FINAL REPORT

SERIOUS INCIDENT 2019/4048

State Commission on Aircraft Accidents Investigation (PKBWL)

UL. CHAŁUBIŃSKIEGO 4/6, 00-928 WARSZAWA
DUTY PHONE (EVENT NOTIFICATION) (+48) 500 233 233

FINAL REPORT

Serious incident

OCCURRENCE NO – 2019/4048

AIRCRAFT – Bombardier DHC – 8 – 402, SP-EQG

DATE AND PLACE OF OCCURRENCE – 9 September 2019, EPPO

The Report is a document presenting the position of the State Commission on Aircraft Accidents Investigation concerning circumstances of the air occurrence, its causes and safety recommendations. The Report was drawn up on the basis of information available on the date of its completion.

The investigation may be reopened if new information becomes available or new investigation techniques are applied, which may affect the wording related to the causes, circumstances and safety recommendations contained in the Report.

Investigation into air the occurrence was carried out in accordance with the applicable international, European Union and domestic legal provisions for prevention purposes only. The investigation was carried out without application of the legal evidential procedure, applicable for proceedings of other authorities required to take action in connection with an air occurrence.

The Commission does not apportion blame or liability.

In accordance with Article 5 paragraph 6 of the Regulation (EU) No 996/2010 of the European Parliament and of the Council on the investigation and prevention of accidents and incidents in civil aviation […] and Article 134 of the Act – Aviation Law, the wording used in this Report may not be considered as an indication of the guilty or responsible for the occurrence.

For the above reasons, any use of this Report for any purpose other than air accidents and incidents prevention can lead to wrong conclusions and interpretations.

This Report was drawn up in the Polish language. Other language versions may be drawn up for information purposes only.

WARSAW 2021

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Abbreviations

Abbreviation	Meaning
AMM	Aircraft Maintenance Manual
AP	Autopilot
ARC	Airworthiness Review Certificate
ATPL(A)	Airline Transport Pilot License (Airplane)
ATC	Air Traffic Control
CA	Calendar Day
CC	Cabin Crew
CPT	Captain
CofA	Certificate of Airworthiness
CVR	Cockpit Voice Recorder
CY	Cycle
TWY	Taxiway
DOP	Airport Duty Officer
ED	Engine Display
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FH	Flight Hours
FL	Flight Level
FO	First Officer
HPT	High Pressure Turbine
IIC	Investigator in Charge
IPC	Illustrated Parts Catalogue
IR	Instrument Rating
kt	Knot

LMT	Local Mean Time
LSRG	Aerodrome Firefighting & Rescue Service
LST	Line Service Technician
PF	Pilot Flying
PLL LOT S.A.	LOT Polish Airlines S.A.
PT	Power Turbine
P&WC	Pratt & Whitney Canada
QAR	Quick Access Recorder
QRH	Quick Reference Handbook
RWY	Runway
RPM	Revolutions per minute
RGB	Reduction gearbox
TOW	Take-off Weight
TSB	Transportation Safety Board of Canada
TRQ	Torque
TWR	Tower
ULC	Civil Aviation Authority of the Republic of Poland
UTC	Coordinated Universal Time

General information

Occurrence reference number:	2019/4048			
Type of occurrence:	SERIOUS INCIDENT			
Date of occurrence:	9 September 2019			
Place of occurrence:	EPPO, Poland			
Type and model of aircraft:	BOMBARDIER DHC-8-402			
Aircraft registration marks:	SP-EQG			
Aircraft user/operator:	LOT Polish Airlines			
Aircraft Commander:	ATPL(A)			
Number of victims/injuries:	Fatal	Serious	Minor	None
	-	-	-	73
Domestic and international authorities informed about the occurrence:	ULC, TSB of Canada			
Investigator-in-Charge:	Roman Kamiński			
Investigating Authority:	State Commission on Aircraft Accidents Investigation (PKBWL)			
Accredited Representatives and their advisers:	TSB of Canada			
Document containing results:	Final Report			
Safety recommendations:	None			
Addressees of the recommendations:	Not applicable			
Date of completion of the investigation:	30 December 2021			

Summary

The airplane departed from EPWA to EPPO at 12:04 hrs UTC[1]. The parameters of both engines from their start-up to FL180 were correct. Eight minutes after reaching the flight level, engine #2 started malfunctioning. The TRQ value dropped to zero and the engine temperature readings began to change abruptly. Asymmetrical operation of the engines led to rolling of the airplane to the right by about 6° with the AP engaged. CPT disengaged AP and took over manual control of the airplane.

At 12:22:35 hrs, when the ITT temperature reached 981°C, a MASTER WARNING „CHECK FIRE DETECT" appeared on the CWP. The engine fire was also noticed by the passengers. At the same time there was a strong jerk of the aircraft. The crew started MEMORY ITEMS for the „ENGINE FAILURE/FIRE/SHUTDOWN" checklist. After completion of the checklist items, the crew determined that the fire had been extinguished. The crew declared MAYDAY, then reported emergency (the fire of engine #2) to the Poznań TWR, informed the TWR about landing on EPPO and asked for firefighting assistance during the landing.

At the same time, a preparation of the passengers for an evacuation was initiated on the captain's command. The uneventful landing was performed with one engine inoperative at 12:48 hrs. The evacuation of the passengers was conducted via the left hand door only. The evacuation was conducted went smoothly.

The investigation into the occurrence was conducted by the PKBWL Investigation Team in the following composition:

Roman Kamiński - Investigator-in-Charge (Commission Member);

Zbigniew Drozdowski - Team Member until 6.10 2020 (Commission Member).

After the investigation PKBWL determined that the cause of the serious incident was fatigue damage to the no. 8 roller bearing in the form of advanced spalling of the rolling surfaces of its rollers and deformations and cracks across the bearing raceway.

PKBWL has not proposed any safety recommendations after the investigation.

[1] All times in the Report are in UTC.

1. FACTUAL INFORMATION

1.1. History of the flight

The flight started with a take-off from EPWA (12:04). The parameters of both engines from their start-up to FL180 were correct.

Fig. 1 The moment when the first symptoms of engine malfunction appeared (12:22). [source: PLL LOT].

Eight minutes after achieving the cruising level, engine #2 began malfunctioning. The TRQ value dropped to zero and the engine temperature readings began to change abruptly, the FUEL FLOW value increased sharply. The plots of recorded parameters of engine #2 are shown below.

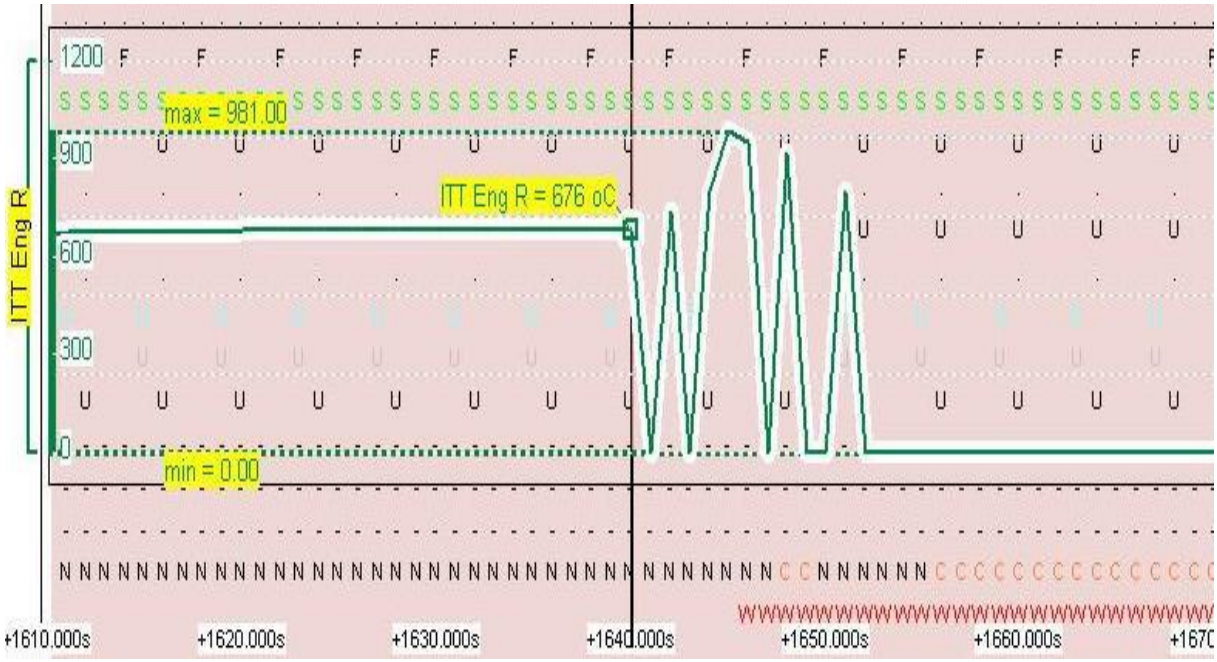

Fig. 2 Engine #2 ITT (12:22:29 – 676ºC.,12:22:35 – 981º C, 12:22:41 – 0º C). [source: PLL LOT].

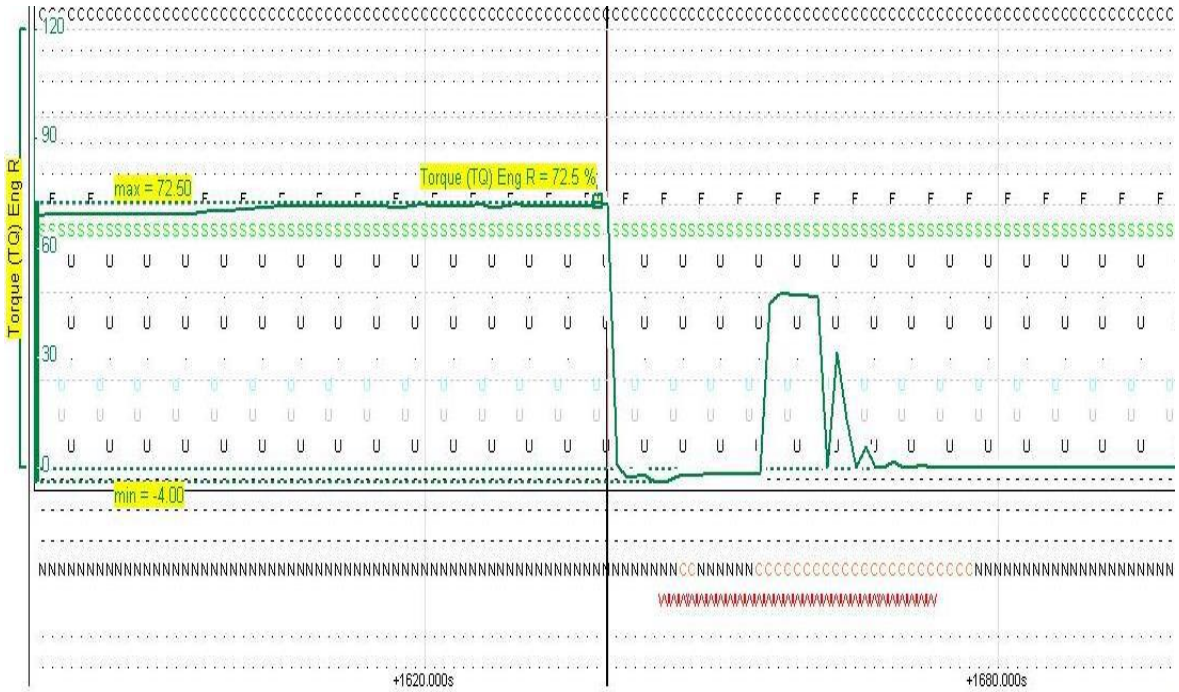

Fig. 3 Engine #2 TRQ (12:22:29 – 72,5%; 12:22:31 – 0%; 12:22:48 – 47,5%)
[source: PLL LOT].

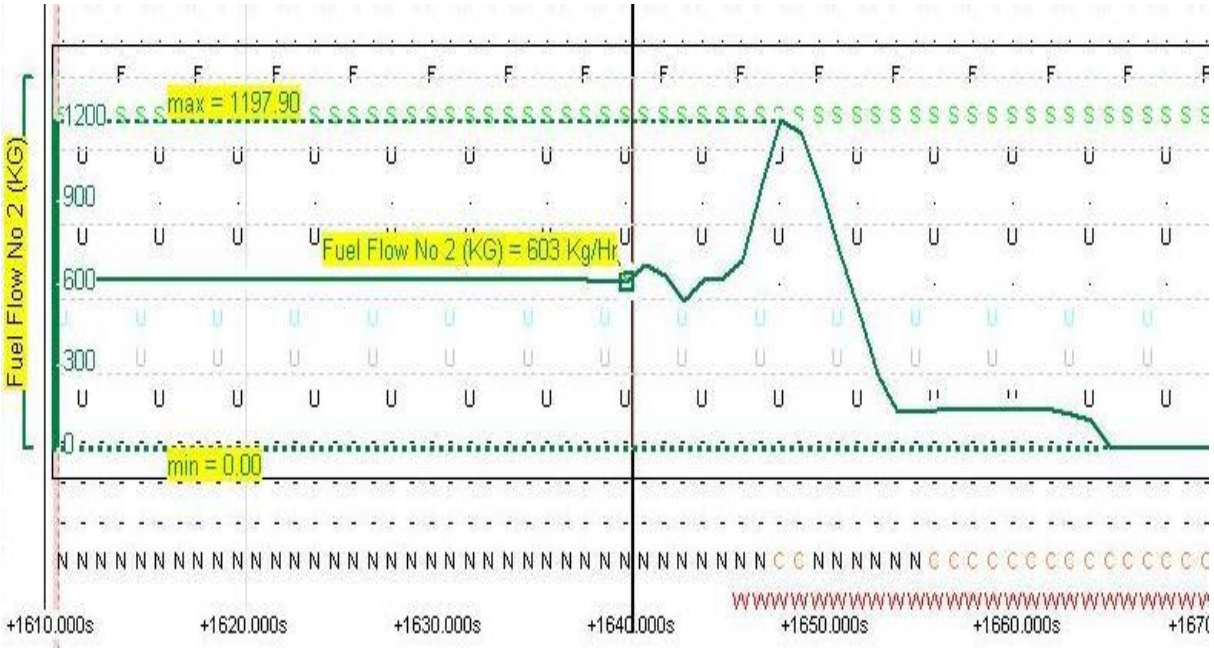

Fig. 4 Engine #2 FUEL FLOW (12:22:29 – 603 kg/h, 12:22:37 – 1197 kg/h,12:22:54 – 0 kg/h).
[source: PLL LOT].

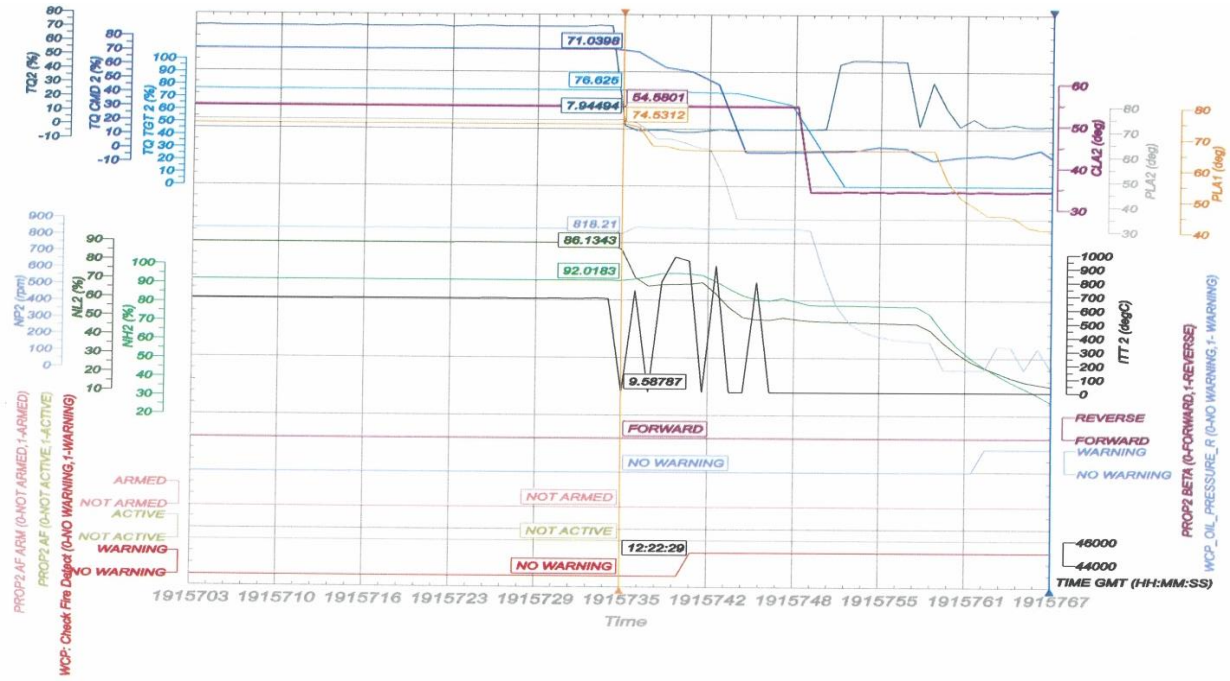

Fig. 5 Engine #2 operation parameters during the occurrence [source: PKBWL].

The asymmetrical operation of the engines caused the airplane to roll to the right by about 6° with the AP engaged. CPT (PF) disengaged the AP and took over manual control of the aircraft. When the ITT temperature reached 981°C, MASTER WARNING „CHECK FIRE DETECT" appeared on the CWP (12:22:35).

At the same time the cabin crew (CC1 and CC2) heard twice a very loud bang and observed a reduction in the airplane altitude and the passengers noticed that the right hand engine (#2) caught fire and they started shouting „fire".

CC1 immediately informed CPT about the situation. CPT confirmed the right hand engine fire and after a while he ordered to prepare the cabin for an emergency landing which was planned within 7-8 minutes. LST engineer, who was on board, noticed the flames and burn marks on the cowl of the right hand engine nacelle (Fig. 6).

Fig. 6 Engine #2 – condition of the nacelle as seen by passengers on board [source: PKBWL].

The crew performed all MEMORY ITEMS from „ENGINE FAILURE/FIRE/SHUTDOWN (In Flight)" checklist and then started to put out the fire using FWD BTL. The fire alarm

went off without necessity to use the second bottle. EMERGENCY: 3 x MAYDAY ENGINE FIRE was reported to the ATC. Once the MEMORY ITEMS were completed, the QRH „ENGINE FAILURE/FIRE/SHUTDOWN (In Flight)" checklist was effected.

The flight crew requested clearance to descend to FL100 and the need for landing with assistance (the number of persons on board, fuel quantity and the absence of dangerous goods were communicated).

At 12:25 hrs, cruising level was abandoned and descent to FL100 was initiated at IAS of approximately 220 kt. ATC reported the availability of the Powidz aerodrome (EPPW) for emergency landing.

Having in mind that the fire was extinguished with only one bottle and the tailwind component during approach to EPPO RWY 28, as well as the lack of familiarization with the EPPW aerodrome, the flight crew decided to land on EPPO RWY 10.

APP BRIEF was extended to include elements related to landing with only one engine and it was planned that after leaving the runway an evacuation would be carried-out on the left side of the airplane what was communicated to CC1 at a joint briefing. ATC was also informed about those intentions. Q-400 engineer who was sitting in the jump seat in the cockpit was also instructed for the evacuation.

At 12:45 hrs, landing approach RNAV to RWY 10 was initiated. Before landing the command „BRACE POSITION" was given. At 12:48 hrs, the airplane landed uneventfully on RWY 10 and a minute later, vacated the RWY via TWY „B"

Then, at 12:49:45 hrs, engine #1 was shut down on TWY„F". At 12:50 hrs, after „CREW AT STATIONS" command, the evacuation to the left side of the airplane under the LSRG assistance was initiated. The evacuation was conducted properly. After taking their hand luggage, the passengers were taken to the arrival hall. After check by the flight crew, the aircraft was towed to an apron.

1.2. Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	**-**	**-**	**-**	
Serious	**-**	**-**	**-**	
Minor	**-**	**-**	**-**	
None	**5**	**68**	**-**	**73**

1.3. Damage to aircraft

All the low and high pressure turbine blades, the power turbine blades, stators and the T/M exhaust pipe elements were damaged. The cowl of the right hand engine nacelle was slightly damaged.

1.4. Other damage

There were no other damages.

1.5. Personnel information (crew data)

1. CPT

Pilot, male, aged 28, holder of ATPL(A) - valid until 31 Dec 2019;

ratings: DHC 8, SEP(L), MEP(L), IR (SE, ME), FI(IR) - DHC8;

Aero-medical certificate: class 1 with VDL limitation - valid until 05 Apr 2020;

Language proficiency: ICAO level 5;

Total flight time: 2389:44 h;

Flight time on DHC-8: 1452:36 h;

Flight time as Pilot-in-Command on DHC-8: 514:08 h;

Flight time as Pilot-in-Command: 1073:43 h;

Flight time over last 30 days prior to the occurrence: 63:31 h.

2. FO

Pilot, male, aged 28;

Holder of CPL(A) with DHC8 /IR ratings - valid until 30 Sep 2020;

Aero-medical certificate: class 1/2 - valid until 15 Oct 2019;

Language proficiency: ICAO level 4;

Total flight time: 1319 h;

Flight time on DHC-8: 1111 h;

Flight time over last 30 days prior to the occurrence: 66:40 h.

1.6. Aircraft information

Year of manufacture	Manufacturer	Airframe Serial no.	Registration marks	Register number	Register date
2012	Bombardier Inc. Canada	4423	SP - EQG	4647	09.08.2018

Certificate of Airworthiness valid until: 31 Aug 2020;

Airframe Total Flight Time Since New: 13476 h;

Total cycles since new: 15569;

Airframe flight time since last repair or check: 1527 h;

Flight time until the next overhaul or inspection: 4472 h;

Date of the last periodic operations: 08/09 Sep 2019;

after total flight time: 11819 h;

performed in: LS TECHNICS KATOWICE.

Engine: Turbojet Pratt & Whitney PW 150 A.

Engine #2 (right)

Year of manufacture	Manufacturer	Serial no.
2013	PRATT & WHITNEY	PCE – FA0985

Date of the engine installation on the airframe: 01 July 2018;

Maximum take-off power: 5000 HP;

Date of the last periodic operations: 11823 h;

Engine total operation time since last major repair: 2238 h;

Service life until the next overhaul or inspection: 5824 h;

Date of the last periodic operations: 08/09 Sep 2019;

after operation time: 11819 h;

performed in: LS TECHNICS KATOWICE.

Engine no. 1 (left)

Year of manufacture	Manufacturer	Serial no.
2012	PRATT & WHITNEY	PCE – FA0931

Date of the engine installation on the airframe: 24 May 2017;

Maximum take-off power: 5000 HP;

Date of the last periodic operations: 12238 h;

Engine total operation time since last major repair: 4295 h;

Service life until the next overhaul or inspection: 5653 h;

Date of the last periodic operations: 08/09 Sep 2019;

after operation time: 12234 h;

performed in: LS TECHNICS KATOWICE.

<u>Oil & lubricants prior to the flight:</u>

Fuel Jet – A1: 3040 kg;

Oil EASTMAN TURBO OIL 2380: 22,2 l.

Total mass of the airplane:

- permissible: 28998 kg;

- actual: 27617 kg.

1.7. Meteorological information

METAR EPPO 091200Z 09007KT 9999 SCT008 OVC041 17/16 Q1009

METAR EPPO 091230Z 12009KT 9999 FEW009 BKN039 17/15 Q100

Weather conditions were adequate to perform the flight.

1.8. Aids to navigation

Standard aids to navigation available on the EPWA-EPPO route were used.

1.9. Communications

During the flight a two-way radio communication with air traffic services was maintained.

1.10. Aerodrome information

Poznań–Ławica Airport

ICAO code: EPPO

Coordinates: N52°25'15.7"; E16°49'34.8";

Elevation: 94 m ASL

Runway dimensions: 2504x50 m;

True heading:108/288.

1.11. Flight recorders

Bombardier DHC-8-402, SP-EQG, was equipped with the flight data recorder (FDR), the cockpit voice recorder (CVR) and the quick access recorder (QAR).

1.11.1. On the day of the occurrence Universal Avionics SSFDR FDR-25 model P/N 1607-00-00, S/N 424 under supervision of PKBWL team members was removed from the airplane and protected to read out. It showed no external signs of damage. Under supervision of PKBWL team members the data from the solid state memory of the FDR was read out at the Avionics Laboratory of LOT AMS Company.

1.11.2. On the day of the occurrence Universal Avionics SSCVR CVR-120A model P/N 1606-00-01, S/N 537 under supervision of PKBWL team members was removed from the airplane and protected to read-out. It showed no external signs of damage. Under supervision of PKBWL team members the data from the solid state memory of the FDR was read out at the Avionics Laboratory of LOT AMS Company.

1.11.3. L3 Communications QAR QAR200 model P/N QAR200-35-04, S/N 000802016 recorded parallelly in the solid state memory the data which was sent to SSFDR. After the occurrence the memory card was taken out of the FDR without the PKBWL knowledge what was against the rules related to the handling of FDR after an occurrence, as well as the operator's procedures. The data from the card was read out and was uploaded into the Aerobytes program then analysed by the manufacturer of the aircraft without the knowledge or consent of the PKBWL.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

None of the passengers or crew suffered any injuries.

1.14. Fire

At 12:23 hrs, MASTER WARNING „CHECK FIRE DETECT" illuminated. The engine #2 fire was also noticed by passengers and the CC. Excerpt from the CC report: *„ (…) we have heard a very loud bang (…) the passengers shouted „fire", (…) I looked out of the window, flames were coming out of the right hand engine*"). LST engineer, who was on board, noticed burn marks on the left hand engine (#2) cowl. The smoke and flames were visible as coming out from the access panel on the cowl of the right hand engine nacelle. CC1 immediately informed captain, who confirmed that the fire had taken place and ordered a preparation for emergency landing and evacuation. The flight crew performed necessary actions, according to the applicable checklist, shut down the engine and extinguished the fire using an extinguisher. After the fire was extinguished, the flight crew decided to land on EPPO.

1.15. Survival aspects

Immediately after the engine fire occurred, CPT communicated to CC1 his decision and specified the evacuation method, the flight time to landing as 8 minutes and the landing site as EPPO. After a short briefing CC immediately started preparation of the passengers for the planned evacuation. Both (CC1 and CC2) familiarized the passengers with the applicable commands during an emergency landing and demonstrated their execution. Then the CC appointed AP to assist at the front and back doors and AP to provide any assistance to the passengers. It was communicated to the passengers that after landing, personal luggage must not be taken with them during the evacuation. The crew checked the preparation and the passengers' understanding of commands, one by one in each row.

After the command „BRACE POSITION" from the cockpit the flight crew loudly repeated commands: „HEAD DOWN" in Polish and English. After landing and hearing the command „EVACUATE TO THE LEFT", at 12:50 hrs, the evacuation started, the door was opened and commands to unfasten the belts, direction of movement, as well as instructions to designated APs were issued. The evacuation was conducted very efficiently and took about 80 seconds.

After the evacuation, the passengers were gathered in two buses. LSRG checked the aircraft to make sure that passengers could return safely to collect their personal luggage and spoke with the passengers to make sure none of them were injured during the evacuation. The passengers in groups of 10-15 assisted by LSRG were returning to the airplane to take their personal luggage. Once the passengers had taken their personal luggage from the airplane, they were transported to the airport terminal to pick up their checked luggage. At the same time, the airplane was towed to an apron where the service and the baggage unloading could begin. After the evacuation the cabin crew together with the flight crew checked the airplane. There was no Medical Rescue Team on site.

1.16. Tests and research

On 9 September 2019, immediately after the occurrence, PKBWL members carried out a technical inspection of the aircraft, paying particular attention to the condition of the engine #2. The airframe inspection revealed signs of damage to the engine #2 nacelle surface that was caused by the fire. After opening the engine #2 cowl, a disconnection of the linkage of the turbine body with the exhaust nozzle was detected as a result of a rupture of the tightening ring (Fig. 7). Fragments of the ring were found on a shelf in the engine area.

In addition, displacement of the exhaust nozzle occurred in the lower part of the linkage and a gap formed between the turbine body and the nozzle, caused the fragments of the turbine blades and other engine elements to come out. Significant amounts of metal debris were also found inside the engine. There were visible signs of fire on the inner surface of the engine cowl and the outer parts of the engine.

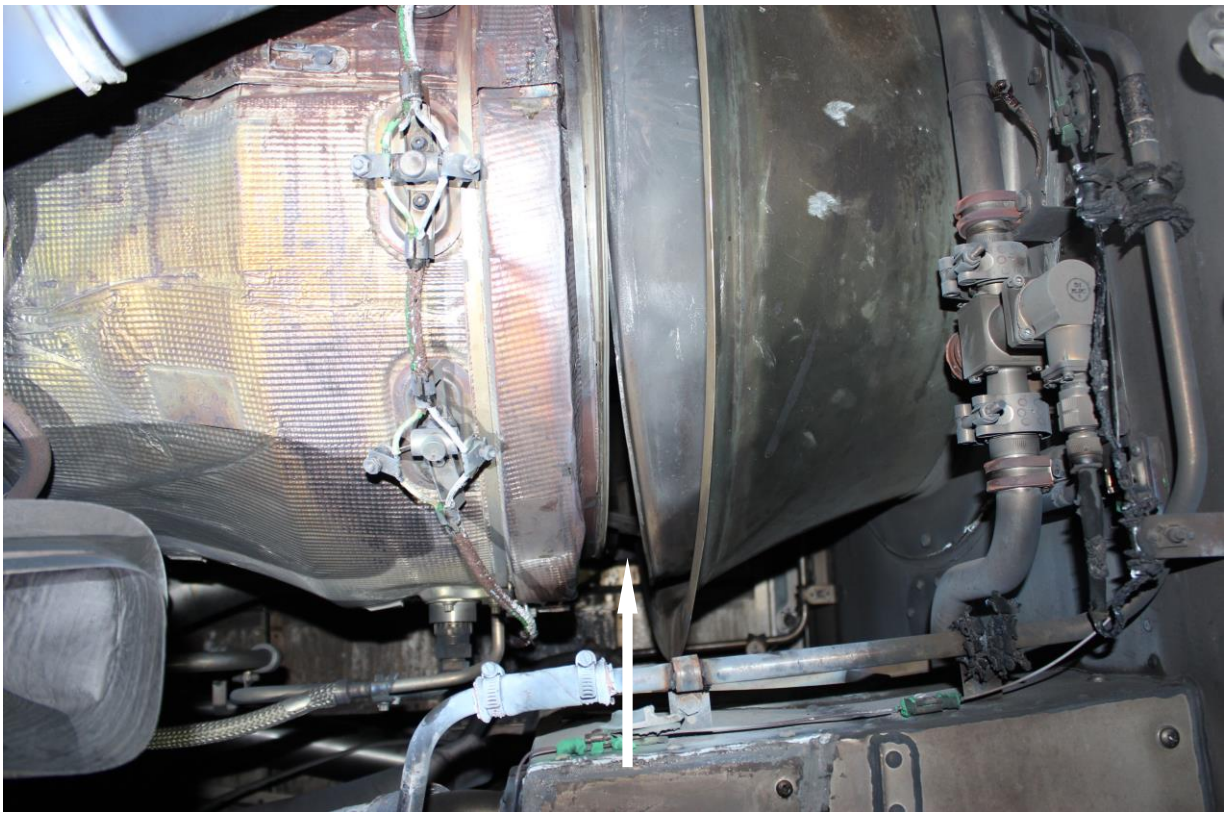

Fig. 7 Visible damage and signs of fire on the left side of engine no 2. [source: PKBWL].

A boroscopic inspection of engine #2 was carried out on the night of 9 and 10 September 2019. Significant damage to the turbine blades and stators were found during the inspection. No damage to the compressor were found. After removing the engine, its mechanical condition was checked and significant damage to the turbine blades, stators and other parts of the engine were found (Fig. 8).

Fig. 8 Engine damage – view from the power turbine [source: PKBWL].

On 20 Sep 2019 the engine was transported to Canada for further examination. On 21–24 October 2019 at Pratt & Whitney Canada Service Centre, examination of the engine with the participation of two PLL LOT representatives was carried out. During the engine disassembly its mechanical condition was evaluated and its parts and elements were tested and described in the report in the order shown in Fig. 9.

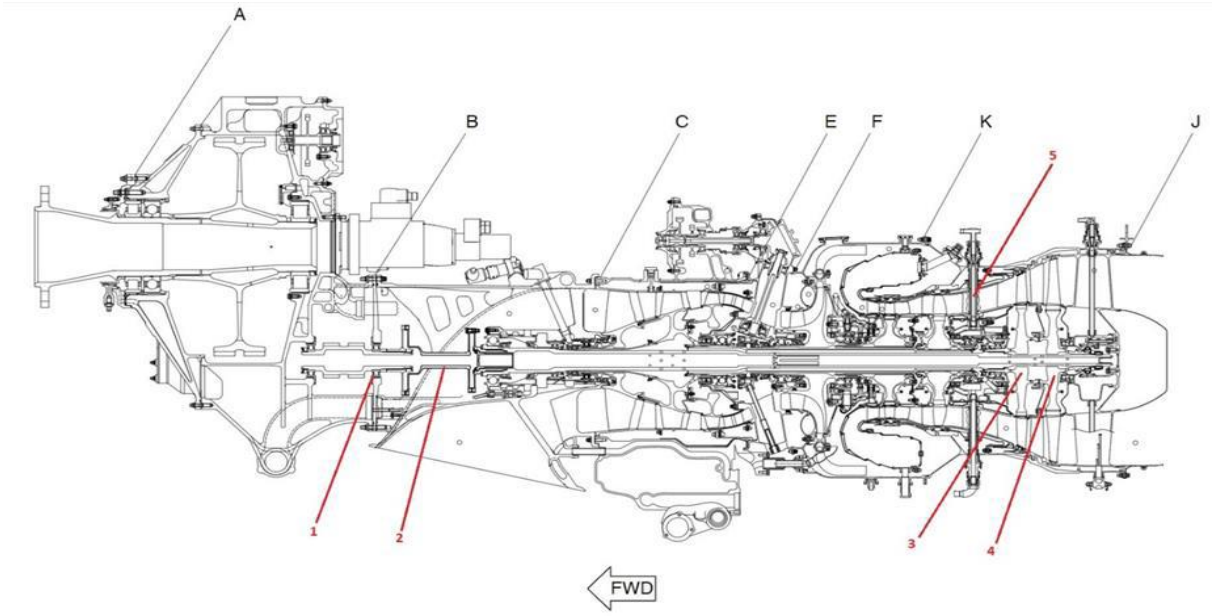

Fig. 9 Longitudinal section of PW150A engine with damaged engine parts [source: P&WC].

1. All elements of the no. 8 roller bearing (Fig. 10) were found significantly damaged. Pieces of its cage were found in the reduction gearbox (RGB). Microscopic damage the toothed wheels teeth were evidence of the movement of the cage pieces inside the gear. According to the manufacturer information, it has been the first case of damage of that bearing in that engine model.

Fig. 10 Elements of the damaged no. 8 roller bearing [source: P&WC].

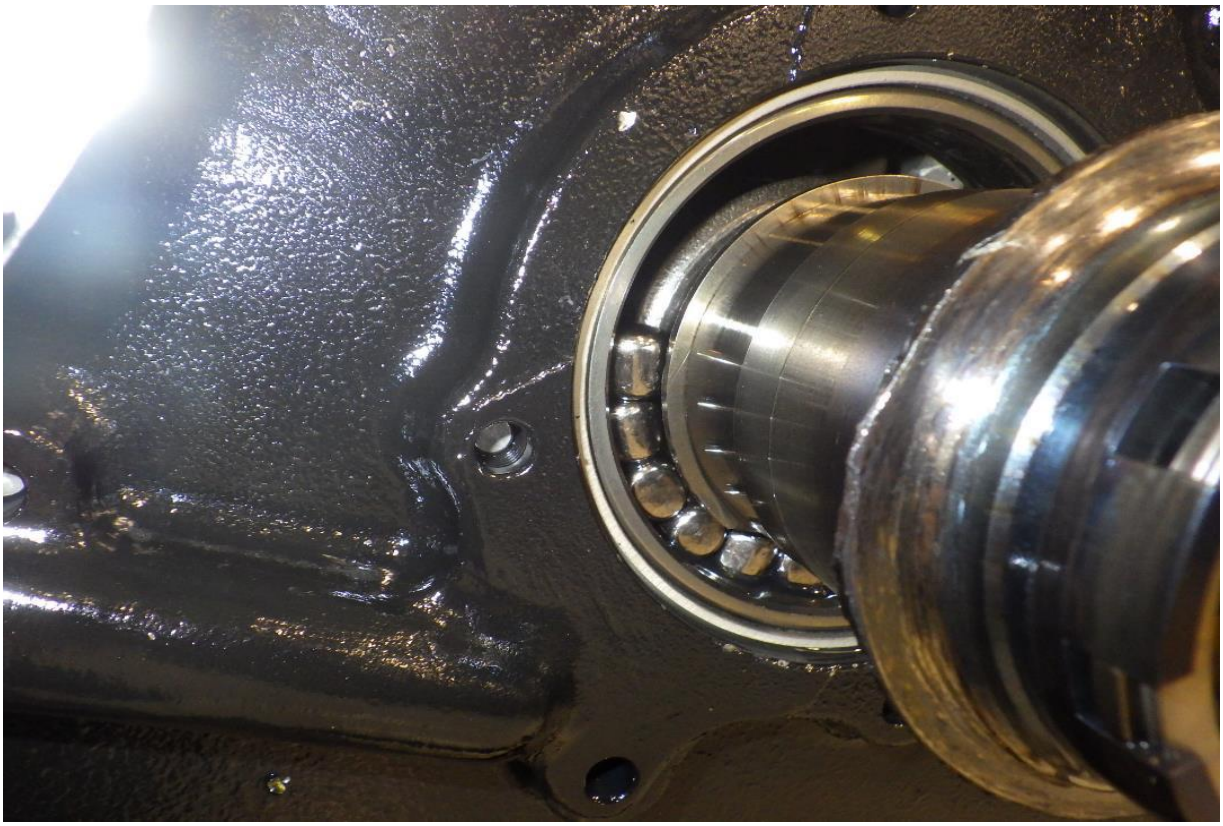

Fig. 11 View of the no. 8 roller bearing. The fractured flange of the diaphragm coupling can be seen in the foreground [source: P&WC].

Prior to the occurrence, on 26 Aug 2019, the airplane user found some filings in the oil system of the engine. On 28 Aug 2019 the oil samples were tested at the Spectro laboratory where the presence of filings composed of M50 were found, but in acceptable quantities.

According to the engine maintenance manual, the oil system was checked and after consultation with the manufacturer, the engine was released for further service under the condition that magnetic chip detector would be checked periodically. Prior

to the occurrence, the magnetic chip detector plug was for the presence of filings after 15FH and 35FH with negative result.

2. Fig. 12 shows the diaphragm coupling which is the element connecting RGB to PT. Torque is transmitted through flanges located at the end of PT shaft and at the output shaft from RGB. A fracture of this element on the flanges at its both ends made the torque transmission between PT and RGB impossible.

Fig. 12 The diaphragm coupling. View of the from the RGB side [source: P&WC].

Fig. 13 The PT shaft tip and its cut flange [source: P&WC].

3. All the blades of the power turbine disc (PT1) were damaged. The disc together with the fragments of the blades was further tested to identify the cause of the damage.

Fig.14. View of the damaged blades of the PT1 turbine [source: P&WC].

4. All the blades of the power turbine disc (PT2) were damaged. The shaft of that disc was broken by twisting.

Fig. 15 View of twisted PT2 shaft and its damaged blades [source: P&WC].

5. Fig. 16 shows the no. 6 and 6.5 bearings oil pressure transfer tube. This tube has been sheared and slightly bent. Through the cracked tube, oil got between the low-pressure turbine and PT1 (the temperature in this area is approximately 840ºC).

Fig. 16 View of the damaged bearings oil pressure transfer tube [source: P&WC].

6. Significant amounts of filings and pieces of other damaged metal components were found inside the main oil tank strainer and the RGB (Fig.17 and Fig.18). The material found in the filters was subjected to laboratory tests.

Fig. 17 Filings inside the main filter of the oil system [source: P&WC].

Fig. 18 Filings and metal debris inside the main filter of RGB [source: P&WC].

The damaged components and elements presented above were examined in laboratories.

The following facts emerge from the examinations:

1. Visual inspection of the front and rear diaphragm coupling shafts showed circumferential fracture of both diaphragms around the shafts. Fig. 19 shows the fractured shafts placed in original position. Optical and scanning electron microscope examination showed fractographic features resulting exclusively from the shear and / or bending overload with no evidence of fatigue. The hardness and chemical composition of both diaphragms material were within the established requirements.

Fig.19. Fractured shafts of diaphragm coupling shown in original position [source: P&WC].

2. All elements of the no. 8 roller bearing were examined. The examination showed that the entire raceway for both rings showed plastic deformation and smearing of material. The inner ring showed a radial crack across the raceway (Fig. 20).

Fig. 20 A crack on the inner ring of the bearing [source P&WC].

During examination of the inner ring by scanning electron microscope the fracture surface was checked and fractographic features of semi-elliptical crack progression marks, characteristic for the fatigue crack propagation were found on it (Fig. 21). The fatigue propagation was observed to originate from the surface radially inwards (yellow dashed lines, Fig. 21). The material hardness and the chemical composition of both rings met the drawing requirements. A cross-section taken through the rings showed that the material at the raceway surface was heat affected resulting in a “white martensite” layer. A tempered martensite is acceptable.

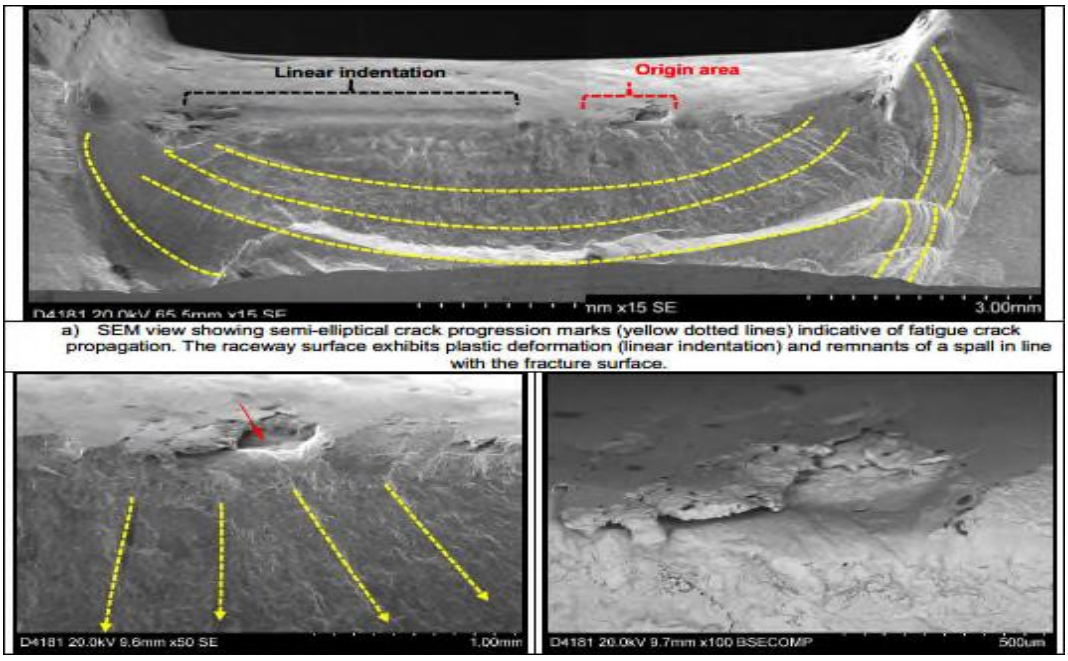

Fig. 21 Fatigue cracks on the inner ring [source: P&WC].

The contact surfaces of the rollers were found obliterated, plastically deformed and smeared. Several rollers also exhibited spalling (rolling contact fatigue) (Fig. 22). A cross-section showed that the material at the contact surface was heat affected

resulting in a “white martensite” layer (a tempered martensite is acceptable). The fractured cage pieces were examined by SEM and were found to have fractured in fatigue. The fatigue was a consequential to the deterioration of the rollers and raceways. The microstructure of the cage base material consisted of acceptable tempered martensite.

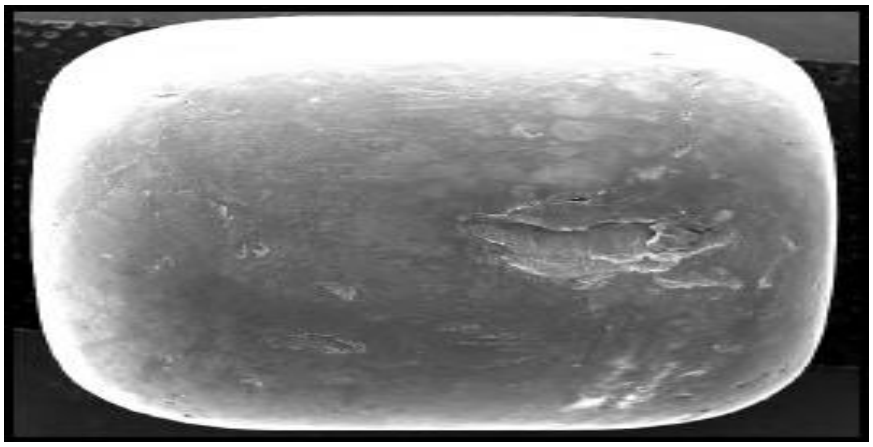

Fig. 22 Spalling (rolling contact fatigue) of the rollers surfaces [source: P&WC].

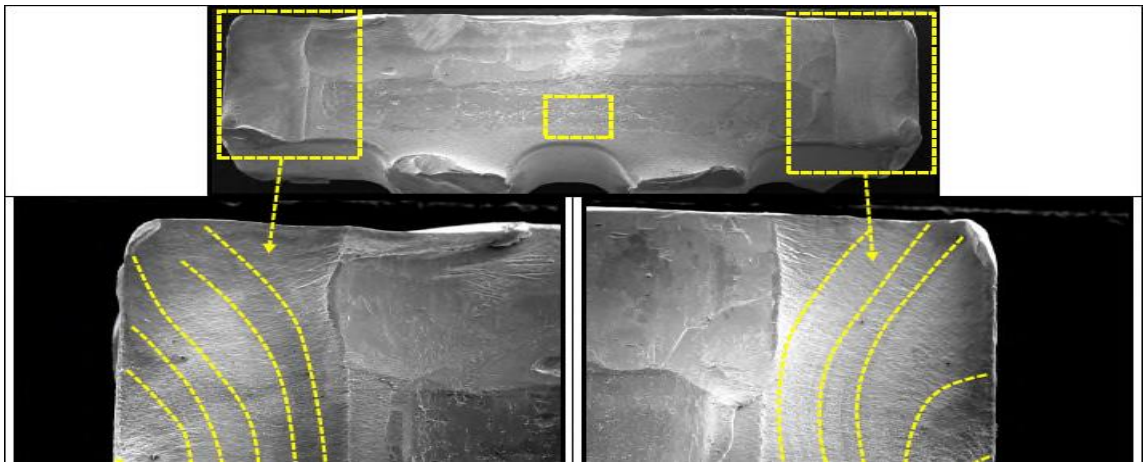

Fig. 23 Fatigue cracks of the RGB couplings on the shaft side [source: P&WC].

3. SEM analysis of the RGB couplings cracks on the shaft side showed fatigue marks, but these should be considered as a secondary damage consequential to the event most probably created by vibrations (Fig. 23).
4. **Optical examination of all the fractured first stage and second stage power turbine blades showed fracture features typical for secondary damage, with no evidence of fatigue.**
5. Chemical analysis of the filings and metal debris collected from the main oil system filter, the RGB filter and the magnetic chip detector was performed at the P&WC Chemical Laboratory. **Materials collected from these places showed that the iron-based particles mainly composed of M50 bearing material (high hardness steel)**. The thermal discolorations were visible on a part of examined material.

1.17. Organizational and management information

At 12:26 hrs, Poznań TWR informed LSRG and DOPL about the fire of engine #2 of the Bombardier airplane, registration marks SP-EQG. It was communicated that 73 persons and 2500 kg of fuel were on board and that the flight crew declared MAYDAY.

The shift commander of LSGR in consultation with the LSGR chief decided to put on alert LSRG and call the external services of PSP Poznań.

At 12:28 hrs, the DOPL informed duty officers of the Border Guards and Airport Security Service (SOL) as well as other officials foreseen for such a situation.

At 12:30 hrs, DOPL informed the Poznań Crisis Management Centre (CMC) about the emergency landing. CMC informed the Emergency Medical Services.

Even before the emergency landing, 9 teams of PSP Poznań, together with LSRG Poznań Ławica were deployed at the airport according to applicable arrangements.

After vacating RWY by the airplane, the abovementioned services assisted in coordination and securing of the ground movement at the airport and in the evacuation process. Until the landing, no vehicles of the National Medical Rescue arrived at the airport.

1.18. Additional information

Accredited representative of TSB of Canada was not present at P&W during the examination of engine #2.

The Draft Final Report was sent for consultation to PLL LOT, but no significant comments regarding the circumstances and causes of the occurrence were received.

The translated Draft Final Report was sent for consultation to TSB Canada and EASA, but no substantive comments were received.

1.19. Useful or effective investigation techniques

Standard investigation techniques were applied.

2. ANALYSIS

2.1 Qualifications of the crew

The cabin crew had valid licences, and aero-medical certificates. The crew's actions showed that their knowledge and familiarity with the aircraft systems were sufficient.

2.2 The weather

Meteorological conditions had no impact on the occurrence.

2.3 The aircraft

Inspection of the engine performed immediately after the occurrence by PKBWL and disassembly ant testing of the engine by the Pratt & Whitney Canada (P&W) revealed the extent and nature of the factors that contributed to engine damage, fire and stoppage.

The engine fire was caused by a broken pipe supplying oil to bearings #6 and #6.5. Through the cracked tube, oil got between the low-pressure turbine and the PT1 turbine

(the temperature in this area is approximately 840ºC). A flame developed and escaped mainly on the left side of the engine through the unsealed connection between the turbine body and the exhaust nozzle.

The bearing #8 was found severely damaged and was comprehensively examined. The examinations showed advanced spalling and fatigue deformations on the roller surfaces.

Due to significant damage to the surface of the rollers, the direct cause of the spalling has not been determined. The rolling surfaces of the raceways of both rings were also significantly damaged. The features of semi-elliptical marks revealed on the inner ring and the direction of crack propagation clearly indicate a fatigue crack. The process of destroying the bearing lasted quite a long time, as evidenced by the fact that on 26 August 2019 the operator detected filings on this engine and following the applicable procedure allowed the engine to be used further. Then, during laboratory tests, it was found that the filings were of M50 alloy, but they were present in acceptable amounts.

Chemical research of the materials found in filters and chip detectors showed that their main component was M50 steel (high hardness steel) present in bearings. Due to the fact that during the investigation no other damaged bearing was found, those filings must have come from the bearing #8.

The failure of bearing #8 progressed over a fairly long time and made their rotation more and more difficult, which caused unstable motions of the front and rear diaphragms of the coupling.

Under such conditions, the stresses produced by the rotating turbines caused breakage of the front and rear shafts of the coupling, and possibly at the same time shear of the drive turbine shaft (PT). The transmission of torque between PT and RGB was interrupted and the engine stopped. **The other engine damage was secondary.**

3. CONCLUSIONS

3.1. Findings

1) The pilots had valid ratings to perform the flight, as well as aero-medical certificates.
2) The airplane had valid CofA.
3) The airplane was properly prepared for the flight.
4) The airplane was equipped and maintained in accordance with applicable procedures.
5) The airplane weight and centre of gravity were within the specified limits.
6) During the flight the flight crew maintained a two-way radio communication with air traffic services and no problem was reported until the occurrence.
7) ATC provided prompt and effective assistance to the flight crew.
8) The flight crew responded correctly to the signalled and visible fire of the right hand engine, performed MEMORY ITEMS for, ENGINE FAILURE/FIRE/SHUTDOWN (In Flight) checklist and extinguished the fire using only one FWD BTL.
9) Captain made a quick decision to land on EPPO, efficiently analyzed the hazard and issued commands appropriate to the situation.

10) Proper cooperation of the flight crew and the cabin crew ensured the safe and efficient evacuation of passengers.
11) The failure of bearing #8 initiated the process of further destruction of the engine and its stoppage. All other engine damage was of a secondary nature.

3.2. Cause of the serious incident

The cause of the serious incident was the fatigue damage to the no. 8 roller bearing in the form of advanced spalling of the rolling surfaces of its rollers and deformations and cracks across the bearing raceway.

4. SAFETY RECOMMENDATIONS

4.1. PKBWL has not proposed any safety recommendation after completion of the investigation.
4.2. OPERATOR'S PREVENTIVE ACTION ACCEPTED BY PKBWL: PLL LOT, as the airplane user entered the PW150A engines into the Oil AT program organised by the manufacturer for early detecting of oil system malfunctions based on tests of oil samples in specified periods.

THE END

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