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Australian Transport Safety Bureau

Fuel exhaustion and collision with terrain involving McDonnell Douglas Corporation 369D, VH-PLY

36km NW Hawker, South Australia | 17 July 2016



Investigation

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Addendum

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Safety summary

What happened

On 17 July 2016, at about 1039 Central Standard Time, a McDonnell Douglas Corporation 369D helicopter, registered VH-PLY, experienced fuel exhaustion and a collision with terrain while performing powerline inspections 36 km north-west of Hawker, South Australia. There were three crew on board the helicopter. One pilot in the front left seat, one line-worker in the front right seat and one line-worker in the rear left seat. The three crew members were seriously injured and the helicopter was substantially damaged.

What the ATSB found

The ATSB found that ground staff mistakenly told the pilot that the aircraft had been refuelled and through distraction, omitted a crosscheck of the fuel quantity before flight. The pilot's monitoring of the fuel in-flight was based on anticipated endurance, which resulted in him not detecting a low fuel level.

The helicopter was operating with an auxiliary fuel tank system, which did not include a fuel quantity indicator. The Civil Aviation Safety Authority and Design Approval Holder provided responses to the ATSB, which indicated that a misunderstanding likely occurred during the design review and approval process. This resulted in the auxiliary fuel tank system approval migrating from the restricted category to the normal category without a fuel quantity indicator.

The ATSB also found the requirements for the development of fuel policy by operators were dispersed throughout the aviation legislation—14 legislative and three guidance material requirements were found—but they did not require the operator to publish procedures for determining fuel on board before and during flight for commercial operators of aircraft less than 5,700 kg maximum take-off weight.

What's been done as a result

The operator immediately removed all auxiliary fuel tanks from their helicopter fleet and restricted their powerline patrols and inspection flights to main fuel tank fuel only. They developed a corrective actions plan, which included modifications to the auxiliary fuel tank system; permanent installation of a remote warning device; and amended their operations manual to include prescriptive fuel check instructions.

To provide clarity for fuel policy requirements for pilots and operators, in 2016 the Civil Aviation Safety Authority initiated a project to change the fuel regulations and guidance material. The Civil Aviation Amendment (fuel and oil requirements) Regulations 2018 are planned to be implemented in November 2018 as *CASA 29/18 – Civil Aviation (Fuel Requirements) Instrument 2018*.

The ATSB has issued a Safety Advisory Notice (AO-2016-078-SAN-009) for Air Operator Certificate holders of aircraft not greater than 5,700 kg regarding fuel management.

Safety message

This accident highlights the importance of crosschecking fuel before flight and in-flight fuel monitoring by pilots to prevent fuel exhaustion accidents. It also highlights the potential consequences of distraction breaking the flow of ongoing activities. In this case, it resulted in the fuel quantity of the auxiliary fuel tank not being visually checked prior to flight. After recognising that a distraction has occurred, it is crucial that pilots re-establish situation awareness.

Operators of aircraft not greater than 5,700 kg maximum take-off weight are advised they can reduce their risk of a fuel exhaustion accident by providing published procedures and crew training for crosschecking fuel on board before and during flight.

The occurrence

On 17 July 2016, at about 1039 Central Standard Time,¹ a McDonnell Douglas Corporation 369D helicopter, registered VH-PLY, collided with terrain after experiencing fuel exhaustion while performing powerline inspections 36 km north-west of Hawker, South Australia (Figure 1). There were three crew on board the helicopter. One pilot in the front left seat, one line-worker (data recorder) in the front right seat and one line-worker (inspector) in the rear left seat. The three crew members were seriously injured and the helicopter was substantially damaged.

Figure 1: VH-PLY accident site



Source: South Australian Police

On 16 July 2016, two powerline inspection flights were recorded in the helicopter flight log (involving the same crew as the accident flight). The first flight was from 0830 to 1130. It started with 350 L of fuel and ended with 40 L. The helicopter was then refuelled from an intermediate bulk container.² As recorded by the pilot on the flight log, the second flight, conducted from 1206 to 1406, started with 350 L of fuel and ended with 170 L of fuel.

On the next day, the crew started their duty at about 0800. They arrived at Port Augusta Airport at about 0814 where they conducted pre-flight checks of the helicopter and established contact with the customer for permission to access the powerlines, and completed the on-site safety management form. The pilot reported he requested full fuel from the operator's ground support person who replied that he had refuelled the helicopter the day before.

The pilot was observed by other team members performing fuel quality checks during the pre-flight inspection, but was not observed conducting fuel quantity checks. The pilot reported he was approached by another helicopter crew at the airport while conducting his pre-flight inspection, which interrupted his inspection and resulted in him omitting a visual fuel quantity check of the helicopter's auxiliary fuel tank (see the *Helicopter fuel system modification* section in this report).

¹ Central Standard Time (CST): Coordinated Universal Time (UTC) + 9.5 hours.

² A 1,000 L fuel container transported on a trailer.

The ground support person departed the airport with the intermediate bulk container at about 0834 to travel to the planned refuel location with a 3-hour SARTIME³ for the helicopter, nominated by the pilot. Before engine start, the pilot was observed performing his normal scan of the instruments and reported to the ATSB that he thought the fuel quantity indicator indicated full. The helicopter departed the airport at about 0849.

The first phase of their task was a ferry flight to a small transmission substation. They arrived at the substation at about 0923 and started their inspection. The pilot reported that at about 50 minutes into the flight he activated the auxiliary fuel tank solenoid valve to start the gravity transfer of fuel from the auxiliary fuel tank to the main fuel tank. He could not recall if he checked to confirm there was fuel transferring.

At about 1035, the helicopter arrived at powerline structure 228 to perform an inspection. The pilot reported that at a height of about 100 ft, as the helicopter started to move from structure 228 to 229, the engine 'just stopped'. The pilot veered the helicopter away from the powerline towards a clear area, called 'brace', but was unable to arrest the rate of descent, resulting in a collision with the terrain.⁴

The line-worker data recorder regained consciousness in the helicopter and activated the Spidertracks⁵ emergency signal at 1039. The line-worker inspector regained consciousness and found himself outside of the helicopter attached to his harness. The harness was still attached to the helicopter. Neither of the line-workers were able to walk or assist the pilot. The pilot was unable to extricate himself from the helicopter and was eventually removed by the first responding police officer.

Helicopter fuel system inspection

The ATSB inspected the wreckage after it was removed to Port Augusta and spoke to the first responders whom attended the accident site. The ATSB investigation identified:

- no post-impact fire
- no smell of fuel in the wreckage
- no evidence of entrapped fuel within the wreckage
- no usable fuel in the main tank fuel bladder
- main tank bladder was intact and the only identifiable puncture mark was at the top of the bladder and considered to be the result of the impact
- no residual fuel in the fuselage cavity housing the fuel bladder
- minimal fuel found in the airframe and engine fuel filter bowls
- auxiliary fuel tank was empty
- the fuel indicator, showing low fuel level, and fuel transfer systems were found to be serviceable.

The ATSB also established the helicopter was not refuelled after the second flight on 16 July and the accident flight on 17 July.

³ A SARTIME is a time nominated by a pilot to trigger an alert if he or she has not communicated with the person or agency holding the SARTIME by the nominated time.

⁴ In the hover at 100 ft placed the helicopter in one of the manufacturer's 'avoid areas'. The avoid area is a height-velocity combination from which there is insufficient height and/or time to establish autorotation when the engine fails. Operating in this area is a task requirement for powerline inspections.

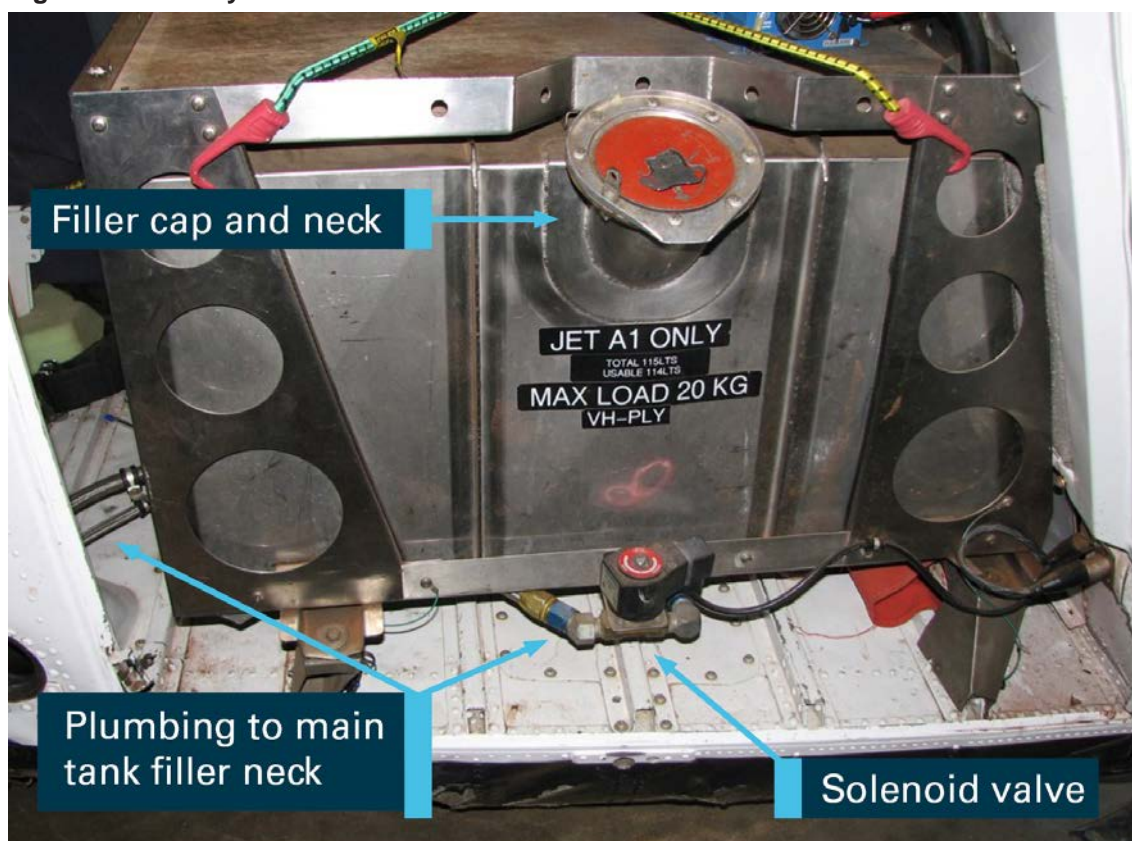
⁵ The helicopter was fitted with a 'Spidertracks' device, which is a satellite tracking device for aircraft. This enables the aircraft's position to be monitored from an internet-connected device. It includes an 'SOS' button, which can be manually activated by the crew in an emergency.

Helicopter fuel system modification

The operations manual fuel policy indicated the helicopter had a main fuel tank capacity of 242 L and auxiliary fuel tank capacity of 115 L (total of 357 L). Fuel consumption was published as between 100 L/h for patrolling and 120 L/h for prolonged high hover.

The operator's fleet of McDonnell Douglas 369 helicopters have had several modifications incorporated,⁶ which included the auxiliary fuel tank (Figure 2).

Figure 2: Auxiliary fuel tank fitted to VH-PLY



Source: ATSB

The auxiliary fuel tank was manufactured from stainless steel. It had a volume of 125 L, but a specified capacity of 115 L when filled to the bottom of the filler neck. The tank was located in the rear right side of the cabin. Fuel transfer was controlled by the pilot operating the solenoid valve switch, located on the instrument panel, marked 'AUX. FUEL TRANSFER'. A green indicating light, located next to the fuel transfer switch would illuminate when the switch was selected to the transfer position. When selected, fuel would gravity drain from the auxiliary tank to the main tank. The main fuel tank provided the fuel supply to the engine.

The pilot reported the transfer of fuel from the auxiliary to the main tank could be verified by the fuel quantity indicator needle not moving, as the fuel would gravity transfer at about the same rate as the engine consumed fuel. He normally activated the fuel transfer switch at about 200–250 lbs (110–130 L) fuel remaining, or 50 minutes of flight time. The pilot reported that he was always taught not to trust fuel quantity indicators and he would therefore manage the helicopter's endurance 'on the clock'.⁷

⁶ The design organisation had provided 24 different engineering orders to the operator, which were applicable to the operator's fleet of McDonnell Douglas 369D model helicopters.

⁷ 'On the clock' or 'by the clock' means the pilot applied an average rate of fuel consumption to the expected total quantity of fuel on board at the start of the flight to monitor the endurance.

The auxiliary fuel tank system did not include a fuel quantity indicator or sight glass or dip stick to check the fuel quantity. Only the main fuel tank system incorporated a fuel quantity indicator. The pilot reported that the auxiliary fuel tank quantity would normally be visually checked by removing the fuel cap before flight, but could not explain how the quantity was verified by a visual check if the tank was filled to less than full.

The pilot reported the decision to use the auxiliary fuel tank was based on the proposed length of the task and the environmental conditions. If no more than two hours of fuel was required or the helicopter performance would be marginal with the extra weight of fuel on board, then the auxiliary fuel tank would not be filled. A review of VH-PLY's flight logs for the week prior to the accident indicated the auxiliary fuel tank was routinely used during powerline inspections.

The ATSB received two separate independent reports during the course of the investigation that the auxiliary fuel tank was routinely used for flying operations, which included flying training. The reports included the practice of managing fuel endurance 'by the clock' with the auxiliary fuel tank.

Design advice

The auxiliary fuel tank design, installation and use started in 1993. The approval holder of the design (the design organisation) changed three times from 1993 to the accident date. Several Design Approvers (CAR 35 authorised persons working for the approval holder) were involved in the various iterations of the tank design and associated documentation. None of those approvers were employed with the current approval holder at the time of the investigation. As a result, historical documents and professional judgement were relied upon, by the design organisation, to provide responses to ATSB questions.

The auxiliary fuel tank design was originally approved in 1993, which required operations to be conducted under a special flight permit.⁸ However, the repeated use of the auxiliary fuel tank for repositioning helicopters made the special flight permit process unacceptable for operations. In 2003, the auxiliary fuel tank was approved for restricted category⁹ operations. The reason for restricted category was recorded as 'tank filled from within cabin & no vapour proof barrier around tank.'

In 2009, a job planning approval form was raised by the approval holder for issue 4 of the auxiliary fuel tank engineering order (EO),¹⁰ which incorporated a 2.9 L expansion space on top of the tank, which cannot be inadvertently filled. This was in accordance with the helicopter certification basis: United States (US) Civil Air Regulations Part 6-*Rotorcraft airworthiness: normal category* (CAR 6¹¹); CAR 6.423 *Fuel tank details – (a) Expansion space*:

Fuel tanks shall be provided with an expansion space of not less than 2 percent of the tank capacity. It shall not be possible to fill the fuel tank expansion space inadvertently when the rotorcraft is in the normal ground attitude.

It was determined in the job planning approval form that the change in type design was 'major', rather than 'minor', which required a request to be submitted to the Civil Aviation Safety Authority (CASA). The reason for the decision was 'some non-compliances with the installation required restricted category approval.' The form identified several factors for consideration, which included 'temporary', 'restricted category' and 'flammability issues'. It required a design advice submission

⁸ A special flight permit may be issued where an aircraft does not meet the applicable airworthiness standards, but is expected to be capable of safe flight for the intended purpose.

⁹ Restricted category indicated that additional limitations on operations were required because the design did not comply with CAR 6 (normal category).

¹⁰ The EO is the technical data which describes the design, shows the design complies with the applicable airworthiness requirements, and provides the production data and instructions for continuing airworthiness.

¹¹ In this report CAR 6 refers to the United States Civil Air Regulations, whereas all other uses of CAR are in reference to the Australian Civil Aviation Regulations.

to CASA with a CAR 6 compliance matrix, and to comply with CASA response's before proceeding to approval.

In support of the job planning approval process, an email exchange took place between the Design Approver and CASA's Airworthiness and Engineering Branch to clarify non-compliance issues. This focussed on the need for a tank expansion space (CAR 6.423(a)). The exchange began in September 2009 with the approval holder's explanation that the tank was only used for repositioning the helicopter and their intent was to approve it in the restricted category. In December 2009, CASA clarified that 'approval of a non-compliant design simply because the aircraft is to be operated under a restricted [category] is not considered acceptable'. This resulted in a modification to the auxiliary fuel tank to incorporate an expansion space and resubmission of the design advice to CASA.

The latest issue design advice¹² was submitted to CASA on 12 January 2010 under Australian Civil Aviation Regulation 35 (CAR 35).¹³ In accordance with CAR 35: *Approval of design of modification or repair*, an application for a modification must satisfy CASA 'that the design conforms with any relevant design standard in respect of the type of aircraft or aircraft component to which the application relates.' The design advice informed CASA that the Design Approver intended to approve the modification in the restricted category. The reason given for the auxiliary fuel tank was:

To provide fuel endurance for positioning the helicopter on specific tasks such as powerline patrolling and inspection.

In addition to a CAR 6 compliance matrix, the design advice included the following restrictions, which would apply in the restricted category:

- the fuel tank is to be installed and used only for repositioning the helicopter in connection with the aerial work operations (powerline washing, inspection, repair, etc.)
- the fuel tank must be removed for all other operations (including the aerial work operations conducted)
- essential crew only on board when fuel tank is fitted
- maximum cabin ventilation must be provided when operating with the fuel tank installed
- either doors off or all available vents open
- the helicopter must at all times have sufficient fuel (including required reserves) in the main fuel tank to reach a safe landing site.

Within the compliance matrix there was no reference to CAR 6.604 – *Powerplant instruments* (a) (1), which required a fuel quantity indicator be installed for each engine or tank. However, there was reference to CAR 6.429 – *Fuel quantity indicator*. CAR 6.429 provided the following standard:

The fuel quantity indicator shall be installed to indicate clearly to the flight crew the quantity of fuel in each tank while in flight. When two or more tanks are closely interconnected by a gravity feed system and vented, and when it is impossible to feed from each tank separately, only one fuel quantity indicator need be installed.

The compliance matrix provided the following statement for CAR 6.429:

The current indication will alert to remaining fuel. Even if the current valve does fail; the pilot can see the fuel is there and increasing.¹⁴

¹² This was the current design advice at the time of the accident.

¹³ CAR 35 was subsequently replaced with Civil Aviation Safety Regulation 21.M and in February 2015 advisory circular (AC) 21-08 was published on the subject: *Approval of modification and repair designs under Subpart 21.M*. AC 21-08 incorporates a section on 'unsafe feature or design characteristic' which was not required under CAR 35. This is a separate and additional requirement in recognition that an unsafe condition may exist despite design compliance with applicable airworthiness standards.

¹⁴ It was unclear what the second sentence meant as the valve could fail open or closed.

The approval holder reported that the Design Approver likely believed that the auxiliary tank modification met the criteria of CAR 6.429, and therefore CAR 6.604 was deemed not applicable. Based on contemporary practices, in determining the certification basis of a modification to which compliance must be shown, only affected requirements are cited.

CASA reported that their response to the design advice was in the context of allowing for the repositioning of the helicopter (ferry flights) prior to undertaking normal flying activities and was conditional upon the limitations documented. In this circumstance, where a fuel quantity indicator was not to be enforced, CAR 6.429 was considered appropriate. CAR 6.604 was appropriate for a permanently installed auxiliary fuel tank.

Issue 3 of the design advice was accepted by CASA on 18 January 2010 and 'found to be compliant with the relevant requirements of CAR 6 (including 6.423(a)) as per the compliance matrix as supplied to CASA by email on 12 Jan 2010.' CASA did not request the associated engineering order (EO) or flight manual supplement (FMS), which were the documents published by the approval holder for the operator. CASA advised the ATSB the decision to review an EO and FMS is dependent upon the experience of the approval holder making the submission. In this case, they were satisfied with the experience of the approval holder and approver.

Engineering order and flight manual supplement

On 9 March 2010, the job planning approval form was updated to include EO issue 5 and FMS issue 3. The reason provided was to clarify the tank capacity on the EO (115 L total and 114 L usable, as measured by the operator) and remove the classification of 'restricted category' from the FMS as the tank complied with CAR 6. When EO issue 5 and FMS issue 3 were published on 9 March 2010 and the restricted category was removed, the operator was allowed to install the auxiliary fuel tank in the helicopter as a permanent fit.

The operating restrictions listed in the design advice submitted to CASA were not published in the FMS or EO. However, the approval holder reported that the removal of the restricted category was contingent upon compliance with EO issue 5, which required the expansion tank to be installed. As the expansion tank was not found fitted, the accident helicopter was not entitled to be operated with the auxiliary fuel tank as a permanent fit.

United States Federal Aviation Administration advisory circular

In 1999, the US Federal Aviation Administration (FAA) published advisory circular (AC) 27-1B on Code of Federal Regulations Part 27 (CFR 27), *certification of normal category rotorcraft*, the replacement for CAR 6.¹⁵ AC 27-1B provided an acceptable means, but not the only means, of compliance with CFR 27 and included the following information about the location of fuel tanks:

Separation of fuel tanks and occupiable areas. Fuel tanks should be located as far as practicable from all occupiable areas. This minimizes the potential post-crash fire sources in occupiable areas and the potential for occupant saturation with fuel on impact. The design should be reviewed to minimize these potential hazards.

The following information was provided in reference to preventing occupant injuries:

Elimination of injurious objects within striking distance of the head and other vital parts can be accomplished by removal of objects with sharp edges or rigid surfaces from within striking distance of vital parts of the occupant.

¹⁵ The Design Approver's compliance obligation was CAR 6 and the requirements of CFR 27 and AC27-1B were either optional (alternative means of compliance), or not available at the time of decision-making.

In 2014, the US FAA issued AC 27-1B change 4, which included an explanation for CFR 27.1337(b) (2),¹⁶ which was equivalent to CAR 6.429, as follows:

Consistent with the requirements of 27.1337(b)(2), a separate fuel quantity indication is necessary for any interconnected fuel tank that has a flow control device, such as a fuel transfer pump or flapper valve, which could fail and trap fuel. This requirement also applies to auxiliary fuel tanks. A sight quantity indicator that is readable by the flight crew in flight may be acceptable for use with auxiliary fuel tanks.

CASA advised that they consider the solenoid valve fitted to the auxiliary fuel tank plumbing to act as a flow-control device. However, they considered it acceptable for the helicopter not to meet the design standards for the purpose of repositioning flights under a special flight permit or in the restricted category. If the auxiliary fuel tank was to become a permanent fit and used for other modes of operation, then it would be expected that the standards in CAR 6 (6.429 and 6.604) should be met following any modifications.

Neither CASA nor the approval holder provided a record to show CASA was informed of the decision to remove the restricted category.¹⁷ If it was determined that the design was compliant with CAR 6, as per CASA's response to the design advice, then the approver could proceed to approval without notifying CASA.

The initial issue of AC 27-1B included the explanation for the purpose of a flight manual with a recommended format, which included the following information:

Section 2 – Normal Procedures:

- (a) Pre-flight Checks. This paragraph would include any exterior, interior, and any system checks prior to starting the engine(s).
- (c) System Checks. This paragraph would include any system check procedures...which should be accomplished before take-off.
- (e) Cruise and/or Level Flight. This paragraph would include any procedures applicable to cruise and/or level flight operation.

The normal procedures in the FMS did not provide any instructions for checking fuel quantity before flight or for checking the operation of the fuel transfer either before flight or in-flight, despite the fact that there was no fuel quantity indicator included in the design. The FMS also did not include a fuel transfer rate, which could be influenced by pressure differences and helicopter attitude changes.

The approval holder advised that the inclusion of the auxiliary fuel tank does not negate the requirement to establish the current fuel state of the helicopter prior to take-off or in-flight. They indicated the auxiliary fuel tank installation included a toggle switch for operation of the fuel-transfer solenoid valve and a 'fuel transfer' indicating light on the instrument panel for the verification of fuel transfer inflight (see the *instrument lights* section in this report).

Fuel policy requirements

Legislation and guidance

As a result of the fuel exhaustion, the ATSB was interested in the legislative requirements which applied to the development of the operator's fuel policy and procedures. CASA's Air Operator's Certificate (AOC) handbook, Volume 2, *Flying Operations - Fuel policy and related requirements* was referenced to identify and locate relevant legislation and guidance material. The ATSB

¹⁶ CFR 27.1337(b) *Fuel quantity indicator*. Each fuel quantity indicator must be installed to clearly indicate to the flight crew the quantity of fuel in each tank in flight. (2) When two or more tanks are closely interconnected by a gravity feed system and vented, and when it is impossible to feed from each tank separately, at least one fuel quantity indicator must be installed.

¹⁷ CASA may have received a copy of the FMS after it was issued to the operator, but this would have been to the CASA team overseeing the operator, rather than the Airworthiness and Engineering Branch.

identified the following two requirements from the AOC handbook as of interest to the investigation:

A method for determining the fuel on board pre-departure, during and after the flight.

A method to cross-check the fuel quantity on board prior to departure.

Regarding a method to crosscheck the fuel quantity on board before departure, the following two legislative references from the AOC handbook were of interest to the investigation:

Civil Aviation Regulation (CAR) 234, *Fuel requirements*:

(1) The pilot in command [PIC]...must not commence a flight...if he or she has not taken reasonable steps to ensure that the aircraft carries sufficient fuel...to enable the proposed flight to be undertaken in safety.

(2) An operator...must take reasonable steps to ensure that an aircraft does not commence a flight as part of the operator's operations if the aircraft is not carrying sufficient fuel...to enable the proposed flight to be undertaken in safety.

Civil Aviation Order (CAO) 20.2, *Air service operations – safety precautions before flight*:

Subsection 6 of CAO 20.2 required the operator to include in their operations manual instructions and procedures for the PIC of an aircraft that has an MTOW [Maximum Take-Off Weight] above 5,700 kilograms to verify the quantity of fuel on board the aircraft before flight.

Regarding a method for determining the fuel on board during flight, the only reference found during the investigation was Civil Aviation Advisory Publication (CAAP) 215-1(2): *Guide to the preparation of operations manuals*. CAAP 215-1(2) appendix B9: *Fuel management*, provided the following guidance:

The operator is to develop procedures to ensure that in-flight fuel checks and fuel management are carried out during the flight. Procedures relevant to the operation should include:

Monitoring for fuel leakage.

How fuel checks are carried out and at what regular intervals during the flight.

How the quantity of remaining fuel is compared with actual consumption to ensure the remaining fuel at any time is sufficient to complete the flight.

The operator's fleet of helicopters were not greater than 5,700 kg MTOW, and in accordance with CAO 20.2, the operator was not required to publish procedures for the verification of fuel on board before flight. CAAP 234-1(1): *Guidelines for aircraft fuel requirements*, provided guidance on crosschecking fuel quantity before flight and applied to all operators of Australian aircraft, but was written as guidance material, as was CAAP 215-1(2).

CASA reported that, in respect to CAO 20.2, it was determined that there was insufficient grounds to justify the requirement being applied to aircraft with a MTOW less than 5,700 kg. It was assessed as being overly burdensome for many operators within that sector of the industry. Increased requirements are applied as aircraft size or complexity increases.

The CASA AOC handbook on fuel policy listed 14 references from legislation and three from guidance material, in addition to CAAP 215-1(2), which could be applicable to the development of an operator's fuel policy and procedures. With respect to what constituted a requirement, CASA reported that the AOC handbook has no legislative power and only those requirements that are empowered by legislation are enforceable.

Operations manual

The operator's operations manual included a fuel policy with flight planning data for each helicopter type in the operator's fleet. The policy included allowances being made for fuel reserves in flight planning, and a note for McDonnell Douglas 369 pilots to refer to the respective FMS if using the auxiliary fuel tank. The refuelling procedures included instructions for post-refuelling checks, which included the pilot in command's responsibility to ensure 'the required amount has

been placed aboard the helicopter'. This last statement was in accordance with pilot's responsibilities under CAR 234.

CAR 215: *Operations manual* required the operator to provide CASA with a copy of their operations manual and to forward to CASA any amendments to the operations manual. The operator's fuel policy and fuel procedures were amended in 2015, but at the time of the accident, there were no procedures for determining the fuel on board before or during flight. No evidence was found to indicate that CASA required the operator to publish these procedures. CASA reported that the standard in CAO 20.2 is deliberately less complex for smaller aircraft than for larger aircraft, and in consideration of the protections contained in other regulatory requirements, there was no need to issue a direction under CAR 215 in relation to fuel-system quantity checks.

Civil Aviation Safety Authority surveillance

The last CASA surveillance of the operator prior to the accident flight was dated 19 June 2015. This was a one-day audit with one CASA Flying Operations Inspector (FOI) and was initiated after a lengthy period since the last audit in 2009. The scope of the audit was:

- flight operations – flight system (process in practice)
- operational personnel – crew scheduling (management responsibility) (process in practice).

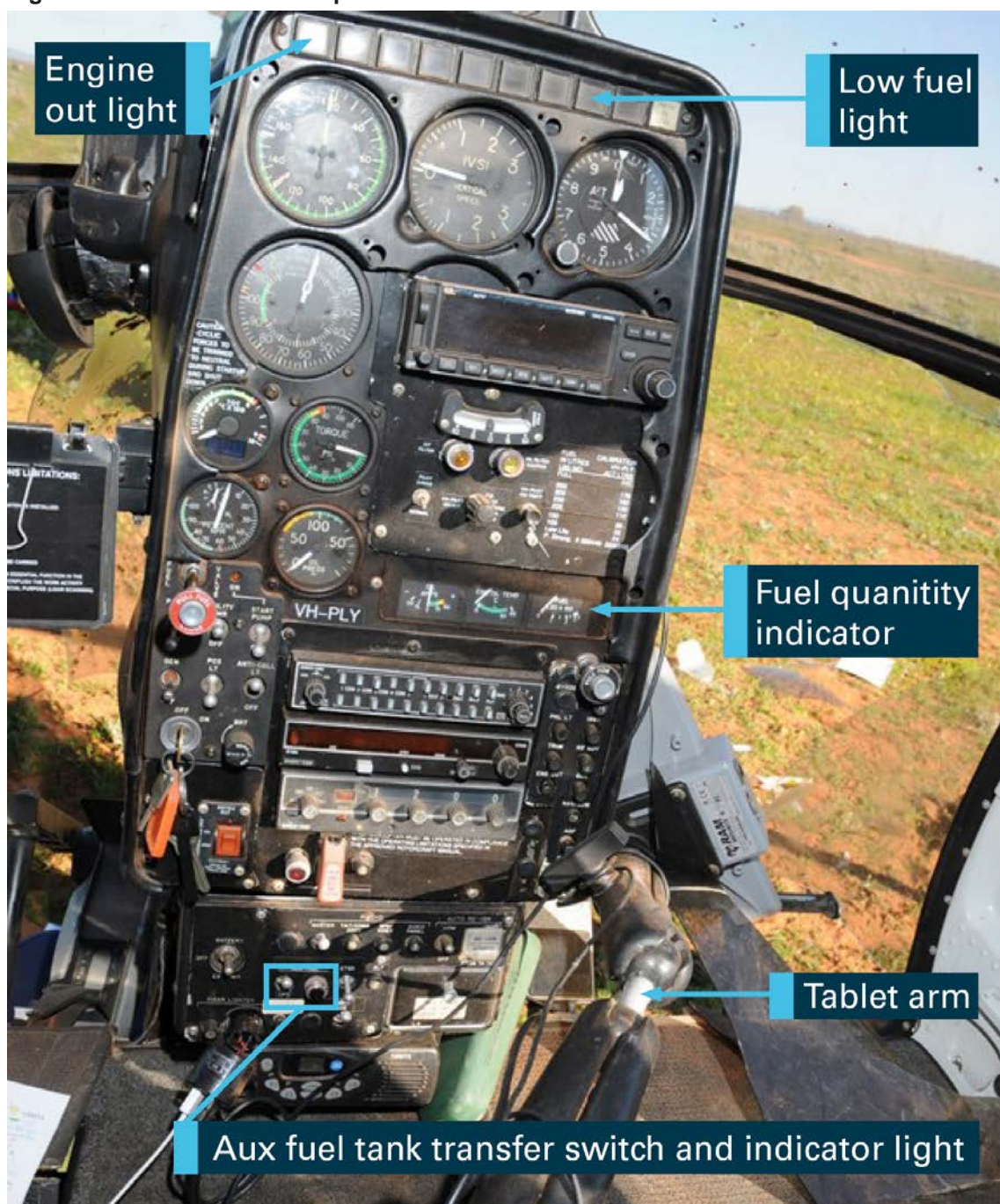
The CASA surveillance manual indicated that much of the information for auditing the 'flight system' was contained in the operations manual. However, the operations manual was not listed as a reference document in the surveillance report. The audit report concluded that the operator's 'internal audits, processes in practice, monitoring and improvement with the aid of [safety information system database] are sound.' No findings were issued.

Cockpit ergonomics

Tablet mount installation

The helicopter was manufactured to be flown by the pilot in command from the left seat instead of the normal right seat helicopter pilot position. The primary flight instruments were located on the left side of the centrally mounted instrument panel and the secondary instruments, including the fuel quantity indicator and low fuel level caution light, on the right side (Figure 3).

Figure 3: VH-PLY instrument panel



Source: South Australian Police, annotated by ATSB

The crew member in the rear left seat performed the role of powerline inspector while the crew member in the front right seat performed the role of data recorder. To assist the crew with the powerline inspection the helicopter was modified with three tablet-mounting arms, two arms located between the front seats and one in the rear. The respective flight manual supplement indicated the tablet-mounts must be stowed for take-off and landing. The pilot must also ensure they do not interfere with any existing systems. Paragraph 2.5 of the operating limitations stated the tablet 'may not be manipulated to a position which obstructs the pilot's view of the instrument panel.'

The pilot reported he had the tablet-mount extended for use and a moving map displayed with the agreed refuelling location marked, which did not obstruct his view of the fuel quantity indicator. Prior to the accident, the right seat crew member was performing his data recorder duties. Neither

the pilot nor the data recorder observed the low fuel level caution light or a low fuel quantity indication prior to the accident.

It was not determined if the front right seat crew member had positioned his tablet-mount in a position which would have obstructed his view of the fuel quantity indicator or low fuel level caution light. At the time of the accident, the right seat crew member was conducting data recorder tasks on his computer with his tablet mount extended. During the investigation, the ATSB adjusted the right seat tablet and found that it could be positioned in a way that would obscure the fuel quantity indicator or low fuel level caution light.

Instrument lights

The master caution panel dimmer system was inspected after the accident and found to be loose and able to be pulled off. The chief engineer reported that when power is turned off, then on, the master caution dimmer is reset to full bright. To dim the master caution panel, the dimmer knob must be pushed in. The pilot reported that during the accident sequence he observed the 'engine-out' light illuminate, which was a red warning light on the far left of the caution/warning panel. This indicated the master caution panel was probably not dimmed.

Position of the sun

The operator reported the low fuel level caution light would activate intermittently at about 30 L fuel remaining and remain on constantly at about 25 L fuel remaining; about 15 minutes of flight time. The sun was in the range of the twelve o'clock position at a low angle leading up to the accident.¹⁸ In this position, the sun would have been in the same general field of view as the instrument panel lights for the pilot in the left seat, who was wearing a helmet with dark visor.

Auxiliary fuel transfer light

The auxiliary fuel tank shutoff solenoid valve had a green indicating light positioned next to the auxiliary fuel transfer switch on the instrument panel. The light was positioned in the circuit between the transfer switch and the solenoid valve and labelled as 'aux fuel transfer' on the wiring diagram. The auxiliary fuel transfer switch was also a circuit breaker. When the switch was selected to transfer, the circuit between the helicopter's electrical power and the solenoid valve closed and the valve powered open. Illumination of the light only indicated that the circuit was closed. It did not indicate the position of the solenoid valve or that fuel was transferring. This was not explained in either the FMS or EO.

Remote warning device

The operator also had an FMS for operating the helicopter with a remote warning device (RWD). According to the FMS, the RWD provided a remote indication of the illumination of any instrument panel caution/warning light within the pilot's field of view¹⁹ and minimised the pilot workload during low altitude, high intensity, operations. However, the RWD was not fitted to the helicopter during the accident flight. According to the operator, it was only fitted for specific operations, such as washing powerline insulators.

Fuel quantity indicator

The helicopter's main fuel tank quantity indicator was a nonlinear indicator, which was more sensitive at lower fuel levels than at higher fuel levels (Figure 4). At the previous routine 100 hourly maintenance inspection, the fuel tank quantity indicator sensor was replaced and a fuel

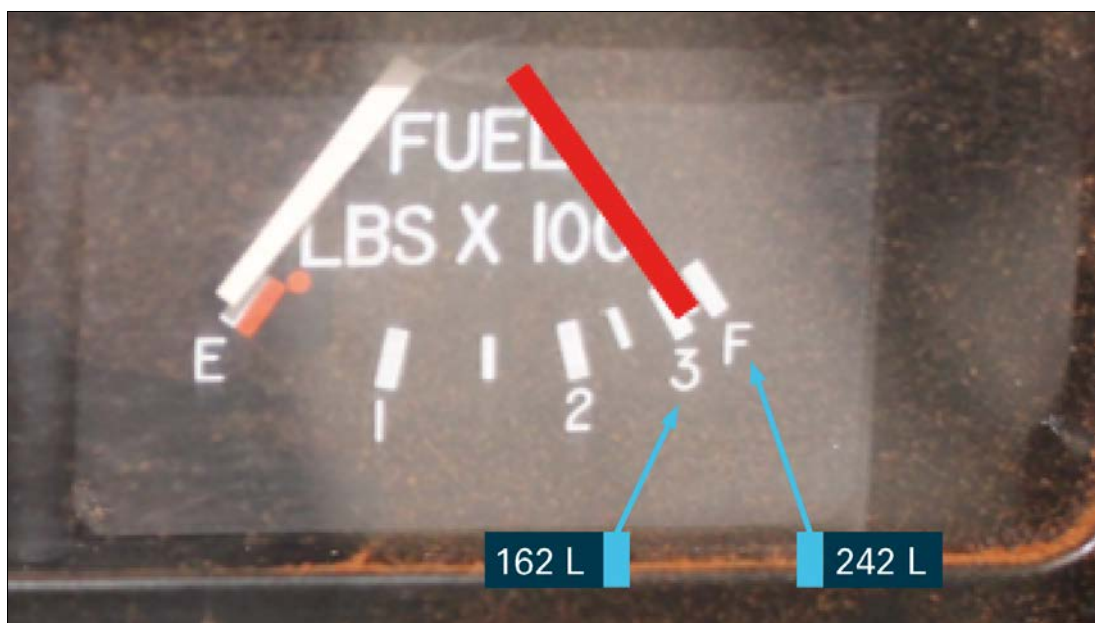
¹⁸ The orientation of the powerline was north-north-east. The approximate elevation of the sun was 34° above the horizon and 22° azimuths east from north on 17 July 2016 at Hawker, South Australia.

¹⁹ The FMS did not specify if this was the pilot's primary field of view, which is 15° either side of centreline and 30° below horizontal in the normal seating position; or secondary field of view, which extends to 30° either side of centreline and from 40° above to 45° below the horizontal (AC 27-1B).

calibration performed. On the fuel quantity indicator, the three hundred pounds' marker (3) was the equivalent of 162 L and the full marker (F) was 242 L.

The pilot reported he was told the helicopter had been refuelled before flight. He was also observed by the right seat crew member performing his normal pre-start instrument scan and he reported he thought the fuel quantity indicator indicated full. The flight log from the previous day was closed with 170 L of fuel remaining after a 2-hour flight and the pilot transferred the auxiliary fuel tank contents into the main fuel tank during the flight.²⁰ In this scenario, the fuel quantity indicator would have indicated close to the red line in Figure 4.

Figure 4: VH-PLY main fuel tank quantity indicator (graduated in pounds x 100)



Source: ATSB

Previous fuel exhaustion events

A search of the ATSB database for the period from 2003 to 2017 found 76 reports of 'fuel exhaustion', which included four accidents with fatalities, three accidents with serious injuries and two accidents with minor injuries, with some accident reports including more than one injury classification. The operations represented in the occurrences included sport aviation, private, aerial work, training, charter and air transport—low capacity. From the 76 occurrences, 26 were for commercial operations, and all reports were for aircraft not greater than 5,700 kg MTOW.

In 2009, the final investigation report into a fuel exhaustion occurrence involving a charter flight in a Cessna 404 in 2007,²¹ the ATSB raised a safety issue against CASA as follows:

Guidance promulgated by the Civil Aviation Safety Authority (CASA) in Civil Aviation Advisory Publication 234-1 regarding aircraft fuel requirements allowed for a fuel quantity cross-check to be conducted after refuelling and without reference to an independent source of onboard fuel quantity information.

At the time, CASA reported they were considering reviewing the information in CAAP 234-1(1) *Guidelines for Aircraft Fuel Requirements* that refers to fuel quantity crosschecking.

²⁰ The flight record of 180 L fuel used for a two-hour flight the previous day was less than the fuel flow rates published in the operations manual but consistent with flight log records of fuel consumption between 90 and 100 L/h while the helicopter was deployed on the contract.

²¹ AO-2007-049: *Engine power loss (fuel tank exhaustion) 102 km north Adelaide, SA 18 October 2007, VH-TMP, Cessna Aircraft Company C404.*

Survivability factors

The ATSB provided the three crew members with the 'iBrace Survivor Questionnaire'.²² The purpose of the questionnaire was to review crash survivability factors. All crew members provided returns, summarised as follows.

The pilot was seated upright in the front left seat with a four-point harness fitted loosely, wearing a helmet. His hands and feet remained on the controls throughout the accident sequence. The impact resulted in a broken back and spinal cord injury. He could not evacuate from the wreckage.

The front right seat crew member was secured firmly in a four-point harness, wearing a helmet. He bent forwards into a brace position during the accident sequence with his feet on the floor. The impact resulted in a broken back, spinal cord injury, and cuts to the hand and temporary loss of consciousness. He was able to evacuate from the wreckage after regaining consciousness.

The rear left seat crew member was wearing helmet and a dispatcher harness with a wander-lead attached to the helicopter. He could not recall what position his body was in during the crash sequence. He was thrown around during the accident sequence and sustained head and spinal injuries, cuts and bruises to the chest and abdomen, and cuts, bruises and fractures of the limbs. He was able to evacuate from the wreckage after regaining consciousness.

²² Davies, J. M., Wallace, W.A., Colton, C.L., & Yoo, K.I. (in press). Two aviation accident investigation questionnaires for passenger & crew survival factors & injuries. *Aviation Medicine and Human Performance*.

Safety analysis

Fuel exhaustion

Prior to departure the pilot requested full fuel for the main and auxiliary fuel tanks from the ground support person. He reported at interview the ground support person replied the helicopter was refuelled the previous day. The only record of a refuel for the previous day occurred between the two flights flown. It is likely that the ground support person confused the sequence of events the day before and believed the helicopter's tanks were full when reporting this to the pilot.

The pilot reported his omission to visually inspect the contents of the auxiliary fuel tank before departure may have been the result of a distraction during his pre-flight inspection. Being told the helicopter had been refuelled the day before would have also given the pilot the expectation that tanks were full, and may have contributed to missing the fuel check during his pre-flight inspection.

Before starting the engine, the pilot was observed conducting his normal instrument scan; however, the fuel quantity indicator had a nonlinear scale, which indicated close to the full (242 L) level mark at 170 L. The expectation that the tanks were full as indicated by the ground support person meant that when he scanned the flight instruments before flight, he would have been expecting to see a full indication. Combined with the nonlinear scale, this would have made it easy to misperceive the main tank as full. In turn, perceiving the main tank as full would have reinforced his belief that the auxiliary fuel tank (which had no fuel gauge) was also full. The helicopter subsequently departed with about 170 L of fuel on board, but the pilot believed it was carrying about 350 L.

It had become normal practice for the pilot to manage the helicopter's endurance 'on-the-clock'. This practice was consistent with the reports from other pilots who had flown with the auxiliary fuel tank fitted. In the absence of a fuel quantity indicator for the auxiliary fuel tank, it was not possible to compute fuel consumption once fuel transfer was started, because the contents remaining in the auxiliary fuel tank became an unknown factor. Hence, there was a need to use a predictive endurance until fuel transfer was completed.

The auxiliary fuel tank transfer light was found serviceable following the accident. Illumination of the transfer light would have provided an immediate response to the pilot when the fuel transfer switch was operated, whereas monitoring the fuel quantity indicator for movement would have provided a delayed response. Therefore, when the pilot selected the fuel transfer in-flight, the auxiliary fuel tank indicator light may have confirmed his expectation that the system was transferring fuel when there was actually no fuel in the auxiliary tank to transfer. The absence of crosschecks between the clock and the fuel quantity indicator resulted in inadequate in-flight fuel monitoring.

The low fuel level caution light was set to illuminate with about 15 minutes of fuel remaining and found to be serviceable following the accident. However, it was possible the position and luminance of the sun reduced the pilot's visual sensitivity to the low fuel level caution light. The operator's remote warning device, used to alert the pilot to the activation of a caution or warning light on the master caution/warning panel, was not fitted. Leading up to the accident sequence, the pilot's hover reference was the powerline on the left side of the helicopter and the front right seat crew member was performing his data recorder duties. Therefore, it was likely that the low fuel level caution light was not detected because neither of the front seat crew members were scanning the instrument panel leading up to the accident.

The power loss occurred at about 1 hour and 50 minutes after departure. The pilot reported that, while in the hover at about 100 ft, the engine went quiet and the 'engine-out' warning light was flashing. Following the accident both helicopter fuel tanks were found empty, which was consistent with a fuel load on departure of about 170 L. No damage was found to the fuel tanks, which would

have resulted in an in-flight fuel leak, therefore it was concluded the power loss and collision with terrain was the result of fuel exhaustion.

Design approval of the auxiliary fuel tank

The helicopter's fuel system was modified with an auxiliary fuel tank fitted in the rear right side of the cabin, in an occupiable area, and without any device for fuel quantity indication. The Design Approver's 2010 design advice submission to the Civil Aviation Safety Authority (CASA) included a compliance matrix for the fuel tank against what they identified as the relevant airworthiness standards. In his email communication and design advice submission, the Design Approver indicated his intent to approve the fuel tank in the restricted category and that it was to be used only for repositioning flights. CASA's Airworthiness and Engineering Branch reviewed the design advice within this context, but responded that the restricted category was not justification for non-compliance with airworthiness criteria, with specific reference to the requirement for a tank expansion space.

In consideration of CASA's position, the Design Approver elected to address the identified non-compliance issue (tank expansion space). The subsequent modification of the fuel tank with an expansion space resulted in a response from CASA that the design complied with the relevant requirements of CAR 6 and the Design Approver may approve the modification. CASA did not enforce the fuel quantity indicator criteria with the understanding that the fuel tank was only to be used for ferry flights, and removed for aerial work operations. However, it was likely that the Design Approver interpreted CASA's response to the effect that there were no CAR 6 non-compliances and therefore the restricted category was unnecessary. An approval in the normal category allowed the fuel tank to become a permanent fit and avoided the additional maintenance burden of removing the auxiliary fuel tank between repositioning flights and the start of aerial work operations.

In 1999, US Federal Aviation Administration advisory circular (AC) 27-1B was published, which provided an explanation and means of compliance for the US Code of Federal Regulations Part 27. Since Part 27 replaced CAR 6, many of the CAR 6 requirements were replicated in Part 27. AC 27-1B indicated that there were risks associated with locating a fuel tank in an occupiable area of the helicopter, which it was desirable to avoid. They included the risks of flailing injuries to occupants and saturation with fuel in the event of an accident. Although not required, a review of AC 27-1B in addition to CAR 6 may have led to the conclusion that the restricted category was more appropriate than the normal category for the accident helicopter with the modified fuel system. Particularly in consideration of the nature of the powerline inspection operation, which involved the helicopter operating for extensive periods in the height/velocity avoid area.

In 2014, AC 27-1B provided an explanation for the equivalent Part 27 standard to CAR 6.429, which indicated that separate fuel quantity indicators were required if there was a flow control device installed between fuel tanks. A single fuel quantity indicator would be unsuitable for the accident helicopter's modified fuel system, because a failure of the solenoid valve in the closed position prior to completion of transfer would result in the fuel quantity indicator over-reading the fuel available for the engine.

On review of AC 27-1B during the investigation, CASA considered the solenoid valve to be a flow control device, but accepted the configuration for operations under a special flight permit or in the restricted category. Since the design advice submission process did not include a copy of the flight manual supplement, CASA's Airworthiness and Engineering Branch did not have visibility of the removal of the restricted category.

Development of fuel policy

The operator had a fuel policy and procedures published in their operations manual at the time of the accident. Their fuel policy and procedures were updated to revision 1 status the year prior to the accident. This would have provided CASA with visibility as it is a Civil Aviation Regulation

(CAR) 215 requirement for the operator to provide them with a copy of the operations manual and forward them any amendments.

CAR 234 (2) indicated the operator had a responsibility to ensure there was sufficient fuel on board before flight. The CASA Air Operator's Certificate handbook indicated that the operator's responsibility is demonstrated by publishing procedures and providing training in accordance with those procedures. However, Civil Aviation Order (CAO) 20.2 did not require commercial operators of aircraft not greater than 5,700 kg maximum take-off weight (MTOW) to have published procedures for the verification of fuel on board before flight. Therefore, CAO 20.2 was not consistent with CAR 234 (2) for those operators.

CASA reported that the apparent non-alignment of CAO 20.2 with CAR 234 (2) was based on an assessment that the CAO 20.2 requirements would be overly burdensome for operators of less complex aircraft. In addition, the material published in Civil Aviation Advisory Publication 215 and 234 was provided as guidance material. Hence, no direction was issued to the operator by CASA to direct a change to their operations manual.

An ATSB aviation occurrence database search for fuel exhaustion events, from 2003 to 2017, found commercial operators represented about one-third of all reports (26 reports from a total of 76), which were all for aircraft not greater than 5,700 kg MTOW. The presence of commercial operators indicated that the applicable fuel regulations may be less than adequate, and shows that commercial operators may not implement effective fuel policies and training to prevent fuel exhaustion events.

Findings

From the evidence available, the following findings are made with respect to the fuel exhaustion and collision with terrain involving a McDonnell Douglas Corporation 369D, registered VH-PLY, 36 km north-west of Hawker, South Australia, on 17 July 2016. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance.

A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing factors

- The Civil Aviation Safety Authority (CASA) accepted that the design advice for the auxiliary fuel tank complied with the relevant requirements of the United States Civil Air Regulation 6. This was within the context of a proposed restricted category approval to permit repositioning flights. However, the response from CASA was likely interpreted by the Design Approver to permit approval in the normal category, which resulted in the auxiliary fuel tank becoming a permanent fit without a fuel quantity indicator.
- The pilot omitted to conduct a visual check of the auxiliary fuel tank contents before departure, which resulted in the helicopter departing with insufficient fuel for the planned flight.
- During the flight, the pilot managed the helicopter endurance 'by the clock', which resulted in him not detecting a low fuel level.
- While conducting powerline inspections the helicopter's fuel supply was exhausted, which resulted in a forced landing.

Other factors that increased risk

- **The current legislation does not require commercial operators of aircraft not greater than 5,700 kg maximum take-off weight to provide instructions and procedures for crosschecking the quantity of fuel on board before and/or during flight. This increases the risk that operators in this category will not implement effective fuel policies and training to prevent fuel exhaustion events.**

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

All of the directly involved parties were provided with 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.

The initial public version of these safety issues and actions are repeated separately on the ATSB website to facilitate monitoring by interested parties. Where relevant the safety issues and actions will be updated on the ATSB website as information comes to hand.

Air Operator Certificate holder fuel policy requirements

Number:	AO-2016-078-SI-01
Issue owner:	Civil Aviation Safety Authority
Operation affected:	Aviation: Air transport, charter, flying training and aerial work
Who it affects:	Air Operator Certificate holders

Safety issue description:

The current legislation does not require commercial operators of aircraft not greater than 5,700 kg maximum take-off weight to provide instructions and procedures for crosschecking the quantity of fuel on board before and/or during flight. This increases the risk that operators in this category will not implement effective fuel policies and training to prevent fuel exhaustion events.

Proactive safety action taken by the Civil Aviation Safety Authority

Action number: AO-2016-078-NSA-008

The Civil Aviation Safety Authority (CASA) has started project CD 1508OS, which was published on their website 20 January 2016. The project contains the proposed changes to Civil Aviation Regulation (CAR) 234, the issuance of a CAR 234 Legislative Instrument, and revised Civil Aviation Advisory Publication (CAAP) 234-1(2): *Guidelines for aircraft fuel requirements*, CAAP 215-1(2): *Guide to the preparation of Operations Manuals, Volume 2, appendix B9: Fuel management*, and the Air Operator's Certificate (AOC) handbook *Volume 2 – Flying Operations – Section 6: Fuel policy and related requirements*. Once made into law, the amendments to the existing CAR 234 will commence on 8 November 2018.

A key outcome of the amendment is providing clarity about the regulatory requirements that apply to fuel by having those requirements set out in a legislative instrument. This overcomes difficulties with the previous arrangement, where requirements were set out in guidance material 'called up' by regulation, in that the requirements were often not readily recognised as having the force of law. CASA 29/18 – Civil Aviation (Fuel Requirements) Instrument 2018 sets out the legislative requirements that:

- specify the matters that must be referenced by the operator and the pilot in command in determining the quantity of usable fuel required for a flight
- specify the quantities required to commence a flight and also to continue a flight
- require that inflight fuel management be conducted, and
- specify the contingencies to which additional fuel calculation must be applied.

To assist industry and CASA understanding of the changes to the fuel requirements in legislation, the amendment to guidance material CAAP 234-1(2) will be published. It will contain enhanced guidance on the generally applicable fuel related areas of the legislative instrument. CAAP 234-1(2) will differentiate between requirements and guidance.

ATSB comment

The ATSB has reviewed the draft project documents for CD 1508OS and considers that the implementation of the CAR 234 Legislative Instrument and CAAP 234-1(2), in conjunction with their requirements reflected in the AOC Handbook, should address the safety issue. The ATSB will continue to monitor the action by CASA. Until that time, the ATSB issues the following Safety Advisory Notice to AOC holders operating aircraft not greater than 5,700 kg.

ATSB safety advisory notice to Air Operator Certificate holders operating aircraft not greater than 5,700 kg

Safety action number: AO-2016-078-SAN-009

From 2003 to 2017, the ATSB has received 26 reports of fuel exhaustion events from Air Operator Certificate holders operating aircraft not greater than 5,700 kg MTOW. Two key contributing factors from these reports are pilots not crosschecking the fuel on board before and/or during flight. Aircraft greater than 5,700 kg MTOW are not represented in the ATSB fuel exhaustion reports. In accordance with CAO 20.2, operators of these aircraft are required to publish instructions and procedures in their operations manuals for the pilot in command to verify the fuel on board before flight. Additionally, CAAP 215-1(2) Appendix B includes guidelines for publishing operations manual procedures for inflight fuel management.

CASA 29/18 – Civil Aviation (Fuel Requirements) Instrument 2018, which contains proposed changes to the current fuel regulations and guidance material, is scheduled to commence 8 November 2018. The ATSB considers that the implementation of these changes should address this safety issue.

Until the proposed changes to the current fuel regulations and guidance material are implemented, the ATSB advises AOC holders for aircraft not greater than 5,700 kg MTOW, to consider this safety issue and take action where appropriate.

Current status of the safety issue

Issue status: Safety action pending

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence

Operator

The helicopter operator has advised the ATSB that they have taken the following safety action:

Corrective actions plan

The operator completed an investigation, implemented interim safety controls and developed a corrective actions plan. Their plan included:

- modifications to the auxiliary fuel tank system
- permanent installation of the remote warning device
- amendment to their operations manual to include prescriptive fuel check instructions.

General details

Occurrence details

Date and time:	17 July 2016 – 1039 CST	
Occurrence category:	Accident	
Primary occurrence type:	Fuel exhaustion	
Location:	36 km NW Hawker, South Australia	
	Latitude: 31° 36.45' S	Longitude: 138° 13.42' E

Pilot details

Licence details:	Commercial Pilot (Helicopter) Licence, issued 13 February 2015
Endorsements:	Gas turbine engine (GTE)
Ratings:	Single engine helicopter (SEH); Night VFR (H); Flight Instructor: Grade 1 training (H), Flight instructor (H), Low level (H), Sling, Grade 2 training (H), CLR (SEH), Design feature; Low level: Sling, Helicopter
Medical certificate:	Class 1, valid to 22 March 2017
Aeronautical experience:	6,679.0 hours
Last flight review:	25 August 2014

Aircraft details

Manufacturer and model:	McDonnell Douglas Corporation 369D	
Year of manufacture:	1981	
Registration:	VH-PLY	
Serial number:	110887D	
Total Time In Service	9,898.90	
Type of operation:	Aerial work – survey	
Persons on board:	Crew – 3	Passengers – 0
Injuries:	Crew – 3	Passengers – 0
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Civil Aviation Safety Authority
- Design Organisation
- Line-worker (data recorder)
- Line-worker (inspector)
- Pilot
- Operator
- South Australian Police.

References

Advisory circular 21.1(1), *Aircraft airworthiness certification categories and designations explained*, Civil Aviation Safety Authority, 2000

Advisory circular 21-08, *Approval of modification and repair designs under Subpart 21.M*, Civil Aviation Safety Authority, 2015

Advisory circular 27-1B, *Certification of normal category rotorcraft*, incorporating change 1-7, US, Federal Aviation Administration, 2016

Air Operator's Certificate handbook volume 2 – *Flying operations*, Civil Aviation Safety Authority, 2016

AV-9986.001-01, *Auxiliary fuel tank shut-off valve wiring*, [Design organisation], 2003

Civil Air Regulations Part 6–*Rotorcraft airworthiness: normal category*, Civil Aeronautics Board, US, Washington D.C. 1957

Civil Aviation Advisory Publication 215-1(2), *Guide to the preparation of operations manuals – Annex B - Aircraft operations*, Civil Aviation Safety Authority, 2014

Civil Aviation Advisory Publication 234-1(1), *Guidelines for aircraft fuel requirements*, Civil Aviation Safety Authority, 2006

Civil Aviation Order 20.2, *Air service operations – safety precautions before flight*, Civil Aviation Safety Authority, 2006

Civil Aviation Regulations 1988

Design advice DA-9986.001-01, *Transfer tank installed – an auxiliary fuel tank which tops up the main tank*, [Design organisation], (submitted 2010)

Design advice response DA-9986.001-01, Issue 3, *Installation of auxiliary fuel tank*, Civil Aviation Safety Authority, 2010

Engineering order EO16660.001/1, Issue 1, *iPad and windows tablet installation*, [Design organisation], 2011

Engineering order EO9986.001/1, Issue 6, *Auxiliary fuel tank*, [Design organisation], 2010

Flight manual supplement FMS16660.001-01, *iPads and windows tablet installation*, [Design organisation], 2012

Flight manual supplement FMS9986-001/1, *auxiliary fuel tank installation*, [Design organisation], 2010

Flight manual supplement for operations with the remote warning device fitted, Issue 2, [Design organisation], 1999

Job planning approval form, *Job No.: AV9986.001*, [Design organisation], 2009

Operations manual, *Fuel policy*, [operator], 2015

Surveillance manual, Civil Aviation Safety Authority, 2015

Surveillance report, [operator], Civil Aviation Safety Authority, 2015

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority, the design organisation, the helicopter operator, Line-worker (data recorder), Line-worker (inspector) and the pilot in command of the accident flight.

The submissions from those parties were reviewed and where considered appropriate, the text of the draft report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 operations involving the travelling public.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

Fuel exhaustion and collision with terrain involving McDonnell Douglas Corporation 369D, VH-PLY, 36km NW Hawker, South Australia on 17 July 2016

AO-2016-078

Final – 2 August 2018