AIRCRAFT ACCIDENT REPORT SI 05/15

Air Accident Investigation Bureau
Ministry of Transport, Malaysia

Final Report on the Serious Incident involving
Fixed wing aircraft ATR72-600 Registration 9M-LMG
in Penang, Malaysia on 28th May 2015

INTRODUCTION

The Air Accident Investigation Bureau of Malaysia

The Air Accident Investigation Bureau of Malaysia (AAIB) is the air accidents and serious incidents investigation authority in Malaysia and is responsible to the Minister of Transport. Its mission is to promote aviation safety through the conduct of independent and objective investigation into air accidents and serious incidents.

The AAIB conducts the investigations in accordance with Annex 13 to the Chicago Convention and Civil Aviation Regulations of Malaysia 2016.

In carrying out the investigations, the AAIB will adhere to ICAO's stated objective, which is as follows:

"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability".

Accordingly, it is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

AIRCRAFT SERIOUS INCIDENT REPORT SI 05/15

Aircraft Type	**:**	**ATR72-600**
Model	**:**	**ATR72-212A**
Owner	**:**	**Malindo Air**
Nationality	**:**	**Malaysia**
Year of Manufacture	**:**	**2013**
Aircraft Registration	**:**	**9M-LMG**
Serial Number	**:**	**1089**
State of Registration	**:**	**Malaysia**
State of Operator	**:**	**Malaysia**
Place and State of Occurrence	**:**	**Penang International Airport, Penang, Malaysia**
Date and Time of Occurrence	**:**	**28.05.2015 1317hrs (LT)**

All times in this report are Local Time (LT) (UTC +8 hours)

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SYNOPSIS

On the 28th May 2015, an ATR72-212A aircraft operated by Malindo Air bearing registration 9M-LMG with a flight number OD1165 departed out of Penang International Airport, Penang (PEN) en-route to Sultan Abdul Aziz Shah International Airport, Subang (SZB).

After take-off from PEN, the aircraft suffered a No. 01 engine fire. Procedures were carried out by the operating crew and after the procedures completed the aircraft returned to the airport and landed safely.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On the 28th May 2015 at approximately 1317hrs (LT), an ATR72-212A aircraft en-route from PEN to SZB with registration number 9M-LMG bearing flight number OD1165 operated by Malindo Air suffered an in-flight external engine fire after take-off.

After flap retraction climbing passing approximately 800 feet, engine fire warning came on EWD. The flight crew carried out all the required procedures, discharged both fire extinguishers and requested for air turn back to PEN.

The aircraft safely landed at the airport. At landing it has been confirmed that there was no fire anymore. There were no passengers on board and the crew members disembarked safely with no injuries.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	04	Nil	Nil

1.3 Damage to aircraft

Please refer Attachments.

1.4 Other damage

Nil.

1.5 Personal Information

15.1 Captain

Status	Commander
Nationality	Malaysian
Age	28 Years old
Gender	Male
Licence Type	CPL/ATPL 4202
Licence Validity	Valid until 29th February 2016
Medical Examination	February 2016
Aircraft Rating	ATR72-600
Certificate of Test	07th July 2015
Instructor Rating	Nil
Flying Hours	Total hours : 852:59hrs Total on type : 4148:45hrs

15.2 Co-pilot

Status	Second Officer
Nationality	Malaysia
Age	27 Years old
Gender	Male
Licence Type	CPL 4880
Licence Validity	Valid until 30th September 2015
Medical Examination	30th September 2015
Aircraft Rating	ATR72-600
Certificate of Test	02nd August 2015
Instructor Rating	Nil
Flying Hours	Total hours : 457:53hrs Total on type : 257:53hrs

1.6 Aircraft Information

Aircraft	ATR72-600
Owner	Malindo Air
Registration	9M-LMG
Serial No.	1089
Air Operator Cert. expiry	31st August 2015
CofA No.	M.1573
CofA expiry	29th July 2015
CofR No.	M.1810
CofR expiry	N/A

Year of manufacture	2013
Operations	Scheduled
Flight Hours	4865
Flight Cycles	5569
Engine type	PW127M
Engine Serial No.	ED0673
Engine Total Time	4865

1.7 Meteorological Information

The meteorological station reported the wind at 1300hrs (LT) as 200/08kts. The weather was clear and the visibility was 7km at the time of occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Nil.

1.10 Aerodrome information

Nil.

1.11 Flight Recorders

The aircraft was fitted with L-3 COMM Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR).

1.12 Wreckage and impact information

Nil.

1.13 Medical and pathological information

Nil.

1.14 Fire

The aircraft had an in-flight external fire and both fire extinguishers were discharged. On landing it has been confirmed that fire had extinguished.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

Please refer attachments.

1.17 Organisational and management information

Nil.

1.18 Additional information

Nil.

1.19 Useful or effective investigation techniques

Not applicable.

2.0 ANALYSIS

2.1 Aircraft operated out of SZB to PEN, and the flight was normal until it landed at PEN.

2.2 After landing in PEN, the Captain reported that the aircraft have radio failure that requires the aircraft to be grounded in PEN while waiting the rescue team to arrive and troubleshoot.

2.3 After troubleshooting, nil defect was found and the aircraft ready for reposition flight back to SZB.

2.4 Not long after take-off from PEN, no. 1 engine fire warning illuminated, the flight crew carried out all the necessary procedures and turn the aircraft back to PEN.

2.5 There was no injury to crew and passengers on board.

3.0 CONCLUSIONS

3.1 Findings

a) The flight crew members were properly licensed, medically fit, well experienced and adequately rested prior to the flight.

b) The aircraft was airworthy and within the validity of the AOC, CofA and CofR.

c) Several parts of the right hand engine have been found damaged by the fire event.

3.2 Probable Cause

The probable cause of the engine fire is due to the fuel leak from No. 3 fuel nozzle manifold 'B' nut.

4.0 SAFETY RECOMMENDATIONS
(See Quality Notice MARA/QN/ATR72/16/04 dated 12 Feb 2016)

4.1 It is recommended that the manufacturer to remind customers of the importance to use the products recommended in the Engine Maintenance Manual (EMM).

4.2 It is recommended that the restoration of fuel nozzle for both engines on one aircraft shall not be performed at the same maintenance visit.

4.3 It is recommended that the engineer in-charge to perform a detailed inspection of the manifold hoses B-nut to ensure no early sign of corrosion is observed.

4.4 It is recommended that manifold with sign of corrosion shall be quarantined and reported to quality Assurance for further investigation.

4.5 It is recommended that the Licensed Engineer shall ensure that only approved solvent/materials listed in Maintenance Manual are to be used throughout the maintenance process.

5.0 APPENDICES

Appendix 1: Engine fire preliminary field inspection report

9M-LMG LH Engine Fire Preliminary Field Inspection Report:
Update 4/Final: at 03-June-2015

A. Detail of Event

Aircraft Registration	:	9M-LMG
Engine Serial Number	:	ED0873
TSN	:	4885 hours
CSN	:	5569 cycles
Date of event	:	28-May-2015

Based on Aircraft Flight and Maintenance Log (AFML) reference A023108 dated 28th May 2015, the aircraft was enrooted to SZB on flight OD01165. Aircraft was turned back and landed at the origin 1338 (LT) uneventful. The discrepancy noted on the logbook was 'ENG NO 1 FIRE AFTER T/O. BOTH FIRE EXTINGUISHER DISCHARGED'.

AFML Number references (A023101 – A023108) were reviewed. Work summary was below:

C check was performed by Airod Sdn Bhd between10th April 2015 and 27th May 2015.

AFML reference A023107 dated 28th May 2015, the aircraft departed on Malindo flight OD01164, from SZB to PEN, pilot reported with defect transponder #1 and #2 inoperative. Operational test carried out. No engine #1 related defect was reported on OD01164.

Malindo has informed that the last fuel nozzle change was performed on 4th April 2015 by Malindo dedicated fuel nozzle team. Post fuel nozzle change, the subject engine has flown 42 hours prior the C check.

B. Field Report and Observation

On site participants were below:

1) Aida Nazliha binti Samingan – Malaysia DCA Assistance Director Airworthiness Sector (email: aida.nazliha@dca.gov.my)
2) Alham Abdullah – Malindo Quality Assurance Manager (email: alham.abdullah@malindoair.com)
3) Kenneth Makunga – ATR Field Support Representative (email:kmakunga@galaviation.ca)
4) Chandra Gunawan – P&WC Customer Manager / Field Support Representative (email:chandra.gunawan@pwc.ca)
5) Lim Chee Ching – P&WC Field Support Representative (email:chee.ching.lim@pwc.ca)

Export Classification: **No technical data**

Page 1

Day 1: 29-May-2015

Photo	Description
	Burn mark observed on the aft cowling and panel on the underwing box. (LH View)
 	The rear RH cowl was delaminated. Observed sign of overheating on the inner pane.
	Sign of burn mark on the engine harness near the fuel nozzle adapter #3 and #4.

Photo	Description
Fuel Nozzle No. 3 	Step 1: Nitrogen leak check at 150 psi and Snoop leak detector applied. Result: All fuel nozzle connections (except fuel nozzle no. 3) to the primary and secondary fuel manifolds were verified and no bubbles were observed. Fuel nozzle no. 3 found with bubble leak at secondary manifold.
Fuel Nozzle No. 3 	Step 2: Torque check using torque wrench PWC45200 Result: Found the B-nut able to turn more than 120 degree without much resistance. B-Nut was sheared.
Fuel Nozzle No. 3 	B-nut completely sheared.
Fuel Nozzle No. 3 	Step 3: Review of previous photo prior to torque check. Result: Found the B-Nut was already cracked.

Photo	Description
Secondary manifold connected to fuel nozzle no. 3  Secondary manifold connected to fuel nozzle no. 3 	Secondary manifold attached to fuel nozzle no. 3, shown with B-nut sheared. Photo taken, after secondary manifold was removed at 02-June-15.
	Inspect fuel nozzle #3 threads. Result: Threads are clean.

Day 2: 02-June-2015
Engine already removed and placed at working stand.
Prior engine removal, torque seal already applied at fuel nozzle B-nuts connection at 29-May-2015, approx. 5 pm.
At 02-June-2015, 04:00 engine removal completed. Torque dial indicator is also available on-site.

Personnel on-site:
Alham Abdullah (Manager QA, Malindo)
Hazwan Janai (Power plant, Technical Services)
Chandra Gunawan (CM/FSR, P&WC)
Kenneth Makunga (FSR, ATR)

Photo	Description
	Torque check using torque wrench PWC45200 (Phase-4 torque wrench). Result: All fuel nozzles, except fuel nozzle #4, the B-nut did not turn further when torque is applied.
Fuel nozzle no. 4, before torque check  Fuel nozzle no. 4, after torque check 	Result: Fuel nozzle #4 able to turn approx. 45 degrees in tightening direction. Note: during Nitrogen leak check with Snoop leak detector at 29-May, no bubbles were observed at fuel nozzle #4.

Photo	Description
	Inspect fuel nozzle no. 4 thread and secondary manifold B-nut thread connected to fuel nozzle no. 4 Result: Found black substance in the thread area of the flex manifold B-nut
	Result: Found black substance in the thread area of the fuel nozzle no. 4
	With using torque wrench dial-indicator type, check break-away torque at B-nuts connection in loosening direction. Result: The result varies from 180 lb. Inch to 220 lb. inch. None of fuel nozzles were over torqued.
	Check flexible manifolds B-nut thread with go-and-no-go gauge (PWC45232) Result: All threads (except at FNZ #3 secondary port, not possible to check) are able to engage with go-and-no-go tool smoothly.

Photo	Description
  	Inspect B-nuts threads at fuel manifolds for anti-seize presence. Result: Found residual of black substance alike at the thread area.

Photo	Description
	Inspect conical gaskets. Result: Found conical gasket at manifold #14 with tangs bent. The rest of conical gaskets at are good, including conical gasket connected at fuel nozzle #3.
  	Fuel nozzle #3, #4, and #5 ports.

C. Parts Removed for Investigation

The following engine parts were removed and sent for investigation to P&WC Service Investigation, Canada.

1) Fuel Nozzle No. 3, P/N: 3079013-01, S/N: DEAAA30046
2) Fuel Nozzle No. 4, P/N: 3079012-01, S/N: DEAAA33052
3) Secondary Manifold Left, P/N: 3059765-01, S/N: 07516478-01
4) Secondary Manifold Right, P/N: 3059764-01, S/N: 07490965-01
5) Primary Manifold, P/N: 3059766-01, S/N: 07557710-01

D. Summary

This field report does not constitute nor replace the engine investigation which will be performed by P&WC Service Investigation.

The investigation report released by P&WC Service Investigation shall be the official and the final investigation report.

Based on the hardware witness on-site, the following findings were observed:

1. Fuel nozzle no. 3 found with leak during nitrogen leak check. Further inspection found with B-nut cracked and subsequently sheared during torque check.
2. Fuel nozzle no. 4 found with loose B-nut. During nitrogen leak check, no bubbles were observed.

   Note: there are two steps of leak check in accordance with EMM. Step 1 is nitrogen leak check with leak detector; Step 2 is by running the engine at high power (80% torque) for 2 minutes. This two steps leak check is an integral part of leak check to be performed post fuel nozzle installation.

   During this field observation, only Step 1 (nitrogen leak check) was performed.

E. Chronology and Progress Report

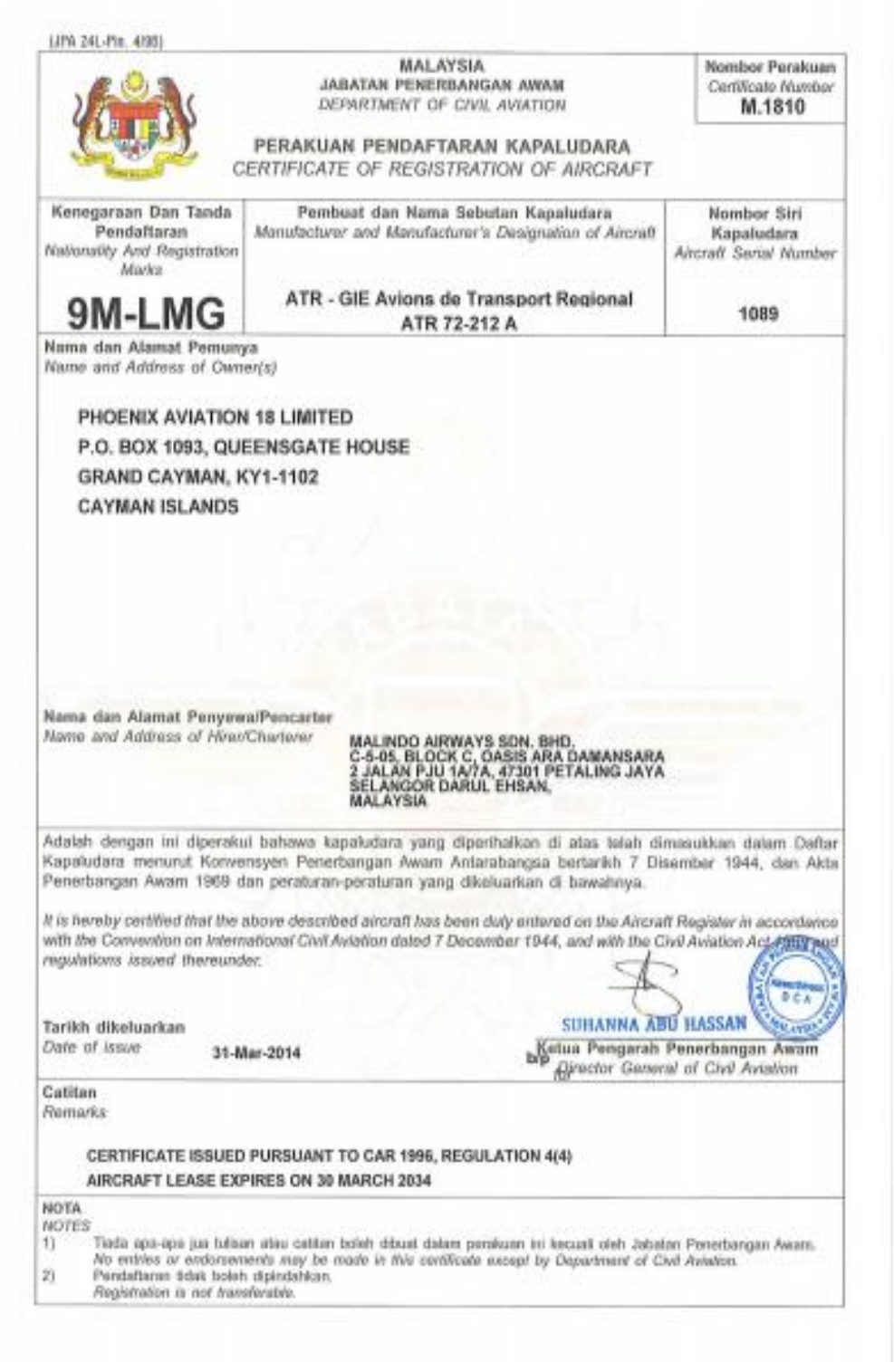
Date	Description	Remarks
28-May	Date of the event Malindo Team, ATR and FSR arrived on-site	
29-May	Field report and observation started. DCA Malaysia arrived on-site	
30-May	ATR requires engine to drop for NDT access. P&WC Preliminary field inspection report issued. To remove flex manifolds and FNZ #3 for investigation.	
30-May	Malindo QA advised to hold engine works, pending for DCA Malaysia go-ahead. In evening, verbal info obtained to continue.	
01-June	ATR Specialist arrived on-site and preliminary inspect the engine and airframe. Engine removal for access was requested for better access to airframe. Engine removal completion expected at 02-June-15.	
02-June	Engine removal completed at 03-June, approx. 04 am. Engine located at working stand. Torque gauge dial indicator is available.	
03-June	Engine field report and observation completed, accompanied by Malindo Manager QA. Flexible manifolds removed (primary, secondary left, and secondary right). Fuel nozzle #3 removed. Fuel nozzle #4 removed Pending shipment to P&WC Service Investigation Canada.	
TBA		

Note:
Chronology and Progress Report will be carried forward separately from this report.

Prepared by,

Chandra Gunawan and Lim Chee Ching
Pratt & Whitney Canada
Date:
29-May-2015, Penang Malaysia (first report issuance)
03-June-2015, Penang Malaysia (this report)

Appendix 2: Certificate of Registration



(JPA 24L-Pin. 4/98)

MALAYSIA
JABATAN PENERBANGAN AWAM
DEPARTMENT OF CIVIL AVIATION

Nombor Perakuan
Certificate Number
M.1810

PERAKUAN PENDAFTARAN KAPALUDARA
CERTIFICATE OF REGISTRATION OF AIRCRAFT

Kenegaraan Dan Tanda Pendaftaran *Nationality And Registration Marks*	Pembuat dan Nama Sebutan Kapaludara *Manufacturer and Manufacturer's Designation of Aircraft*	Nombor Siri Kapaludara *Aircraft Serial Number*
9M-LMG	ATR - GIE Avions de Transport Regional ATR 72-212 A	1089

Nama dan Alamat Pemunya
Name and Address of Owner(s)

PHOENIX AVIATION 18 LIMITED
P.O. BOX 1093, QUEENSGATE HOUSE
GRAND CAYMAN, KY1-1102
CAYMAN ISLANDS

Nama dan Alamat Penyewa/Pencarter
Name and Address of Hirer/Charterer

MALINDO AIRWAYS SDN. BHD.
C-5-05, BLOCK C, OASIS ARA DAMANSARA
2 JALAN PJU 1A/7A, 47301 PETALING JAYA
SELANGOR DARUL EHSAN,
MALAYSIA

Adalah dengan ini diperakui bahawa kapaludara yang diperihalkan di atas telah dimasukkan dalam Daftar Kapaludara menurut Konvensyen Penerbangan Awam Antarabangsa bertarikh 7 Disember 1944, dan Akta Penerbangan Awam 1969 dan peraturan-peraturan yang dikeluarkan di bawahnya.

It is hereby certified that the above described aircraft has been duly entered on the Aircraft Register in accordance with the Convention on International Civil Aviation dated 7 December 1944, and with the Civil Aviation Act 1969 and regulations issued thereunder.

Tarikh dikeluarkan
Date of issue 31-Mar-2014

SUHANNA ABU HASSAN
bagi/*for* **Ketua Pengarah Penerbangan Awam**
Director General of Civil Aviation

Catitan
Remarks

CERTIFICATE ISSUED PURSUANT TO CAR 1996, REGULATION 4(4)
AIRCRAFT LEASE EXPIRES ON 30 MARCH 2034

NOTA
NOTES
1) Tiada apa-apa jua tulisan atau catitan boleh dibuat dalam perakuan ini kecuali oleh Jabatan Penerbangan Awam.
No entries or endorsements may be made in this certificate except by Department of Civil Aviation.
2) Pendaftaran tidak boleh dipindahkan.
Registration is not transferable.

Appendix 3: Certificate of Airworthiness

MALAYSIA
JABATAN PENERBANGAN AWAM
DEPARTMENT OF CIVIL AVIATION

Nombor Perakuan
Certificate Number
M.1573

PERAKUAN KESELAMATAN TERBANG
CERTIFICATE OF AIRWORTHINESS

Kenegaraan Dan Tanda Pendaftaran *Nationality And Registration Marks*	Pembuat dan Nama Sebutan Kapaludara *Manufacturer and Manufacturer's Designation of Aircraft*	Nombor Siri Kapaludara *Aircraft Serial Number*
9M-LMG	ATR – GIE Avions de Transport Regional ATR 72-212 A	1089

Kategori *Category*: TRANSPORT (PASSENGER)

Perakuan Keselamatan Terbang ini dikeluarkan menurut Konvensyen Penerbangan Awam Antarabangsa bertarikh 7 Disember 1944, dan Akta Penerbangan Awam 1969 dan peraturan-peraturan yang dikeluarkan di bawahnya, untuk kapaludara yang tersebut di atas yang didapati layak untuk terbang jika diseenggarai dan dikendalikan menurut peraturan-peraturan yang tersebut, dan had-had penerbangan yang bersabit. Manual Penerbangan yang diluluskan oleh Jabatan Penerbangan Awam adalah merupakan sebahagian daripada Perakuan ini.

This Certificate of Airworthiness is issued pursuant to the Convention on International Civil Aviation dated 7 December 1944, and with the Civil Aviation Act 1969 and regulations issued thereunder, in respect of the above-mentioned aircraft, which is considered to be airworthy if maintained and operated in accordance with the foregoing regulations and the pertinent operating limitations. A Flight Manual approved by the Department of Civil Aviation forms part of this Certificate.

Tarikh dikeluarkan *Date of issue*: 24/Jul/2014

AIDA NAZLIHA BINTI SAMINGAN
b/p **Ketua Pengarah Penerbangan Awam**
for Director General of Civil Aviation

Catitan *Remarks*: REPLACEMENT OF CERTIFICATE ISSUED ON 02 AUGUST 2013.

Perakuan ini adalah sah bagi tempoh yang ditunjukkan di bawah ini : *This Certificate is valid for the period(s) shown below :*		Tandatangan dan Tarikh *Signature and Date*
Mulai dari : *From :* 24/Jul/2014	Hingga : *To :* 29/Jul/2015	24/07/2014
Mulai dari : *From :*	Hingga : *To :*	
Mulai dari : *From :*	Hingga : *To :*	
Mulai dari : *From :*	Hingga : *To :*	
Mulai dari : *From :*	Hingga : *To :*	

Tiada apa-apa jua tulisan atau catatan boleh dibuat dalam Perakuan ini kecuali oleh Jabatan Penerbangan Awam.
No entries or endorsements may be made in this Certificate except by Department of Civil Aviation.

Appendix 4: Air Operator Certificate

AIR OPERATOR CERTIFICATE

MALAYSIA
JABATAN PENERBANGAN AWAM
DEPARTMENT OF CIVIL AVIATION

DCA MALAYSIA

AOC NO. 47 Expiry Date **31-08-2016** *CERTIFICATION* *I hereby certify that this is a true copy of the AOC No. 47 issued at PUTRAJAYA on 07-09-2015 by The Department of Civil Aviation signed at PUTRAJAYA on 07-09-2015* CAPT. PHILIP JOSEPH SEDARAJU Senior Assistant Director Flight Operation Section Department of Civil Aviation Malaysia	OPERATOR NAME **MALINDO AIRWAYS SDN. BHD.** (Company No.) Dba: **MALINDO AIR** OPERATOR ADDRESS MALINDO AIRWAYS SDN. BHD. C-5-05, BLOCK C, OASIS ARA DAMANSARA, NO. 2, JALAN PJU 1A/7A, ARA DAMANSARA, 47301 PETALING JAYA, SELANGOR. TELEPHONE : +6 03 2035 6699 FAX : +6 03 2035 6698 EMAIL : ajmain.harith@malindoair.com	OPERATIONAL POINTS OF CONTACT: Contact details at which operational management can be contacted without undue delay, are listed in: MALINDO AIR OPERATIONS MANUAL Part A Chapter 1.2.3 POINTS OF CONTACT: CAPT. AJMAIN HARITH (Director of Flight Operations) TELEPHONE : +6012 3881 354

This certificate certifies that

MALINDO AIRWAYS SDN. BHD.

is authorised to perform commercial air operations under Regulation 24 of the Civil Aviation Regulations 1996 and as defined in the attached operations specifications, in accordance with the Operation Manual.

Date of Issue: **07-09-2015**	Signature : Name : DATO' SRI AZHARUDDIN B. ABDUL RAHMAN Title : Director General Department of Civil Aviation Malaysia

Appendix 5: Lion Air B-Nut Presentation

EXPORT CLASSIFICATION

Classification	
1. Canadian ECL(s):	
2. ECCN(s):	
3. P-ECCN(s):	9E991
4. USML (ITAR):	
5. P-USML:	

DISCLAIMER

This document is used for presentation only and it is extracted from Field Report.
This document does not constitute nor replace P&WC Investigation Report, which will be conducted by P&W Service Investigation.

AGENDA

Reported cracked B-nut events

Review of investigation results

Identification of source for hydrogen embrittlement

Test performed

Fleet review

Summary & recommendations

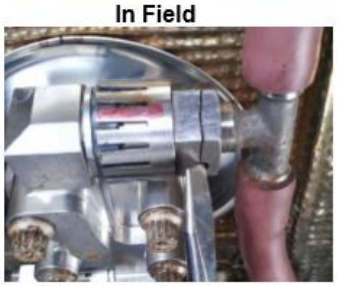
CRACKED B-NUT – 3 CASES REPORTED

Malindo (ED0673)

Event: Engine Fire / Fuel Leak
Operator : Malindo, Msn 1089
FN position: #3
Event Date: 28 May 2015
Last FN change: 4 April 2015
PW127M / ED0673, TTSN: 4,865hrs
Engine production: Jan 2013

Wings Air (ED0613)

In Field

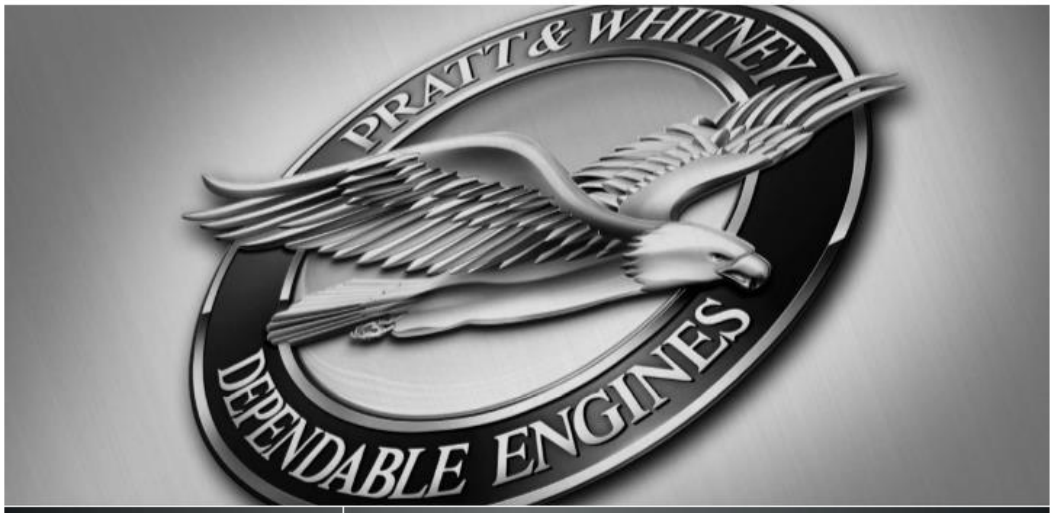


Event: Crack observed during maintenance
Operator: Wings Air, Msn 1067
FN position: #11
Event Date: 26 Feb 2015
Last FN change: 26 Feb 2015
PW127M / ED0613, TTSN: 5,103hrs
Engine production: Sep 2012
Note: Manifold transferred to ED0564 for repair during engine shop visit

In Laboratory

Same manifold
Crack in lab. After 3 days
Operator: Wings Air
22 June 2015 – Torqued at 2x EMM
25 June 2015 – cracked observed

Hydrogen embrittlement confirmed on the 3 B-nuts (2 engines)



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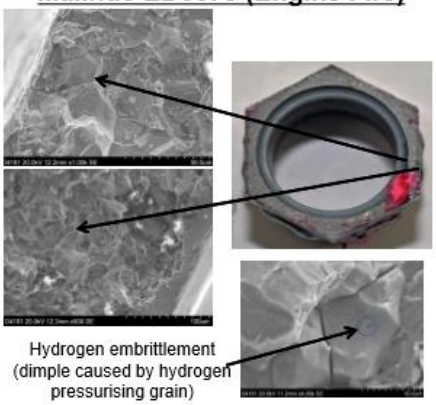
Review of investigation results

DEPENDABLE

ENGINES | SUPPORT | INNOVATION | PEOPLE

INVESTIGATION - LAB RESULTS

Malindo ED0673 (Engine Fire)



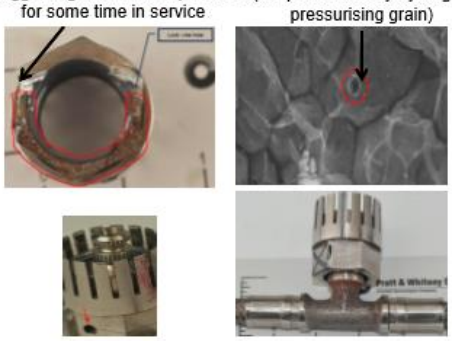
Hydrogen embrittlement (dimple caused by hydrogen pressurising grain)

Magnified view of the brittle intergranular fracture

Wings Air ED0613 (In Field)

Reddish corrosion products Suggesting a crack was present for some time in service

Hydrogen embrittlement (dimple caused by hydrogen pressurising grain)

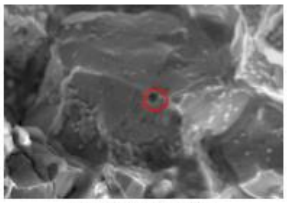


T fitting general condition (opposite side)

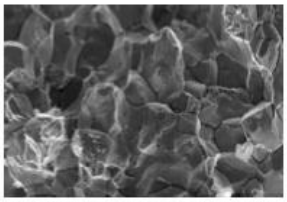
LAB RESULTS – ED0613 – CRACKED IN LAB

Laboratory analysis was performed on ED0613 manifold in order to duplicate the failure. Higher torque (twice the one recommended in EMM) was applied to manifold and crack was observed few days after application.

Presence of reddish corrosion products suggesting crack present prior torque test



Typical "fisheyes" consistent with hydrogen embrittlement

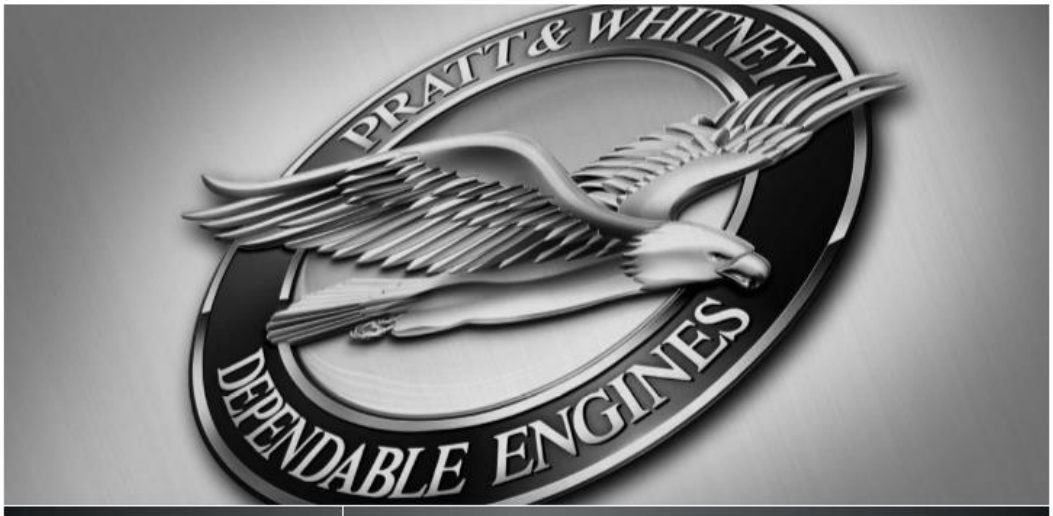


Fracture surface near external edge
Absence of corrosion products on this portion

Higher corrosion level inside, suggesting corrosion progressed from inside out

June 22 – Installation (2X recommended Tq)
June 23 – No crack
June 24 – Holiday (no inspection)
June 25 – Crack observed

P&WC recommended immediate removal of other 2 manifolds on engine ED0613



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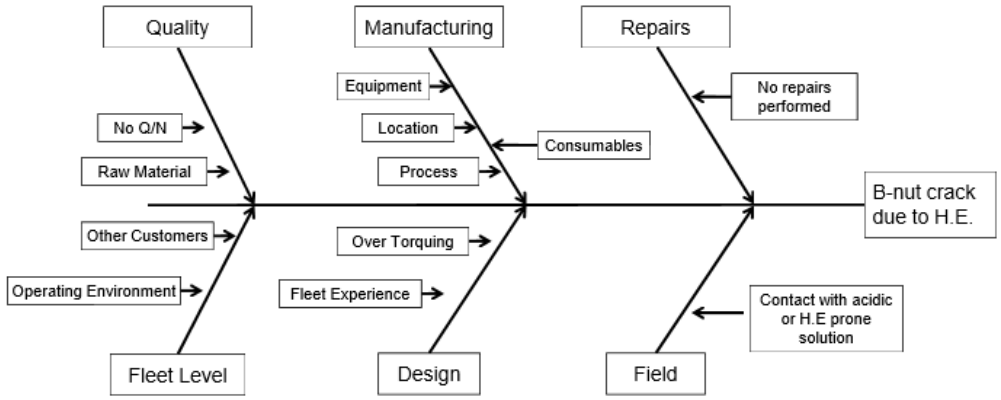
Identification of source for hydrogen embrittlement

ENGINES SUPPORT INNOVATION PEOPLE

FISHBONE – HYDROGEN EMBRITTLEMENT



SUPPLY CHAIN REVIEW

Supplier process/quality review

	Modification to					
	Location	Equipment	Process	Inspection	Consumables	QN (Mat'l defect)
Manifold Assembly	N	N	Y*	N	N	N
B-Nut Manufacturing	N	N	N	N	N	N

*Additional pre-torquing task added in 2014

- Modifications introduced with the phase 4 fuel nozzle
- No consumables used at this operation
- Introduced after the manufacturing of ED0613/ED0673 manifolds
- No other changes in the last 10 years

Quality Notifications (QN) reviewed for manifolds and B-nuts

- No Q/N`s related to H.E. or material defect
- Leak at test, tool mark, damage on hose (porosity, tear, cut)

MANIFOLD ASSEMBLY PROCESS

START

PTFE hose and fire sleeve are received

Machined items including nuts are delivered in kit form

PTFE hose is cut into the correct lengths. The Hose is cut to length using a rotating blade. No liquids are used in this process.

Fire Sleeve is cut into the correct lengths. The fire sleeve is cut to length using a guillotine tool. No liquids are used in this process.

The manifold is manufactured using a dedicated assembly fixture. The PTFE hose and fire sleeve are placed in the correct build sequence on the fixture.

The ferrule is placed over the PTFE hose and the internal diameter of the PTFE hose expanded.

MANIFOLD ASSEMBLY PROCESS

The appropriate machined fitting is then fully inserted into the PTFE hose and the ferrule located against the shoulder of the machined fitting.

Each ferrule is then swaged individually. No liquids are used during the swaging process.

Each swaged joint is then checked using the appropriate go/no go gauge.

A mandrel is inserted into the PTFE hose and P80 lubricant is applied to the external surfaces. The fire sleeve is then manually pushed over the PTFE hose.

P80 lubricant is applied directly to the PTFE hose.

The manifold is located in the assembly fixture checking for correct fit and orientation. The assembly it then pressurised using de-mineralised water only.

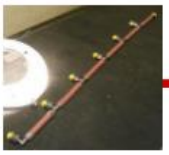
De-mineralised water

MANIFOLD ASSEMBLY PROCESS

The assembly is part marked using a Stainless Steel tag and the dot peen marking process. No adhesives or liquids are used to secure the tag.

The nut and thrust wires are fitted as the last operation to the manifold.

The manifold is final inspected in a dedicated inspection area on the manifold assembly line.



Final cleaning of the manifold to CPW152 is completed using a cleaning rig. Isopar K is used as the cleaning fluid. The cleaning media passes through the internal bores of the manifold. External surfaces may come into contact with small amounts of Isopar K fluid. Once the cleaning processes is complete the manifold is immediately sealed in a protective sleeve.

Manifolds are stored in sealed clear protective sleeve prior to the DQCR and Dispatch process.

B-NUT MANUFACTURING PROCESS

Nuts (800000578-06) are machined complete on a citizen sliding head M32 machine. The nuts are manufactured in Excelcut 429 cutting oil.

The trays are then loaded into a cleaning machine where the parts are cleaned & degreased using Triklone LE (Trichloroethylene)

Parts are then passed to the inspection department (still in the cleaning trays). After inspection the parts are moved to the stores (still in the trays) where they are packed in Netlon (nylon mesh sleeving)

dry film lubricant applied

Prior to the nut being returned to Teknequip the parts are again degreased using Trichloroethylene.

Parts are once again inspected before being stored on a finished goods rack.

Moeller Lockring / Sleeve install using a press

Following the installation of the Moeller components, the parts are torqued twice (per recent EC) and then again inspected prior to being placed into kit boxes for delivery to Marston.

PRODUCTS USED DURING MANUFACTURING OF MANIFOLDS

List of products used during manifold manufacturing/assembly

Product Name	Product Type	Details	B-Nut	Manifold	Source for H.E
Excelcut 429	Cutting oil	recommended for stainless steel manufacturing	X		Unlikely
Triklone LE	Trichloroethylene	Vapor degreaser Highly volatile	X		No
P-80	Rubber lubricant	Alkaline (Ph 8.4)		X	No
	De-mineralized water			X	No
Isopar K	Hydrotreated naphita	Petroleum solvent (Varsol)		X	No

Same products/process used for over 10 years

Over 1,606 new engines produced (Over 47,000 nuts)

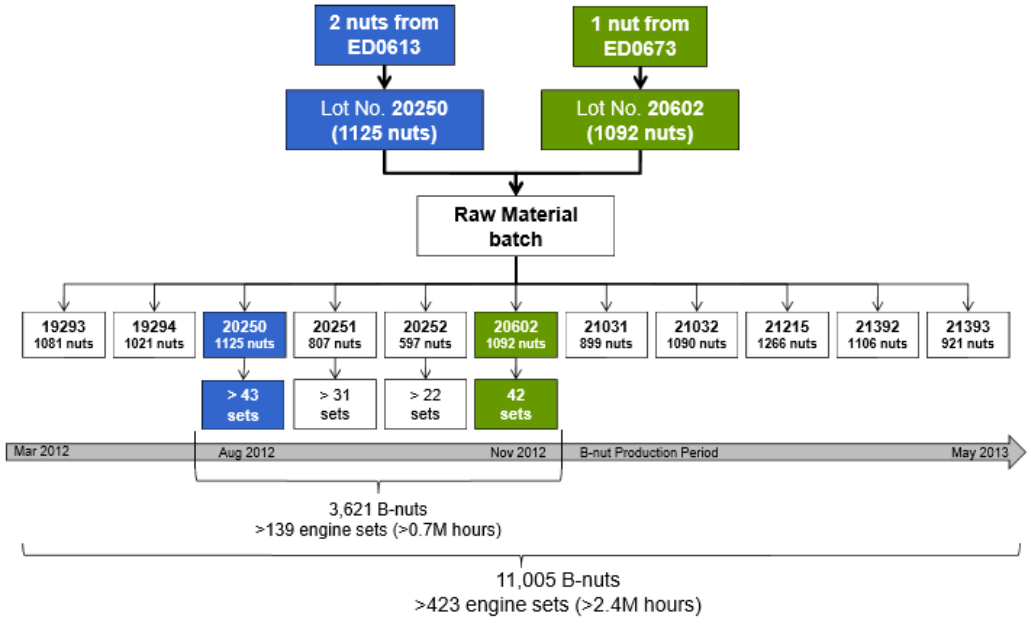
Excelcut 429

Chemical composition not fully known (proprietary)

Over 10 years of usage at B-nut machining

P&WC will be conducting tests on Excelcut 429

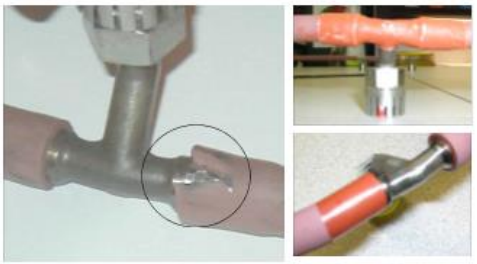
B-NUT PRODUCTION REVIEW



REPAIR & OVERHAUL

Minor repair per EMM, 72-01-00

- Limited to fire retardant protection
- Manifolds did not receive this repair



Major repair

- Proprietary repair to HS-Marston
- No cracked B-nut were received for repair

	Last 12 Months	Last 5 Years	Last 9 Years
3059764-01 (7)	58	232	235
3059765-01 (8)	21	201	206
3059766-01 (11)	76	389	594
Total:	155	822	1035

Only B-nut crack known case is the manifold received from Lion Group

PRATT & WHITNEY
DEPENDABLE ENGINES

Pratt & Whitney Canada
A United Technologies Company

Fleet Review

DEPENDABLE
ENGINES SUPPORT INNOVATION PEOPLE

FLEET INSPECTION FOR CORROSION PITS

			>ED0300	>ED0375	>ED0450	>ED0525	>ED0600	>ED0675	>ED0750	>ED0825	>ED0900	>ED0975	>ED01050
	All	<=ED0300	<=ED0375	<=ED0450	<=ED0525	<=ED0600	<=ED0675	<=ED0750	<=ED0825	<=ED0900	<=ED0975	<=ED01050	<=ED01125
LionAir Group													
Excluded	16	0	0	0	0	0	0	0	0	0	4	10	2
No Corrosion	53	7	1	3	1	3	3	9	7	9	10	0	0
Corrosion	41	9	7	4	4	7	6	2	1	1	0	0	0
All	110	16	8	7	5	10	9	11	8	10	14	10	2
Ratio (corrosion)	44%	56%	88%	57%	80%	70%	67%	18%	13%	10%	0%	--	--
World Wide Fleet													
No Corrosion	63	28				5	14	6	1	3	5	1	

World Wide Fleet inspection
9 operators
63 engines inspected
No report of corrosion pits

Typical condition of manifolds inspected at other operators

Applying the Lion Air Group ratio to other operators would result in 27 engines

FLEXIBLE MANIFOLDS DESIGN AND IN-SERVICE EXPERIENCE

Design

B-nut design within existing P&WC design experience

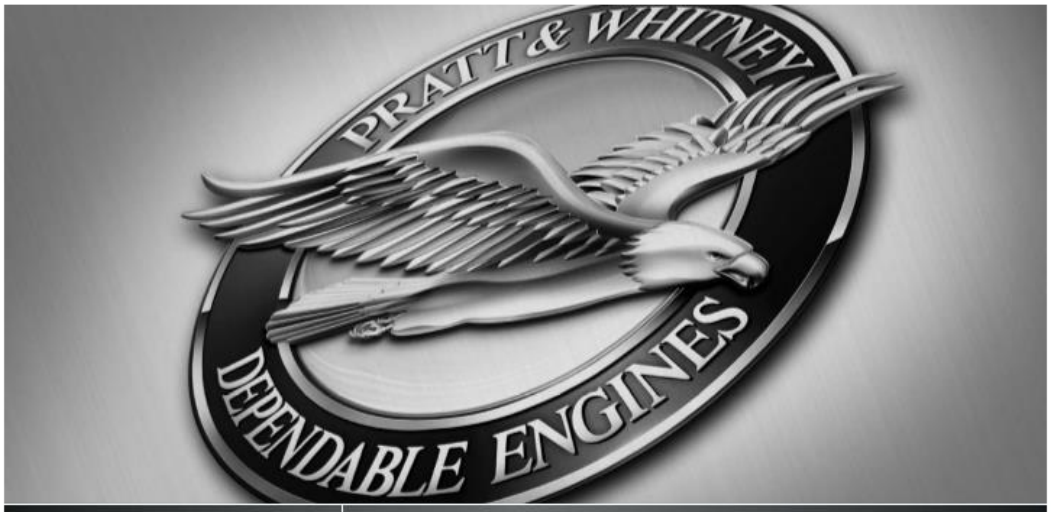
Flexible Manifold Conf. (Post-SB21705) - 43 detail parts

Field Experience

PW127 with Flexible (Nov 1999)	
Engine produced with flexible manifolds	1,740
Total Fleet hours	Over 15M
Fleet leader engine	35,500hrs
Estimated No. of FN change	Over 15,000

Other Models

Model	Qty Produced	Fleet hours (M)
PW150A	1141	12.5
PW901	924	31.2
PW980	224	7



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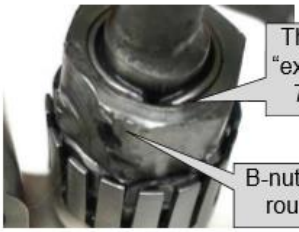
Test Performed

DEPENDABLE

ENGINES | SUPPORT | INNOVATION | PEOPLE

TORQUE TEST – PERFORMED AT P&WC



Tests performed to validate design margin

B-nut inspected per FPI. No crack found

EMM torque limit: 250-270 lb-in

Nut & Crowfoot condition after 1320 lb-in

Cracked B-nut reported by Lion Air

Unable to replicate observed failure mechanism, overtorque ruled out

REVIEWS AT MALINDO & LION AIR

Fuel Nozzle Process Review performed on June 18 and 19

Questions raised during process review:

- Use of a Cee Bee product
- Use of Electrical Contact Cleaner (CRC, C&C) to "cool down" the nuts before FNZ change
- Leak detector check with local solution instead of recommended product

Cee Bee products and Hand soap returned to MTL for Lab analysis on (on-going)

- No cracks observed to date
- P&WC Material specialist confirmed products would not cause Hydrogen Embrittlement

C & C cleaner analyzed in Indonesia lab

- Lab results indicates many chemicals containing hydrogen
- Unclear if chemicals can contribute to Hydrogen Embrittlement

High level of variability for mix of products, concentration and temperature

P&WC EXPERIENCE

Pratt & Whitney Canada

S.I.L NO. PT6A-214

SERVICE INFORMATION LETTER

Subject Use of non approved cleaning product on fuel nozzle tips

Applicability All PT6A Large Engines

Reference N/A

This Service Information Letter (SIL) is issued to inform all operators and maintenance providers of the importance of using only those cleaning products defined in the relevant P&WC engine maintenance manual to clean PT6 fuel nozzle tips. An ongoing investigation has revealed that a certain repair service provider used by a customer was using Mirachem 250, which is not called up in the P&WC maintenance manuals for this operation. In fact, this cleaning solution is not considered fully compatible with the base material of the fuel nozzles and tips. In order to prevent any possible damage to the fuel nozzle tips, such practice must be discontinued. In the mean time, no other action is required other than P&WC's recommendation that operators or their repair supplier does not use Mirachem 250 or any other products not specificly defined in the P&WC maintenance manual.

Additionally, for PT6's engines equipped with Duplex type fuel nozzle tips, we remind operators you that it is not an acceptable practice to remove and re-install fuel nozzle tips without processing the tips through the overhaul level workscope. Install only overhauled or new nozzle tips when processing fuel nozzles.

For further information, please contact your local P&WC Field Support Representative, or the P&WC Customer Help Desk, Tel +1 450-647-8000 or +1-800-268-8000. We can also be reached at cfinf@pwc.ca, or our website www.pwc.ca.

Pascale Benoit-Lapointe
Customer Service

This Service Information Letter is valid until superseded or cancelled by revision

EXPORT CONTROL CLASSIFICATION: This document does not contain technical data.
ISSUED: October 24/2013

Page 1 of 1

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Mirachem 250 on PT6A engine

- Used during maintenance
- Causing hydrogen embrittlement

Product advertised as non acidic and safe for stainless steel by manufacturer

Review of MSDS presence of phosphoric acid up to 10%

TESTING OF PRODUCTS


CEEBEE 280 / Torque at 600 lbs-in

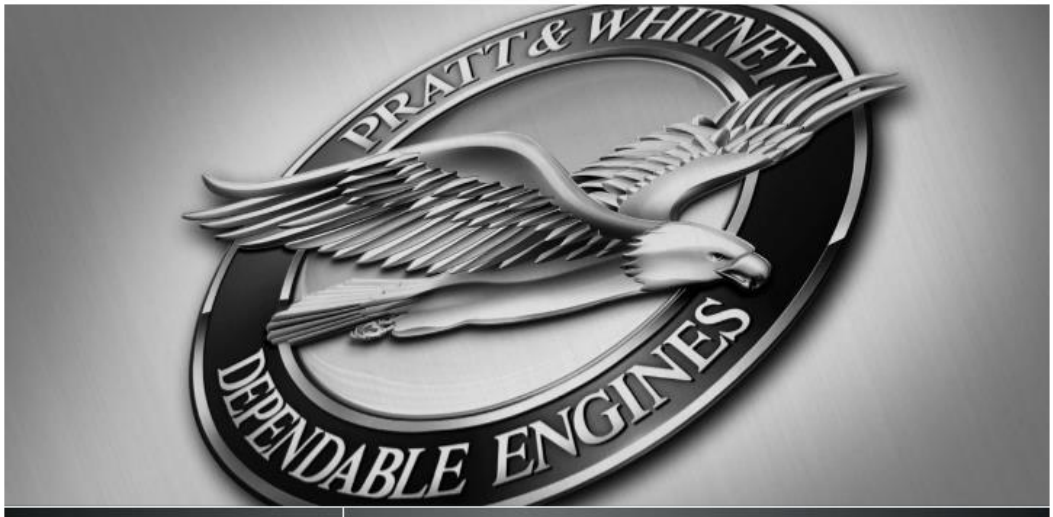

Super BEE 210 / Torque at 600 lbs-in


Hand Soap / Torque at 600 lbs-in

P&WC received 3 products
- 2 B-nuts exposed to each product
- B-nut torqued at 600 lbs-in
- Test initiated on July 22nd
- No B-nut cracked

Test procedure formalized

Further tests to be conducted on
- Mirachem 250 - In process
- Excelcut 429 - Material in procurement
- C&C cleaner - Shipping hardware to Indonesia



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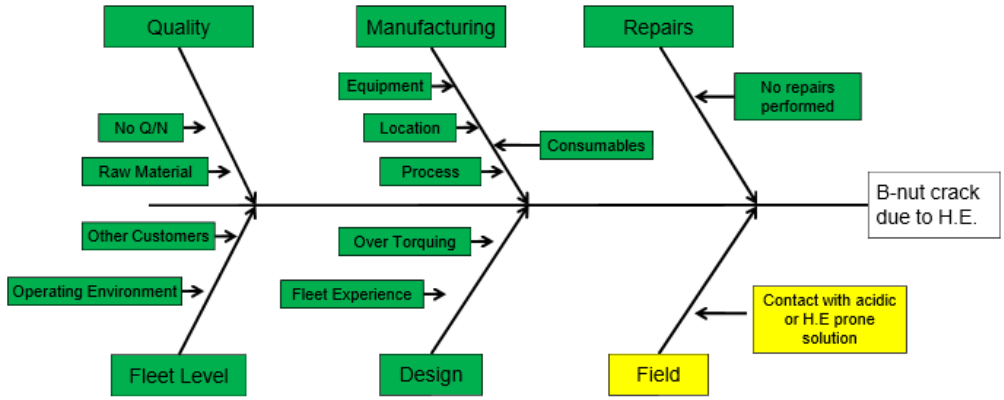
Summary & Recommendations

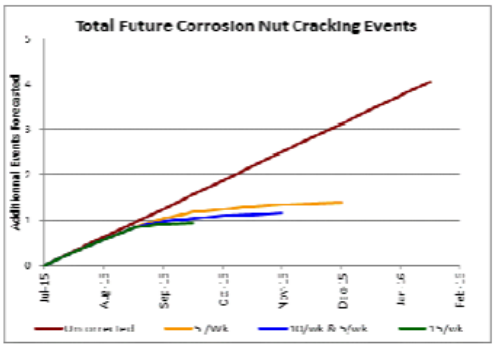
INVESTIGATION SUMMARY



Challenges

Source of Hydrogen Embrittlement (H.E.) not identified
No methods available to segregate manifold affected to H.E.
No repair possible for parts affected by H.E.
H.E. causes sudden failure of parts when under stress

RISK ASSESSMENT / PRIORITY



Priority levels

Per risk assessment
At aircraft level
Following SI 71-2015 results

P&WC recommendations

Follow EMM instructions
Perform SI 71-2015
Replace manifolds potentially exposed to H.E.

Current status
9 engines upgraded
16 engines considered not exposed
41 engines with corrosion

Assumptions:
Fleet exposure initiated Jul `14
"Fast" population – corrosion on T fittings
"Slow" population – no corrosion on T fittings
Ratio of 41 "fast" out of 94 total affected
3 B-nut fractured events considered

Priority			No. of engines	Upgraded
Level	Description	Recommendation		
1	A/C with both engines showing signs of corrosion	Replace one engine set within 100FH	16	9
2	A/C with one engine showing signs of corrosion	Replace engine set within 200FH	24	1
3	A/C with no eninge showing signs of corrosion	Replace by Oct 15th	27	0
4	Remaining engines + spares	Replace by Nov 30th	27	0
N/A	Enigne without any FN change		16	

As of August 21st, 2015

CONCLUSION

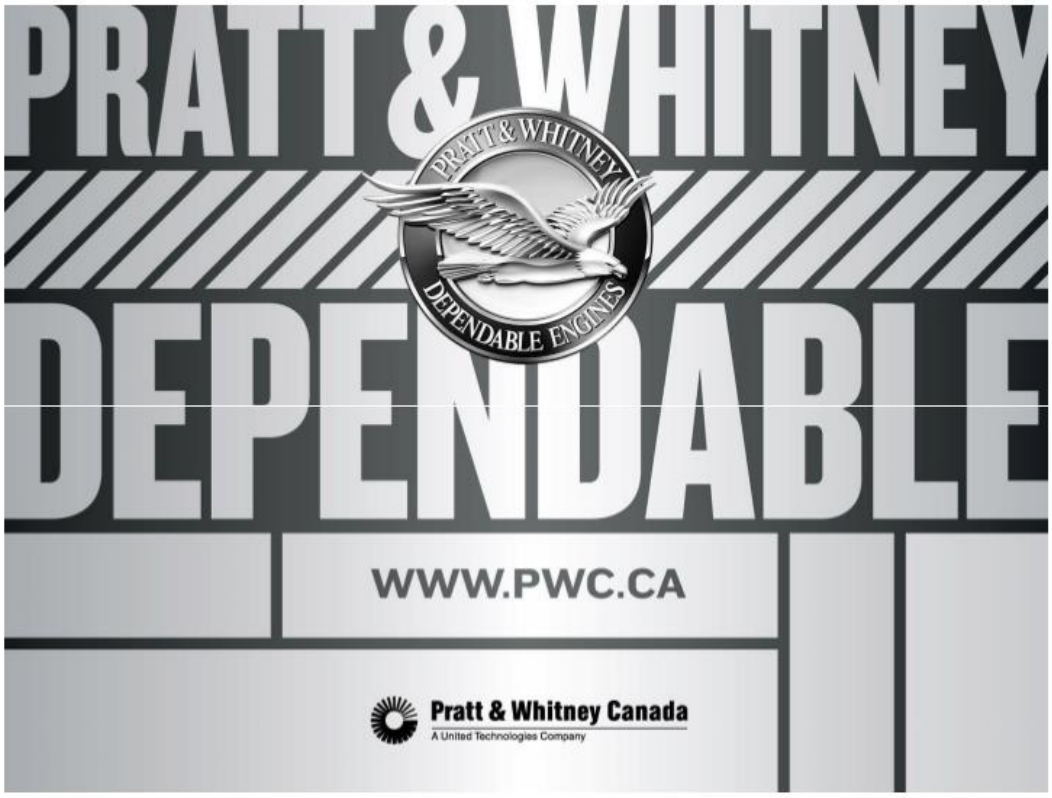
Production/quality issue can be ruled out as a source for B-Nut cracking

Source of contamination / corrosive agent is still undetermined
- P&WC and Lion Group are still conducting testing

Replacement of all manifolds potentially exposed by the end of November

Need to coordinate logistics to accelerate rejuvenation
- Custom clearance, point of use shipment

P&WC is fully committed to support
- Training, assisting maintenance crew, parts and commercial support



Appendix 6: Pratt & Whitney Service Information Letter

Pratt & Whitney Canada
A United Technologies Company

S.I.L NO. PW100-169R1

P&WC 11524 (2015-12) MRO Information Management (9298)

SERVICE INFORMATION LETTER

WARNING - PROPRIETARY RIGHTS NOTICE

Subject Use of non-approved product on PW100 Flexible Manifold

Applicability PW100 Engines with flexible fuel nozzle manifolds

This Service Information Letter ("SIL") is revised to provide the final conclusions on the associated investigation.

P&WC investigated two cases of flexible manifold B-nut reported cracked (Ref. Figure 1). Both cases were reported by the same operator group and the review of the material confirmed hydrogen embrittlement.

Hydrogen embrittlement occurs when hydrogen diffuses into the metal. It changes the material properties and the exposed metal becomes brittle. In the case of the flexible manifold, the B-nut may become susceptible to cracking in service, thus potentially causing an external fuel leak. The fractured surfaces analyzed by P&WC show no signs of a crack propagating by fatigue and suggests a sudden fracture mechanism.

Figure 1 : Cracked B-nut

Corrosion attacks and pits on the B-nut surface and the T fittings (Ref. Figure 2) was also observed. It is believed that the observed condition resulted from exposing the material to an aggressive product, likely acidic. In some cases, the corrosion pits showed a reddish appearance (Ref. Figure 1) that can be more or less visible (Ref. Figure 2). It is also possible that corrosion pits are not observed on B-nut affected by hydrogen embrittlement.

This Service Information Letter is valid until superseded or cancelled by revision.

Export Control Classification			
			(X) if Applicable
Contains no Technical Data			(X)
Not Subject to the EAR pursuant to 15 CFR 734.7(a)(1) or Not Subject to the ITAR pursuant to 22 CFR 120.11 (NSR)			( )
Jurisdiction and Classification based on Physical Location of the Item.	Location	Regulations	
		EAR	ITAR
	Outside US*		
* Additionally, refer to the classification under the local export regime where the item is located, as provided in the grid.	U.S.		
		EIPA (ECL)	DPA (CG)
	Canada		

ISSUED: 06/30/2015
REVISED: 06/01/2016

PRATT & WHITNEY CANADA CORP.
MARIE-VICTORIN, L'ONGUEUIL
QUEBEC, CANADA J3G 1A1
PRINTED IN CANADA

P&WC was able to replicate the above observations and the distress by hydrogen embrittlement via exposing the B-nut to a chloride acid (HCl) solution while the B-nut was under tension load. P&WC selected chloride acid for the tests as this acid is well known to liberate hydrogen and it was expected to get results rapidly.

However, any product or any chemical reaction between two or more products liberating hydrogen may lead to hydrogen embrittlement. For the reported events, the product that caused hydrogen embrittlement has not been identified. The investigation concluded however that the B-nuts were exposed to an acidic product while installed on the engine.

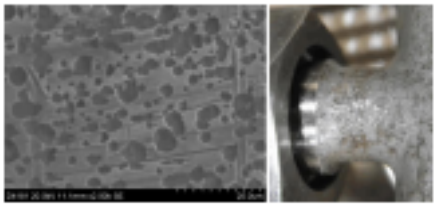


Figure 2 : Corrosion pits (left B-nut / Right T-fitting)

P&WC would like to remind all customers of the importance to use the products recommended in the Engine Maintenance Manual "EMM" (Ref. 72-01-40, FUEL SYSTEM) for fuel nozzles and fuel manifolds removal, installation and cleaning. P&WC also confirms that all products approved by P&WC and listed in the EMM will not cause Hydrogen Embrittlement.

There is no inspection available in the field to identify manifolds affected by hydrogen embrittlement. Additionally, it is not possible to predict the remaining life of B-nuts affected by this condition as it depends of many parameters, notably, the aggressiveness of the product and the exposure time. Therefore, any manifold suspected to have been exposed to an acidic product or any other product suspected to liberate hydrogen should be removed from service immediately.

Yours, Truly,

PRATT & WHITNEY CANADA CORP

Daniel Gagnon
Customer Engineering
PW100 Engine Program

Vincent St-Pierre
Manager, Customer Engineering
PW100 Engine Program

PRATT & WHITNEY CANADA CORP.
MARIE-VICTORIN, LONGUEUIL
QUEBEC, CANADA J4G 1A1
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Appendix 7: Malindo Air Quality Notice

Malindo air
www.malindoair.com

Ref : MAQA/QN/ATR72/16/04
Date : 12 February 2016

QUALITY NOTICE

TITLE : FUEL NOZZLE RESTORATION OF PW127M (ATR 72-600)

1. INTRODUCTION/BACKGROUND.

1.1 It was reported of incident of engine fire involving Malindo Air PW127M engines installed on ATR 72-600.

1.2 A thorough investigation lead by Pratt & Whitney Canada team has been performed and as a result of the investigation, it was found that the engine fire was due to fuel nozzle B-nut crack **(refer appendix).**

1.3 In conclusion to this finding, it was found that the B-nut cracking was due to *hydrogen embrittlement*. In theory, *hydrogen embrittlement* may occur with existence of the following elements:

1.3.1 Time
1.3.2 Material Susceptibility
1.3.3 Tensile Stress
1.3.4 Source of hydrogen (acidic product/solution)

1.4 PW127M B-nut is made from stainless steel (17-4PH – hardened to H1075) which is in intermediate range of susceptibility. With the presence of acidic product onto the material whilst it is under tensile stress (torque) has created a condition susceptible for *hydrogen embrittlement* **(refer appendix)**. With sufficient time for the hydrogen to react with the material, the material than become brittle thus causing it to crack/break.

2. ACTIONS

From this, Quality Assurance has outlined several mitigating action to minimize any possibilities of maintenance lapses.

1.4.1 All task involving removal and installation (restoration) of PW127M fuel nozzle is considered as crucial and critical to engine propulsion and aircraft safety. Thus, a **duplicate inspection** is required whenever above task is involved.

1.4.2 In addition, restoration of fuel nozzle for both PW127M engines on one aircraft **shall not be performed** at the same maintenance visit .

a member of Lion Group
C-5-05, Block C, Oasis Ara Damansara, 2 Jalan PJU 1A/7A, 47301 Petaling Jaya, Selangor, Malaysia
www.malindoair.com E-mail: info@malindoair.com Tel:+603-7845 5888 Fax:+603-7845 5888 Call Centre:+603-7845 5888

1.4.3 It is crucial for the engineer in-charge to perform a detailed inspection of the manifold hoses B-nut to ensure no **early sign of corrosion** is observed. A manifold with sign of corrosion shall be quarantined and reported to Quality Assurance for further investigation.

1.4.4 Licensed Engineer shall ensure that **only approved solvent/materials** listed in Maintenance Manual are to be used throughout the maintenance process.

Please be guided accordingly. Thank You

MALINDO AIR Quality Assurance M & E

General Manager Quality Assurance

Malindo air

www.malindoair.com

APPENDIX

Image above shows one of the findings of B-nut crack.

Malindo ED0673 (Engine Fire)

Image above shows magnified view of brittle intergranular fracture confirming on Hydrogen embrittlement.