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Aviation Safety Occurrence Report (ASOR) - Full Details

Defence Aviation Safety Authority

Defence Flight Safety Bureau

Reference Number: **ASOR: CFS-019-2011**

Workflow Phase	Historical	Classification	Accident
Occurrence Date	18 May 2011	Occurrence Time	15:15
Location	East Sale	Location Details	
		Six miles south west approximately 2800 ft AMSL.	
Parachute Incident Report	NO	Movements Incident Report	NO
Physiological Incident Report	NO		
DAAFS	YES	ATSB	NO

Weather

Light Conditions	Day	Meteorological Conditions	Visual Meteorological Conditions
Environmental Facts	N/A		

Aviation Unit:

Central Flying School

Keywords:

Keyword L1	Keyword L2
Materiel	Engine

Aircraft Details:

Aircraft: PC9/A

Tail Number: A23-039

NVD Aided	External NVG	Search NVG	Strobe Lights On	Landing Lights On	Anti Collision Lights On	Helmet Mounted Device	Engine Shut Down	Engine Mission Abort	Speed (KIAS)	Altitude (Feet AMSL)	Flight Path	Flight Phase
No	No	No	Yes	No	Yes	No	Yes	No	100 to 200	Greater than 2000	Clear	Departure

Aircraft: PC9/A

Tail Number: A23-039

Fuel Dump	Fuel Dump Detail
No	-

Title:

ENGINE FAILURE LEADING TO AIRCRAFT ABANDONMENT

Narrative:

The aircraft had just departed and was approximately six miles outbound on a Flying Instructors Course Navigation exercise climbing above approximately 3000 ft AMSL.
The AC reported hearing a bang or boom followed by a loss of power and numerous CWS red and amber captions. A turn

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back towards East Sale was commenced, the ELS Isolated and FCU manual toggle attempted with no power response; NG indicated approximately 20 percent. The engine was shutdown and a glide approach attempted to East Sale. A Mayday was declared with Sale approach, who secured a landing clearance for runway 04. The approach did not achieve safe parameters for a landing and a successful ejection by both crew was made with the aircraft crashing approximately 2500 ft short of runway 04.

Investigation Details:

Investigation Status:	Completed	Investigator:	s47E(d)
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Analysis:

Reference No.	Agency	Title	Comment
01	Air Training Wing	Accident Investigation Report	Refer to DDAAFS AAIT located at ATW File 2005/1099080 ID:W337434

Findings:

Reference No.	Title	Comment
s22		
11	Aircraft Flap Position	A23-039s flaps were in the UP position immediately prior to impact
12	Engine Components	The core engine components had not suffered a catastrophic failure or other unserviceability that led to the loss of power
13	Spline Drive	The drive spline exhibited wear in the drive teeth where they engaged the coupling shaft, to the extent that it was unlikely that engine power would have been able to drive the pump.
14	Power Loss	A23-039 lost engine power due to fuel starvation as a result of High Pressure Fuel Pump failure.
15	Spline Failure	The pump drive splines failed as a result of a mechanical wear mechanism.
16	Spline Failure Analysis	<p>Analysis showed the wear in the pump drive splines likely occurred over time, rather than as a result of instantaneous failure, although a specific wear rate could not be quantified.</p> <p>The wear failure in HPFP S/No 501 was initiated and progressed to ultimate pump failure within, at most, 1560.1 ENHRs.</p> <p>It is likely that the wear in the pump drive mechanism was present when the HPFP was subjected to a B/S 1 service in February 2011.</p> <p>The inspection of the HPFP drain port during B/S 1 failed to reveal the extent of spline wear</p> <p>Due to the level of damage sustained by the drive splines, a definitive source of the initiation of the wear damage could not be identified</p> <p>For the model of HPFP fitted to A23-039 at the time of the accident, the drive spline teeth and the internal teeth of the coupling shaft were required to be chrome-plated, resulting in a chrome-on-chrome material pairing in the pump drive system</p> <p>Chrome-on-chrome material pairing is considered a poor choice in terms of resistance to fretting and galling wear.</p>
17	Visual Inspection	Prior to the accident, the drive spline of HPFP S/No 501 had not been visually inspected for as little as 4.9 years (1400.9 elapsed ENHRs), or as much as 7.9 years (1560.1 elapsed ENHRs).
18	Pump Wear Correlation	There is a possible correlation between pump elapsed life, undisturbed installed



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		duration and the likelihood of wear failure in the drive splines being detected
19	HPFP Inspection	High Pressure Fuel Pump 501 passed an inspection for iron-oxide deposits in June 2006, at 4560.8 ENHRs, and was refitted to A23-039.
2	Terrian	Terrain was not contributory to the accident, nor to the injuries sustained by the aircrew
20	HPFP Bay Service 2	Maintenance instructions for a HPFP Bay Service 2 or similar pump face inspection do not require the removal of the coupling shaft and examination of the drive spline teeth for evidence of corrosion or wear
21	Servicing Swabs	Swabs used to test HPFP S/No 501 were not retained at AIE following the conduct of the B/S 1 in February 2011 There is no defined requirement for swabs used in B/S 1 maintenance activities to be retained following completion of an investigation.
22	PW&C HPFP Policy	The P&WC recommended maintenance policy for HPFP inspections carries an inherent error rate in detecting developing wear
23	HPFP Servicing Difficulties	Internal construction of the drain port cavities on the HPFP imposes difficulties in accessing the intended cavity in order to inspect for corrosion residue Concentration on achieving the required depth of penetration of the swab into the drain port may increase the likelihood the FCU drain cavity will be accessed, rather than the HPFP drain target cavity. Adaptations of the procedure have been suggested (but not enacted) by individuals to assist in accessing the correct cavity of the HPFP drain port The B/S 1 inspection procedure as demonstrated to the AAIT by the incident technicians varied from the procedure for the inspection in the Engine Maintenance Manual in so far as the angle of insertion was not entirely consistent with the documented guidance. It is possible that inspection of the FCU cavity drain may result in corrosion residue present in the target HPFP drain cavity being missed during a swab test.
24	Servicing Training	PC9 technicians at Airflite East Sale receive formal instruction at a systems level for PC9 maintenance activities and on-the-job training prior to receiving authorisations to conduct maintenance on the aircraft. No formal instruction in the conduct of a B/S 1 was provided to PC9 technicians as the B/S 1 was considered to be a standard maintenance task with no associated special training or authorisation requirements
25	Ineffective B/S 1	The most probable explanation for the ineffective B/S 1 on HPFP S/No 501 in February 2011 is that corrosion residue was not present in sufficient quantities for detection in the areas swabbed in accordance with the test procedure; or that the incorrect area of the drain port was examined and residue present was not detected
26	Feathering Solenoid	The most likely source of the failure of the propeller to feather is the presence of an intermittent fault in one of the two feathering microswitches that prevented the feathering solenoid from receiving the electrical signal to energise

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Contributing Factors:

Contributing Factor Level 1	Contributing Factor Level 2	Contributing Factor Level 3	Contributing Factor	Contributing Factor Priority	Contributing Factor Other
Preconditions for Unsafe Acts	Substandard Conditions	Equipment	Unreliable/ Faulty	Most important (or equal most important) contributing factor	-

Risk Management:

Strategies:	-	Effective:	No
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Risk Management Narrative:**Unit Actions:**

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Unit Recommendations:

Reference No.	Agency	Status	Date	Title	Comment	Response	Rejected Reason
1	Air Training Wing	Completed	27/05/2014	EFCU Limit	AFTG is to address the perception spread by a small proportion of the PC9 instructional community that intentionally violating the published EFCU limit is acceptable.	ATW PC9 technical and training documentation and guidance clearly indicates that 40% is the minimum Ng for the use of the EFCU. The issue was discussed at the ATW Standardisation Conference (18-19 Oct 2012), CFS and 2FTS have confirmed that the clear guidance to staff is that 40% Ng is the minimum allowable Ng for use of EFCU.	-
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15		Completed	27/05/2014	Source of Spline Damage	TASPO, in cooperation with P&WC, ascertain likely sources of damage	The P&WC design package discusses likely sources of damage. It concludes that the wear mechanism is fretting and galling of the driveshaft and coupling splines under operational contact stresses, with associated corrosion of the base material. DSTO state that	-

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	Air Training Wing				initiation to HPFP drive splines to mitigate against further in-service failures, with specific consideration to rotational free-play in the coupling shaft.	the chrome-on-chrome interface at the drivespline and coupling interface is prone to wear. To mitigate, P&WC has recommended replacement with an alternate HPFP (which doesn't have this wear mechanism) or increased inspection frequency. The new maintenance policy addresses this issue.	
16		Completed	27/05/2014	Rate of Spline Wear	TASPO, in cooperation with P&WC, attempt to determine representative rates of wear in HPFP drive spline assemblies should wear damage be initiated	P&WC states that driveshaft wear rates are highly dependent on a combination of factors including lubrication, contact surface coating depth and pump alignment. They have not been able to determine representative wear rates. They have instead used service experience, field data and Weibull analyses to determine an appropriate maintenance policy for the RAAF HPFP. TASPO/DGTA concur with this method, as it is the same method that TASPO MRD uses when developing maintenance policy.	-
17		Completed	27/05/2014	Alternative mechanism	TASPO assess options for alternative configurations of the pump drive mechanism which may eliminate the drive spline/ coupling shaft interface and possible problematic material pairs.	An alternate HPFP configuration is currently available. The alternate HPFP has a solid splineshaft and coupling so there is no interface for wear to develop. This HPFP is not certified for the PC9/A PT6-62A variant but P&WC is working towards certification by end Dec 12. TASPO has conducted a Cost Benefit Analysis of the Life Cycle Costs of the current HPFP configuration against the new configuration and concluded at this time, it is cost prohibitive to procure the new HPFPs. With the significantly more conservative maintenance policy for the existing HPFP, the residual risk is considered acceptable. Procurement can be revisited as required once certification of the new HPFP on the PC9/A is completed. It is recommended that no further action be taken at this time and this recommendation be closed.	-
18		Completed	27/05/2014	HPFP Asset History	TASPO should conduct an assessment of High Pressure Fuel Pump asset histories for PC9 aircraft to confirm any correlation between pump elapsed life, undisturbed installed duration and drive spline wear damage	TASPO completed an assessment of HPFP asset histories based on data from two sources: STI 538 results and wear results from a sample of 25 RAAF gearsets examined by P&WC Montreal. There is no direct correlation between wear and gearset life. Because no correlation has been identified, alternative means were used to determine an appropriate maintenance policy for the HPFP. Refer to task #6 for more information.	-

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19	Air Training Wing	Completed	27/05/2014	HPFP Bay Service 2	TASPO ensure instructions for the conduct of a HPFP Bay Service 2 or similar pump face inspection require removal of the coupling shaft and visual inspection of the drive spline and coupling shaft teeth for evidence of wear, corrosion or deterioration of the protective chrome plating	TASPO, DGTA and P&WC agree that the removal and re-installation of the coupling to the drive shaft is a wear initiator and should be avoided. The existing BS2 inspection will detect corrosion products and effectively reduce the risk of HPFP failure to an acceptable level, without the need to remove the coupling. Therefore, TASPO recommends that no further action is required.	-
2		Completed	27/05/2014	Review Simulated Airborne Emergency Training	AFTG is to review simulated airborne emergency training events to identify instances where the simulated case has significant differences from the likely emergency scenario and address the impact of these differences.	ATW reviewed simulated emergencies related to major aircraft systems (Hydraulic, Engine, Fuel, Oxygen, Electrics) and found the only significant infidelity related to cockpit indications. And although the existing guidance provided by aircraft system lectures, pre-flight briefings, and OIP was mostly satisfactory, deficiencies were identified with the information about engine failure performance with an unfeathered propeller. This deficiency was highlighted by an amendment to CFS MRPs	-
20		Completed	27/05/2014	HPFP Swabs	TASPO assess the benefit of revising maintenance procedures for HPFP Bay Service 1 inspections to ensure testing agencies preserve and retain swabs used during the maintenance, to assist in retrospective	-	This recommendation is not applicable as the RAAF maintenance policy no longer includes the BS1 swab test.

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	Air Training Wing				assessment of the items if required		
21		Completed	27/05/2014	Review Bay Service 1	TASPO, in conjunction with P&WC, should review the effectiveness of the Bay Service 1 and its resulting applicability to RAAF maintenance actions	TASPO and DGTA were concerned about the effectiveness of the BS1 and have agreed that it should be replaced by a visual inspection of the pump face (BS2). The P&WC-recommended maintenance policy addresses this requirement.	-
22		Completed	27/05/2014	Bay Service 1 Instructions	TASPO review the adequacy of the maintenance instructions for, and technician training provided, for the Bay Service 1	This recommendation is not applicable as the RAAF maintenance policy no longer includes the BS1 swab test.	-
23		Completed	27/05/2014	Reduction in Inspection Interval	TASPO, in conjunction with P&WC, reduce the inspection interval for Bay Service 2 inspections to an appropriate level as informed by this accident	"TASPO has completed Design Acceptance on the P&WC recommendations for the new HPFP maintenance policy. The new HPFP maintenance policy: removes the requirement for a BS1 (the in-situ swab test) due to TASPO/DGTA concerns regarding the effectiveness of this maintenance task implements a BS (which replicates the old BS2 inspection) as follows: - for gearsets TSN < 3000 ENHRs BS every 600 ENHRs - for gearsets TSN >= 3000 ENHRs BS every 300 ENHRs reduces the current HPFP overhaul life from 4000 ENHR/8ELPYR to 3000 ENHR interval The new HPFP maintenance policy has been issued. TAR approval of the DAR recommendation to remove 600ENHR limitation from the PC9/A fleet has been provided. It is recommended that no further action be taken and this recommendation be closed."	-
24		Completed	27/05/2014	Advice to PT6 Operators	P&WC advise PT6 operators the circumstances of this accident and the implications on HPFP maintenance actions	P&WC has released a Service Bulletin to all operators with a revised maintenance policy for the HPFP. The SB is similar to the RAAF maintenance policy but the RAAF maintenance policy is more conservative as it essentially replaces the BS1 with the BS2.	-

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25	Air Training Wing	Completed	27/05/2014	Feathering Solenoid History	TASPO is to review the history of PC9 feathering system failures, the current on condition maintenance policy for feathering system microswitches, and determine current serviceability trends for the feathering system	<p>A review of historical defect records and a fleet-wide inspection of the propeller feathering system determined that:</p> <ul style="list-style-type: none"> - the system failures were predominately attributed to worn feathering solenoids rather than micro switches, - the reliability of feathering solenoids declines with age, and - the maintenance/overhaul instructions lacked clarity and were therefore unlikely to detect system failures. <p>In reviewing OEM advice, TASPO have determined the following actions to achieve an acceptable level of risk of feathering system failure:</p> <ul style="list-style-type: none"> - amend the maintenance publications with revised feathering system inspection and testing instructions provided by the OEM, and - implement a replace-on-condition maintenance policy for the feathering solenoids. <p>The revised maintenance policy has been submitted for publishing. As of 20 Mar 13, 19 aircraft have had the propeller feathering system check completed in accordance with the revised instructions. Two faults have been discovered and rectified. The remaining 44 aircraft will be inspected prior to Nov 13.</p> <p>TASPO considers the intent of this action to be met and recommends the action be closed.</p>	-
26		Completed	27/05/2014	Feathering Solenoid Replacement	TASPO is to determine if the introduction of a scheduled replacement or preventative maintenance policy for feathering system microswitches is warranted	<p>Pilatus report stated that the solenoid was an order of magnitude more likely to fail when compared to the microswitches.</p> <p>The microswitches are functionally checked at each R2 and after each flight on engine shutdown, and replaced on-condition. There is no discernable trend to microswitch failures. The on-condition maintenance policy is consistent with microswitch maintenance policy across other aircraft fleets.</p> <p>The current maintenance policy, and the frequency of confirming the functionality of the microswitches, are considered adequate and it is recommended that no further action be taken and this recommendation be closed.</p>	-
3		Completed	27/05/2014	Review SATG Guidance Regarding Glide Speed	AFTG is to review the current SATG guidance regarding glide speed (prior to PCLOFF) to ensure that a standardised technique is applied within the RAAF PC9 community.	ATW reviewed SATG guidance on optimum glide speed before and after the selection of PCLOFF, and recommended techniques. The current Student Air Training Guide (SATG) information is deemed appropriate and adequate.	-

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4	Air Training Wing	Completed	27/05/2014	AIR 5428 to be advised of the lack of a suitable Synthetic Training Device	AFTG is to ensure that Project Air 5428 personnel are made aware of the shortcomings of the legacy AFTG PC9 training systems regarding the absence of a suitable Synthetic Training Device (STD) for the practice and assessment of emergency training serials.	HQ AFTG staff members have participated in the Air 5428 Integrated Project team (IPT) for Operational Concept Document (OCD). The approved OCD (V2.11.4 18 May 12) mandates the provision of high fidelity Flight Training Devices/Simulators for a number of tasks including emergency handling and currency testing.	-



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HTA Actions:

-

HTA Recommendations:

-

Damage Details:

The aircraft sustained Category 5 damage and was destroyed in the impact.

Supervisor Comments:

DDAAFS AIT actions and recommendations completed through ATW and higher actions.
Discussion included in responses to AAIR.

CO Comments:

Nil



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Board Review:

Closed out of session upon documenting the obj ID for the AAIR. A minute from ACAUST to CAF (obj ID AC827250) stating that to his satisfaction, all action items required had been completed.

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