UAE General Civil Aviation Authority

AAIS Case Reference: 04/2012

AIR ACCIDENT INVESTIGATION SECTOR

FINAL

AIR INCIDENT INVESTIGATION REPORT

ENGINE FAILURE

IL-76TD
RA76799
Abakan Avia
Sharjah International Airport
5 February 2012

General Civil Aviation Authority
of
United Arab Emirates

United Arab Emirates

Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates

OBJECTIVE

This Investigation is limited to the aspects related to the engine failure and the associated operations, aircraft design, performance and airworthiness issues.

This Investigation is performed pursuant to the UAE Federal Act No 20 of 1991, promulgating the Civil Aviation Law, Chapter VII, Aircraft Accidents, Article 4. It is in compliance with the UAE Civil Aviation Regulations, Part VI, Chapter 3, in conformity with Annex 13 to the Convention on International Civil Aviation and in adherence to the Air Accidents and Incidents Investigation Manual.

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.

AIRCRAFT INCIDENT BRIEF

GCAA AAI Report No.:	04/2012
Operator:	Abakan Avia
Aircraft Type and Registration:	IL-76TD, RA76799
No. and Type of Engines:	Four D-30KP-2 Turbofan Engines
Date and Time (UTC):	5 February 2012, 1131 UTC
Location:	Runway 12 of Sharjah International Airport
Type of Flight:	Cargo Transport
Persons on Board:	Eight
Injuries:	None
Nature of Damage:	No. 2 engine damage, no subsequent damages to the Aircraft had occurred

The occurrence of the Ilyushin (IL)-76TD cargo Aircraft, registration mark RA76799, was notified to the General Civil Aviation Authority (GCAA) through a call to the Director General of the General Civil Aviation Authority.

Immediately after the notification, an Investigator from the Air Accident Investigation Sector (AAIS) launched to the occurrence site and started to collect the on-site data.

After the Initial/On-site Investigation phase, the occurrence was classified as an "Incident".

Next day, an Investigation Team was formed to investigate the case as a fulfillment to the obligation of the United Arab Emirates (UAE) as being the State of Occurrence.

The investigation into this Incident is limited to the events leading to it; no in-depth analysis to non-contributing factors was made.

Notes:

[1] Whenever the following words are mentioned in this Report with first Capital letter, it shall mean the meaning opposite to each:

- (Aircraft)- the aircraft involved in this Incident.
- (Airport)- Sharjah International Airport, UAE.
- (Investigation)- the investigation into this Incident
- (Incident)- this investigated Incident
- (Report)- this Incident Final Report

[2] Unless otherwise mentioned, all times in this Report are Coordinated Universal Time (UTC), (UAE Local Time minus 4).

[3] In this Report, the word “Cockpit” and “Flight Deck” are synonyms.

[4] All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft looking forward (ALF) as is the convention. The direction of rotation of the engine low and high rotors is clockwise. All numbering in the circumferential direction starts with the No. 1 position at the 12:00 o’clock position, or immediately clockwise from the 12:00 o’clock position and progresses sequentially clockwise ALF.

[5] Photos used in the text of this Report are taken from different sources and are adjusted from the original for the sole purpose to improve clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast or addition of text boxes, arrows or lines.

ABBREVIATIONS AND DEFINITIONS USED IN THIS REPORT

AC	Alternating Current
AFM	Airplane Flight Manual
AFT	Aftward
AGL	Above Ground Level
AOC	Air Operator Certificate
ASDA	Accelerate-Stop Distance Available
ATS	Air Traffic Service
CoA	Certificate of Airworthiness
CoR	Certificate of Registration
CSD	Constant Speed Drive
CVR	Cockpit Voice Recorder
FDR	Flight Data Recorder
fpm	Feet per minute (climb-descent speed measurement unit)
ft	Feet (distance unit)
FWD	Forward
GCAA	General Civil Aviation Authority of the United Arab Emirates
Hr(s)	Hour(s) (time unit)
IAC	Interstate Aviation Committee
ICAO	The International Civil Aviation Organization
IFR	Instrument Flight Rules
Km	Kilometer (distance unit)
Km/hr	Kilometers per hour (speed unit)
kt	Knot(s) (airspeed unit)
LDA	Landing Distance Available
LH	Left hand
m	Meters(s)
m/s	Meters per second (speed unit)
MSN	Manufacturer Serial Number
NGV	Nozzle Guide Vanes
No.	Number
P/N	Part Number

RH	Right Hand
RWY	Runway
s	Second(s)
S/No.	Serial Number
TODA	Takeoff Distance Available
TORA	Takeoff Run Available
UAE	The United Arab Emirates
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VGV	Variable Guide Vanes

CONTENTS

1. FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On 5 February 2012, after landing of Ilyushin (IL)-76TD, RA76799, operating flight No. ABG9352, Kandahar (OAKN) to-Sharjah (OMSJ), for Abakan Avia, and while taxiing out the landing runway (RWY) 12 at Sharjah International Airport, the tower controller noticed a smoke emitting from the exhaust of No. 2 engine followed by flame, consequently the captain was instructed to stop.

Fire brigade was launched to the Aircraft and fire extinguisher was fed to the engine inlet, the Aircraft was towed to the cargo stand without further consequences. (Figure 1).

The captain stated that he didn't notice any abnormal indications in the cockpit.

Figure 1- Aircraft towing to the maintenance bay

1.2 INJURIES TO PERSONS

Table 1- Injuries to persons						
Injuries	**Flight Crew**	**Cabin Crew**	**Other Crew Onboard**	**Passengers**	**Total Onboard**	**Others**
Fatal	0	0	0	0	0	0

Serious	0	0	0	0	0	0
Minor	0	0	0	0	0	0
None	5	0	3	0	8	0
TOTAL	**5**	**0**	**3**	**0**	**8**	**0**

1.3 DAMAGE TO AIRCRAFT

The Aircraft was intact; no damage was noted except the confined No. 2 engine damage.

The turbine blades had severely damaged with some of them disintegrated and departed the engine.

None of the adjacent structure was observed to be affected by any engine debris.

1.4 OTHER DAMAGE

None.

1.5 PERSONNEL INFORMATION

The flight crew encompassed: the captain, co-pilot, flight engineer, radio operator and navigator.

Flight operator was also onboard the cargo cabin for cargo handling.

Two ground engineers: mechanic and avionics were onboard occupying two cabin attendant seats behind the flight deck.

Table 2 illustrates the qualifications of the flight crew.

Table 2- Flight crew qualifications

Crewmember	Age	Gender	License	Validity	Issuing State	Medical certificate/ expiry	Last line check
Captain	59	Male	ATPL	21/4/2012	Russia	Class 1, 21/4/2012	19/01/2012
Co-pilot	48	Male	ATPL	04/6/2012	Russia	Class 1, 04/5/2012	19/01/2012
Flight engineer	57	Male	Flight Engineer	03/6/2012	Russia	Class 1, 03/6/2012	19/03/2011
Navigator	58	Male	Navigator	13/12/2012	Russia	Class 1, 13/12/2012	11/10/2011

Radio operator	49	Male	Radio Operator	04/03/2012	Russia	Class 1, 04/03/2012	21/12/2011

1.6 AIRCRAFT INFORMATION

1.6.1 General

Type: IL-76TD

MSN: 1003403075

Registration Mark: RA76799

State of Registration: Russian Federation

Date of Certificate of Registration (CoR) issue: 26 January 2009

Certificate of Airworthiness (CoA) validity: 31 July 2013

According to the records provided to the Investigation, there was no reported significant defect on the Aircraft prior to the Incident.

1.6.2 No. 2 Engine Information

Refer to Appendix C for engine schematic.

Type and Model: Д-30КП-2

S/N: 53028602064

Manufacturer: NPO Saturn, Russian Federation

Date of manufacture: 23 June 1986

Number of overhauls: 3

Date of the last overhaul: 17 May 2009

Guaranteed service life: 2,000 hrs

Time, cycles since new: 8,603 hrs, 2,762 cycles

Time, cycles since last overhaul: 1,152 hrs, 542 cycles

No. 2 engine logbook (Appendix A) showed that the engine was overhauled at Saturn in accordance with document 44TY200-88 and issued a certificate of release to service accordingly.

The engine was installed on the Aircraft in July 2009 and continued on-wing until its removal after the Incident.

The planned next overhaul was after 4,000 hrs/1,540 cycles from the last overhaul, or within 6 years whichever comes first.

According to the engine document No. 44 TY200-88, the engine operation during the time between overhauls is limited to 100 hrs on ground mode, 880 hrs on idle mode, 2,400 hrs on reverse mode and 2,400 starting times.

The Д-30КП-2 is a turbofan, two-spool engine which consists of the following main assemblies[1]:

- Compressor;
- Intermediate casing with accessory drive gear boxes;
- Combustion chamber;
- Turbine;
- Thrust reverser.

The engine compressor is of a two-rotor axial-flow type. The Low Pressure Compressor (LPC) has 3 stages, driven by the Low Pressure Turbine (LPT).

The High Pressure Compressor (HPC) is driven by the High Pressure Turbine (HPT) and has 11 stages including Variable Guide Vanes (VGV).

The combustion chamber is can-annular type and has twelve cans located between the HPC and the HPT. The construction of the combustion chamber provides for inspection and replacement of the cans, nozzle boxes, fuel nozzles and other parts with a partial disassembly of the engine. Partial disassembly is possible when the engine is on-wing.

The engine turbine is axial-flow reaction type. The HPT and LPT are 2 and 4 stages, respectively. The discs, nozzles guide vanes (NGV) and rotor blades of both LPT stages are air-cooled.

The engine and aircraft accessories are mounted on two accessory drive gearboxes located at the engine bottom. The front accessory gearbox is installed on the intermediate casing, while the rear accessory drive gearbox is suspended within the recess of the front outer shroud of the combustion chamber.

The engine is equipped with a differential constant-speed drive (CSD) with an air turbine to drive the AC generator at a constant speed.

The Д-30КП-2 engine is equipped with the following detection/monitoring systems:

- Compressor rotor maximum speed and HPC outlet pressure limit systems;
- Exhaust gas temperature limit system;
- Constant-speed drive turbine over speed protection system and AC generator switching-off signalling system;
- Chip detection warning system;
- Inlet nose cone and LPC inlet guide vanes anti-icing system; and
- Engine vibration control and warning system.

[1] Reference: IL-76 (TD) Maintenance Manual Part 4, Section 41 Power Plant, Engine 41-00 page 1

Various monitoring and measuring equipment items mounted on the engine are used to monitor the operation of the oil and fuel systems, the thrust reverser, the compressor variable elements and other units and accessories.

1.6.3 Fuel System Description

Fuel is stored in 12 integral tanks located over the whole wingspan between the front and rear spars.

All tanks are combined into four isolated group (one group per engine) comprising three tanks each. Each group consists of main, auxiliary and standby tanks. Each engine is fed from its own group tanks. Fuel is supplied to the engine by fuel booster pumps through separate pipes interconnected by electrically operated cross feed valves, which provide for transferring, in case of need of all the tanks of two adjacent engines, as well as all the tanks of the fuel system.

Fuel used from each group of tanks is assured by pumping it into a sealed feed reservoir of the main tank in the following order: standby tank, auxiliary tank and the main tank.

1.6.4 Fuel Filters Inspection

As per the line maintenance schedule manual of IL76-TD section 3.072.01.08, the fuel filters undergo inspections and are washed during the Phase B check (Форма Б).

A one year back history revealed that the filters were inspected and washed in twelve Phase B check which were approximately one month apart.

1.7 METEOROLOGICAL INFORMATION

Not a factor.

1.8 AIDS TO NAVIGATION

Not a factor.

1.9 COMMUNICATIONS

Not investigated.

1.10 AERODROME INFORMATION

Sharjah International Airport is a GCAA certificated aerodrome under Part IX of the UAE Civil Aviation Regulations- *Aerodromes Regulations*.

The Airport is located 7 NM southeast of Sharjah city, UAE. It is capable of IFR and VFR operations.

The category for firefighting is CAT 9 upgradable to CAT 10. The capability for removal of disabled aircraft is airbags and hydraulic jacks capable for aircraft sizes up to and B747-400. Additional lifting capacity is available at 4 hrs notice.

The Airport has only one asphalt runway 12/30, 4,500 m long and 45 m wide with 300 m concrete. The slope of RWY 12 is -0.37% (first 917 m), -0.20% (next 150 m), +0.05% (next 1,200 m), +0.41% (next 150 m), +0.59% (next 1,347 m), +0.51% (next 299 m). The slope of RWY 30 is 0.51% (first 299 m), 0.59% (next 1,347 m) -0.41% (next 150 m), -0.05% (next 1,200 m), +0.20% (next 150 m) and +0.37% (next 917 m).

The TORA, TODA, ASDA for both sides of the runway are 4,063 m. The LDA for RWY 12 is 4,063 m and is 3,764 m for RWY 30.

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

1.11 FLIGHT RECORDERS[2]

Both flight recorders were found intact

Cockpit Voice Recorder (CVR)

P/N: MARS-MB

S/N: 225014

The CVR was downloaded at the Interstate Aviation Committee (IAC), the contained recordings were found irrelevant to the Incident.

Flight Data Recorder (FDR)

Type: MLP-14-5

S/N: 30521

The FDR was downloaded at the IAC. The Investigation was not able to obtain a software copy due to system's limitations. Many snapshots were taken by the Investigation for the displayed screen in the FDR lab.

1.12 WRECKAGE AND IMPACT INFORMATION

The Aircraft was intact.

[2] The CVR and FDR were opened and downloaded at the Interstate Aviation Committee (IAC) premises in Russian Federation.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Not investigated.

1.14 FIRE

There was no sign of pre-landing fire.

The smoke that was noticed by the ATC was emitted due to the turbine overheat and the consequent mechanical damage.

1.15 SURVIVAL ASPECTS

The crew disembarked the Aircraft normally.

1.16 TESTS AND RESEARCHES

1.16.1 No. 2 Engine Forensic Examination

The engine was shipped to the manufacturer's facilities for forensic examination, the following were revealed:[3]

- Combustion cans showed signs of insignificant, within-limits, heat damage with cracks. A noticeable corrosion area due to concentrated heat and fire agent was found at the 6-O'clock position.
- The nozzle diaphragm of the 1st turbine stage was intact with discoloration marks due to overheat.
- Rotor blades of 1st turbine stage damaged at their tips.
- Approximately 80% of the rotor blades and NGVs of the 2nd to 6th turbine stages severely damaged.
- The examination did not reveal marks of damage due to foreign object.

Appendix B shows examples of no. 2 engine damaged parts.

[3] Engine forensic examination was performed during the period from 25 to 29 June 2012 at NPO "Saturn" Joint Stock Company, the Russian Federation.

1.16.2 Fuel Nozzles Testing[4]

The flow rate capacity test of the fuel nozzles was performed twice: before and after the removal of the burnt deposits.

The test revealed that the fuel consumption through the manifolds, the irregular atomisation and the angle of atomisation before and after removal of the burnt deposits were in conformance with the technical limitations.

Figure 2 shows the most fuel nozzle, out of twelve nozzles, that was adversely affected by residues of solid contaminants and existent gum.

After the removal of the burnt deposits, the test of all fuel nozzles characteristics revealed that they met the technical limitations.

Figure 2- the most affected fuel nozzle

1.16.3 Fuel Control Unit (FCU) Forensic Examination

Refer to Appendix D that shows a 3-D technical drawing of the FCU.

[4] The forensic examination of the fuel nozzles was performed during the engine forensic examination at Saturn. Reference Fuel nozzle test report dated 03.07.2012

The No. 2 engine FCU (P/N HP-30KII, S/N 10110124083) was examined and the following were revealed:

- The cap on the adjustment screw of the hydraulic booster was missing.
- The inlet filter was missing.
- No seals on the adjustment screws of the units were missing.
- Foreign particles such as sand were found at the central filtering unit.
- The strip off locking devices from a few connection
- The unit was completely disassembled and inspected. Some parts depicted significant corrosion. Foreign metal and other solid particles were found on the central filters of the unit.[5]

1.16.5 Fuel Sample Lab Test[6]

The drained fuel from the FCU was examined in the manufacturer's fuel and oil laboratory, most of the contents of the fuel contamination was 'existent gum' with 10.4 mg per 100 ml, whereas the permissible contamination for TC-1 fuel is 3.0 mg per 100 ml (Russian Standard: GOST 10227-86[7]) and for Jet A-1 is 7.0 mg per 100 ml (Russian Standard GOST R 5205-2006).

Out-of-limits solid and water particles were also found in the sample.

1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

1.17.1. The Operator

JSC "Abakan Avia Airlines" was founded in December 1992. The first flight was performed in July 1993.

At the time of this Report, the Operator's fleet comprised two lL-76T, four IL-76TD, three MIL-26, four MIL-8T, four MIL-8MTV, two MIL-2 and three Eurocopter AS-350B3.

The charter flights of the Operator cover different countries in South East Asia, Africa and Middle East.

The Operator operates flights for the United Nations most frequently to Sudan, Congo, Uganda, and Democratic Republic of Congo.

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5 Reference: the FCU manufacturer's forensic examination, report No. 48/12, dated 32 October 2012 after the forensic examination of the FCUunit parts (hp-30k no. 10110124083,-30K and T -30K No. T0506062)

6 Reference: the report of the Fuel and Oil Laboratory, Chief Metallurgist Department, Saturn, dated on 6 July 2012

7 GOST is the fuel standards of the Russian Federation

1.17.2 The Operator's Fuel Contamination Control System

According to the Refuelling Instruction Card carried on board the Aircraft: *"the fuel type shall be checked according to the standard reference to make sure of the following:*

- *The applicability to the aircraft type;*
- *Availability of the anti-icing additives;*
- *Date and time of checking the fuel in the bowser;*
- *Confirm the signature and stamp;*
- *Check the fuel for contamination and availability of out-of-limit water quantity;*
- *Open the hatch cover to centralized refuelling system and the cover to the shield;*
- *Make sure for electrical earthling;*
- *After 15 minutes of refuelling, drain 0.3-0.4 litre of fuel in 0.5 litre glass container and check for contamination and water."*

1.18 ADDITIONAL INFORMATION

1.18.2 Historical Similar Case

A similar engine failure incident occurred in the UAE on 27 October 2010 when the captain of IL-76TD advanced the engines power to 80% at the runway lineup as per the operations procedures and kept monitoring the relevant indicators. After approximately 20 s of power advancement, the captain observed low oil pressure on No. 2 engine indicator associated with vibration red alert, accordingly he retarded No. 2 engine throttle lever and instructed the flight engineer to switch the engine off by the fuel cut handle located at the central pedestal, the other three throttle leavers were also retarded to lower power setting.

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

Seven safety recommendations were designed in that report. Four safety recommendations were directed to the operator to: Carry out hot section inspections on the other similar engines installed on his IL-76TD fleet; enhance, after consultation with the engine manufacturer, the hot section inspection procedures and techniques especially on fuel nozzles; enhance his quality system to include audit activities on fuel suppliers and fuel contamination control during aircraft refueling; and enhance his maintenance program and maintenance practices to assure the reliability of the flight recorders, especially the CVRs, installed on his aircraft fleet.

One safety recommendation was directed to the CAA of the operator to carry out comprehensive oversight on the Operator to assure that he takes the necessary remedy actions on the aircraft inspection and quality system especially on fuel control.

One safety recommendation was directed to the GCAA of the UAE to establish a system of fuel sampling on random basis through cooperation with local specialized labs.

The seventh safety recommendation was directed to the Ilyushin Design Bureau to, 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. The response of the Ilyushin Design Bureau to the AAIS recommendation was that "*there is no issue with the fuel system periodic inspection from the design perspective and that the fuel flow failure was only due to operational issue and there is no essential need for changes on inspection tasks and/or intervals*."

1.18.3 The Existent Gum

The *existent gum* is a material that is usually found in the contents of the crude oil and is one of the heaviest hydrocarbon 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 existent gum at the fuel nozzles orifices narrows down the diameter of the orifice and thus results in 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 leads to heat stress due to differential heat distribution.

1.18.4 Departure and Destination Airports

Table 3 illustrates an extract from the Aircraft technical logbook of the departure and destination airports of the Aircraft during the period from March 2010 to January 2012 as well as the fuel supplier in each airport.

Table 3- Departure-destination airports with June 2011 to January 2012

Airport name	ICAO 4-letters designation	Fuel supplier
Kabul international Airport, Afghanistan	OAKB	DAWI OIL
Bagram Airport, Afghanistan	OAIX	DAWI OIL
Kandahar International Airport, Afghanistan	OAKN	DAWI OIL
Camp Bastion Airport, Afghanistan	OAZI	DAWI OIL
Herat International Airport, Afghanistan	OAHR	DAWI OIL
Sharjah International Airport, UAE	OMSJ	ADNOC/EMARAT
Al Maktoum International Airport, UAE	OMDW	ADNOC/EMARAT

Kuwait International Airport, Kuwait	OKBK	KAFCO
Jinnah International Airport, Karachi, Pakistan	OPKC	Pakistan State Oil Company
Dubai International Airport, UAE	OMDB	SHELL
Fujairah International Airport, UAE	OMFJ	ADNOC
Allama Iqbal International Airport, Lahore, Pakistan	OPLA	Pakistan State Oil Company

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

None.

2. ANALYSIS

The No. 2 engine turbine nozzle diaphragm and NGVs depicted marks of heat stress concentrated on the area expanding between the 6 to 9-O'clock positions. The turbine gas temperature (TGT) at that area was extreme due to the torch effect of the flame resulting from inhomogeneous fuel flow coming from the fuel nozzle located at position No. 7 (refer to figure 3) due to accumulated deposits resulted from the burn of the existent gum and other solid particles.

The malfunction of the FCU due to the surplus of contaminants adversely affected the homogeneity of fuel flow. The mechanical condition of the FCU made it vulnerable to contaminants from the environment: metal, sand and water particles penetrated the fuel system through improperly protected ports and lost filters. The contaminants accumulated on the FCU caused the moving parts inside the unit to stuck and consequently to malfunctioning FCU.

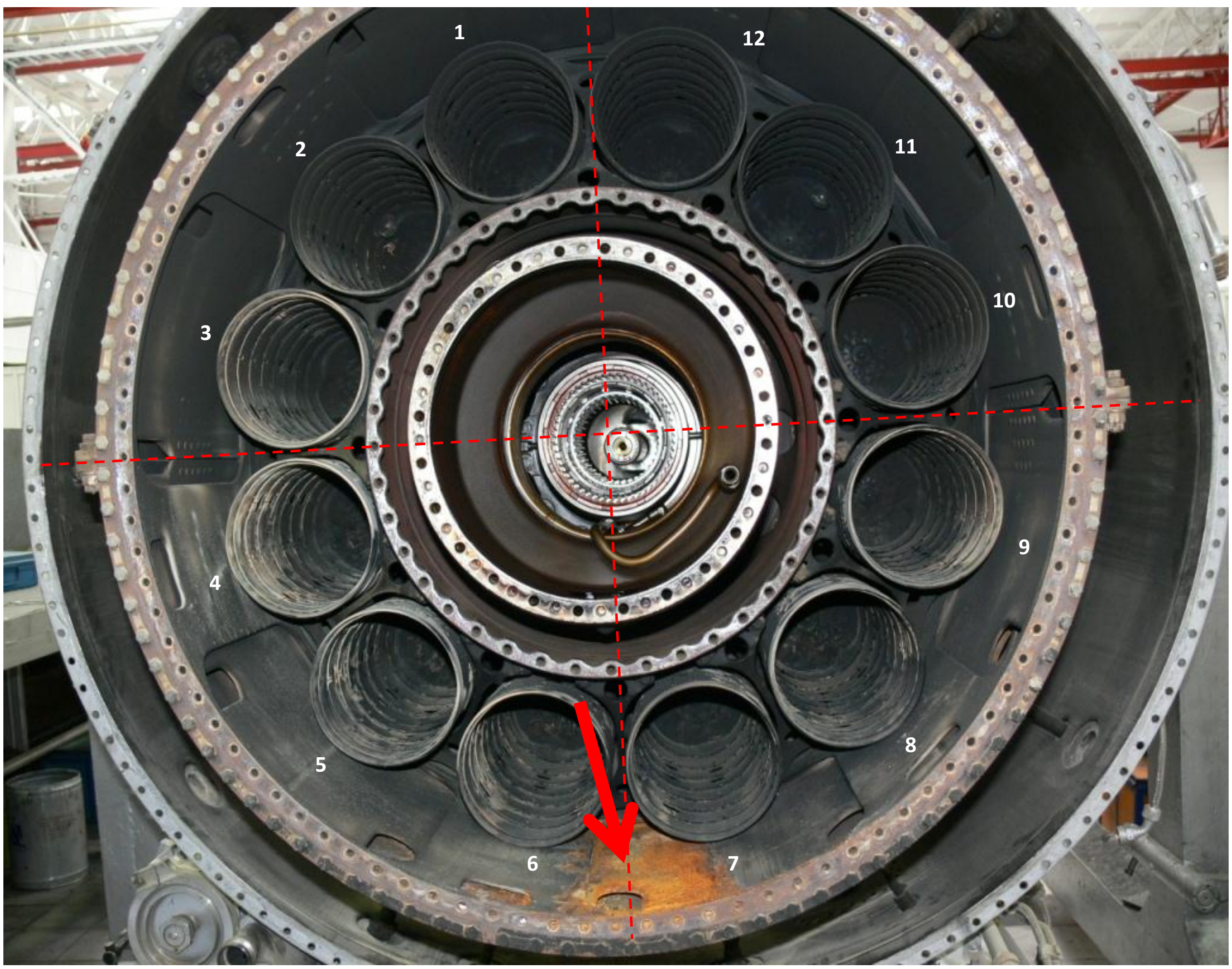

Figure 3- Combustion cans

According to the engine teardown report, the nozzle diaphragms of the 1st stage had shown insignificant damage with signs of overheat discoloration. The 1st stage of the turbine rotor showed damage at the tip of the blades whereas 80% of the turbine rotor blades and NGVs of the 2nd to 6th stages showed severe damage.

The Investigation finds that it is highly probable that one of the 2nd stage NGVs had dismantled after the heat stress reached to a critical point. The dismantled debris continued with the gas stream causing mechanical damage to the consequent parts of the turbine where they had already exposed to heat stress less than a critical point leading to their distortion and then dismantling.

During the last engine overhaul, which was accomplished on 17 May 2009; the fuel nozzles and the FCU were inspected and overhauled, thus the accumulation of the existent gum and other solid contaminants had started after that date and could not be detected thereafter since the on-wing inspections of the FCU was not sufficient. Moreover, the on-wing engine checks did not include steps to remove the fuel nozzles on the ramp and then to 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*[8], did not also include steps pertinent to fuel nozzles, nor there was an inspection technique that can detect the accumulation of contaminants in the FCU or their deposits on the fuel nozzles.

According to the Operator's maintenance schedule, the intervals between the fuel filters lab contamination checks was 150 hrs or Phase B check. The Investigation believes that the Operator's maintenance system was not sufficient to sort the removed contaminants during the filters inspection/cleaning and then investigate their origin in order to prevent their future accumulation before becoming significantly affecting the performance of the FCU.

The quality of the fuel would be hardly controlled since the Aircraft operation was widely diversified. The Aircraft used to fly amongst various continents; consequently the purity of fuel supplied by various fuel providers could not be assured. The fuel contamination would not be detected and prevented by inadequate fuel quality assurance system.

The chemical fuel contamination detectors that are usually used on the ramp by the maintenance personnel to test the fuel contamination during refueling are are not capable to detect the various kinds of contaminants. By such tests, the water may be the only contaminant that appears after the addition of the detection chemical. Solid particles may be seen in the fuel test ampule if their size is big enough to be seen by naked eyes. The existent gum and smaller solid particles are neither detectable by the chemical test powder nor observed by the maintenance personnel.

Auditing the fuels stations at various airports within the network of the Operator could have helped him figure out the potentials of such fuel beyond-limits contaminants, but there were no clues to the Investigation that the Operator had performed the necessary quality audits on his destination/departure airports including the fuel stations.

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[8] 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.

The Investigation believes that the temperature increase rate could have been addressed if the EGT indication system was working properly and the crew was monitoring the indicators on proper frequency (see Appendix E for EGT indicators). Proactive engine shutdown action could have been taken by the crew in order to save the engine. The Investigation could not determine either an EGT indication system malfunction or insufficient crew instrument monitoring was the cause of detecting the high EGT. Moreover no engine EGT pertinent check item was contained in the “After landing Checklist” that might have enhanced the engine indication crew awareness.

The UAE adopts Safety Assessment of Foreign Aircraft (SAFA) program which contains items pertinent to aircraft and operations. As other similar well-known systems such as the European SAFA, the GCAA SAFA checklist does not contain items pertinent to fuel contamination test.

Although the ramp fuel contamination test is limited to certain contaminants such as water and noticeable size solid particles, a mechanism for further tests and analysis could be improved to detect other contaminants such as smaller size solid particles and existent gum. This system may consider fuel sampling from certain points in the fuel supply system and examining it in the lab. Scheduling these broader extent tests could be based on statistical data that may infer the existence of such contaminants before their accumulation becomes significant.

Therefore, in order to minimize the risk associated with any flight operation, the Investigation believes that a more proactive approach can be implemented in the UAE to enact relevant regulations that authorize the GCAA SAFA inspectors to perform more fuel checks based on pre-established feasible program.

3. CONCLUSIONS

3.1 GENERAL

From the evidence available, the following findings, causes and contributing factors were made with respect to this Incident, these shall not be read as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this Investigation, the following sections are included in the "Conclusions" heading:

- **Findings-** are statements of all significant conditions, events or circumstances in this Incident. The findings are significant steps in this Incident sequence but they are not always causal or indicate deficiencies.
- **Causes-** are actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing factors-** are actions, omissions, events, conditions, or a combination thereof, which, directly contributed to this Incident and if eliminated or avoided, would have reduced the probability of this Incident occurring or mitigated the severity of its consequences.

3.2 FINDINGS

(a) The crewmembers possessed the required licenses and certificates issued by the Russian Federation State Oversight Flight Safety Department.

(b) The Aircraft was issued Certificates of Registration and Airworthiness by the Russian Federation State Oversight Flight Safety Department.

(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) The FCU was not functioning properly.

(e) The metered fuel to No. 2 engine was not as per the power setting pre-designed fuel flow.

(f) The contaminated fuel blocked partially one of the fuel nozzles leading to flame torch.

(g) The flame concentration heated a small area in the turbine NGVs where the temperature had raised significantly.

(h) The Investigation could not determine whether the EGT indication system was malfunctioning or the crew was not aware of that the increasing No. 2 engine EGT had reached exceeded the maximum EGT shown in the EGT cockpit gauge

(i) Part of the 2nd stage turbine nozzle guide vanes heated up until it failed due to heat stress and then dismantled.

(j) The subsequent turbine parts mechanically failed due to the domestic dismantled which went downstream.

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

(l) The Operator had no adequate quality program to audit outstations fuel stations.

(m) The fuel contaminations detectors were not able to detect the various types of contaminants.

(n) The Operator had lacked a properly established quality system which is sufficient to assure the quality of maintenance and operations functions.

(o) The UAE SAFA program is not broad to include fuel contamination check items.

3.3 CAUSES

The Air Accident Investigation Sector determines that the causes of this Incident were:

(a) The mechanical damage of No. 2 engine turbine;

(b) The damage started with a dismantled part that departed the 2nd stage NGVs due to heat stress;

(c) The subsequent turbine parts failed mechanically by the domestic dismantled object;

(d) The heat stress was caused by the malfunctioning FCU and flame torch coming out of one of the twelve fuel nozzles followed by uncontrolled gas temperature;

(e) The FCU malfunction was caused by beyond-limits contaminants.

3.4 CONTRIBUTING FACTORS TO THE INCIDENT

Contributing factors to the Incident were:

(a) Inadequate Operator's quality system that can proactively capture fuel contaminants;

(b) Inadequate Operator's maintenance control system to detect engine fuel system malfunction through efficient maintenance and inspection program; and

(c) Lack of crew awareness on the engine high EGT.

4. SAFETY RECOMMENDATIONS

4.1 GENERAL

The "Safety Recommendations" listed in this Report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation[9], and are based on the "Conclusions" listed in heading 3 of this Report, the GCAA expects that all safety issues identified by the Investigation are addressed by the receiving States and organizations.

4.2 FINAL REPORT SAFETY RECOMMENDATIONS

The Air Accident Investigation Sector recommends that:

4.2.1 The Operator to-

SR 62/2013

Carry out hot section inspections on the other similar engines installed on his IL-76TD fleet at the nearest scheduled check.

SR 63/2013

Enhance, after consultation with the engine and aircraft manufactures the engine fuel system inspection and maintenance program.

SR 64/2013

Reduce the intervals of filters lab contamination checks in order to be less than the current interval.

SR 65/2013

Enhance his quality system to include audit activities on fuel suppliers.

SR 66/2013

Enhance his fuel quality assurance system.

SR 67/2013

[9] Paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation states: "*At any stage of the investigation of an accident or incident, the accident or incident investigation authority of the State conducting the investigation shall recommend in a dated transmittal correspondence to the appropriate authorities, including those in other States, any preventive action that it considers necessary to be taken promptly to enhance aviation safety*".

Improve the "After Landing Checklist" in order to include engine instruments monitoring.

SR 68/2013

Establish procedures for providing the UAE GCAA with samples of fuel drained from various locations on the aircraft at a certain intervals.

4.2.2 The Russian State Oversight Flight Safety Department to-

SR 69/2013

Supervise and oversee the Operator's remedy actions to SR 62/2013 to SR 68/2013.

4.2.3 The Ilyushin Design Bureau to-

SR 70/2013

Together with the engine manufacturer, enhance the engine fuel system inspection and maintenance program and procedure.

4.2.4 The General Civil Aviation Authority of the United Arab Emirates to-

SR 71/2013

Improve its SAFA program by adding fuel test items on certain foreign operators based on scientific sampling program.

The fuel testing may be performed through a cooperation with UAE specialized fuel test labs.

Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates

APPENDIX A- ENGINE LOGBOOK SUMMARY

A. Engine Prolongation

Prolongation date	Prolongation to (in hrs since last L/OH):
7/12/1995	2,247
10/04/1996	2,568
18/06/1996	2,844
13/01/1997	3,152
17/04/1997	3,452
04/10/1997	3,595
12/12/1997	3,800
11/02/1998	3,902
27/11/1998	4,000
28/05/1998	6,500

B. Total Life Prolongation

On 27/05/1999, the Total Life Time was prolonged to 9,000 hrs/4,620 cycles

TBO was prolonged up to 2,332 hrs.

TBO 5,000 hrs (page 365).

Total Life Time: 12,000 hrs, 6,160, Ref.: document 44TY200-88

C. Engine Movement

On 21/04/2003, the engine was installed on another aircraft at No.2 position.

On 08/05/2008, the engine was removed from that aircraft for O/H

In July 2009, the engine was installed on RA76799, at No. 2position

The engine was removed in February 2012 after the Incident.

D. Engine Acceptance

Engine D-30Kp-2 No 53028602064 has been overhauled at Saturn IAW the Ref: 44TY200-88 and considered airworthy for operation.

Time till next OH: 4,000 hrs, 1540 Cycles, within calendar time 6 years, including 6 years conservation and packing by OH organization, storage in open area 4 years.

Engine Operation during this period not exceeding:

- On ground mode : 100 hrs
- Idle mode: 880 hrs
- Reverse mode: 2,400 hrs
- Number of starting: 2400

APPENDIX B- EXAMPLE OF ENGINE DAMAGED PARTS

Figure B1- Nozzle diaphragm overheat mark

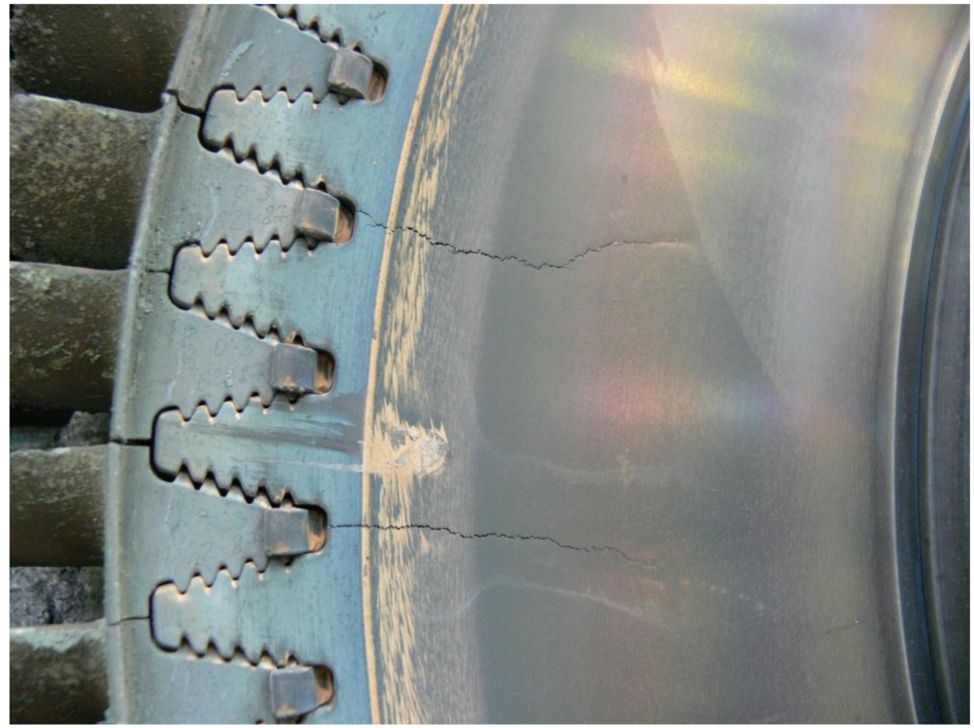


Figure B2- Example of turbine disc overheat discoloration and cracks

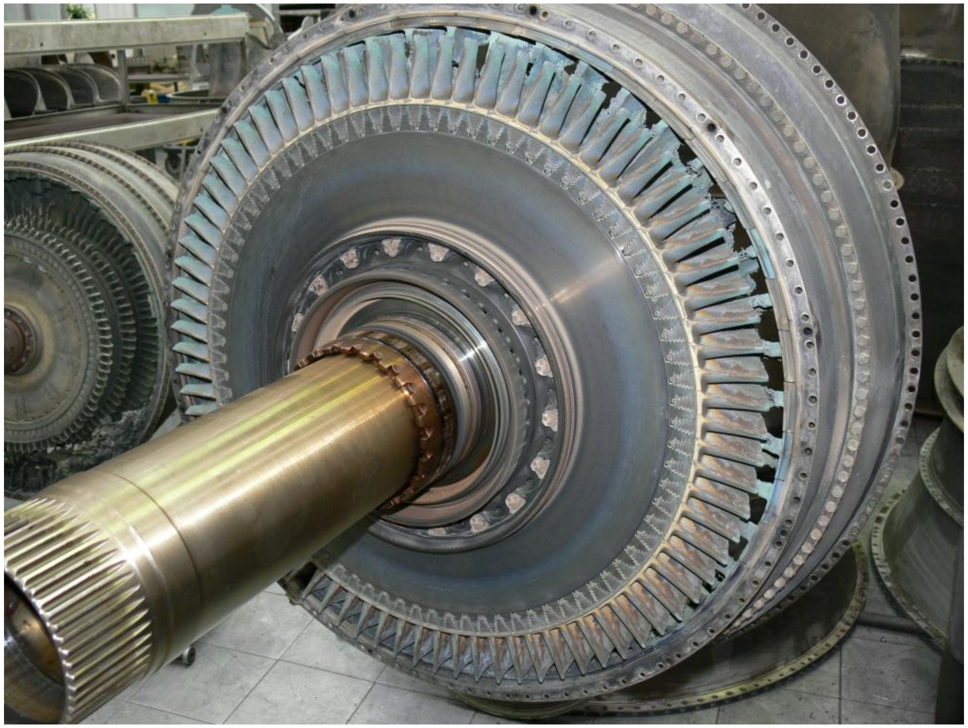
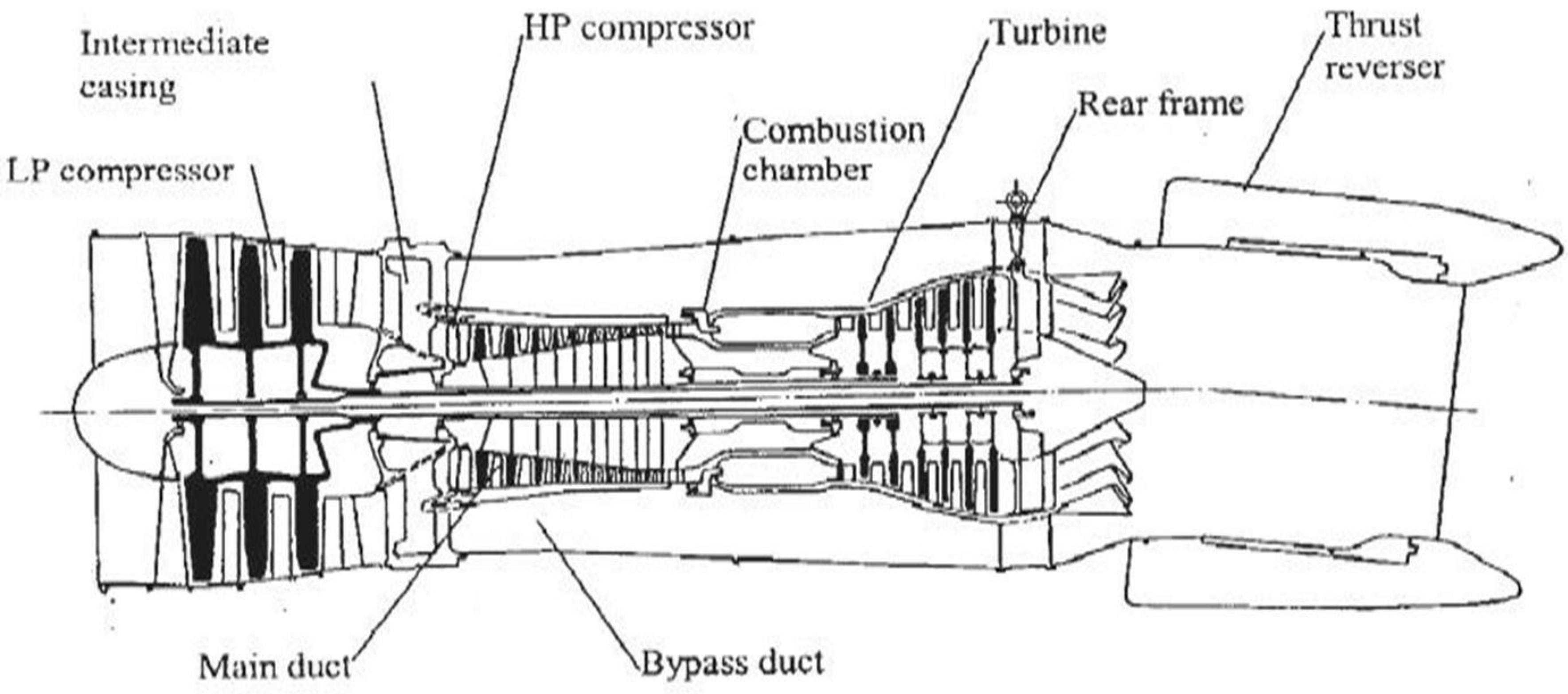


Figure B3- HPT damaged rotor blades

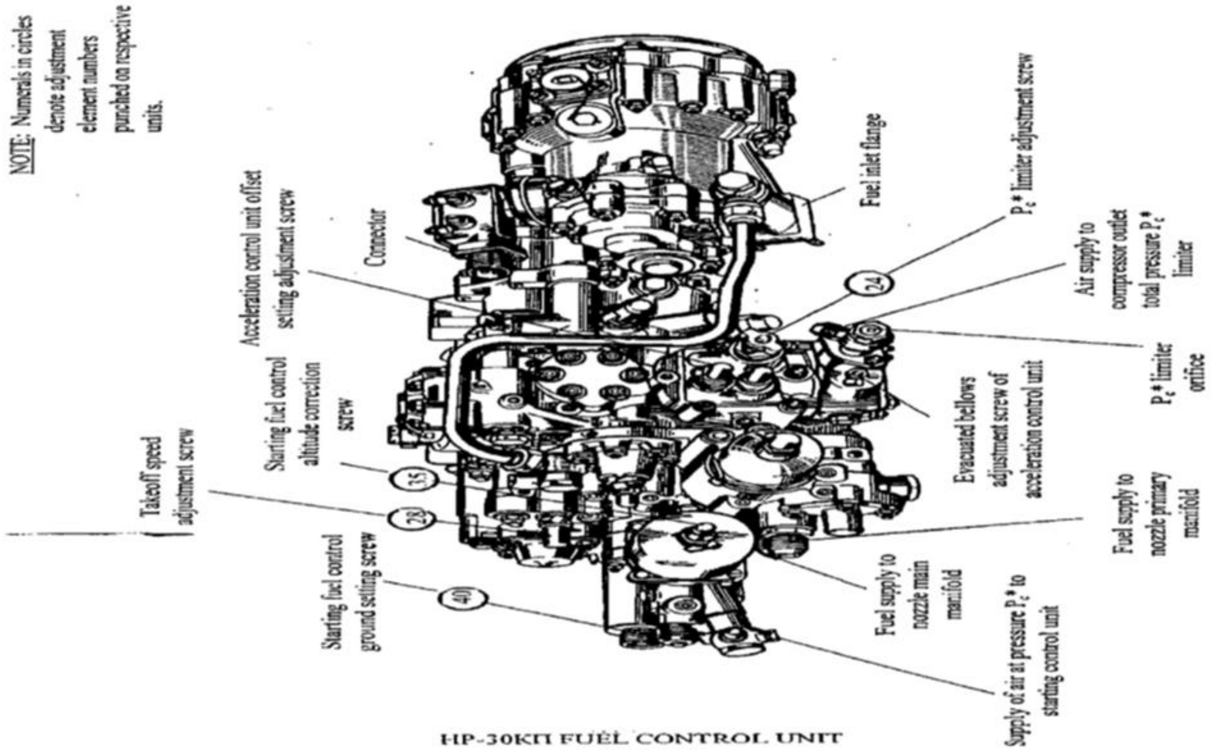
APPENDIX C- ENGINE SCHEMATIC

(Reference: IL-76TD Maintenance Manual, Part 4, Section 41- Powerplant-Engine)



APPENDIX D- FUEL CONTROL UNIT

IL 76
MAINTENANCE MANUAL



HP-30KП FUEL CONTROL UNIT
Figure 202

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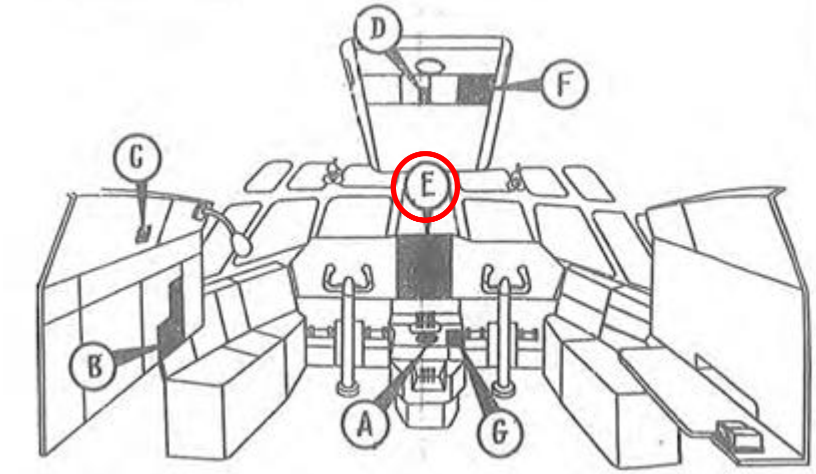
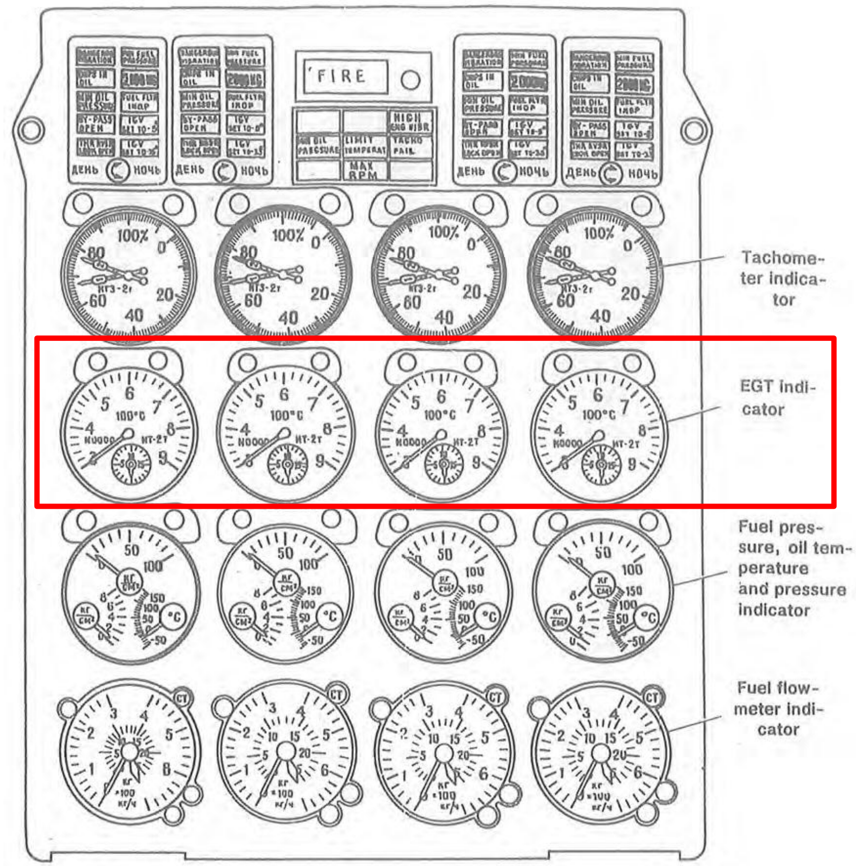
APPENDIX E- CENTRAL INSTRUMENT PANEL[10]





E Pilots' central instrument panel

[10] Reference: AFM, Book 2 (Sec. 6), 6.1 *Engines*