusual noises.
Smoke or fire.

Emergency directly after takeoff or during descent

In this case the remaining time for passenger preparations is very limited. Therefore priority should be given to the following items:

- Sitting position
- Signal to brace
- Seatbelts
- Safety on board card
- Sharp and pointed objects

Evacuation

In case of an unprepared emergency, the following will be the vital actions, which shall be taken in order to assure a successful evacuation:

Signal / order evacuation.

Before opening all available exits, check for fire or any other danger and that the engines are shut down.

Start evacuation without delay and without awaiting assistance.

In case of unserviceability or fire, re-direct passengers.

Check if flight crew needs help if they have not been seen during the evacuation.

Additional in case of ditching:

Order passengers to put life vest on & to pull red tab to inflate vest when leaving through the exits.

Only use exits above waterline.

Emergency call from cabin to Flight deck

If the cabin crew observes any kind of non-normal conditions in the cabin, the cabin crew must inform the flight deck crew immediately.

This can be done by using the Emergency call from cabin to Flight deck, using the interphone by pressing **emergency call.**

If there is no emergency call button, use interphone & press flight deck button and without delay call out loud and clear **"Emergency"**

Flight deck crew must respond immediately.

Rejected take off

If the flight deck crew performs a rejected take off, and the situation is under control, the flight deck crew will command: (3x)

"standby"

Wait for further info from flight deck.

Dear Mr.
Dear Mr.

With reference to the Draft document N. 0002148/12 dated May 4th 2012, after completing the consultation process as established by EU Regulation 996/2010, we are now officially submitting the Safety Recommendations on the events on subject.
We look forward to receiving information of any possible follow-up action to be taken on the subject items.

Best Regards

IIC

Postal address:
Langebjergvaenget 21
4000 Roskilde
Denmark

Phone:
38 71 10 66

Telefax:
38 71 92 31

aib@havarikommissionen.dk
www.havarikommissionen.dk

Investigation on the serious incidents to PW127 engines

Factual information of the events

1. ATR42-500 registration YR-ATG on 17th of June 2011 at Budapest Airport (LHBP)

After take-off from runway 31 L, at around 1200 ft AGL, the crew noticed what sounded like engine stall of engine N°2. They set the affected engine to Flight Idle. Shortly thereafter the Engine Low Oil Pressure Warning came in, followed by Engine Fire Warning.

The crew performed - from memory - the required emergency checklist actions (in-flight engine fire or severe mechanical damage). The propeller of the malfunctioned engine was set to feather. The crew declared an emergency by reporting MAYDAY and requested an immediate landing. The Tower secured runway 13L for the emergency landing.
The captain took the aircraft into a tight right turn while the first officer initiated the fire extinguishing system by discharging first the agent N°1 then N°2. The fire inside the engine nacelle was successfully put out.

The passengers saw the flames and the smoke coming out of the engine nacelle. Some smoke was visible inside the main cabin which caused panic among the passengers.
A single engine landing was performed on runway 13L. Once the aircraft stopped on a taxiway, the passengers were evacuated on the captain's command.

The aerodrome emergency services were waiting for the aircraft but there was no need for intervention because the fire had already been stopped.

Based on the information received from the operator, the crew used a QRH issued by the manufacturer in December 2009.

2. ATR72-212A registration OY -Cl M on 13th of September 2011 at Copenhagen Airport, Kastrup (EKCH)

Shortly after take-off from runway 22R while climbing through approximately 134 feet Radio Altitude (RA), a cockpit Master Warning was triggered referring to left engine low oil pressure. The cockpit Master Warning was silenced. Subsequently, a cockpit Master Caution was triggered referring to left engine high Inner stage Turbine Temperature (ITT).

Smoke was present in the cockpit and in the passenger cabin. The flight crew decided to shut down the left engine (memory items). While climbing through approximately 750 feet RA, a cockpit Master Warning was triggered referring to left engine fire. The cockpit Master Warning was silenced.

A Mayday call to Kastrup Tower was made. A left hand visual circling to runway 22L was initiated. The flight crew noted the left engine fire warning lights. Sequentially, both engine fire agents were discharged and the flight crew decided to land on runway 30.

Descending through approximately 486 feet RA, a cockpit Master Warning was triggered.

Postal address:
Langebjergvaenget 21
4000 Roskilde
Denmark

Phone:
38 71 10 66

Telefax:
38 71 92 31

aib@havarikommissionen.dk
www.havarikommissionen.dk

The Master Warning was silenced.

A single engine landing was performed.

On runway 30, the flight crew observed that the fire had extinguished and they cancelled the emergency evacuation of the aircraft.

The total Digital Flight Data Recorder (DFDR) recorded airborne time was five minutes and two seconds.

3. A TR72-212A registration 1-ADCC on 3rd of October 2011 at Firenze Airport, Peretola (LIRQ)

After a bleed-off aircraft configuration take-off from runway 23, at around 400ft AGL, the cockpit Master Warning was triggered referring to Engine 1 low oil pressure, but shortly after any malfunction indication disappeared.

Climb continued till acceleration altitude with one more short Eng1 oil LP indication.

At 1570 ft, when climb sequence was completed and Bleed valves switched on, oil LP indication popped up again while ITT value dropped to zero.

In absence of additional abnormal parameters, the crew believed in a faulty indication, but soon visual and aural warnings notified an Eng 1 fire condition, together with smoke in the cabin.

So, an in-flight engine fire emergency procedure was applied by shutting down the engine and attempting to discharge the extinguisher agent.

An emergency call was made to Firenze APP and the crew stated his intention to come back to the airport to land on runway 05.

Approach and landing took place uneventfully and the precautionary fire brigade assistance was provided when aircraft stopped on Taxiway P. Precautionary evacuation was carried out at that stage due to "HT brake warning light on".

The investigation highlighted that the "fire or severe mechanical damage" emergency procedures were revised by A TR at least three times in fourteen months (only the month is edited on the revised pages) and introduced with a consistent delay in the AFM owned by the operator, therefore being effective for the crew.

Common Findings

During the joint meeting held at ANSV premises in Rome on 7-9 Feb. 2012, the safety investigation authorities in charge of the three events verified the following main commonalities:

- all events occurred at initial climb;
- the events were all due to the initial distress of a Power Turbine 1st stage rotor blade causing subsequent damages and heavy unbalance of the whole PT assembly, further unbalance of the LP rotor through No. 6 & 7 bearing housing, and final oil leakage due to breaking of No. 6 & 7 bearing

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compartment retaining bolts and distress of the radial transfer tubes. Fire was then originated by such a leakage in presence of hot parts;

- in all these serious incidents distress of the PT1 rotor blade was due to a crack propagated from an internal casting defect (shrinkage porosity) in the vicinity of the blade core pocket. Propagation is in accordance with a Low Cycle Fatigue mechanism.

Recommendations

Based on the information gathered up to now and shared among the safety investigation authorities, Accident Investigation Board Denmark (AIB DK) considers necessary to issue the following recommendations:

Recommendation DENM-2012-03

Motivation:

Investigations revealed that the emergency procedure (air conditioning smoke) did not direct the flight crew's decision making on how to remove smoke from the cockpit and cabin if smoke persisted.

Comparing to similar aircraft types (Saab 340, Fokker 50 and Dash 8), differences were noted and it was found that the A TR smoke emergency procedures seemed not to be sufficient if smoke was persisting and cockpit/passenger cabin ventilation was required.

Although in the serious incidents on subject this finding was not considered as a contributing factor, however, whether or not a similar incident takes place shortly after takeoff or at any altitude, no ATR smoke removal emergency procedure seemed to be at the disposal of a flight crew. For that reason, the signing investigation authorities regarded this finding as a flight safety issue, which needed further consideration.

Addressee: EASA

Text: To review the emergency procedures on ATR aircraft in order to ensure efficient removal of persisting smoke and appropriate cockpit/passenger cabin ventilation.

Recommendation DENM-2012-01

Motivation:

Fatigue failure of PT1 rotor blade was found a recurrent failure on this engine, with a total of at least 28 events already due to this root cause in the timeframe 2005-2011, with a peak in 2008-2009.

As a consequence, in April 2008 the engine manufacturer improved the X-Ray inspection on the new blades by introducing an additional view specifically to be taken in the area of interest (core pocket). In addition, all

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4000 Roskilde
Denmark

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Telefax:
38 71 92 31

aib@havarikommissionen.dk
www.havarikommissionen.dk

retained X-Ray films were reviewed and 68 blades were limited in terms of service life in accordance with SB 21766.

Furthermore, a previous recommendation was issued in 2010 by ASC-Taiwan as a result of a similar event occurred during take-off at Magong airport on 11 Feb 2009, requiring "to incorporate measures to efficiently detect the shrinkage porosity which beyond maximum allowable limits".

However, the recurrence of the failure in a wide range of accumulated cycles/flight hours shows that time to rupture can't be predicted and it is mainly dependant on the size of the original shrinkage porosity. So, all other blades currently in service could be potentially affected by the same kind of deferred fatigue failure when a defect, not revealed at the first and only check for blades manufactured before 2007 or not detected at the second check in case of blades manufactured between 2007 and 2008, is big enough to propagate a crack.

Addressee: Transport Canada

Text: **To consider the need to early withdraw from service the PT1 rotor blades manufactured before the introduction of NOT improvement or, alternatively, to urgently introduce a one shot X-Ray inspection on all those blades having accumulated a number of cycles beyond a limit to be established (e.g. 2000), specifically focused on the pocket area to exclude the presence of a fatigue crack.**

Recommendation DENM-2012-02

Motivation:

One more fatigue breakage was observed on new PT1 blades manufactured after implementing the improved X-Ray inspection, although at the moment they only have accumulated a limited number of cycles.

In effect, in absence of a robust POD (Probability of Detection) study and with no knowledge of the minimum casting defect able to promote the crack growth, it seems there is still some uncertainty on the effective improvement achieved in terms of reliability of the parts.

The significant increase in rejection rate at production, being only limited to 2011, at the moment can't be considered as a proof of the effectiveness of the modifications introduced since 2008.

Addressee: Transport Canada

Text: **Taking into account the high volume of PT1 rotor blade production, to consider the opportunity to introduce in production, at least as a temporary measure, an additional Computed Tomography check on a representative sample of blades in order to gain confidence on the effective improvement achieved through the review of the X-Ray methodology implemented in 2008.**

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Denmark

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Telefax:
38 71 92 31

aib@havarikommissionen.dk
www.havarikommissionen.dk

Recommendation DENM-2012-04

Motivation:

All events were due to a severe mechanical damage and occurred at initial climb, although not necessarily immediately recognized as such by the crews and treated as an in-flight fire at a following stage.

The investigation highlighted an uncertainty on the emergency procedure in force at the time of the event, considering the several amendments issued and ongoing on this subject.

Examination of the existing documentation, namely the EU-OPS 1.130, seems not able to clarify in mandatory terms the timeframe and the procedures to achieve the effective operator compliance on this item when the AFM modification is not accompanied by a dedicated AD.

Addressee: EASA

Text: To consider the need to harmonize the procedures, or to review the existing documentation as necessary, in order to establish in all cases a time limit within which to make effective in the AFM owned by operators the amendments approved by EASA.

Recommendation DENM-2012-05

Motivation:

ATR AFM Temporary Revision of the "engine fire at take-off' emergency procedure approved in Nov. 2011 introduced a large number of further memory items.

The increasing number of memory items seems to reflect a general trend in the implementation or review of the emergency procedures; however, it seems highly desirable that a careful consideration take place on the potential negative effects of the consequent build-up of the crew workload.

In this case, in addition to a delay of the shutoff action on the affected engine, it may potentially cause an area of hazard taking into consideration the criticality of the phase of flight.

Addressee: EASA

Text: To promote an internal debate (e.g.: dedicated working group, workshop, etc.) to carefully evaluate the pros and cons of a continuously increasing of memory items introduced in the implementation or review of the emergency procedure, mainly when to be applied in a critical phase of flight.

Postal address:
Langebjergvaenget 21
4000 Roskilde
Denmark

Phone:
38 71 10 66

Telefax:
38 71 92 31

aib@havarikommissionen.dk
www.havarikommissionen.dk

Enclosure 19 - Saab 340 smoke removal

SMOKE REMOVAL

COCKPIT

1. DESCENT ..... INITIATE
   – Descend to 10000 ft or minimum altitude for terrain clearance, whichever is higher.
2. Altimeters ..... SET/ X–CHECK
3. CABIN DIFF PRESSURE–REDUCE to 1.5 psi or less by manual control of cabin altitude, select MODE SELECTOR switch to MAN and rotate MANUAL CONTROL knob clockwise to increase cabin altitude. Partly open GROUND COM HATCH. The cabin altitude can be easily controlled by opening the hatch more or less.

◆ **Smoke PERSISTS:**

NOTE: If not deemed necessary to dump earlier, wait until a differential pressure of about 1 psi is obtained.

4. PRESS DUMP switch ..... ON
5. AIRSPEED–REDUCE to 160 KIAS or below and open the crew hatch to ventilation position.
6. LAND as soon as possible.
7. Close Ground Communication Hatch prior landing so as not to interfere with Nose Wheel steering
8. End of procedure.

◆ **Smoke DISAPPEARS.**

4. Close Ground Communication Hatch prior landing so as not to interfere with Nose Wheel steering.
5. End of procedure.

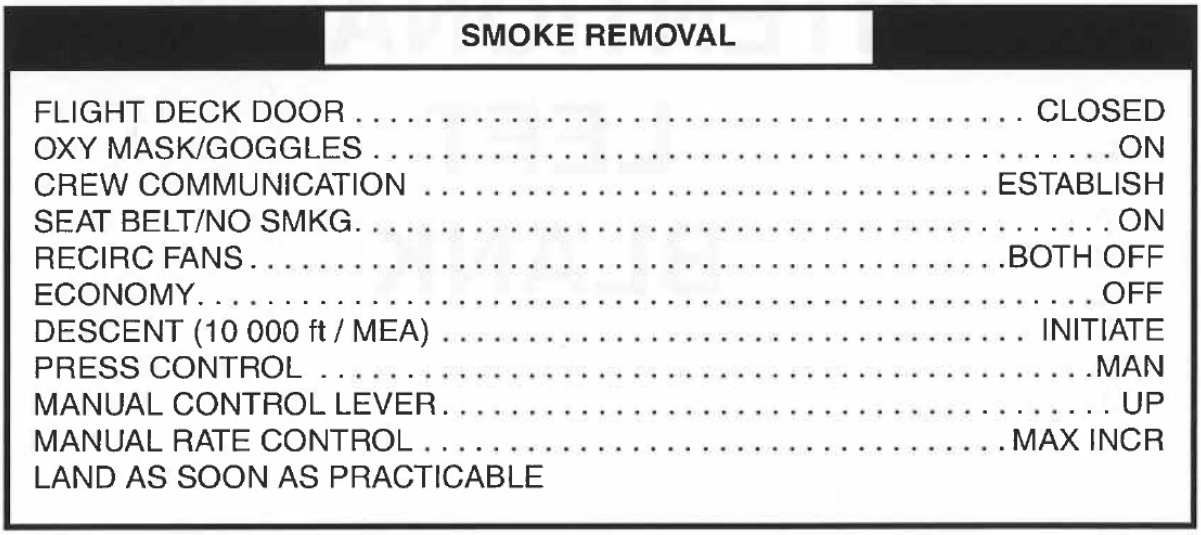
CABIN

1. DESCENT ..... INITIATE
   – Descend to 10000 ft or minimum altitude for terrain clearance, whichever is highest.
2. Altimeters ..... SET/ X–CHECK
3. CABIN DIFF PRESSURE–REDUCE to 1.5 psi or less by manual control of cabin altitude, select MODE SELECTOR switch to MAN and rotate MANUAL CONTROL knob clockwise to increase cabin altitude.

   NOTE: If not deemed necessary to dump earlier, wait until a differential pressure of about 1 psi is obtained.
4. PRESS DUMP switch ..... ON
5. LAND as soon as possible.

   NOTE: It is possible to remove an overwing emergency exit during flight at airspeeds below 120 KIAS to evacuate smoke in an extreme CABIN smoke situation. However consider the risk for falling overboard as well as other possible hazards like high noise level (cabin communication may be impossible), cold temp. etc.
6. End of procedure.

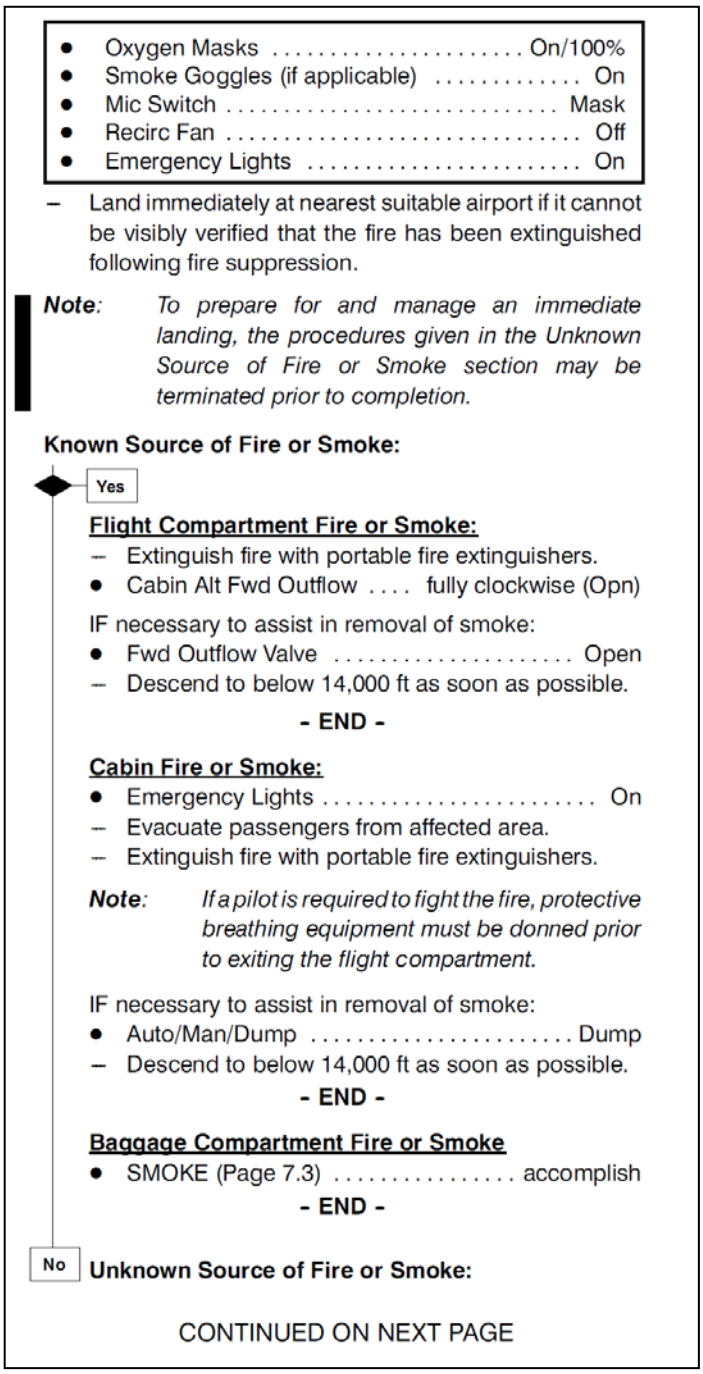
Enclosure 20 - Fokker 50 removal



SMOKE REMOVAL

FLIGHT DECK DOOR . . . . . CLOSED
OXY MASK/GOGGLES . . . . . ON
CREW COMMUNICATION . . . . . ESTABLISH
SEAT BELT/NO SMKG. . . . . ON
RECIRC FANS . . . . . BOTH OFF
ECONOMY. . . . . OFF
DESCENT (10 000 ft / MEA) . . . . . INITIATE
PRESS CONTROL . . . . . MAN
MANUAL CONTROL LEVER. . . . . UP
MANUAL RATE CONTROL . . . . . MAX INCR
LAND AS SOON AS PRACTICABLE

Enclosure 21 - Dash 8 – smoke removal



- Oxygen Masks On/100%
- Smoke Goggles (if applicable) ..... On
- Mic Switch ..... Mask
- Recirc Fan ..... Off
- Emergency Lights ..... On

– Land immediately at nearest suitable airport if it cannot be visibly verified that the fire has been extinguished following fire suppression.

Note: *To prepare for and manage an immediate landing, the procedures given in the Unknown Source of Fire or Smoke section may be terminated prior to completion.*

Known Source of Fire or Smoke:

Yes

Flight Compartment Fire or Smoke:

– Extinguish fire with portable fire extinguishers.
- Cabin Alt Fwd Outflow .... fully clockwise (Opn)

IF necessary to assist in removal of smoke:

- Fwd Outflow Valve ..... Open
– Descend to below 14,000 ft as soon as possible.

- END -

Cabin Fire or Smoke:

- Emergency Lights ..... On
– Evacuate passengers from affected area.
– Extinguish fire with portable fire extinguishers.

Note: *If a pilot is required to fight the fire, protective breathing equipment must be donned prior to exiting the flight compartment.*

IF necessary to assist in removal of smoke:

- Auto/Man/Dump ..... Dump
– Descend to below 14,000 ft as soon as possible.

- END -

Baggage Compartment Fire or Smoke

- SMOKE (Page 7.3) ..... accomplish

- END -

No **Unknown Source of Fire or Smoke:**

CONTINUED ON NEXT PAGE

No **Unknown Source of Fire or Smoke:**

Bleed Source or Air Conditioning Suspected

Yes

- Bleed Air 1 . . . . . Off

Wait up to 1 minute.

Improvement:

Yes

- Leave selected switch in the Off position.

– END –

No

- Bleed Air 1 . . . . . On
- Bleed Air 2 . . . . . Off

Wait up to 1 minute.

Improvement:

Yes

- Leave selected switch in the Off position.

– END –

No

- Bleed Air 2 . . . . . On
- Flt Comp Pack . . . . . Off

Wait up to 1 minute.

Improvement:

Yes

- Leave selected switch in the Off position.

– END –

No

- Flt Comp Pack . . . . . Auto/Man
- Cabin Pack . . . . . Off

Wait up to 1 minute.

Improvement:

Yes

- Leave selected switch in the Off position.

– END –

No

- Cabin Pack . . . . . Auto/Man

No **Source of Fire or Smoke cannot be Identified:**

CONTINUED ON NEXT PAGE

No

Source of Fire or Smoke cannot be Identified:

- DC Gen 1 and 2 ..... Off
- AC Gen 1 and 2 ..... Off
- Storm/Dome Lights ..... Storm (if req'd)
- Main, Aux and Stby Batteries ..... Off
- Emergency Lights ..... Off (until req'd)

– Land immediately at the nearest suitable airport.

Caution: *Battery duration for operation of essential services is 30 minutes (45 minutes JAA).*

Note: *Engine bleed air flow to ECS packs is lost. Cabin will de-pressurize.*

– Ventilate aircraft, when below 14,000 ft:

- Auto/Man/Dump ..... Man
- Man Diff ..... Incr (50 sec)
- Cabin Alt Fwd Outflow .. fully clockwise (Opn)
- Fwd Outflow Valve ..... Open

Note: *Ram ventilation is most effective above 150 KIAS.*

---------- **END** ----------