United Arab Emirates

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الهيئة العامة لطيران المدني
UAE General Civil Aviation Authority

AAI Case Reference: 16/2010

AIR ACCIDENT INVESTIGATION DEPARTMENT

FINAL AIR INCIDENT INVESTIGATION REPORT

ENGINE FAILURE DURING WARM-UP

IL 76 TD

EK76442

Phoenix Avia

Dubai International Airport

October 27th, 2010

General Civil Aviation Authority
of
United Arab Emirates

United Arab Emirates

Air Accident Investigation Department
General Civil Aviation Authority
United Arab Emirates

OBJECTIVE

This investigation is performed in accordance with the UAE Federal Act No 20 of 1991, promulgating the Civil Aviation Law, Chapter VII, Aircraft Accidents, Article 48, and in conformity with ICAO Annex 13 to the Chicago Convention.

The sole objective of this investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

As per paragraph 6.1 in Annex 13, the format of this report is adapted from the Final Report Format as laid down in the Appendix to Annex 13, certain subheadings in the Factual Information heading were skipped since they are either not investigated or not been considered as contributing factors.

FACTUAL INFORMATION

HISTORY OF THE FLIGHT

On 27th October 2010, Ilyushin 76 TD, EK76442, operated by Phoenix Avia, departed the cargo stand at Dubai International Airport at approximately 0300 LT (UTC+4), then reached to RWY 12R via entry M4 at approximately 0313. According to the crew statements, the AFM dictates that one of the line-up checks is to advance the four engines' power to 80% for 1 minute period and check all the engines' related parameters including oil pressure and temperature, RPM, EGT and vibration. In the incident flight, the captain advanced the engines power to 80% and kept monitoring the relevant indicators. After approximately 20 seconds of power advancement, the PIC observed low oil pressure on engine no. 2 indicator associated with vibration red alert, accordingly he retarded engine 2 throttle lever and instructed the Flight Engineer to switch engine 2 off by the engine fuel cut handle located at the middle pedestal, the other three throttle leavers were also retarded to lower power setting.

The crew reported to Dubai ATC that they had engine problem and they should return to the stand for further inspection, they were instructed to clear RWY 12R via exit M5 and to park at cargo stand E23 where the crew disembarked normally. No emergency was declared.

INJURIES TO PERSONS

Injuries	Crew	Passengers	Total in Aircraft	Others
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	7	0	7	0
TOTAL	7	0	7	0

DAMAGE TO AIRCRAFT

The Aircraft was intact; no damage was noted except the confined engine damage.

No damage to engine 2 nose cowl, inlet guide vanes or the first stage fan blades, whereas last stage turbine blades had severely damaged with some of them had disintegrated and departed the engine. None of the adjacent structure was observed to be affected by any engine debris.

Fuel leak was observed underneath the L/H wing but couldn't be linked to any of the engine debris.

OTHER DAMAGE

None

AIRCRAFT INFORMATION

Type:	IL 76 TD
MSN:	1023414450
Registration:	EK76442
State of Registration:	Republic of Armenia
Date of C of R Issue:	January 14st, 2010
C of A, Validity:	April 20st 2011

ENGINE INFORMATION

Engine No. 2:	D-30KP-2, S/N 03053019302028
Manufacturer:	NPO Saturn, Russian Federation
Date of manufacture:	18.05.1992
Number of overhauls:	2
Date of the last overhaul:	26.02.2003 (NPO Saturn).
Guaranteed service life:	2000 hours.
Time Since New:	8622 hours
Time Since Lat Overhaul:	2476 hours.

According to the maintenance, upon expiration of the guaranteed service life, life between overhauls was extended by stages of 333 hours up to 2666±30 hours.

AERODROME INFORMATION

The last inspection on Runway 12R did not reveal any foreign objects that might have been ingested by the engine.

FLIGHT RECORDERS

The following recorders were sent to Volga Dnepr Gulf Company at S F Z for readout and analysis.

Cockpit Voice Recorder

- 70 A 10M, Serial No 343027.
- No recordings pertinent to the incident flight.

Flight Data Recorders

Primary-

Type: MLP-14-5

S/N: 00796

The flight recorders showed that the engines were started normally and no significant change of engines' parameters was recorded for almost 29 minutes after the start.

Thereafter, an increase in engine No. 2 rear mounting vibration was recorded associated with a decrease in 1st stage compressor rotation followed by severe vibration.

Consequently, engine No. 2 was shutdown, followed by engine No. 3, and then engines No. 1 and 4.

Secondary-

Type: K3-63:

S/N: 30312

SURVIVAL ASPECTS

The crew disembarked the Aircraft normally.

TESTS AND RESEARCHES

Engine Teardown

The engine was removed and shipped to the manufacturer for opening up and conduction detailed lab examination, the following were revealed: [1]

- Most of the rotor blades of the turbine stages from 2 to 6 ripped-off (Figure 1).

  Failure of all Stage 3 nozzle guide vanes and such damages as nicks and tear-out of material on all Stage 4, 5 and 6 nozzle guide vanes.

Figure 1- Damage of stage 3 turbine nozzle guide vanes and stage 2 rotor blades

[1] Saturn Lab Examination Report No. 44-53745, dated 13th July 2011.

- Failure of vane 40 in Stage 2 HPT NGV (Figure 2). Availability of the material fusion on the remaining vane fragment and on NGV outer shroud ring gives evidence of increased temperature effect in this zone.

Figure 2- Damaged stage 2 nozzle guide vane No. 40

- The Metallographic Examination showed that the vane failure was related to intensive overheating of the material up to the fusion temperature.[2]
- No failures were found on Stage 1 turbine blades.
- Material fusion on Stage 1 nozzle guide vanes at the leading edge, outer platform of one of the blades and on cooled insert (Figure 3).
- On most of the combustion cans, there were thermal damages such as burning-out, distortion and cracking of material (Figures 3).

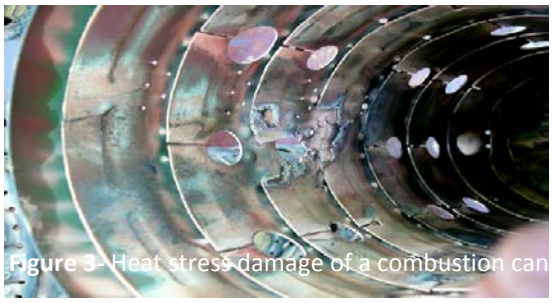

Figure 3- Heat stress damage of a combustion can

- No failures in the HP and LP compressor flowpath.
- Testing the fuel nozzles flow rate capacity before and after the deposit removal on most of the fuel nozzles, absence or reduction of fuel flow through the primary orifice fuel manifold, increased irregularity of fuel atomization, reduced fuel spray pattern, and spraying availability, were observed.
- Foreign deposits on connections, filters, adapters, main and primary fuel sprayers and on faces of fuel nozzle bodies were found.
- At adapters of some fuel nozzles the primary manifold orifices were partially or completely clogged with the foreign deposit (Figure 4).

Figure 4- Deposits at the fuel orifice

Deposits Analysis

The examination of the foreign deposits found on connections, filters, adapters, main and primary fuel sprayers, and the surface of fuel nozzle bodies of engine; revealed that:

- The foreign deposit was of a superficial nature and could easily removed.
- No damage caused by corrosion was observed.
- A significant quantity of ferrous and sulfur oxides was detected in the chemical composition of the foreign deposit. [3]

[2] Saturn Metallurgical examination report No. 712MO-11 dated 7th July 2011 of a fragment of Stage 2 guide vane No. 40.

Fuel Sample

The fuel drained from the constant-speed drive governor (P/No РППО-30К and S/N Т10412005) showed that *existent gum* content in the fuel exceeded the permissible rates.

GOST R 5205-2006[4]) for Jet A-1 fuel limits the existent gum contents to no more than 7 mg per 100 ml. GOST 10227-86 for fuel TC-1 fuel limits the existent gum contents to not more than 33.5 mg per 100 ml, rate– no more than 3 mg per 100 ml.

Other measured parameters showed values within limits.[5]

ADDITIONAL INFORMATION

The *existent gum* is a material that is usually found in the contents of the crude oil and one of the heaviest materials at the base of the crude oil. It is hard to be removed completely during the fuel refining process, so the standards permit its existence but with limited permissible percentage.

The accumulation of the existing gum is most probable at the fuel nozzles where the orifices of the nozzles start to narrow down with inhomogeneous outlets, so the fuel spray becomes irregular and then the flame becomes concentrated with a *torch effect*.

The flame torch concentrates the heat on a certain area leaving other areas much cooler, which would lead to heat stress due to differential heat convictions.

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[3] Saturn deposit examination report No.765-LKhTP-11, dated 11th July 2011.

[4] GOST is the fuel standards of the Russian Federation.

[5] Report of Saturn Fuel & Oil Laboratory of the Chief Metallurgist Department, dated 4th July 2011.

ANALYSIS

- The Investigation eliminated the probability of that the engine had ingested a foreign object during the Aircraft taxiing to the departure runway since the compressor was clear of any damage or any foreign object marks. All the damages hardware was belonging to stages later that the compressor aftward.

- From the engine examination, the following sequence could have been inferred:

  - Failure of the turbine stage 2 nozzle guide vane No. 40 occurred due to overheat stress of the vane at the outer span zone caused by exposure to local increased gas flow temperature.

  - Formation of local increased gas temperature was a result of the malfunction fuel nozzles which orifices were partially blocked by resin deposits.

- The foreign resin deposit could be attributed to the accumulation of the *existent gum* as could be concluded from the analysis of fresh fuel drained from the constant-speed drive governor which showed extreme exceedence of this content in comparison with the permissible rate depicted in the fuel standards.

- The accumulation of the existent gum resulted in a flame torching and then overheat stress on the combustion can, and the turbine 2nd stage nozzle guide vane forcing it to dismantle and then depart the shroud. The defragmented vane went downstream the engine flow passing through the consecutive turbine rotor blades and guide vanes leaving high impact damage to them.

- At the time of the engine last overhaul, which was conducted on 26th February, 2003, the nozzles were inspected and cleaned, so it would be an acceptable hypothesis that the accumulation of the existent gum had started after that date and could not be detected thereafter since the on-wing inspections did not include items to remove the fuel nozzles and perform bench inspection on them.

- According to the engine's maintenance schedule, the borescopic inspection, that should be performed frequently for the purpose of *engine's prolongation*[6], did not also include items pertinent to fuel nozzles, nor there was an inspection technique that might enable the inspection of them.

- The quality of the fuel would be hardly assured since the Aircraft operations was widely diversified, the Aircraft used to fly amongst various continents; consequently the purity of fuel fed by various hydrants and/or trucks at different airports could not be assured, the fuel contaminations could not be detected by fuel plants poor quality system.

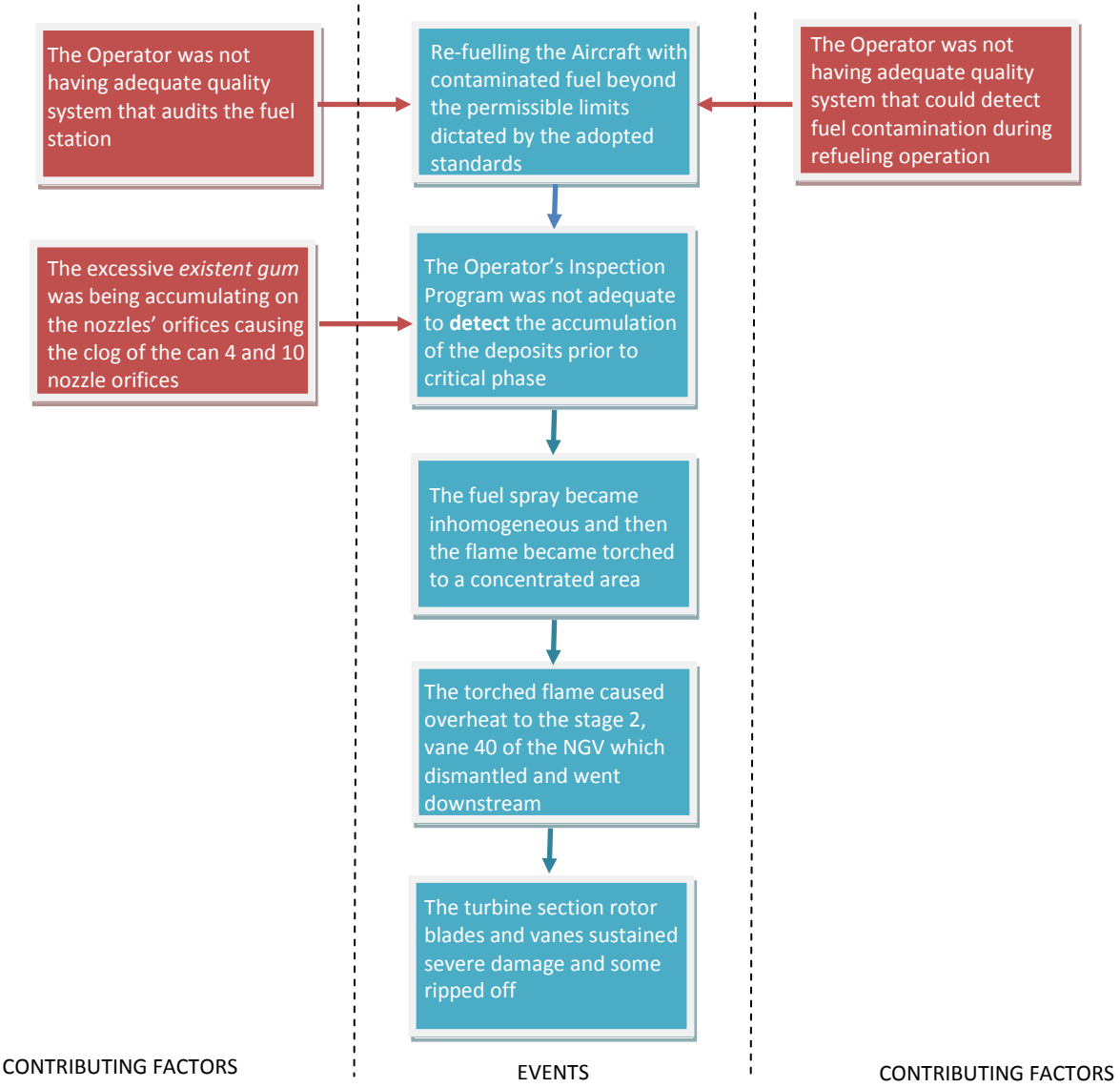
- The fuel contamination detectors, that are usually used on the ramp for detecting the fuel contamination during the refueling operation, were not capable to detect the concentration of the

[6] Engine Prolongation- is a system followed by the engine manufacturer which extends the engine life after 2000 hours of its last overhaul by periods of 333 hrs until the second 2000 hours are reached. The prolongation requires certain inspections to be performed on the engine to assure its continuous airworthiness.

existent gum within the fuel contents; therefore it would not be possible to have occasions where the refueling was stopped due to the presence of out-of-limits *existent gum*.

- Auditing the fuels stations at various airports within the network of the Operator could have helped him figure out the potentials of such exceedence in fuel permissible contents, but there were no clues to the Investigation that the Operator had performed the necessary quality audits on his destination airports including the fuel stations.
- The Cockpit Voice Recorder was empty of any recordings pertinent to the Incident flight, the Investigation did not cover the reasons behind the malfunction.

The tree below illustrates the Events Link Analysis Network ("ELAN") of the Incident as well as the contributing factor of each event.



CONCLUSIONS

FINDINGS

(a) The Aircraft was properly possessing Certificate of Airworthiness and Certificate of Registration.

(b) The crew was properly possessing pilot and medical licenses.

(c) The fuel onboard the Aircraft at the time of the Incident was not up to the standards imposed by the Aircraft Maintenance Manual.

(d) There was no adequate engine inspection program that might have detected the accumulation of fuel deposits at the fuel nozzles' orifices.

(e) The Operator had no adequate Quality Assurance Program to audit outstations fuel stations.

(f) The fuel contaminations detectors were not able to detect the excessive *existent gum*.

(g) The Cockpit Voice Recorder did not contain recordings pertinent to the Incident flight.

PROBABLE CAUSE

The Air Accident Investigation Department determines that the probable cause of engine No. 2 failure was internal damage caused by heat stress resulting from the use of highly contaminated fuel.

SAFETY RECOMMENDATIONS

The Air Accident Investigation Department recommends that:

THE OPERATOR-

SR 01/2012

Carry out hot section inspections on the other similar engines installed on his Ilyushin 76 TD fleet.

SR 02/2012

Enhance, after consultation with the engine manufacturer, the hot section inspection procedures and techniques especially on fuel nozzles.

SR 03/2012

Enhance his quality system to include audit activities on fuel stations and fuel contamination control during aircraft refueling.

SR 04/2012

Enhance his maintenance program and maintenance practices to assure the reliability of the flight recorders, especially the Cockpit Voice Recorders, installed on his aircraft fleet.

THE GENERAL DEPARTMENT OF CIVIL AVIATION OF ARMENIA-

SR 05/2012

Carry out comprehensive oversight on the Operator to assure that he takes the necessary remedy actions on the aircraft inspection system and quality system especially on fuel control.

THE GENERAL CIVIL AVIATION AUTHORITY OF THE UNITED ARAB EMIRATES-

SR 06/2012

Establish a system of fuel sampling on random basis through cooperation with local specialized labs.

ILYUSHIN DESIGN BUREAU

SR 07/2012

Together with the engine manufacturer, review the engine inspection program to study the possibility of including inspection items that detect the *existent gum* content at early stages.

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