Aviation safety investigations & reports

Cessna Aircraft Company 208, VH-CYC

Investigation number:
200400443
Status: Completed

A Cessna C208 aircraft, registered VH-CYC (CYC), with two pilots on board, was being operated for pilot type endorsement training. Air Traffic Control (ATC) had cleared the pilots to conduct upper level air work between 4,000 and 5,000 ft above mean sea level (AMSL) within a 5 NM radius of Green Island, Queensland. Following the upper level air work, the crew requested, and were granted a clearance for, a simulated engine failure and descent to 2,000 ft.

The pilot in command (PIC) reported that while completing the simulated engine failure training, he had retarded the power lever to the FLIGHT IDLE stop and the fuel condition lever to the LOW IDLE range, setting a value of 55% engine gas generator speed (Ng). The pilot under training then set the glide attitude at the best glide speed (for the operating weight) of about 79 knots indicated airspeed (KIAS). The PIC then instructed the pilot under training to place the propeller into the feathered position, and maintain best glide speed. The PIC reported that he instructed the pilot under training to advance the emergency power lever (EPL) to simulate manual introduction of fuel to the engine.

According to the PIC, he then noticed that there was no engine torque increase, with the engine inter-turbine temperature (ITT or T5) and Ng rapidly decreasing, and a strong smell of fuel in the cockpit. While the pilot under training flew the aircraft, the PIC placed the ignition switch to the ON position and also selected START on the engine starter switch. He then reportedly placed the EPL to the CLOSED position, the propeller to the UNFEATHERED position and the fuel condition lever to the IDLE CUTOFF position to clear the excess fuel from the engine. The PIC reported that they then increased the aircraft airspeed to 120 KIAS, at which point he reintroduced fuel into the engine by advancing the fuel condition lever. He reported that following these actions, the strong fuel smell persisted.

As the aircraft approached 1,500 ft, the PIC broadcast a MAYDAY, informing ATC that they had a 'flameout' of the engine and that they were going to complete a forced landing water ditching near Green Island. While the pilot under training flew the aircraft, the PIC placed the propeller into the feathered position, closed the fuel condition lever to the IDLE CUTOFF position and turned off the starter and ignition switches. They then completed a successful landing in a depth of about 2 m of water near Green Island. The pilots evacuated the aircraft without injury.

The aircraft, which sustained minor damage during the ditching, but subsequent substantial damage due to salt water immersion, was recovered to the mainland. Following examination of all connections and control linkages, the engine was removed for examination under the supervision of the Australian Transport Safety Bureau (ATSB) at the engine manufacturer's overhaul facility. The engine trend monitoring (ETM) data logger was also removed from the aircraft for examination.

Engine information

Manufacturer:	Pratt & Whitney (Canada)
Model:	PT6A-114
Serial number:	17099
Time since new:	8,473.9 hours
Cycles since new:	15,924 cycles
Time since overhaul:	4,713.4 hours

The general condition of the engine was good except for exfoliation corrosion of the magnesium and aluminium alloy components as a result of salt-water immersion. The first-stage axial compressor blades displayed significant erosion of the blade leading edges at the blade root portion of the airfoil. The erosion of the blades measured a maximum of .250 inch (.635 cm). According to the engine manufacturer's maintenance manual, the erosion limits of the compressor blade at the root was .250 inch without repair. The eight engine thermocouple probes were also examined. Testing of the probes indicated that they all passed the heat response test, but two probes did not pass the insulation test. The engine igniters operated satisfactorily when tested.

The engine fuel control unit (FCU) was removed to another facility for disassembly and examination under ATSB supervision. The examination of the FCU revealed no evidence of any internal component failure or anomaly, which would have prevented normal operation prior to salt-water immersion.

Engine temperature indicating system

The engine temperature indicating system consisted of a bus-bar assembly, eight individual thermocouple probes connected in parallel, a wiring harness incorporating a terminal block and an adjustable trim harness incorporating a T1 thermocouple probe.[1] The T1 thermocouple probe was connected in parallel with the T5 wiring harness to bias the T5 signal and give the system a reference point. The engine manufacturer's maintenance manual included a note in the Engine Condition Trend Monitoring (ECTM) Shift Fault Isolation Chart stating that the T5 indication usually decreased when the thermocouple probes were unserviceable. The chart also noted that:

> If several probes are broken or damaged, the loop resistance would not necessarily fall outside the allowable tolerance. However, erroneous temperature indications could occur due to reduced sampling.

An anomaly with the insulation of the thermocouple probes would typically manifest itself in abnormally low temperature readings.

Engine trend monitoring data logger

The ETM data logger recorded Ng, bus voltage, engine torque, T5, engine shaft horsepower (SHP), fuel consumption, airframe hours, engine total cycles, starts and duration and system exceedances. This information was electronically stored on a removable data key. Information stored

on the data key could then be downloaded into a computer. The pilot reported that the data key was installed into the ETM display unit at the commencement of flight. However, after the aircraft was recovered, the data key was not found.

After preservation, the ETM data logger was shipped to the manufacturer for downloading. The manufacturer successfully recovered nineteen exceedances covering a period from 1 January 2003 to 3 February 2004. The majority of those logged were exceedances of propeller RPM and engine SHP.

Engine emergency power lever

The EPL, which was connected through linkages to the manual over-ride lever on the FCU, governed the fuel supply to the engine should a pneumatic section malfunction occur in the FCU. The EPL permitted the pilot to restore engine power by activating the lever to manually introduce fuel to the engine.

The aircraft manufacturer's Service Kit, SK208-142, provided for the installation of mechanical devices allowing for the installation of copper witness wire to the EPL. If the EPL was been moved from the NORMAL position, the copper witness wire would fracture and provide a physical indication that it had been activated. The installation of SK208-142 was not mandatory for Australian registered aircraft. However, the requirements of SK208-142 had been complied with on the aircraft.

Cessna Alert Bulletin, CAB01-15, included a requirement to ensure the fitment of the copper witness wire to the EPL of all aircraft that had SK208-142 installed. Compliance with the requirements of CAB01-15 was not mandated for Australian or United States (US) registered aircraft. According to the flight crew, no copper witness wire was installed on the aircraft at the time of the occurrence.

The aircraft maintenance manual stated that if the EPL witness wire was broken or missing, a determination was to be made as required by the engine maintenance manual, to assess if the engine limitations had been exceeded.

The aircraft manufacturer's information on the operation of the EPL stated that the use of the EPL was for emergency purposes only, and contained cautions about the use of the EPL for any other purposes. Further information about the aircraft manufacturer's use of the EPL is contained in appendix A.

The engine manufacturer's Service Information Letter (SIL) Number PT6A-053R2 addressed the use of the EPL. Although it also stated that the EPL was for emergency purposes only, it mentioned the use of the EPL for training purposes under supervision to maintain emergency practices proficiency. It included a note which suggested that familiarization training using the EPL be conducted on the ground. Further information on the operation of the EPL is contained in appendix B.

The pilot reported that, based on the reference to familiarization training in the SIL, he considered that the use of the EPL for in-flight familiarization training was acceptable.

Civil Aviation Regulation 1988, Part 50E addressed inconsistent requirements relating to aircraft operation and maintenance. Part 50E noted that by order of priority, the aircraft manufacturer's requirements superseded the requirements of an aircraft component manufacturer such as an engine manufacturer.

Recent engine maintenance

Date	Engine hours since new	Maintenance
22 January 2002	7,243.2	Remove and replace two thermocouples, hot section inspection, compressor turbine disc and FCU replaced.
9 July 2002	7,704.1	T5 busbar and thermocouples replaced.
25 November 2002	8,110.9	Compressor turbine disc inspected and reinstalled.
18 November 2003	8,431.5	Inspection in accordance with AD/ENG/5 (compressor first-stage)
28 January 2004	8,482.0	Hot section inspection (extension from 1,250 to 1,760 hours)

There were no engine logbook entries concerning engine compressor erosion. Engine compressor washes had been completed on a periodic basis as required. Civil Aviation Safety Authority requirements for the aircraft are contained in appendix C of this report. Engine trend data for the aircraft's engine are contained in appendix D.

The pilots of CYC were conducting in-flight simulated engine failure training, which involved activation of the emergency power lever (EPL). The engine ignition switch was not in the ON position during the initial operation of the EPL during this training. The pilot's operating handbook (POH) contained a requirement to place the engine ignition switch in the ON position during an actual malfunction of the fuel control unit (FCU). However, because the aircraft manufacturer only included requirements for an actual FCU malfunction, the POH did not address the engine control settings for training of this type.

The POH contained a caution which stated that the use of the EPL was for emergency purposed only, and did not mention the use of the EPL for in-flight or ground familiarization training. The engine manufacturer's Service Information Letter (SIL) noted the use of the EPL for familiarization training, while suggesting that this training be completed on the ground. The discrepancy between these two documents may have led to the flight crew's belief that the use of the EPL for familiarization training in-flight was acceptable.

Disassembly and inspection of the engine and fuel control unit did not identify any anomaly of the engine that could have resulted in the in-flight shutdown (flameout). However, the erosion of the first-stage compressor blades to the engine manufacturer's maximum service limits would have reduced the aerodynamic efficiency of the compressor blades. This may have affected the optimum compression ratio of the compressor section and resulted in decreased airflow through the engine.

According to the pilots, the engine power setting was low (reported at 55% Ng) at the time fuel was manually introduced using the EPL. If the airflow through the engine had been affected by the first-stage compressor erosion, the engine would have had a further reduced airflow rate for that given power setting and excessive fuel may have been introduced.

Analysis of the Engine Condition Trend Monitoring (ECTM) information, which indicated higher parameters for engine fuel flow, T5, and engine gas generator speed (Ng), should have alerted maintenance personnel to the erosion of the compressor. The inspection of the compressor completed 42.4 airframe hours before the incident should have noted and recorded the erosion of the first-stage compressor blades. Additionally, the ECTM information indicated increases in fuel flow and Ng, with marginal decreases in T5 temperatures. The decrease in T5 temperatures below the baseline values was believed to be related to the insulation anomaly of the two thermocouple probes.

1. The pilots of CYC were conducting in-flight familiarization training using the emergency power lever. That procedure was not contained in the aircraft manufacturer's pilot operating handbook.
2. The engine manufacturer's documentation contained information on the use of the emergency power lever, which did not preclude the use of the emergency power lever for in-flight familiarization training.
3. The engine sustained a flameout at an altitude above mean sea level from which reignition of the engine was not successfully completed.
4. Erosion of the first-stage compressor blades would have reduced the aerodynamic efficiency of the compressor blades.

Engine manufacturer

On 10 November 2004, the engine manufacturer issued Service Information Letter Number (SIL) PT6A-053R3 (revision three) to SIL PT6A-053R2, to clarify that the utilisation of the EPL is for emergency use only, in accordance with the aircraft manufacturer's pilot operating handbook. SIL PT6A-053R3 removed any reference to conducting familiarization training with the EPL.

Civil Aviation Safety Authority

The Civil Aviation Safety Authority has advised the ATSB that, following the release of the Bureau's final report, they will issue a letter informing their field offices responsible for surveillance of evidence of operation of the EPL by pilots for in-flight training, and that the operation of the EPL in this manner is in conflict with the aircraft pilot's operating handbook.

RECOMMENDATIONS

The following recommendation was issued by the Australian Transport Safety Bureau on 24 May 2004:

Recommendation 20040058

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority assess the safety benefit of mandating Cessna Alert Bulletin CAB01-15 with regards to the Emergency Power Lever on all Approved Single Engine Turbine Powered Aeroplane Australian registered C208 aircraft.

CASA response

On 14 July 2004, CASA responded to the recommendation as follows:

> CASA has assessed the safety benefit of mandating Cessna Alert Bulletin CAB01-15 and has agreed to issue an Airworthiness Directive (AD), which will mandate the Cessna Bulletin.

This recommendation remains on MONITOR status awaiting the issuing of the Airworthiness Directive.

Appendix A: Aircraft manufacturer emergency power lever information

The pilot's operating handbook (POH) included a CAUTION addressing use of the emergency power lever (EPL), which stated:

> The emergency power lever and its associated manual override system is considered to be an emergency system and should be used only in the event of a fuel control unit malfunction. When attempting a normal start the pilot must ensure that the emergency power lever is in the NORMAL (full aft) position; otherwise, an overtemperature condition may result.
>
> When using the fuel control manual override system, engine response may be more rapid than when using the power lever. Additional care is required during engine acceleration to avoid exceeding the engine limitations.
>
> Inappropriate use of the emergency power lever may adversely affect engine operation and durability. Use of the emergency power lever during normal operation of the power lever may result in engine surges, or exceeding the ITT[T5], Ng, and torque limits.

The POH stated that a WARNING was an operating procedure, technique, or maintenance practice, which may result in personal injury or loss of life if not carefully followed. A CAUTION was an operating procedure, technique, or maintenance practice, which may result in damage to equipment if not carefully followed.

The aircraft manufacturer advised the ATSB that it 'did not recommend the operation of the EPL for training'.

Appendix B: Engine manufacturer emergency power lever information

In February 1998, the engine manufacturer issued Service Information Letter (SIL) Number PT6A-053R2 addressing the use of the emergency power lever (EPL) in C208 aircraft. Revision 2 (8 January 2004) of that SIL included a statement noting that the EPL was 'sensitive' in movement and should be operated as follows:

> Slowly advance the EPL from the "NORMAL" position, to increase power. Slowly decrease the EPL position, to reduce engine power.

NOTE: There may be some lever travel, where the EPL movement results in no change in engine power. This condition is called "deadband" and is typically at least the first inch of travel past the opening detent, which is normal.

NOTE: In the existing installation, EPL sensitivity is further accentuated because maximum EPL travel is attained approximately two inches before the forward range of the slot on the pedestal.

The SIL also noted that:

The EPL should only be used to modulate engine power to allow the pilot to continue flight to the nearest airport should one of the following conditions occur:

1. Uncommanded engine power roll back and unable to recover with the Power Lever Assembly (PLA).
2. No response to PLA movement when starting from or around idle.
3. PLA becomes stuck at or around idle.

The EPL does not duplicate the function of the PLA and should not be used as an optional means of controlling the engine. It must be left in the "NORMAL" position during all normal engine operation.

P&WC would also like to re-emphasize that the system is intended "for emergency purposes only" as outlined in the applicable Cessna Pilot's Operating Handbook (POH) and should be used accordingly. The system can also be used for training purposes under supervision in order to maintain emergency practices proficiency.

NOTE: It is suggested that familiarization training with the EPL be conducted on the ground to ensure better control, less distraction, and close monitoring of the engine parameters for exceedances.

Appendix C: CASA requirements

CASA aircraft requirements

In August 2000, the Civil Aviation Safety Authority (CASA) issued Aircraft Airworthiness Circular (AAC) 1-116 entitled 'Approved Single Engine Turbine Powered Aeroplane' (ASETPA). AAC 1-116 and CAR 174A and 175B documented the requirements for the operation of single-engine turbine powered aircraft permitted to carry passengers for hire or reward under the Instrument Flight Rules (IFR) and at night under the Visual Flight Rules (VFR) subject to CASA approval. CYC was being operated under ASEPTA approval. Eligibility for ASETPA operations approval included a requirement for the aircraft to demonstrate several design standards, increased engine reliability rates, increased maintenance scrutiny and to be equipped with additional equipment including Engine Condition Trend Monitoring (ECTM).

Also included in the criteria was a requirement for the engine ignition system to be:

1. An automatically activated engine ignition system which activates in the event of a loss of an engine parameter such as engine speed, turbine temperature or engine torque, or
2. An ignition system which can be selected `ON' and had a duty cycle greater than one hour.

The engine did not have an automatically activated engine ignition system, but it had a duty cycle greater than one hour.

CASA engine requirements

The engine was being maintained in accordance with the requirements of CASA Airworthiness Directive AD/ENG/5 *Turbine Engine Continuing Airworthiness Requirements*, Amendment 8, effective 11 June 2003. Appendix A, item 2 of this directive included a requirement for the use of a ECTM program. The operator had complied with the requirements of item 2, by utilising the engine manufacturer's ECTM system. The operator had complied with the requirements of the AD/ ENG/5 by having the ECTM data analysed by authorised personnel within the organisation. Appendix A item 8 of this directive also included a requirement for an inspection of the first-stage compressor to be carried out at intervals not to exceed 220 hours time in service.

Appendix D: Engine trend data

The Australian Transport Safety Bureau (ATSB) and the engine manufacturer's representatives conducted a review of the trend data for a period of approximately 18 months prior to the occurrence. That review indicated that both the fuel flow and the engine Ng had been above baseline values (increased) for the majority of the last 3 months of the data. However, engine T5 had been at, or below (decreased), baseline values during the same time frame. According to the data, this T5 downward trend began on 16 April 2003, 9 months prior to the occurrence.

The engine manufacturer provided a detailed description of it's ECTM system in the company publication *ECTM User's Guide & Reference Manual (7th edition, September 2001)*. The manual noted that erosion of the axial compressor normally increased engine parameters for corresponding power settings (eg the compressor was less efficient and power output decreased, therefore the power lever angle must be increased). The manual noted that this change would be progressive as the erosion resulted over a prolonged period. The aircraft ECTM data indicated that the engine Ng baseline was 0.7 percent. The charted values for the 3 month period varied from 0.7 to 2.0 percent (excluding peaks). Referencing delta Ng, the manual stated:

1. Net change of .75 to 1.0 %: Should be investigated when convenient.
2. Net change of 1.5 to 2%: Action should be taken as soon as possible.

The engine manufacturer's maintenance manual included a note that stated:

> Compressor deterioration (which increases Ng) and hot section normal deterioration (which reduces Ng) may balance each other and the effect deterioration has on Ng will be very small or zero (i.e. Ng will remain constant).

It further noted on the ECTM Shift Fault Isolation Chart that, with all engine parameters increasing, the probable anomaly could be compressor erosion.

[1] Gas temperatures (T) are measured at various points throughout the engine and are numbered by convention to identify their location within the engine. Examples are inlet air temperature (T1), compressor discharge temperature (T3), and inter turbine temperature (T5).

General details

Date:	08 February 2004	**Investigation status:**	Completed
Time:	1610 hours EST		
Location (show map):	Green Island		
State:	Queensland	**Occurrence type:**	Engine failure or malfunction
Release date:	10 December 2004	**Occurrence category:**	Accident
Report status:	Final	**Highest injury level:**	None

Aircraft details

Aircraft manufacturer	Cessna Aircraft Company
Aircraft model	208
Aircraft registration	VH-CYC
Serial number	20800108
Type of operation	Aerial Work
Damage to aircraft	Minor
Departure point	Cairns, QLD
Departure time	1537 hours EST

Destination	Cairns, QLD

Crew details

Role	Class of licence	Hours on type	Hours total
Pilot-in-Command	ATPL	211.0	5333

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