



PAKISTAN CIVIL AVIATION AUTHORITY
(SAFETY INVESTIGATION BOARD)



FINAL REPORT

SERIOUS INCIDENT OF IN-FLIGHT FIRE (ENGINE NO 2) M/S PIAC
FLIGHT NO. PK – 213, A310-308 AIRCRAFT, REG NO. AP-BEC,
(SECTOR KHI – DXB) AT JIAP, KARACHI
ON 06TH OCTOBER, 2013

FINAL REPORT

INVESTIGATION INTO SERIOUS INCIDENT OF INFLIGHT FIRE (ENGINE NO 2) M/S PIAC FLIGHT NO. PK – 213, A310-308 AIRCRAFT, REG NO. AP-BEC, (SECTOR KHI – DXB) AT JIAP, KARACHI ON 06TH OCTOBER, 2013

Synopsis

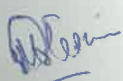
On 06th October 2013, M/s PIAC Airbus 310-308 aircraft, Reg # AP-BEC, Flight PK-213 (sector Karachi – Dubai) was a scheduled passenger flight. The flight took off at 1719 UTC from JIAP Karachi runway 25L and cleared for MELOM 2A by ATC Tower Controller JIAP Karachi. The aircraft followed the ATC Tower controller instructions and executed the departure. While passing 3000 ft of altitude, a loud bang was heard by the cockpit crew without observing any anomaly in aircraft instruments' indications. After few seconds No 2 (right) Engine Fire Warning came "ON". The No 2 engine fire drill was carried out and fire got extinguished after second Fire Bottle was operated. The physical fire presence on Engine No 2 was also confirmed by cabin crew. The affected engine was secured and all the recommended remedial actions as per QRH, FCOM and Ops Manual were carried out promptly by the cockpit crew. The Approach Radar was informed by cockpit crew at 17:20:39 UTC for immediate recovery back to JIAP, Karachi. The radar vectors were given to the mishap aircraft by Area Control Centre (ACC), Karachi and the mishap aircraft landed safely on runway 25R through single engine landing at 1733 UTC. All the emergency services responded promptly and after landing aircraft taxied back to Bay No 26 as no anomaly / physical fire was visually observed by emergency services staff.

Investigation Authority

DG CAA issued notification vide Letter No HQCAA/1901/361/SIB/545 dated 07th October, 2013 (attached as Appendix "A") authorizing Safety Investigation Board (SIB), CAA Pakistan to investigate the serious incident.

1. FACTUAL INFORMATION

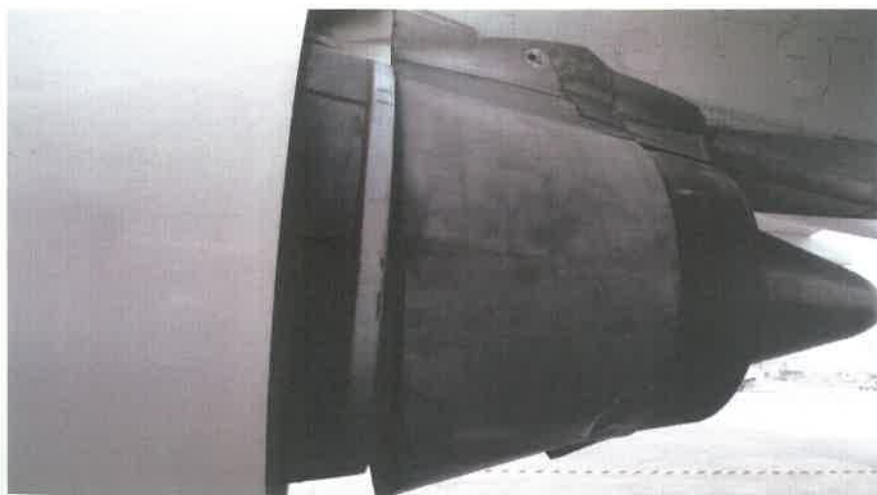
- 1.1 **History of the Flight.** The mishap aircraft had operated three scheduled revenue flights on sectors ISB-KHI, KHI-RUH and RUH-KHI before experiencing the in-flight fire serious incident while operating Flight PK-213 (Sector KHI-DXB) on 06th October, 2013. The Transit Check, Start-up, Taxi and Take-off were normal until the Engine No. 2 fire event.
- 1.2 **Injuries to Persons.** A total of 66 souls were onboard the mishap aircraft including operating crew. No one onboard the mishap aircraft received any minor / major injury as a result of this occurrence.
- 1.3 **Damage to Aircraft.** As a result of the said occurrence, mishap aircraft suffered extensive apparent damages on engine No 2 which included both Thrust Reverser cowls, Core cowls and electrical / engine build up items around Main Engine Control (MEC).



1.3.1 The physical damages are shown below:



Thrust reverser cowlings lower side damage from in-flight fire



Bursted and De-shaped Thrust reverser and Core cowl

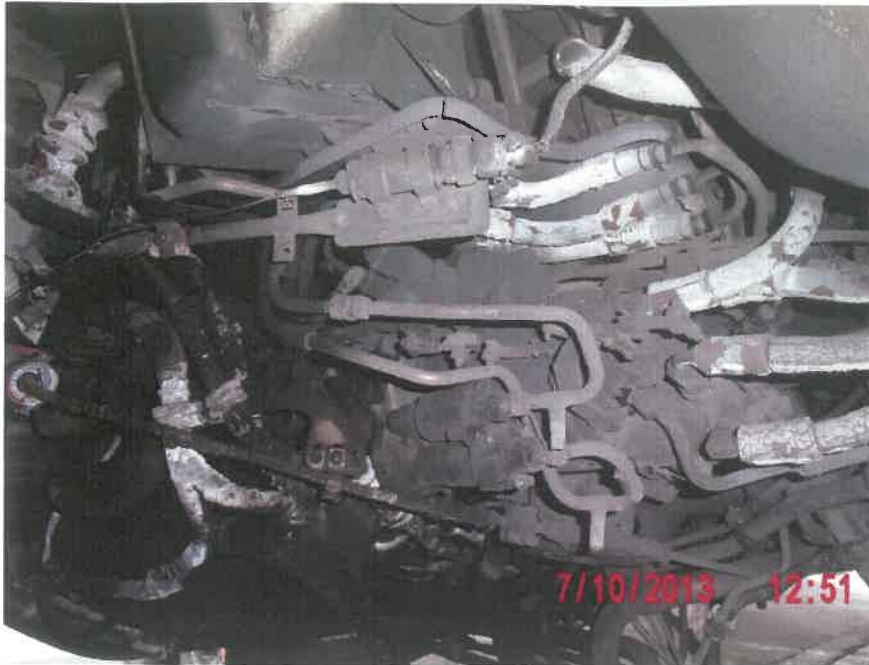


Right Hand Thrust Reverser Cowl Damage



Left Hand Thrust Reverser Cowl Damage

- 1.3.2 Some electrical and engine build up items around Main Engine Control (MEC) were found severely affected due to in-flight fire. The pictures of these damages are attached below:



Components on Lower Right Side of Engine around MEC



Components on Upper Right Side of Engine above MEC



Components Aft of MEC on Right Side of Engine



Burnt Fuel Hoses on MEC



Wiring Damaged by In-Flight Fire on Lower Right Side of Engine



Detailed View of Damages on Lower Side of Engine

- 1.4 **Other Damages.** No other apparent damage was observed to any other person, property or equipment on ground as a result of said serious incident.

[Signature]

[Signature]

- 1.5 **Cockpit Crew Information.** There was a set of two cockpit crew onboard the aircraft including Captain and First Officer. The cockpit crew detailed data is attached as Appendix "B", however brief details are as under:

(a) **Captain Jarrar Zafar**

• Date of Birth	:	06 th March, 1959
• Date of Last Medical	:	30 th May, 2013
• ATPL No	:	1059
• Date of last Simulator Check	:	03 rd May, 2013
• Flying experience total	:	10385:00 Hrs
• Total Command Experience	:	1478:00 Hrs
• On type Command Experience	:	299:00 Hrs
• CRM Refresher	:	30 th May, 2012

(b) **First Officer Shayan Junaid**

• Date of Birth	:	11 th July, 1985
• Date of Last Medical	:	30 th December, 2012
• CPL No	:	2636 valid till April, 2014
• Date of last Simulator Check	:	02 nd April, 2013
• Total Flying experience	:	3500:00 Hrs
• On Type Flying Experience	:	500:00 Hrs
• Total Command Experience	:	150:00 Hrs
• CRM Refresher	:	02 nd October, 2013

- 1.6 **Aircraft Information.** The mishap aircraft (Reg # AP-BEC) was inducted by M/s PIAC and taken on Pakistan Civil Register on 22nd November, 1990.

- 1.6.1 The detailed aircraft and engine related data is appended below:

AIRCRAFT GENERAL

Aircraft Type	A310-308
Aircraft Make	Airbus
Aircraft MSN	590
Aircraft FH Since New	72498
Aircraft Cycles Since New	25056
Aircraft Landings Since New	24959

ENGINES

Engine Type: CF6-80C2
Engine Make: General Electrics

	ENGINE NO.1	ENGINE NO. 2 (MISHAP ENGINE)
Engine Serial No.	695-411	695-403
Engine TSN	56062	59383
Engine CSN	18724	20604
Engine TSO	3812	1570
Engine CSO	1436	613
Engine TSI	3558	430
Engine CSI	1355	157
Engine installation date	04/12/2012	21/08/2013

1.6.2 The transit check of mishap aircraft was carried out on 06th October, 2103 prior to the departure of Flight PK-213 and no defect was recorded. No anomaly in any of the aircraft system performance was observed by cockpit crew before hearing a loud bang and experiencing in-flight fire on engine No 2.

1.7 **Meteorological information.** On 06th October, 2013 the weather reported by meteorological department JIAP, Karachi at 1700 UTC was 270°/09 kts, visibility 7 km, scattered at 2,000 ft, 28° / 22° QNH 1004 mb with no significant weather at and around JIAP, Karachi. The weather reported at 1730 UTC was 280°/10 kts, visibility 7 km, scattered at 2,000 ft, 28° / 23°, QNH 1004 mb with no significant weather at and around JIAP, Karachi (Refer Appendix "C").

1.8 **Navigation Aids.** Airbus 310-308 aircraft was equipped with serviceable ADF, VOR / DME and ILS equipment for the conduct of flying operations.

1.9 **Communication Aids.** Airbus 310-308 aircraft was equipped with serviceable two VHF and one HF radio set for its two way radio contact with all concerned / relevant agencies during the conduct of flight.

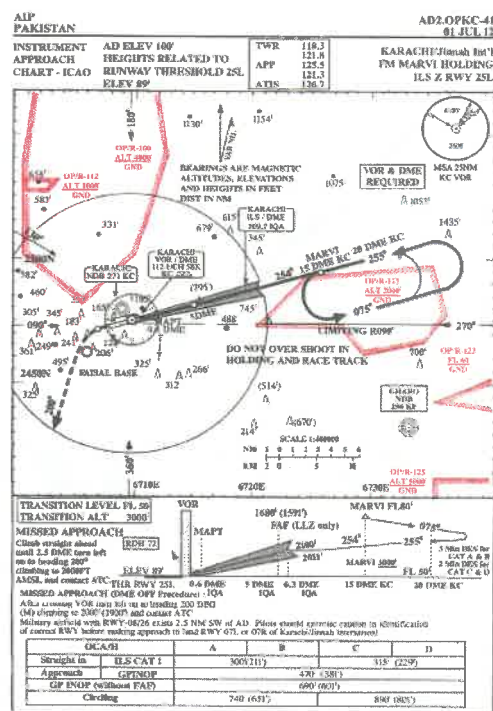
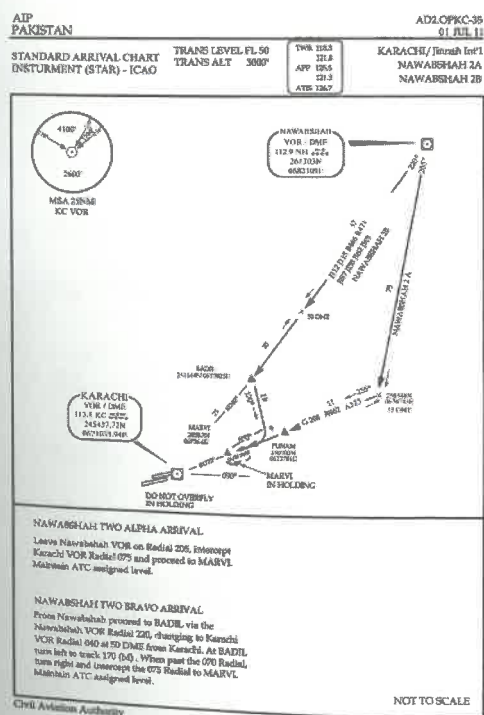
1.10 **Impact Information.** Not applicable

1.11 **Aids to Navigation Availability.** All the navigation aids were available and found serviceable at JIAP Karachi at the time of occurrence.

1.12 **Aids to Communications Availability.** All the communication facilities were available and found serviceable at JIAP Karachi at the time of occurrence.

1.13 **Aerodrome information**

1.13.1 The JIAP Karachi standard arrival chart along with ILS approach runway 25L are appended below:



1.13.2 The JIAP Karachi detailed aerodrome data is appended below:

OPKC AD 2.12 RUNWAY PHYSICAL CHARACTERISTICS					
Designations RWY NR	True bearing	Dimensions of RWY (M)	Strength (PCN) and surface of RWY and SWY	THR coordinates	THR elevation and highest elevation of TOL of precision APP RWY
07L	074.29	3200 x 45	54/R/C/X/U CONCRETE	245416.95N 0670561.02E	THR 23.50M / 77FT
25R	254.29		Aide for ACFT having Max T/O/F Weight Approx 42000 KG (115700 LB)	245444.85N 0671040.54E	THR 30.40M / 100FT
07R	074.29	3400 x 45	57/R/B/W/T CONCRETE	245402.15N 0670930.59E	THR 21.52M / 71FT
25L	254.29		SWY bitumen	245431.17N 0671030.29E	THR 27.25M / 89FT

Designations RWY NR	Slope of RWY/SWY	SWY dimension (M)	CHY dimension (M)	Slope dimension (M)	Obstacle Free Zone
07L	0.24% UP	305 x 45	914	3531 x 305	-
25R	0.166% LP	305 x 45	873x150	4753 x 150	-
07R		301 x 45	883		
25L		301 x 45	883x150		

Remarks: RWY 07R RESA - 95M X 123M					
OPKC AD 2.13 DECLARED DISTANCES (M)					
Designations RWY NR	TORA	ASDA	TODA	LDA	Remarks
07L	3200	3605	4114	3200	-
25R	3200	3605	3730	3200	-
07R	3400	3705	4270	3400	-
25L	3400	3705	3883	3400	-

OPKC AD 2.14 APPROACH AND RUNWAY LIGHTS									
Designations RWY NR	APCH LGT type LEN INTST	THR LGT colour WBAR	VASIS (HEH) PAPI	TOLW LGT LEN	RWY Centre line LGT Length spacing colour WBAR	RWY Edge line LGT Length spacing colour WBAR	RWY End LGT spacing colour WBAR	SWY LGT LEN (M) colour	Remarks
07L	PALS LH 330 M	GREEN	PAPI Left 3"	-	3200 M 60 M	RED	-	Stroke LGT	
25R	PALS LH 330 M	GREEN	PAPI Left 3"	-	WHITE LH 3400 M 60 M	RED	-	-	
07R	PALS LH 330 M	GREEN	PAPI Both sides 2.91"	-	3400 M 60 M	RED	-	-	
25L	PALS LH 300M	GREEN	PAPI Both sides 2.98"	900 M	Last 900 M alternate white/red	RED	-	-	Flareless

OPKC AD 2.16 ATIS COMMUNICATION FACILITIES					
Service description	Call sign	Frequency	Hours of operation	Remarks	
THR	KARACHI Tower	118.3 MHz	H24	Primary	
		118.8 MHz	H24	Secondary	
		121.5 MHz	H24	Emergency	
		121.6 MHz	H24	Primary	
		118.4 MHz	H24	Secondary	
APRON	Karachi Ground	121.5 MHz	H24	Vehicle	
		123.0 MHz	H24		
ATIS	ATIS	126.7 MHz	H24		
		125.5 MHz	H24	Primary	
		121.3 MHz	H24	Secondary	
APP	Karachi APP	121.5 MHz	H24	Emergency	
		121.5 MHz	H24		
DS	Radio	930 KHz	HX	0130-1900 HR	
DS	Pakistan	1450 KHz	HX	Variable SCHED	

OPKC AD 2.19 RADIO NAVIGATION AND LANDING AIDS						
Type of aid CAT of ILS (VAR VOR/ILS)	ID	Frequency	Hours of operation	Site of transmitting antenna coordinates	Elevation of DME transmitting antenna	Remarks
1	2	3	4	5	6	7
GP 25R L2 25R	Dots/Dashes INC	334.4 MHz	H24	045447.11N 0671029.32E	-	
110.1 MHz	H24	045413.64N 0670537.82E	-			
ILS CAT I (1°E) 1956	LDM	235 KHz	H24	045547.74N 0671449.51E	-	3.6 NM FM THR
75 MHz	H24	045453.00N 0671107.51E	-	0.67 NM FM THR		
GP/TIME 25L	Dots/Dashes	333.2 MHz CH 33	H24	045432.38N 0671037.51E	-	2.98° RM 72 FT
L2/L2L ILS CAT I (1°E) 1956	QA	129.7 MHz	H24	045159.00N 0670320.51E	-	
DME	KC	271 KHz	H24	045533.60N 0670336.29E	-	Coverage 500NM
VOR - NDB	KC	112.1 MHz CH 56K	H24	045437.72N 0671035.51E	37.83M	Coverage 200NM Radial 300 un-reliable

OPKC AD 2.16 ATS COMMUNICATION FACILITIES				
Service designation	Call sign	Frequency	Hours of operation	Remarks
TWR	KARACHI Tower	118.3 MHz	H24	Primary
		118.6 MHz	H24	Secondary
		121.5 MHz	H24	Emergency
APRON	Karachi Ground	121.6 MHz	H24	Primary
		118.4 MHz	H24	Secondary
		121.5 MHz	H24	Vehicle
		123.0 MHz	H24	
ATIS	ATIS	126.7 MHz	H24	
APP	Karachi APP	125.5 MHz	H24	Primary
	Karachi APP	121.3 MHz	H24	Secondary
	Karachi APP	121.5 MHz	H24	Emergency
SS	Radio	830 KHZ	HX	0130-1900 HRS
SS	Pakistan	8450 KHZ	HX	Variable SAVED

OPKC AD 2.19 RADIO NAVIGATION AND LANDING AIDS						
Type of aid CAT of ILS (VAR VOR/ILS)	ID	Frequency	Hours of operation	Site of transmitting antenna coordinates	Elevation of DME transmitting antenna	Remarks
GP 25R	Dots/Dashes	334.4 MHz	H24	045448.11N 0671029.30E	-	-
LZ 25R	MC	110.1 MHz	H24	045413.64N 0670937.81E	-	-
ILS CAT I (1°E) 25R						
LCM	KD	235 KHZ	H24	045547.74N 0671449.01E	-	3.8 NM FM THR
MM		75 MHz	H24	045453.08N 0671107.99E	-	0.57 NM FM THR
GP/DME 25L	Dots/Dashes	333.2 MHz CH 343	H24	045432.38N 0671013.96E	-	2.96 NM FM THR
LZ 25L ILS CAT I (1°E) 25R						
ILS	QA	100.7 MHz	H24	045159.00N 0670320.54E	-	-
NDB	KC	271 KHZ	H24	045523.60N 0670356.29E	-	Coverage 600NM
VOR - DME	KC	112.1 MHz CH 55K	H24	045427.72N 0671035.54E	37.83M	Coverage 200NM Radial 300 unreliable

1.14 **Fire.** After landing visible in-flight fire evidences were observed on Engine No 2 under cowl in the nacelle area around MEC. All the available evidences were collected and preserved for further examination and analysis.

1.15 **ATC Tape Extract.** ATC Tape Extracts (Refer Appendix "D") were retrieved for detailed analysis.

1.16 **Cockpit Voice Recorder (CVR) / Digital Flight Data Recorder (DFDR).** CVR and DFDR were retrieved for analyses by investigation team. The CVR and DFDR data was made available by using M/s PIAC facilities. The DFDR data did not reveal any anomaly before or during this occurrence. The N1, N2, EGT, Fuel flow and vibrations were within normal operating range.

1.17 **Crew Resource Management (CRM).** At the time of occurrence, Captain of aircraft was the Pilot Flying (PF) whereas FO was Pilot Monitoring (PM). Both the cockpit crew had valid CRM certification at the time of serious incident.

1.18 **Survival aspects.** Not applicable.

1.19 **Tests and research.** No special tests were performed. However, detailed visual inspections of engine and its related components were carried out and conformance to standard procedures and practices were verified to determine the root cause of occurrence.

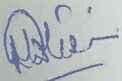
1.20 **Useful or effective investigation techniques.** References were made to QRH Procedures, Standard Operating Procedure, DFDR/CVR data, Crew statements, Aircraft Engineers statements and Aircraft Maintenance Manuals. For Technical investigation, Reverse engineering technique was used during investigation after acquiring of all evidences from the aircraft. The MEC of

Engine No 2 was removed in accordance with Aircraft Maintenance Manual and all parts / components of MEC were removed with care and recording of all torque values was carried out to find out the root cause of the serious incident.

2 ANALYSES

2.1 Operational Analysis

- 2.1.1 The mishap Flight PK-213 took off at 1719 UTC on 06th October, 2013 from runway 25L JIAP, Karachi for Dubai as per the schedule.
- 2.1.2 The flight after takeoff executed Standard Instrument Departure.
- 2.1.3 While the mishap flight was crossing 3000 ft of altitude, a loud bang was heard by the cockpit crew, however all instrument indications were normal (Refer Appendix "E").
- 2.1.4 After about 10 seconds, Engine No 2 Fire Warning Light came steady "ON". Subsequently, the presence of physical fire was also confirmed by cabin crew.
- 2.1.5 The cockpit crew carried out the remedial actions to handle in-flight fire on Engine No 2 as per QRH, FCOM and Operational Manual and secured the affected engine.
- 2.1.6 The Engine No 2 Fire Warning Light got extinguished after operating both the Fire Bottles.
- 2.1.7 The non normal situation was transmitted to Area Control Centre Karachi by cockpit crew for immediate recovery back to JIAP Karachi.
- 2.1.8 The mishap flight was given radar vectors for quick positioning of aircraft on ILS final approach for runway 25R JIAP, Karachi.
- 2.1.9 The mishap aircraft landed back safely at 1733 UTC with single engine.
- 2.1.10 The effective and efficient handling of mishap flight by radar controller since the in-flight fire incident reporting was acknowledged and appreciated by the cockpit crew.
- 2.1.11 As per the DFDR analysis, touchdown and landing parameters were well within the authorized limits.
- 2.1.12 The cockpit crew handled in-flight fire non-normal situation in an extremely professional manner while maintaining cool and calm environment on the flight deck.
- 2.1.13 All the emergency services responded very promptly and reached the mishap aircraft after landing on runway 25R at JIAP Karachi.



2.1.14 After confirmation regarding non existence of physical fire on the aircraft by the emergency services staff, the cockpit crew taxied back to the allocated stand and switched off the serviceable engine.

2.1.15 The passengers were disembarked through normal procedures.

2.2 Technical Analysis

2.2.1 History of Aircraft.

2.2.1.1 The Engine No 2 was installed on the mishap aircraft on 21st August 2013. There had been no reported defects / observation of fuel leakage from Engine No 2 till 30th September, 2013.

2.2.1.2 At Madina on 30th September 2013 just before departure of PK-744 on MED-KHI sector, severe fuel leakage was observed under Engine No 2. The leakage rate from engine drain mast was beyond Aircraft Maintenance Manual allowable limits. The troubleshooting revealed that fuel was coming from MEC drive pad. The MEC replacement was planned at Madina due to MEC shaft seal leakage. The flight coverage engineers of PK-744 left the aircraft and night stop was declared. The recovery team along with tools, equipment and components was arranged at Karachi for MEC replacement at Madina.

2.2.1.3 After the arrival of M/s PIAC Engineering recovery team at Madina, Engine No 2 MEC (Part No. 8061-889) replacement took place (Serial No. WYG 61534 was replaced with Serial No. WYG 55448). Additionally, Variable Stator Vane (VSV) and Variable Bypass Vane (VBV) static rigging was performed. Engine wet motoring along with fuel leak check was carried out and found satisfactory. Engine Idle power check was performed, fuel leak check on MEC was carried out after engine ground run-up and found satisfactory. Base check of MEC was carried forward as Base action and was performed after arrival of aircraft at Karachi. (Refer Appendix "F").

2.2.1.4 During Base action on 03rd October 2013, minor fuel leak was observed from Compressor Inlet Temperature (CIT) sensor signal P6 port. The CIT Nipple along with packing was replaced and fuel leak check was carried out as per Aircraft Maintenance Manual (AMM) and found satisfactory.

2.2.1.5 On 06th October, 2013 the incident of in-flight fire occurred. The mishap aircraft had flown fifteen revenue flights since MEC replacement at Madina without any reported defect of fuel leakage except minor fuel leakage observed from CIT sensor signal P6 port during Base action.

2.2.2 On Wing Examination

2.2.2.1 After the in-flight fire occurrence, during investigation when the Engine No. 2 Fire Handle was pushed "IN" without fuel booster pumps ON, fuel under gravity feeding was found leaking from top of MEC. Pictures attached below:



Fuel Leaking from Top of MEC Under Gravity



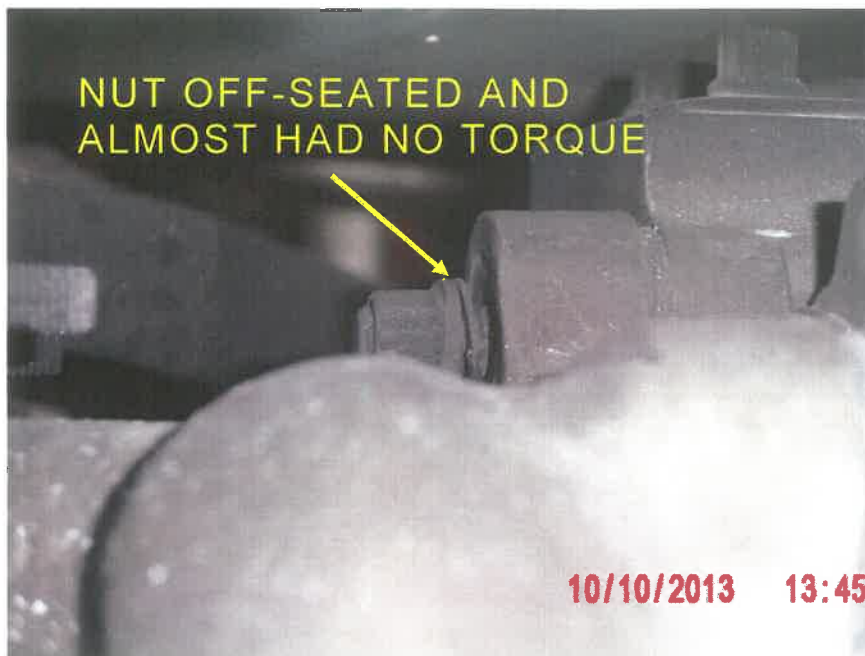
Fuel Leaking From top of MEC Under Gravity

- 2.2.2.2 During detailed visual inspection, one top MEC mount Nut Part No. J1092P05 was observed "off seated" from its actual torqued position. The pictorial evidence is appended below:

W. Lee

W. Lee

Page 12 of 29
W. Lee



MEC Top Nut "Off Seated" from its Position

- 2.2.2.3 All engine build-up items, ducting, lines / hoses and engine accessories were found intact during detailed visual inspection.



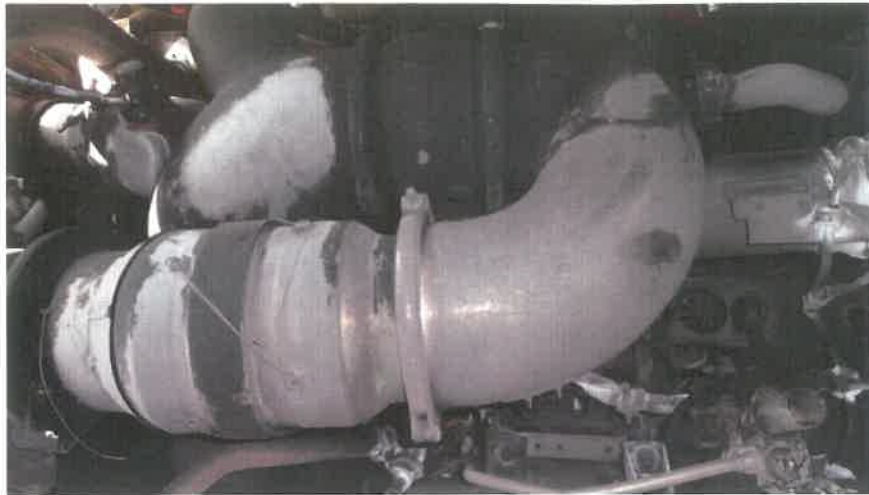
Right Lower Side of the Mishap Engine

DB

[Signature]

Page 13 of 29

[Signature]



Right Upper Side of the Mishap Engine



Left Lower Side of Mishap Engine



Left Upper Side of Mishap Engine

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

2.2.3 **Strip Examination in Power Plant Overhaul (PPOH) Shop.** After having detailed on wing examination and collection of evidences, Engine No 2 was removed from the aircraft for strip examination.

2.2.3.1 MEC Part No. 8061-889, Serial No. WYG55448, TSN/CSN: 41085/13785, of affected engine was removed in Power Plant Overhaul (PPOH) Shop for further examination. During removal of MEC, un-seated (opening) torques of MEC mount nuts were measured and recorded. The torque range as per Aircraft Maintenance Manual (AMM 73-21-01, Page 401, Refer Appendix "G") is 175 to 200 lbf in, whereas the measured un-seated torque values (Refer Appendix "H") were observed as 0, 60, 110, 310, 150 and 50 lbf in as shown below:



Measured Un-seated* Torque Values of MEC Mount Nuts



Mishap Gasket and MEC

Des

Ante

Page 15 of 29
PS



Removed Mishap MEC

2.2.3.2 Break (opening) torques of fuel hoses connecting on different ports of MEC were also measured and recorded. Following are the break torque values along with torque ranges as per AMM (Refer Appendix "G").

S/No	MEC OPENINGS	AMM TORQUE RANGE (lbf in)	MEASURED BREAK TORQUE (lbf in)
a	Variable Bypass Vane (VBV) rod-end port	180-200	175
b	VBV head-end port	270-300	50
c	Compressor Discharge Pressure (CDP) signal port	180-200	180
d	Variable Stator Vane (VSV) rod end port	270-300	150
e	VSV head end port	360-400	250
f	T2 sensor (P7) signal port	180-200	120
g	N1 sensor (P8) signal port	180-200	100
h	Overboard drain port	180-200	200
j	T2 sensor return (PB) port	270-300	350

k	Compressor Inlet Pressure (CIT) sensor signal (P6) port	180-200	120
L	Turbine clearance signal (Tc) port	180-200	180
M	Pressure Case Regulator (PCR) port	135-150	100
N	N1 sensor return (PBR) port	270-300	300
P	Compressor Bleed Pressure (CBP) port	135-150	350

2.2.3.3 One MEC mount washer Part No. AN960C516L was observed missing during removal of MEC.



One Washer Found Missing

2.2.3.4 It was also observed that one out of five washers was of more thickness (0.057 inch against the standard thickness of 0.022 – 0.042 inch.), refer CF6-80C2 Airbus Engine Illustrated Parts (IPC 72-00-05 Fig. 25) Accessory Drive Module – Main Engine Control (**Refer** Appendix "I"). The remaining four washers were of correct thickness (0.029, 0.031, 0.028, 0.029 inch).



One Washer of More Thickness

2.2.3.5 The conditions of Nuts Part No. J1092P05 and Studs Part No. MS51833A203-16 were also inspected and found normal.

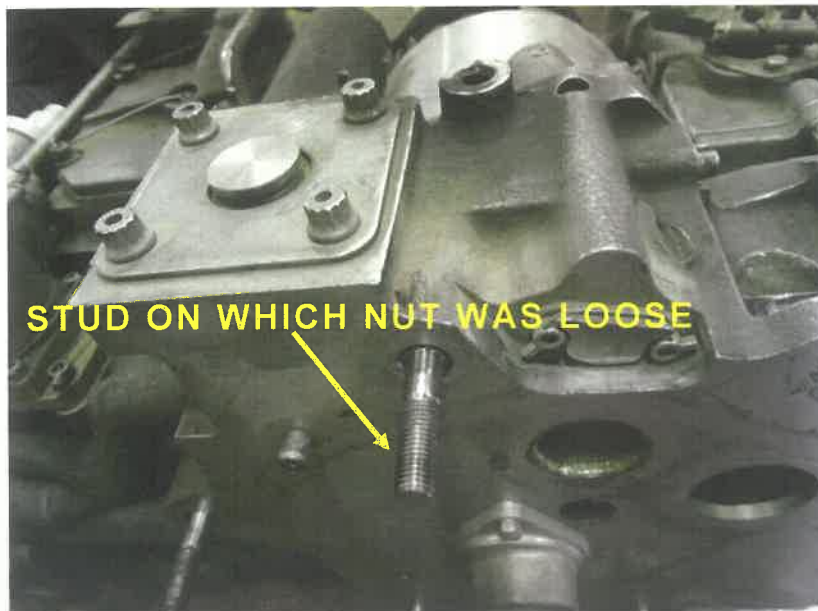
[Signature]

[Signature]

Page 17 of 29
RST



MEC Mounting Nuts Condition Normal



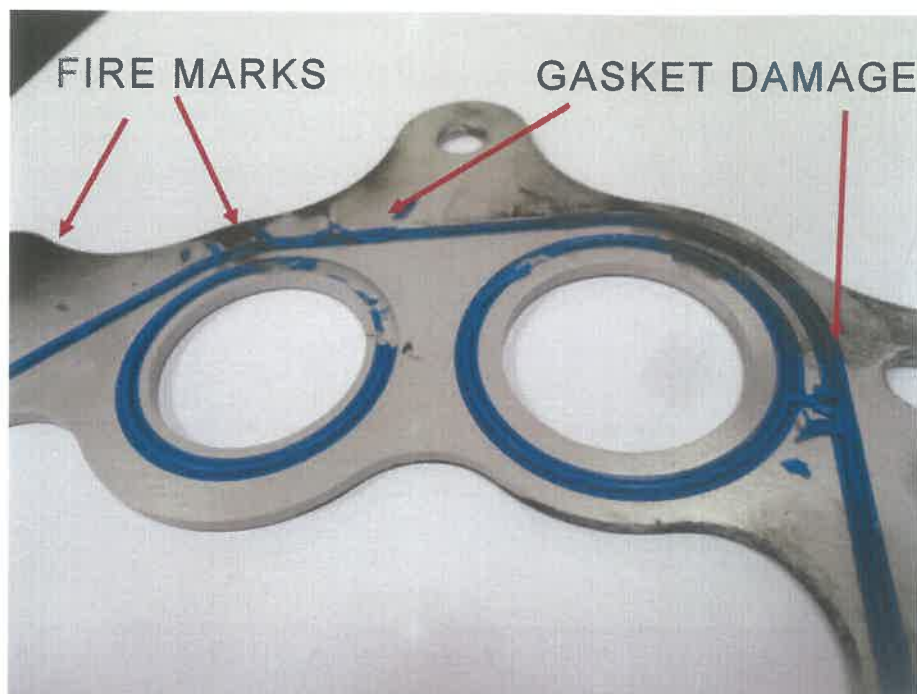
Condition of Stud Normal

- 2.2.3.6 The Blue coloured Fluorocarbon (Viton) rubber seal of MEC gasket Part number 9378M27P01 (TSN/CSN: 56/15), was found damaged. Black soot marks indicating Fire were visible on the upper half of the gasket and on its side facing the Accessory Gear Box (AGB). MEC gasket thickness was checked on surface plate but due to erosion / damage of seal, it was not possible. MEC gasket was also found slightly bent (metal part) after removal.

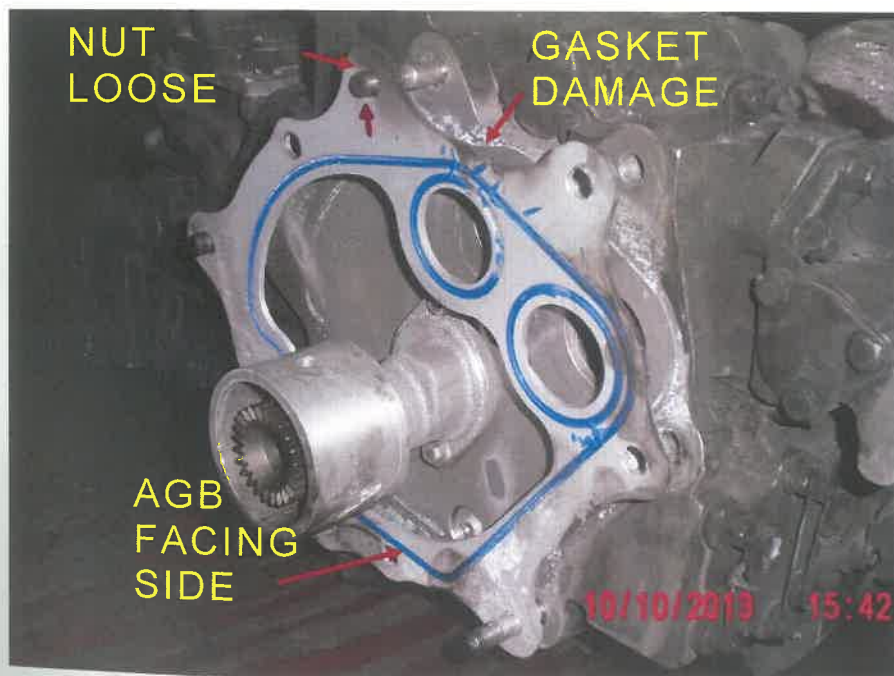
Blair

Ant

Page 18 of 29
P-28



MEC Gasket AGB Side Damage



Gasket along with MEC

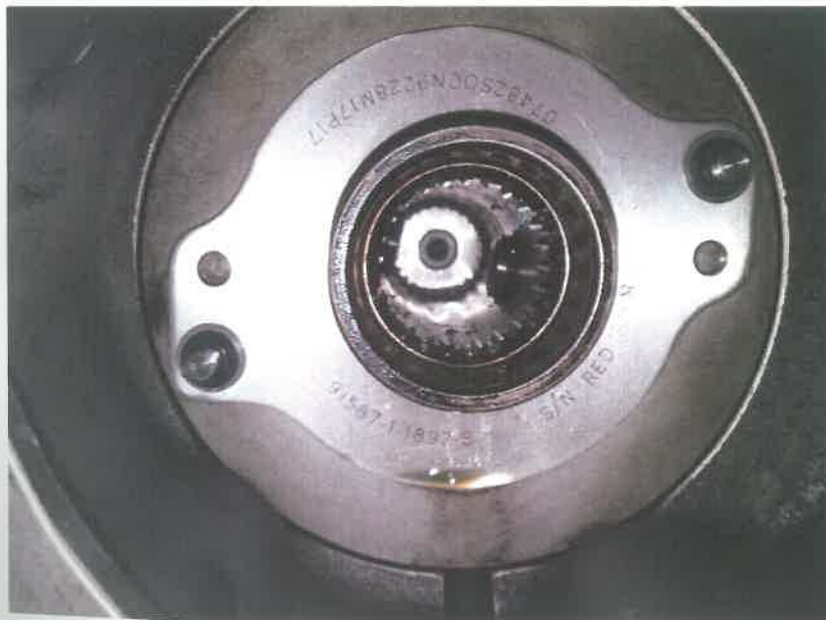
Adrian

W. Co. 6

2.2.3.7 Both the AGB and MEC faces contacting the Gasket were normal and were not damaged.

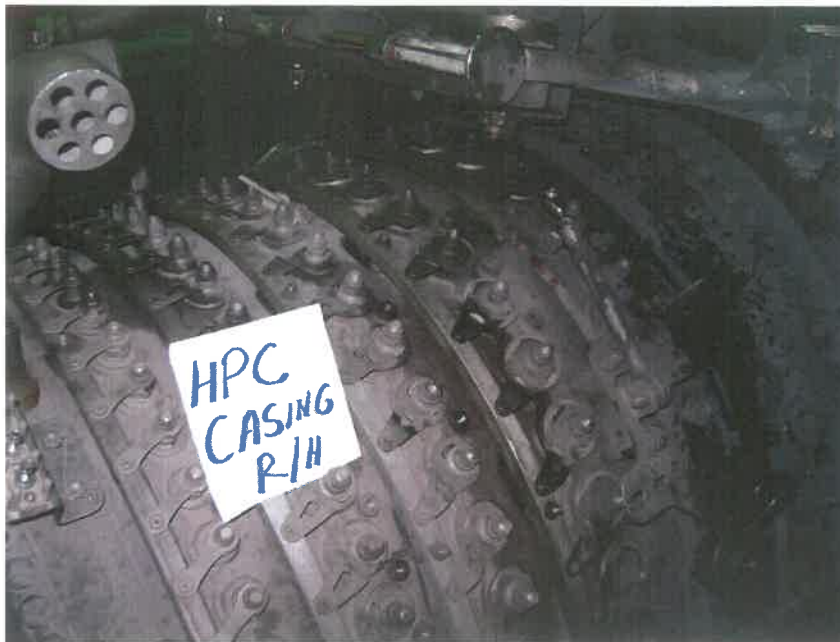


MEC Splines and Face



AGB Splines and Face

2.2.3.8 During strip examination of engine, no damage to the engine casing and its modules was observed. Only rubberized and soft material items / components were found damaged on the engine in nacelle area.



High Pressure Compressor Casing



High Pressure Turbine and Low Pressure Turbine Casing

[Signature]

[Signature]

[Signature]

2.2.3.9 Boroscope Inspection (BSI) of engine was carried out and no damage / discoloration on engine High Pressure Compressor (HPC) blades, combustion chamber and High Pressure Turbine (HPT) was observed. Only a few blades of HPT 1st stage had leading edge erosion and Thermal Barrier Coating (TBC) missing. One of the HPT blade had leading edge missing material in area-A. However, all these anomalies were not the result of in-flight fire occurrence and were also within the permissible AMM specified limits (Refer BSI Report attached as Appendix "J").

2.2.4 Circumstances Leading to Technical Errors

2.2.4.1 From the above mentioned examination and analysis, it was observed that MEC gasket became un-serviceable due to the inadequate torques applied, use of improper sized washer and missing of one out of six washers during MEC replacement at Madina.

2.2.4.2 Further investigation revealed that the Aircraft Engineer who had been detailed to go from Karachi for replacement of MEC was not properly rested before undertaking the task at Madina. He had performed night duty followed by frequent calls from the office during the day regarding his detailing and completion of departure formalities. He left his residence at 2115 PST, verified all the tools / equipment to be taken to Madina and departed to Madina on PK-735 at 2350 PST. Upon arrival at Madina (0430 PST), he immediately started to complete the assigned task due to high organizational pressures. It is evident from these facts that the Aircraft Engineer had been on job for the last about twenty one hours (since departure from his residence) in violation of organizational documented procedures (Refer Appendix "K"). Subsequent replacement of MEC was completed at about 1800 PST indicating the extent of prolonged working hours resulting into fatigue and unnecessary stresses on the Aircraft Engineer.

2.2.4.3 It was also observed that Duplicate Inspection essentially required as per ANO-001-AWRG-5.0 after installation of Engine Controls was not carried out at Madina mainly due to non-detailing of another aircraft engineer (Refer Statement of the Aircraft Engineer Appendix "O").

2.2.4.4 While releasing the aircraft to service at Madina, the Aircraft engineer logged in the Technical Log book that Base action was to be performed at Karachi, which is a routine action whenever any major rectification / repair work is carried out away from the Base station. However, during accomplishment of Base action, the re-verification of maintenance away from Base was not properly performed which led to the anomaly of MEC mount nut remaining off seated. Moreover, the mandatory requirement of Duplicate Inspection which was left over at Madina was also not fulfilled during re-verification of work.

2.2.4.5 The mishap aircraft flew fifteen flights prior to the occurrence of Engine No 2 in-flight fire mainly due to the fact that the rubber seal embedded in the gasket did not give in initially. Subsequently due to the un-evenness of torque values, one missing washer and another oversized washer, and one nut not tightened at all resulted into unsymmetrical loading on the gasket and forcing the rubber seal to rupture. In the mishap flight, the ruptured rubber

seal could not withstand the fuel feeding into the MEC under pressure and heavy fuel leakage started from it. The accumulated and vaporized fuel caught fire when it came in contact with the hot area resulting into intense in-flight fire.

2.2.5 Significant Observations

2.2.5.1 Technical

2.2.5.1.1 Duplicate Inspection was not carried out after replacement of MEC at Madina mainly due to inordinate importance given to the safety inspection after maintenance performed on the Engine Controls essentially required as per ANO-001-AWRG-5.0 (Refer Appendix "L").

2.2.5.1.2 Duplicate Inspection has also not been properly defined in the Engineering Procedure Manual (EPM) or Maintenance Organization Exposition (MOE) (Refer Appendix "M").

2.2.5.1.3 Details of Base action criteria and scope are not adequately elaborated in Line Maintenance EPM or MOE to facilitate the maintenance personnel in performing their task in accordance with Standard and Recommended Practices (SARPs).

2.2.5.2 **Human Factors.** The Human factors (Refer Statements Appendix "O") which led to errors involved in the serious incident are; Lack of Awareness, Lack of Resources, Pressures, Stress and Fatigue. These are briefly described in the proceeding paras:

2.2.5.2.1 **Lack of Awareness.** The Maintenance Staff sent for MEC replacement was not aware of their individual job description as analyzed through their explanations and interviews.

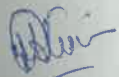
2.2.5.2.2 **Lack of Resources.** No spare sets of MEC mounting nuts and washers were available along with the team sent to Madina for replacement of MEC to cater for any unforeseen situation. Similarly, no other aircraft engineer was sent to Madina for carrying out Duplicate Inspection after MEC replacement.

2.2.5.2.3 **Pressures.** The unnecessary persistent management pressure was observed on the maintenance team for expeditious recovery of the aircraft detained at Madina to meet further scheduling requirements.

2.2.5.2.4 **Stress.** The maintenance team replaced the MEC at Madina with limited spares and resources which led to non-conformance of AMM procedures.

2.2.5.2.5 **Fatigue.** The aircraft engineer detailed for MEC replacement at Madina had already performed his last duty in the night shift. Subsequently insufficient rest, stress and travelling discomfort were the factors leading to fatigue.

2.2.5.3 Safety recommendations were forwarded to CAA Pakistan {Cessna-172D Reg # AP-BHT forced landing accident investigation



finalization (Refer Appendix "N") regarding Duplicate Inspection system which have not yet been implemented. Same are appended below:

2.2.5.3.1 CAA Pakistan is to devise a mechanism for strict implementation of Duplicate Inspection System of all vital points and control systems by all operators, maintenance organizations and airworthiness inspectors.

2.2.5.3.2 All operators and maintenance organizations are to ensure that the requirements listed in Duplicate Inspection Checklist / Task Card cover elaborately all the vital steps as per the OEM recommended procedures in the applicable service manuals / publications.

3 Findings

3.1 Operational

3.1.1 The mishap Flight PK-213 took off at 1719 UTC on 06th October, 2013 from runway 25L JIAP, Karachi for Dubai as per the schedule.

3.1.2 The flight after takeoff executed Standard Instrument Departure.

3.1.3 While the mishap flight was crossing 3000 ft of altitude, a loud bang was heard by the cockpit crew with all instrument indications normal. However, Engine No 2 Fire Warning Light came steady "ON" after about 10 seconds.

3.1.4 The presence of physical fire on Engine No 2 was also confirmed to the cockpit crew by cabin crew.

3.1.5 The cockpit crew carried out the correct recommended remedial actions to handle in-flight fire on Engine No 2 as per QRH, FCOM and Operational Manual and secured the affected engine.

3.1.6 The Engine No 2 Fire Warning Light got extinguished after operating both the Fire Bottles.

3.1.7 The non normal situation was transmitted to Area Control Centre Karachi by cockpit crew for immediate recovery back to JIAP Karachi.

3.1.8 The mishap flight was given radar vectors for quick positioning of aircraft on ILS final approach for runway 25R JIAP, Karachi.

3.1.9 The mishap aircraft landed back safely at 1733 UTC with single engine.

3.1.10 The effective and efficient handling of mishap flight by radar controller after experiencing in-flight fire was acknowledged and appreciated by the cockpit crew.

3.1.11 As per the DFDR analysis, touchdown and landing parameters were well within the authorized limits.

3.1.12 The cockpit crew handled in-flight fire non-normal situation in an extremely professional manner while maintaining cool and calm environment on the flight deck.

3.1.13 All the emergency services responded very promptly and reached the mishap aircraft after landing on runway 25R at JIAP Karachi.

3.1.14 After confirmation by emergency services staff regarding non existence of physical fire on mishap aircraft, the cockpit crew taxied back to the allocated stand and switched off the serviceable engine.

3.1.15 The passengers were disembarked through normal procedures.

3.2 Technical

3.2.1 The mishap aircraft was serviceable on the day of occurrence, was properly serviced and inspected before flight.

3.2.2 There was no outstanding defect related to Engine No 2.

3.2.3 After experiencing the in-flight fire on Engine No 2, the cockpit crew took the remedial actions and landed back safely without encountering any other anomaly related to aircraft or engine systems / sub-systems.

3.2.4 During post occurrence inspection, extensive fire damage effects were observed in under cowl nacelle area, lower half of Thrust Reverser and Core cowl of Engine No 2.

3.2.5 During trouble shooting, when Fire Handle was pushed in to reset, heavy fuel leakage was observed from the top of MEC.

3.2.6 No fuel leakage was observed from any other engine component.

3.2.7 Subsequent strip examination revealed improper torquing of MEC six mounting nuts.

3.2.8 One MEC mounting nut on top side was found off-seated (in zero torque condition); whereas, threads of its stud and nut were in satisfactory condition.

3.2.9 Four mounting nuts had varying torque values less than the lower limit (175 lbf in).

3.2.10 The sixth nut had torque value much higher than the upper limit (200 lbf in).

3.2.11 Out of six washers installed with these nuts, one was completely missing and another one was of more thickness than the specified limits.

3.2.12 History of the previously performed maintenance revealed that MEC was replaced at Madina on 02nd October, 2013 fifteen flights before the occurrence.

3.2.13 The different un-seated torque values of MEC mounting nuts indicate that proper tooling / torque meter was not used during MEC installation at Madina.

3.2.14 The break torque values recorded during removal of fuel hoses installed on the MEC were varying in relevance to installation torque values as mentioned

in the relevant AMM which also pointed towards noncompliance of MEC installation procedure.

3.2.15 The missing of one MEC mount nut washer and another of more thickness indicated nonconformity of AMM procedure.

3.2.16 No spare mounting nut and washer was carried by the team for replacement of MEC at Madina.

3.2.17 Duplicate Inspection of Engine Controls after MEC replacement contrary to Operator and Regulatory requirement was not performed at Madina.

3.2.18 The improper torqueing of MEC mounting nuts could not be detected and essentially required Duplicate Inspection of Engine Controls was also not performed during Base action after arrival of the aircraft at base station Karachi.

3.2.19 The un-evenness of torque values, one missing washer, one over sized washer and one nut not tightened at all, resulted into unsymmetrical loading on the gasket and forced the rubber seal to rupture.

3.2.20 The ruptured rubber seal could not withstand the fuel pressure in the input and output fuel ports of MEC and heavy fuel leakage started from it.

3.2.21 The accumulated and vaporized fuel caught fire when it came in contact with the hot area resulting in explosion and intense in-flight fire.

3.2.22 There was no abnormality on the mating surfaces of MEC and AGB which could lead to gasket damage.

3.2.23 The extent of damage as a result of in-flight fire was limited to nacelle area surrounding the MEC.

3.2.24 There was no internal damage to the engine core.

3.2.25 The human and logistics resources for retrieval of aircraft and MEC replacement at Madina were not managed properly by operator which led to number of errors committed by the engineering recovery team.

4 **Summary of Factors Leading to the Serious Incident of In-Flight Fire.**
The summary of factors which led to the serious incident of in-flight fire on Engine No 2 are appended below:

4.1 Non conformance of OEM recommended procedures and violation of laid down instructions during and after MEC replacement.

4.2 Non-availability of sufficient spares with the recovery team to cater for any unforeseen requirement during the assigned task at Madina.

4.3 Violation of Air Navigation Order ANO-001-AWRG-5.0 whereby Duplicate Inspection was not performed.

4.4 Fatigue and stress on the Aircraft Engineer resulting from inadequate rest before undertaking MEC replacement task and organizational demands for expeditious recovery of the aircraft.

4.5 Number of Managerial lapses contributed towards the Maintenance Errors and non-conformance to the Standard and Recommended Practices. Significant Managerial lapses are appended below:

4.5.1 Arrangement of properly rested Aircraft Engineer

4.5.2 Availability of sufficient spares (consumable / non-consumable) to cater for 100 percent or on-condition replacement items

4.5.3 Properly defined maintenance requirements

4.5.4 Availability of Qualified Aircraft Engineer for performing Duplicate Inspection

5 Conclusion

5.1 The mishap aircraft experienced in-flight fire on Engine No 2 after takeoff from JIAP, Karachi. The cockpit crew promptly carried out the remedial corrective actions as per QRH, FCOM and Ops Manual. The affected engine was secured / switched off. The aircraft safely landed back at JIAP Karachi through shortest positioning for runway 25R by Area Control Centre JIAP Karachi.

5.2 Fifteen flights prior to this in-flight fire serious incident, the MEC on Engine No 2 was replaced at Madina. Number of non conformances and maintenance errors committed during replacement of MEC resulted into its improper installation which subsequently damaged the gasket installed between the MEC and the AGB. The damaged gasket caused heavy fuel leakage which accumulated, vaporized and resulted in explosion followed by in-flight fire.

5.3 Number of managerial lapses regarding proper planning and management of resources by M/s PIAC were the significant contributory factors leading to the said non conformances and maintenance errors.

6 Finalization

6.1 The cause of in-flight fire serious incident was heavy fuel leakage from the joint of Engine No 2 MEC and AGB due to the damaged gasket caused by poor maintenance working ethics and non implementation of standard and recommended procedures / practices at operator level during and after last MEC installation.

7 Safety Recommendations

7.1 M/s PIAC is to ensure the following:

7.1.1 Standard procedures laid down by the OEM are implemented in letter and spirit at all levels.

- 7.1.2 Whenever a retrieval team is arranged for any maintenance task away from the base, the concerned officials are to ensure that the team is properly prepared along with the required resources (including man, material and tooling) to perform the task requirements mandated by the OEM and Regulatory authorities.
- 7.1.3 A comprehensive list of items elaborating all Vital Points and Control Systems for Duplicate Inspection is prepared and included in the Maintenance Organization Exposition (MOE) and Engineering Procedure Manual (EPM) for clarity and compliance at all levels of maintenance.
- 7.1.4 Scope of Base action for re-verification of maintenance performed away from the Base is clearly explained in MOE and EPM.
- 7.1.5 Quality Assurance section is made responsible for implementation of all OEM and Regulatory requirements.
- 7.1.6 M/s PIAC is to conduct recurrent training for all Engineering and Maintenance Personnel highlighting the findings and safety recommendations of this in-flight fire serious incident.
- 7.1.7 M/s PIAC may like to commend the cockpit crew of mishap flight for handling a serious in-flight emergency in a professional manner.
- 7.2 All operators and maintenance organizations are to ensure that vital points and control systems are clearly identified from the applicable service manuals / publications and listed in the maintenance program / schedule approved by DG CAA Pakistan.
- 7.3 CAA Pakistan is to study and devise a mechanism for strict implementation of Duplicate Inspection System of all Vital Points and Control Systems by all operators, maintenance organizations and airworthiness inspectors.
- 7.4 CAA Pakistan may like to commend the involved Area Control Centre (ACC) and Air Traffic Control Tower (ATC) controllers for professional handling of mishap flight to execute immediate recovery and safe landing at runway 25R JIAP Karachi.

