Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Investigation – 200606542
Final

Engine failure – Townsville Airport, Qld
1 November 2006
VH-UBX
Cessna Aircraft Company 207

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Figures 1, 2 and 6 Fuel system schematic, Typical Engine Fuel Pump with Aneroid assembly and Engine fuel system schematic derived from data supplied by Teledyne Continental Motors.

Figure 7 Fuel Flow Stabilisation Procedure card supplied by Cessna Aircraft Company.

Abstract

On 1 November 2006 at 1201 Eastern Standard Time, the pilot of a Cessna Aircraft Company 207, registered VH-UBX, was on final approach to runway 07 at Townsville Airport, when the engine stopped. The pilot attempted to restart the engine, but was unsuccessful. To avoid the airport perimeter fence, the pilot elected to conduct a forced landing into an adjacent tidal swamp. The pilot landed the aircraft in the swamp and the aircraft sustained major damage. The pilot and three passengers were uninjured.

An inspection of the aircraft revealed that there was adequate fuel on board to complete the flight. Further investigation found several mechanical problems with the engine-driven fuel pump that were associated with foreign object debris and errors in maintenance.

The investigation identified safety issues with a third party maintenance provider's procedures and the operator's in-flight engine restart procedures.

As a result of this accident, the third party maintenance provider has made changes to its operation and recalled a number of pumps that were subject to unauthorised maintenance.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

Sequence of events

On 1 November 2006 at about 1201 Eastern Standard Time[1], the pilot of a Cessna Aircraft Company 207 (C207), registered VH-UBX, was on final approach to runway 07 at Townsville Airport, Qld. The pilot reported that the aircraft was a little high on the approach and the throttle setting was reduced to correct the profile. Once the aircraft was re-established on the approach, the pilot advanced the throttle lever, but there was no response from the engine. The engine had stopped with the propeller windmilling.[2] The pilot stated that she believed at the time that the problem was fuel starvation, possibly from a ruptured fuel line. An attempted to restart the engine was made by selecting the opposite fuel tank, maintaining the mixture control to full rich, adjusting the throttle and applying the electric driven fuel pump to the high position for about 20 seconds. The engine did not restart.

As the aircraft was rapidly approaching the airport boundary fence and did not have adequate altitude to avoid a collision with the fence, the pilot elected to conduct a forced landing in an adjacent tidal swamp.

The aircraft came to rest in shallow water and tall reeds. The aircraft sustained major impact damage. The pilot and three passengers were uninjured and exited from the left door of the aircraft. Damage to the right wing prevented the right passenger door from being opened.

Aircraft information

The aircraft was manufactured in 1969 (serial number 20700138) and at the time of the accident had accumulated 15,906 airframe flight hours. In 1994, the aircraft was modified under a Supplemental Type Certificate[3] to fit a '0' hour Time Since Overhaul Teledyne Continental Motors IO550F2B engine.

In 2000, the engine and its associated components were removed and overhauled as specified under the schedule of maintenance. At the time of the accident, the engine had operated for 1,176 hours since that overhaul.

The aircraft had flown 3 hours 54 minutes on the day of the accident and had accumulated 93 flying hours since the issue of the maintenance release. There were no defects endorsed on that maintenance release. The aircraft was in the class B

1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

2 Inoperative engine, driven by ram air flow through the propeller.

3 Authorised alteration to aircraft, engine or other item operating under approved type certificate.

category[4] and was being maintained under Civil Aviation Safety Authority (CASA) Schedule 5 and applicable CASA Airworthiness Directives.

Since the maintenance release had been issued, routine maintenance consisting of the replacement of one tyre, and an oil and oil filter change had been performed.

During the last 100-hourly inspection, key maintenance tasks in relation to the fuel system included:

- fuel filter inspection
- in-house engine flexible fuel hose manufacture and replacement.

The Engine Fuel Pump (EFP) had been overhauled about 6 years previously. Since overhaul, that EFP had accumulated 1,176 hours with 524 hours remaining until the next overhaul.

Pilot information

The pilot held a commercial pilot (aeroplane) licence and had accumulated 6,021 hours at the time of the accident, with 4,949 hours on type, and had flown 94 hours in the last 90 days.

The pilot had owned and operated the aircraft for 9½ years, primarily in the Charter category.

Aircraft final approach to Townsville Airport

A review of the Townsville Air Traffic Control (ATC) recorded radar data and automatic voice recording revealed that at 1151:10, the aircraft was approaching the airport from the north-west. At 11:54:48 the pilot reported 'visual'[5] at 1,000 ft and at 1157:12 the aerodrome controller issued a clearance to land on runway 07 to the pilot. At 1157:29, the aircraft was turned to align with runway 07. At 1157:58, the pilot reported that there was a 'fuel failure and would drop short of the airstrip'. There was no more radio communication from the pilot. The aircraft's radar track ceased at 1159:00.

The data and interviews with the pilot did not indicate any operational issues that may have contributed to this engine failure such as inadequate fuel quantity / fuel management, a prolonged uncoordinated turn or unusual flight attitude that may have uncovered the fuel tank outlets.

Fuel calculations

Prior to the accident, the aircraft had been flown from Townsville to Chillagoe, Balcooma Mine, Ingham and back to Townsville. The flight duration was

4 Civil Aviation Regulation 1988, defines a class B aircraft as an Australian aircraft that is not a class A aircraft. Class A refers to aircraft with a Certificate of Airworthiness issued in the transport category, or one that is used for regular public transport operations.

5 The pilot has established and can continue flight to the aerodrome with continuous visual reference to the ground or water.

approximately 4 hours. Prior to departure from Townsville, the pilot established that there was 255 litres of usable fuel on board. A further 100 litres of fuel was added to the aircraft at Chillagoe. The pilot calculated that the useable fuel on board the aircraft, after landing at Townsville, would be 35 litres in the right fuel tank and 40 litres in the left fuel tank, based on a fuel burn calculation of 1.19 to 1.08 litres per minute, depending on the flight profile of climb, decent and cruise.

Examination of aircraft

Inspection of the aircraft after it was removed from the swamp, found that the fuel selector and the ignition switch were selected to OFF. It was later reported that another operator had selected the fuel from the left tank to OFF and the ignition from BOTH to OFF after the accident under the supervision of the airport safety officer.

An inspection by the operator's maintenance provider, under the supervision of the Australian Transport Safety Bureau (ATSB), found that the left wing tank had 57 litres of fuel, of which 13.2 were unusable, and that the fuel system was capable of delivering fuel to the engine's fuel injectors.

The right tank had ruptured outboard of the fuel tank drain valve. Approximately 15 litres of fuel remained in the root area and this included 13.2 litres of unusable fuel. The fuel quantity prior to impact could not be definitively established; however, fuel records and fuel burn calculations indicated that there should have been up to 35 litres of useable fuel. A witness confirmed that he had observed fuel leaking from the right wing as a result of the damage.

A fuel injector line was disconnected and the fuel system was briefly pressurised. Fuel, clear of air, was observed to flow from the line when either the right or left tank was selected.

The main fuel filter was found to contain some fine particles of debris. The investigation considered that the particles were consistent with the environmental conditions that the aircraft had been operated in and long term refuelling from drum stock. Fuel samples from both wing tanks were tested. Those tests established that the fuel quality was adequate to support combustion.

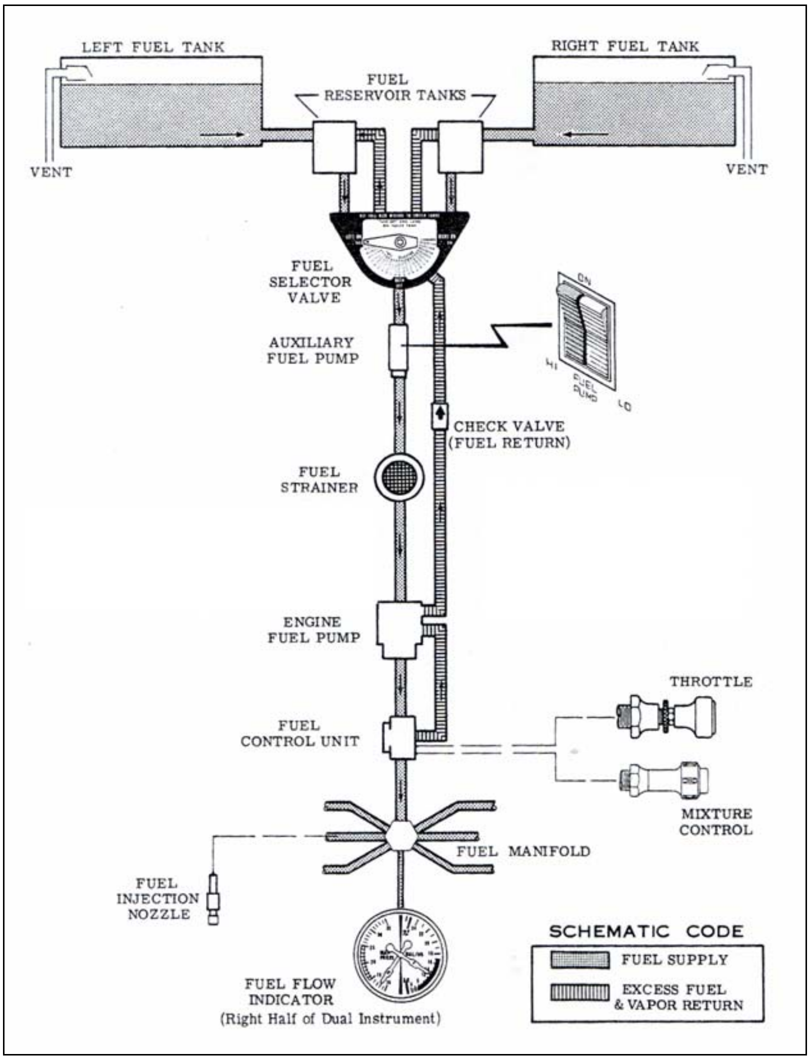
An inspection of the aircraft fuel system, the electrical system, continuity of the power plant drivetrain and the interphase between the engine and airframe was conducted. This inspection did not reveal any defects that may have contributed to the accident. The EFP was removed for further examination.

Fuel system

In normal operation, fuel is gravity fed from the C207's main fuel tanks (located in the left and right wings) to the respective fuel reservoir tank, through the tank selector valve (selector valve selected to left – fuel is fed from the left fuel tank, selector valve selected right – fuel is fed from the right fuel tank). Fuel then travels through the auxiliary fuel boost pump (normally OFF, but selected ON in the event of an EFP failure), through the main fuel filter, then to the EFP. The EFP pumps fuel to each of the cylinders in a metered amount via the fuel control unit (FCU) and a fuel manifold. Fuel pressure indication is measured at the fuel manifold. Excess fuel (as a result of the metering function) is returned from the FCU to the

EFP and from there, returned to the reservoir tank via the EFP ejector valve (Figure 1).

Figure 1: Fuel system schematic



Engine fuel pump

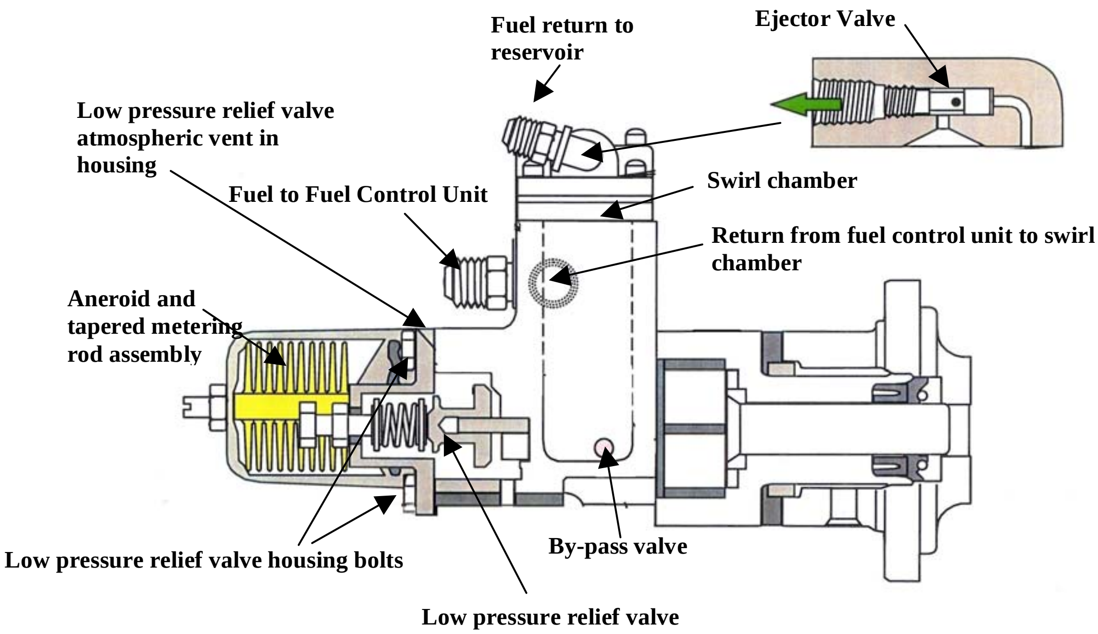
The EFP (Figure 2) was a pressure inlet sensitive, positive displacement, vane type pump. It is the only continuous moving part in the fuel injection system. The primary functions of the fuel pump include supplying fuel under pressure to the injection system and performing certain metering functions. Since the fuel pump is engine driven, the EFP outlet pressure and flow varies with engine RPM. As engine RPM increases, the outlet fuel flow and pressure will increase.

To ensure an adequate fuel supply to the engine, the EFP delivers more fuel than the engine can use and a return line is necessary to recirculate excess fuel. The recirculation path will reduce the fuel pump output pressure, so an orifice in the return line increases pressure and allows the pump to maintain excess capacity. The faster the pump runs, the greater will be its output. Because the orifice in the fuel return line remains fixed, any increase in output will also increase output pressure.

The fixed orifice in the return fuel path plays an important role in fuel metering. Should the orifice become partially or completely restricted, excessive output pressure may result and upset the balance of proper fuel metering and subsequent fuel flow.

The pump must provide adequate fuel flow and pressure at low engine speed as well as the higher ranges. At idle or low power, the output flow and pressure will be low. The fixed orifice cannot maintain the required outlet pressure at low idle range. A low pressure relief valve in series with an adjustable orifice enables the required pressure to be maintained via a diaphragm and spring acting against a valve assembly.

Figure 2: Typical engine fuel pump with aneroid assembly



Testing of the EFP was conducted at a component repair facility. During this test, several abnormalities were noted. During test at low speed, the EFP made cavitating noises and produced a mixture of fuel and air at the outlet port. At high and mid-speed, the pump leaked fuel from the body seals and produced significantly higher pressure than was required for the engine installation.

Repair of the engine fuel pump

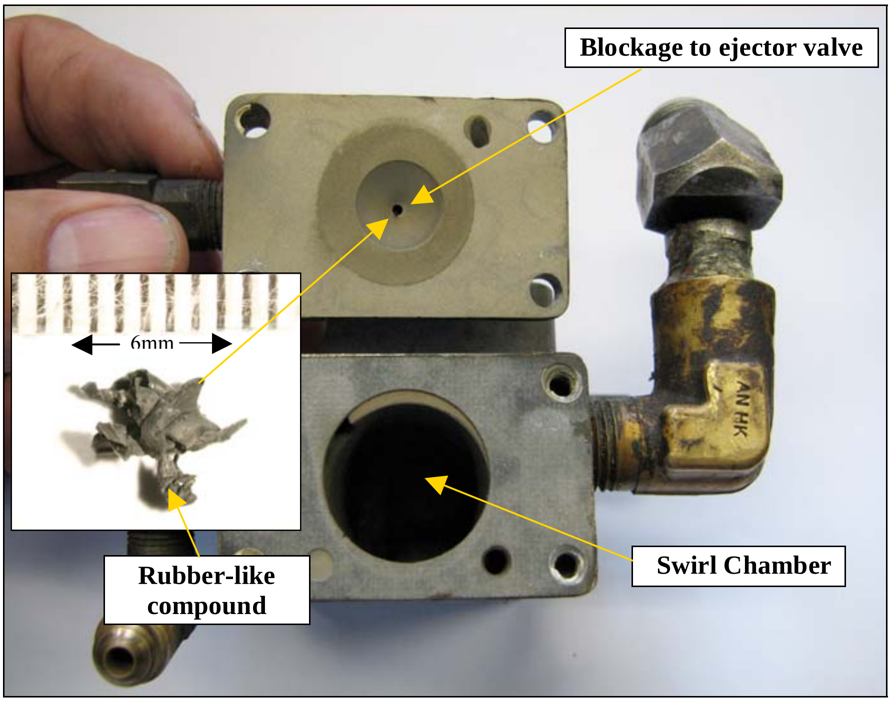
On reviewing the circumstances of the EFP overhaul that was conducted 6 years previously, it was established that the overhaul organisation was CASA-approved, subject to having approved data available from the pump manufacturer. The EFP manufacturer did not provide approved data to the industry. The lack of any manufacturer data required the EFP to be returned to the manufacturer for repair or exchange.

The overhaul organisation did not have the approved data and repaired the EFP based on technical data for other model pumps. The organisation had not complied with the limitations of the CASA Certificate of Approval.

Ejector valve

The ejector valve (Figure 3) was removed and was found to be blocked with rubber-like debris. The ejector valve operates on a vacuum principle through a venturi that ejects any air that accumulates in the swirl chamber. Excess fuel from the EFP is also returned to the swirl chamber. Excess fuel is then returned to the respective fuel reservoir tank through the same ejector valve (Figure 4). With the ejector valve blocked, excessive fuel from the EFP could not return to the reservoir tank.

Figure 3: Rubber-like debris found in the ejector valve

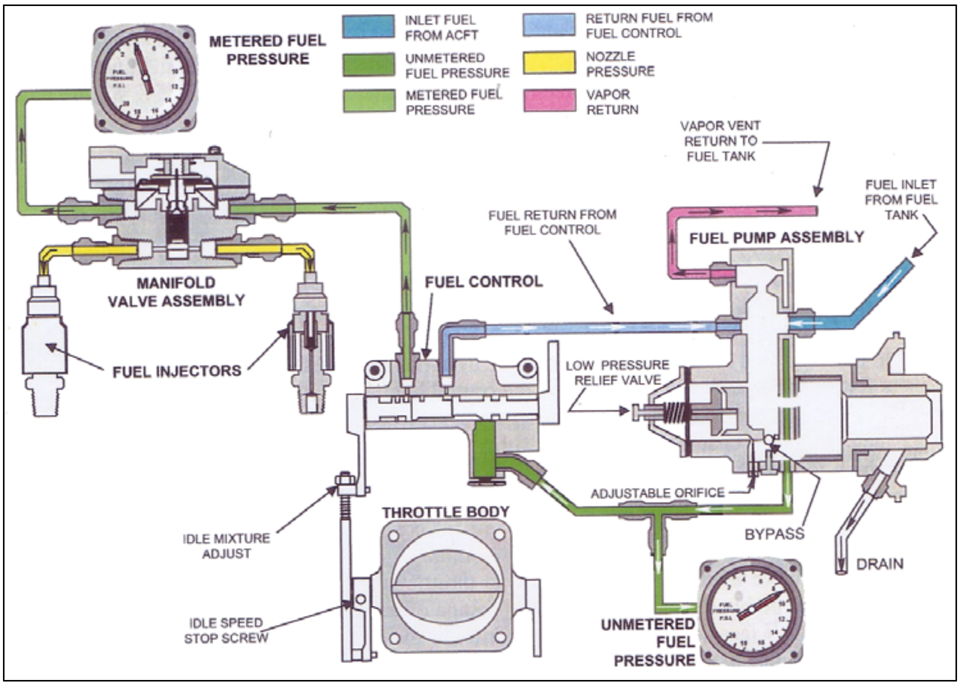


Between the electric fuel pump and the EFP, there was a fuel strainer (Figure 1) that was designed to capture particles/debris in the fuel. That fuel strainer was inspected and very fine debris was found. The debris was consistent with what could be expected from using drum stock fuel and from the local operating environment over time. The rubber-like debris found in the ejector valve was greater in size than the mesh fuel strainer.

The physical size of the rubber-like debris was insufficient to conduct tests that may have determined its origin.

The manufacturer advised that if the ejector valve was blocked, the EFP would run ‘rich’; that is, there would be a high fuel to air mixture.

Figure 4: Engine fuel system schematic



Aneroid

This EFP was also fitted with an aneroid assembly that was designed to reduce unmetered EFP pressure at altitude. This was achieved by a tapered metering rod attached to the aneroid. The aneroid is sealed at normal atmospheric pressure and the aneroid housing is vented to atmosphere. The aneroid expands with a reduction of atmospheric pressure (any altitude higher than sea level has a lower atmospheric pressure). As the sealed aneroid expands, it extends the metering rod into the EFP housing and enables fuel to recirculate and reduce the EFP pressure. An increase in internal recirculation of the EFP reduces the output pump pressure and reduces the fuel flow. This would be the normal function for flight at higher altitudes.

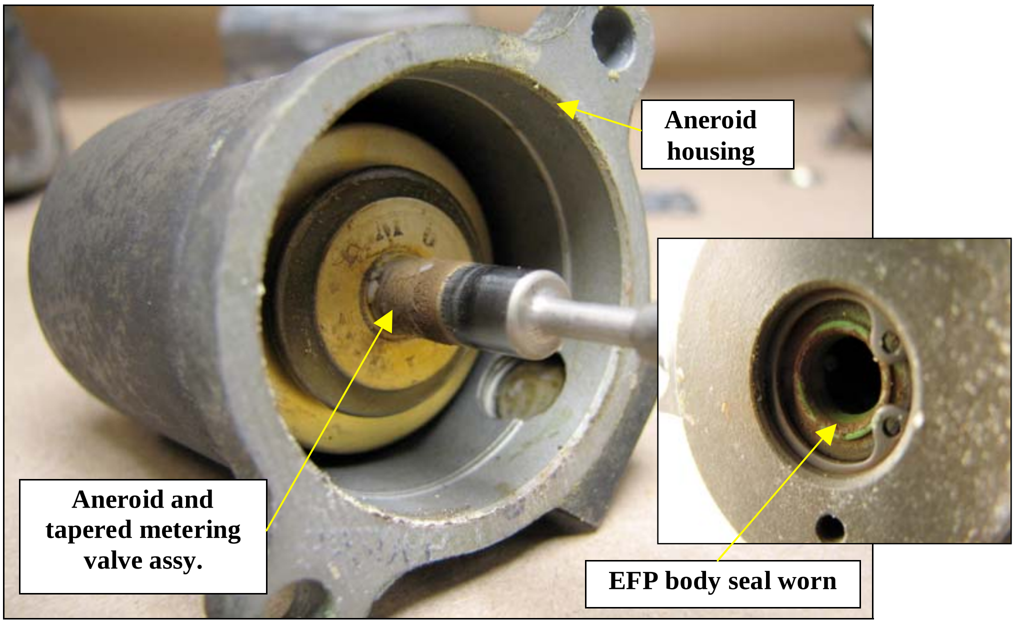
As altitude is reduced, the aneroid is compressed by higher ambient pressure and the metering rod is retracted from the EFP housing. This increases the fuel pressure.

The aneroid assembly was removed from the EFP and inspected. That inspection found that the tapered metering rod was extended and stuck in the EFP housing, but released easily with a small amount of force. There was an accumulation of debris on the tapered metering rod shaft (Figure 5) and the main body seal that received the tapered metering rod, was worn. The aneroid housing was also full of fuel.

The manufacturer advised that if the tapered metering rod was stuck in the fully extended position, it would lead to an increased internal bypass that would reduce the output pump pressure, unless the blockage due to the debris reduced the bypass. A blockage would lead to an increased output pump pressure.

The manufacturer also advised that if the aneroid housing was full of fuel then the engine fuel/air mixture would be 'rich'.

Figure 5: Aneroid and tapered metering valve, housing and EFP body seal

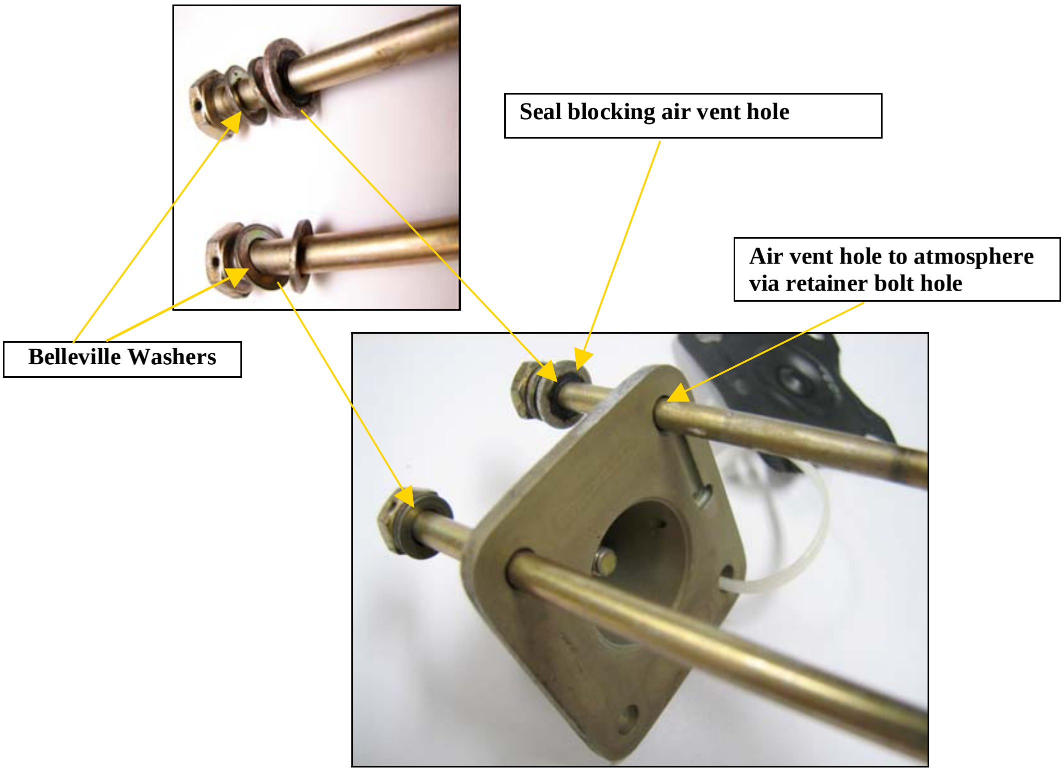


Low pressure relief valve housing

The low pressure relief valve housing was attached to the main pump body by four through bolts. This assembly would normally have a set of Belleville washers[6] fitted under each bolt head as a locking device to retain the correct bolt tension. When inspected, it was found that an additional seal had been fitted under the head of one of the bolts (Figure 6). That bolt corresponded to the air balance hole. The non-standard installation of that seal had covered the air balance hole and prevented the low pressure relief housing from venting to atmosphere. The manufacturer advised that this would also have restricted the rate of movement of the diaphragm and hampered the operation of the low pressure relief valve.

6 Washer, usually of thin elastic metal in form of flat or convex/concave disc, which offers calibrated resistance to linear deflection of centre, perpendicular to plane of washer.

Figure 6: Low pressure relief valve housing



Note: The Belleville washers, air vent hole and the seal fitted under the bolt head adjacent to the air balance hole.

During the life of the engine installation, the aircraft had been maintained by several different maintenance providers. There was no record found in the operator's maintenance log books of an EFP fuel leak or of any maintenance being performed on the EFP that would have indicated the reason for, or the time of the fitting of the non-standard seal on the housing through bolt.

The manufacturer advised that blocking of the air vent hole on the low pressure relief valve would cause the engine fuel / air mixture to be 'rich'.

Emergency Procedures

The operator's 1969 Skywagon Owner's Manual referred to the mixture lever position and auxiliary fuel boost pump application during starting. The manual had a specific section, Starting Engine (section 2-7) that stated:

> …Engine starting in hot weather or a hot engine is sometimes hampered by vapour formation in the fuel lines. To purge the vapour, move the mixture control to full rich, open the throttle 1 ½ inches, and prime with the auxiliary fuel pump switch in the "HI" position until the fuel flow indicator reads 4-6 gal/hr. Then shut off the fuel pump switch and engage the starter. As the flooded mixture becomes progressively leaner, reaching a combustible mixture, the engine will start. If the engine tends to die, turn the auxiliary fuel pump switch momentarily to "HI" at appropriate intervals, until vapour is fully cleared and the engine runs smoothly.

The Owner's Manual did not have a specific section on restarting the engine in-flight or in an emergency procedure section.

The pilot stated that the restart procedure, adopted at the time, was to check that the mixture was full rich, that the throttle was at least half way open, select opposite fuel tank and select the auxiliary fuel boost pump to high for about 20 seconds. During this period, the pilot believed that the fuel-flow gauge was showing proper flow. The engine did not restart.

This aircraft did not have and was not required to have a flight manual. A CASA Civil Aviation Advisory Publication stated that:

> A number of light aircraft do not require a basic AFM [Aircraft Flight Manual] under the new system, because the airworthiness standards that were applied at the original type certification by the relevant NAA [National Airworthiness Authority] did not require an AFM.
>
> These standards allowed the AFM information to be provided to the pilot using placards in the aircraft. This is the case for some light aircraft models built by one maker between 1953 and the mid-1970s. It is also the case for a few other makes and models, some very old.

The aircraft had placards that provided procedures/information to assist a pilot in various emergency situations in relation to fuel problems. They were:

- fuel fluctuations / power surges event procedures
- engine driven pump failure procedures
- selection of the electric driven pump to Hi[gh] in emergencies only.

A placard located above the co-pilot control column (Figure 7), detailed the procedure to action major fuel flow fluctuations / power surges. This placard was fitted as a result of CASA Airworthiness Directive (AD) AD/CESSNA 207/20 dated October 1979. The AD had a terminating requirement of 100 hours time in service after 31 October 1979. This AD also referred to US Federal Aviation Administration (FAA) AD 79-15-01, Amendment 39-3517. The action for compliance was in accordance with Cessna Service Information Letter (SIL) No SE79-25, Supplement No 1.

Section 1 (a) and 1(b) of this SIL, which was applicable to the aircraft stated:

a. Placard (Part Number 1205252-2) - -
This placard displays the recommended procedures to stabilize fuel flow in the event fuel flow fluctuations or power surges are experienced. This placard is to be attached to the affected aircraft in full view of the pilot.

b. A special procedure card (Part Number D1189-13) has been developed which details fuel flow stabilization and in-flight engine restart procedures. In order to comply with this Service Information Letter, this procedure card is to be kept in the aircraft readily accessible to the pilot.

The intent of that AD was to 'provide instructions for recognition of fuel system vapour blockage and operating procedures to restore normal fuel flow'. This placard also referred to procedure card D1189-13, for expanded instructions (Figure 8).

Figure 7: Placard above co-pilot control column

MAJOR FUEL FLOW FLUCTUATIONS / POWER SURGES

1. **AUX FUEL PUMP – ON. ADJUST MIXTURE.**
2. **SELECT OPPOSITE TANK.**
3. **WHEN FLOW STEADY, RESUME NORMAL OPERATIONS.**

SEE PROCEDURE CARD D1189-13 FOR EXPANDED INSTRUCTIONS

1205252-2

The procedure card had a Fuel Flow Stabilization Procedure and an In Flight Restarting Procedure. The pilot reported that this card was not on board the aircraft and had not been seen during the 9½ years of operating the aircraft. The pilot also stated that she believed the term 'expanded instructions', as used on the placard, meant that the Emergency Procedures Card would reiterate what was on the placard but using more words.

During the investigation, the pilot obtained a copy of the card and subsequently noted it was in two sections - Fuel Flow Stabilization Procedure and In- Flight Emergency Restart Procedure. The pilot believed that the card did not give expanded instructions but contained an additional section on In-flight Engine Restarting Procedures.

The In-Flight Engine Restarting Procedures (Figure 8) Item 4 stated:

> When the fuel flow is in the green arc range with a windmilling propeller, turn the Aux pump off.

Item 5 of that procedure (Figure 8) stated:

> Lean the mixture from full rich until restart occurs.

Figure 8: Procedure card D1189-13

FUEL FLOW STABILIZATION PROCEDURE

If fuel flow fluctuations of 5 lbs./hr. – 1 gal/hr. or more or power surges occur, the following procedures are recommended to eliminate vapor and stabilize fuel flow.

1. Switch auxiliary fuel pump to "On" or "Hi" position (as applicable for your model).
2. Reset the mixture as required.
3. If symptoms of vapor continue, turn the fuel selector to the opposite tank.
4. The auxiliary fuel pump may be used as long as necessary to eliminate and avoid fuel vapor accumulation.
5. When fuel flow has remained steady for several minutes, the auxiliary fuel pump can be turned off and the mixture reset.

Anytime after the fuel vapor is eliminated and the fuel flow stabilized, the other tank can be selected provided there is fuel in the tank.

NOTE

If the opposite tank cannot be used because of a lack of fuel, then retarding the throttle quickly to 10 inches or less of manifold pressure for 30 seconds will also aid in eliminating vapor in the system.

IN-FLIGHT ENGINE RESTARTING PROCEDURES

In the very unlikely event of power interruption due to fuel vapor accumulation, immediately perform the following procedures.

1. Switch auxiliary fuel pump to "On" or "Hi" position (as applicable for your model).
2. Turn fuel selector to the opposite tank.
3. Position throttle at least half open.
4. When the fuel flow is in the green arc range with a windmilling propeller, turn the auxiliary fuel pump off.
5. Lean the mixture from full rich until restart occurs.
6. Reset mixture.
7. Adjust power as required.

The other tank may be used again any time after vapor is eliminated and fuel flow is stabilized.

The March-April 2005 edition of CASA's *Flight Safety Australia* included an article highlighting the importance of decals (or placards) and the necessity of compliance with their installation in aircraft.

There are also several ATSB reports (200403210, 200402049 and 200601688) that had previously referred to the importance of ensuring an awareness of engine re-starting technique for different aircraft types and the critical requirement to follow the appropriate emergency procedures.

ANALYSIS

Introduction

The investigation established that the circumstances of the occurrences were consistent with an engine failure at low altitude, where the pilot was unable to restart the engine. It is probable that the engine stopped during the landing approach as a result of a blockage and mechanical defects within the engine fuel pump (EFP).

This analysis will discuss the factors involved in the engine power loss and the pilot’s response, and examine a number of safety issues identified by the investigation.

Blockage and mechanical defects with the engine fuel pump

There were a number of defects identified in the EFP, with the primary defect being a blockage of the ejector valve. That prevented the fuel pump returning excess fuel back to the fuel tank and probably caused an over rich fuel /air mixture during the landing approach.

The pilot had conducted three uneventful landings and the aircraft had flown for about 4 hours that day without any reported problems. Consequently, it is most likely that the ejector valve became blocked by the rubber-like debris during the flight from Ingham to Townsville.

The mesh fuel strainer was fine enough to have filtered something similar in size to the rubber-like debris if it had originated up stream of the strainer. Consequently, it is probable that the rubber-like debris that blocked the ejector valve originated from one of the fuel components that were between the outlet of the main fuel filter and the EFP, including the fuel control unit and associated plumbing. However, the origin of the debris could not be determined.

The other defects found (the aneroid housing full of fuel, the blocked aneroid housing air vent hole and the tapered metering valve extended and jammed in the fuel pump housing) were secondary defects, in that they may have contributed to the engine stopping by supplying incorrect fuel metering for the selected power settings.

Unapproved engine fuel pump repairs

A review of the aircraft maintenance log books and an interview with the current maintenance provider couldn’t establish when the additional seal that blocked the low pressure relief valve vent hole and the aneroid air balance hole had been fitted. However, the current maintenance provider was conversant with the operation of the fuel system, the function of the air vent hole and the necessity of applying the correct maintenance practices. As the aneroid housing utilises the same air vent hole, it is also likely that the aneroid housing had been filled with fuel for some time, rendering the device ineffective.

The debris on the tapered metering rod may have contributed to the accelerated wear of the EFP body seal that is designed to prevent fuel from entering the aneroid housing. That wear probably enabled fuel to leak into the aneroid housing and to fill the housing, eventually leaking out of the air vent hole. This may have prompted maintenance personnel to fit the additional seal in an effort to stop the fuel leak. The addition of the seal was an unapproved repair.

The build up of debris on the tapered metering valve shaft may have also contributed to the shaft being stuck in the body seal. The extended shaft would have reduced the fuel pressure at sea level. However this reduction may have been insignificant as the aircraft had most probably been operated for some time in this condition, with no apparent anomalies.

Engine operating procedures

The pilot suspected that the engine had probably stopped due to fuel starvation and attempted to restart the engine. As the propeller was already windmilling, the initial response was to advance the throttle, select the opposite fuel tank and check that the mixture was in the full rich position, while selecting the auxiliary pump to the Hi[gh] position for about 20 seconds. During this restart attempt the pilot reported that the fuel-flow gauge was showing proper flow. This procedure was unsuccessful.

The pilot was unaware of the over rich fuel / air mixture due to the technical problems with the EFP. That situation would have been further exacerbated by the emergency procedure of applying the electric fuel pump to Hi[gh] for 20 seconds with the fuel-flow gauge showing proper flow while maintaining the mixture control to rich. Nevertheless, it could not be determined if the engine could have been restarted with the mechanical problems found with the EFP.

Even though there were no specific instructions for an engine restart due to an unexplained event, the in-flight engine restarting procedure as detailed in the procedure card D1189-13 (Figure 8), may have been the most appropriate method at the time. The placard located above the co-pilot's control column (Figure 7), stated the procedure to arrest Major Fuel Flow Fluctuations / Power Surges. This placard referred to procedure card D1189-13 for expanded instructions (Figure 8). In the section on In-flight Engine Restarting Procedures, Item 4 of that Procedure Card instructed pilots 'When the fuel flow is in the green arc range with a windmilling propeller, turn the aux pump off' and Item 5 states 'Lean the mixture from full rich until restart occurs'. Had the pilot been aware of the procedure card, she may have been in a position to incorporate that technique during the restart process, subject to there being adequate time for the pilot to complete all the actions required.

Unapproved engine fuel pump overhaul

It was established that the EFP was overhauled 6 years previously by an organisation that held a Civil Aviation Safety Authority Certificate of Approval, but which had not complied with the requirements of the approval, by overhauling the pump without the approved manufacturer's data. However, the investigation could not determine to what extent the EFP overhaul had contributed to the accident.

Conclusion

The engine stopped during the landing approach as a result of technical problems with the EFP. The pilot was unaware of other procedures or techniques that may have assisted in the engine restart. The procedure that the pilot adopted to restart the engine during the in-flight emergency did not result in a successful engine restart. The low altitude of the aircraft at the time of the engine failure did not enable the pilot to reach the runway. As it was, the pilot elected to abandon further restart attempts to maintain control of the aircraft and to conduct a forced landing into the swamp. It could not be established if the engine was able to be restarted by alternative methods, given the identified defects within the EFP.

The investigation highlighted the importance of:

- maintenance personnel complying with the requirements of a Certificate of Approval
- pilots being familiar with all of the operating procedures
- aircraft being compliant with the appropriate Civil Aviation Safety Authority Airworthiness Directives.

FINDINGS

From the evidence available, the following findings are made with respect to the engine failure and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The engine stopped while the aircraft was at a low altitude on final approach.
- The engine fuel pump had debris blocking the ejector valve.
- The aneroid tapered metering valve was jammed in the fuel pump housing.
- A non-standard seal was fitted over the air bleed hole of the aneroid housing that prevented the aneroid functioning as designed.
- The combination of the debris, jammed metering valve and the fitment of the non-standard seal resulted in an over rich fuel/air mixture.
- The pilot was unable to restart the engine.

Other safety factors

- The engine fuel pump overhaul organisation did not comply with the requirements of its Civil Aviation Safety Authority Certificate of Approval.
- The pilot was unaware of the contents of the emergency procedure card that included a leaning technique and auxiliary boost pump operation.
- The pilot did not comply with the In-flight Engine Restarting Procedures as stated on the Procedure Card D1189-13.

SAFETY ACTION

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Engine fuel pump overhaul organisation

The organisation that overhauled the engine fuel pump reported that it has:

- recalled other pumps that were repaired without technical data and replaced them with factory exchange units
- briefed staff on the importance of following the company procedures manual and in particular, not to overhaul components without approved data
- briefed staff to adhere to the scope of their Certificate of Approval
- notified their quality assurance staff (internal and external) of this occurrence.

Operator

The operator has acknowledged the relevance and importance of the procedure card.

Civil Aviation Safety Authority

On 16 October 2007, the Australian Transport Safety Bureau briefed the Civil Aviation Safety Authority on the outcomes of the investigation.

On 31 October 2007, the Civil Aviation Safety Authority issued an Airworthiness Bulletin: AWB28-006 *Cessna Fuel Stabilisation*, to remind operators and maintainers of the applicable Cessna 200 model aeroplanes to periodically ensure that all placards and emergency instructions are in place as required by the applicable Airworthiness Directive,

http://www.casa.gov.au/airworth/awb/28/006.pdf, also refer to Appendix A.

On 16 November 2007, CASA provided the following advice as part of their response to the draft investigation report:

> At the 16 October meeting, the inclusion of pilot training for this kind of emergency for pilots of Cessna 200 and 300 series with this fuel system, into the pilot seminars conducted by CASA was discussed. The purpose of this training would be to raise awareness with these pilots so that their response under similar circumstances would be a well practiced one.
>
> Following reconsideration of the issue, CASA does not believe that this is an appropriate response to the ATSB on this matter for the following reasons.
>
> … CASA's view is that it is unlikely that an awareness campaign/training program as discussed at the 16 October meeting would have changed the outcome of this accident.

As the proposed training was type specific, CASA would expect commercial operators to deliver this type of training to their pilots as part of their normal safety management responsibilities. In addition, the SMS package that has been available to industry for some years, and which is now being updated, provides a set of protocols that if followed by industry organisations, would address this issue. As a reminder for operators of these aeroplanes, including private owners, CASA is preparing an Airworthiness Bulletin [see above] to reinforce the need to display an engine fuel system placard next to the fuel flow indicator and require that a Cessna special procedure card PIN Dl189-13 be placed in the aircraft. CASA considers this will be a sufficient reminder to C200 operators in this case.

CASA notes the report identifies an action by an approved maintenance organisation that inappropriately overhauled the Electric Fuel Pump without use of appropriate manufacturers approved data. Such an action is not allowed under the present regulations and will not be allowed under the proposed regulations.

At the meeting on 16 October the ATSB mentioned that there is currently no requirement to carry out a periodic review of the aircraft's complete technical records for the aircraft to ensure continued compliance with all applicable Airworthiness Directives. Such a review would have disclosed a missing special procedures card.

CASA's Maintenance Regulations Team is presently involved in developing policy on this issue, leading to the new regulations. It is not clear at this time that the new regulatory requirement for an annual airworthiness review, including a check of all Airworthiness Directives, will be extended to all aircraft types in all Classes of Activities. Some sectors of industry are strongly opposed to this initiative, and we are considering alternatives to achieve a similar result or the actual need to undertake the review at all on aircraft or operations which do not attract sufficient risk to require an Air Operators Certificate (AOC) as a mitigator.

As you are aware, the new operational legislation is still being developed, however, the current proposal for Part 135 operations (the VH-UBX accident flight would have been operated under this part) will attract an AOC requirement and this requirement will also drive specific maintenance and continuing airworthiness requirements, including an annual airworthiness review.

As some additional factual information was added to the final report as a result of submissions from Directly Involved Parties that was not available to CASA during its review of the draft report, the ATSB provided CASA with a copy of the proposed final report on 3 January 2008 with a view to confirming its previously provided response in light of the additional information.

On 2 April 2008, CASA responded to the ATSB that it maintained its previously stated opinion and in addition noted its opinion that:

- It was not reasonable for the pilot to assume that the procedure card contained no more information than what the placard stated.
- The actions of the pilot, subject to this matter, were otherwise reasonable.

- This is not a matter addressed by training seminars. It is a matter addressed by pilots themselves by ensuring they discharge the obligation imposed by paragraph 4.4(a) of CAO 40.1.0 and be familiar with the normal and emergency flight manoeuvres and flight planning procedures.
- The placard clearly required the pilot to take steps to ascertain the detail of emergency procedures.

APPENDIX A: AIRWORTHINESS BULLETIN 28-006

Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

Cessna Fuel Stabilisation

AWB 28-006 **Issue** : 1
Date : 31 October 2007

1. Applicability

Cessna 200 Series aeroplanes to which a CASA Airworthiness Directive Titled: "Fuel Flow Stabilisation Placards" and FAA CESSNA AD 79-15-01 apply.

2. Purpose

Remind operators and maintainers of the applicable Cessna 200 Model aeroplanes to periodically ensure that all placards and emergency instructions are in place as required by the documents referred to in applicable Airworthiness Directives.

3. Background

A feature of the Continental Avgas fuelled engines which employ the constant-flow, fuel injection system design, is a fuel vapor purging system to ensure that solid fuel is delivered to the injectors. Under certain conditions, however, the fuel system can suffer from accumulated vapor in the fuel lines and cause unstable fuel flow which may result in rough running, power surges and, if not handled correctly, a complete loss of engine power, requiring an in-flight engine re-start.

Full instructions for identifying various types of unstable fuel flow events and the proper corrective actions, are contained in Cessna Service Information Letter (SIL) SE79-25 (Supplement #1) which introduces two documents, a fixed placard and an expanded instruction card which should be within reach of the pilot at all times.

This requirement is mandated by AD/CESSNA 205/14, AD/CESSNA 206/29, AD/CESSNA 207/20 and AD/CESSNA 210/41, all of which make reference to CESSNA FAA AD 79-15-01.

The affected aeroplanes may not have a flight manual or Pilots Operating Handbook and therefore depend on a fixed placard and an expanded instruction card to provide the emergency operating instructions for the engine fuel system.

To ensure integrity of the approved data, any system of maintenance for the aeroplane should include a periodic check to ensure that all required placards are in place. For example, for any aeroplane maintained in accordance with CASA Schedule 5, note the following extract:

Section 4 - The Instruments

(1), *Check* internal and external required placards.

NOTE: Reference should be made to the aircraft flight manual and airworthiness directives for the required placards

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This means, for example, that compliance with CASA AD/CESSNA 206/29 Fuel Flow Stabilisation Placard is to be checked and certified for at each periodic inspection, even though there is no repetitive requirement in the AD.

Adherence to the manufacturer's instructions will ensure that in the event of an unstable fuel flow condition being encountered, power for flight is restored as quickly as possible.

4. Recommendation

CASA recommends that all operators and maintainers check that the required engine fuel operating instruction placards are in place, including the expanded instruction cards as required by the requirements of the aircraft flight manual and applicable Airworthiness Directives.

5. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletins should be made via the direct link e-mail address:

AirworthinessBulletin@casa.gov.au

Or in writing, to:

Airworthiness Engineering Branch
GPO Box 2005, Canberra, ACT, 2601