Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A11Q0036

THREE HELICOPTERS REFUELLED WITH WRONG FUEL TYPE

ROBINSON R44 RAVEN II (HELICOPTER) C-FNZO
FORESTVILLE, QUEBEC
01 MARCH 2011

Canada

Aviation Investigation Report

Three Helicopters Refuelled with Wrong Fuel Type

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Report Number A11Q0036

Synopsis

The Robinson R44 Raven II helicopter (serial number 11759, registration C-FNZO) was on a visual flight rules flight from Port-Menier, Quebec, to Québec, Quebec, with 2 people on board and with 2 refuelling stopovers planned. It was accompanied by 2 other Robinson R44 II helicopters. During the stopover at Forestville, the 3 helicopters were refuelled with Jet A-1 fuel instead of the required AVGAS 100LL.

At about 1620 Eastern Standard Time, during its initial climb, C-FNZO lost engine power and the pilot made a forced landing in a residential neighbourhood in Forestville. Both people on board had minor injuries and were taken to hospital. The helicopter was substantially damaged. The 2 other helicopters landed near C-FNZO and sustained no damage. The emergency locator transmitter did not activate following the hard landing. The accident occurred during daylight hours.

Ce rapport est également disponible en français.

Factual Information

History of the Flight

On the day of the accident, the pilots of 3 helicopters were returning to Québec, Quebec, using the same itinerary in reverse as they had used for a cross-country flight to the island of Anticosti, Quebec. Two fuelling stopovers were planned: one at Sept-Îles (CYZV) and one at Baie-Comeau (CYBC) before arriving at Québec (Figure 1). The flight from Port-Menier (CYPN) on Anticosti to CYZV was uneventful. While flying from CYZV to CYBC, the pilots decided not to land at CYBC because of localized snow showers in the area and made an unplanned detour to Forestville (CYFE). One of the pilots contacted another pilot by cell phone and asked to call CYFE to inform the refueller of the 3 helicopters' arrival time and confirm the availability of aviation gasoline (AVGAS) 100LL fuel. The 3 helicopters landed in front of the fuel tanks at CYFE around 1530. [1] The refueller had already started to pull out the fuel hose. However, it was the Jet A-1 fuel hose. None of the pilots noticed this, and the refueller was asked to refuel the helicopters.

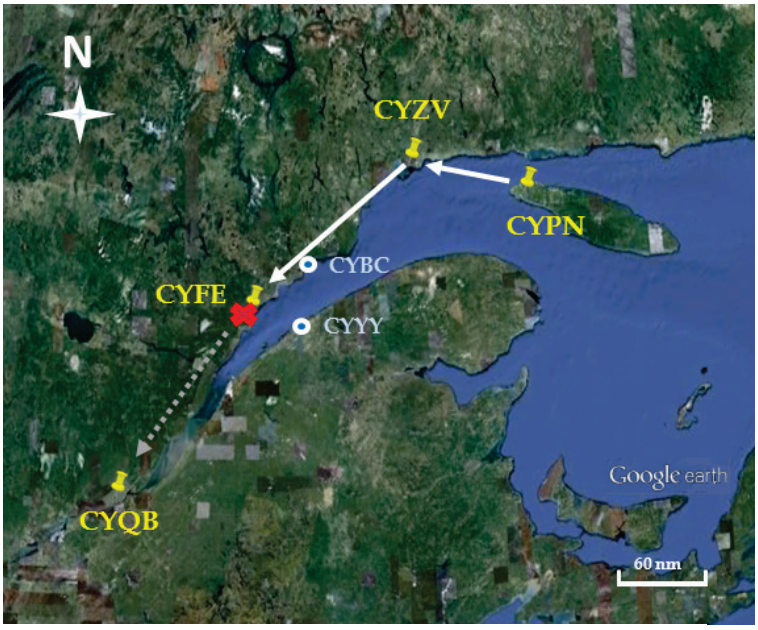

Figure 1. Flight route and points of interest

Two of the pilots and the passengers went inside the terminal, and the pilot of C-FNZO [2] remained with the aircraft while the first helicopter was being refuelled. However, the pilot then went into the terminal to use the washroom. Upon returning, the refueller was finishing refuelling the auxiliary tank in the pilot's helicopter. The 3 helicopters were refuelled in no particular order and each had only 1 tank refuelled. The refueller saw the manufacturer's placards (text boxes 1 and 2) but did not pay any particular attention to them. The refueller was alone when refuelling the aircraft and did not use a ladder. The refueller seemed to be less than adept with the hose, allowing it to come into contact with the surface of the helicopters; but the pilots did not question his knowledge of refuelling R44s.

Shortly thereafter, the refueller joined the pilots and their passengers inside the terminal. One of the passengers signed 2 of the invoices and the third one was signed by one of the pilots.

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1 All times are Eastern Standard Time (Coordinated Universal Time minus 5 hours).

2 From this point on, "the pilot" refers to the pilot of the occurrence aircraft, C-FNZO.

Although the price was lower than expected, neither the passenger nor the pilot noticed that Jet A-1 fuel had been used, as indicated on the invoices.

C-FNZO was the last of the 3 helicopters to take off. During take-off, the fuel gauges were showing less than full. After a few radio exchanges among the 3 helicopters, and at approximately 1000 feet above ground level (agl), the pilots concluded that the wrong fuel had been used. C-FNZO experienced reduced power and there were indications that the engine was overheating. Almost immediately, noises were heard from the engine and a significant loss of power occurred. The pilot performed an autorotation [3] and landed on a street in a residential neighbourhood in Forestville. C-FNZO was substantially damaged due to the force of the impact. The landing skids collapsed and the tail boom broke at the end of the tail assembly, leaving the tail rotor attached by only the tail skid. During the autorotation, the pilot radioed these observations, leading the others to land immediately and thus without incident.

Weather Conditions

The weather conditions in the flight area exceeded the conditions required for VFR flight, and there is no indication that they played a role in this occurrence.

According to the Transport Canada *Aeronautical Information Manual* (AIM), night began 25 minutes after sunset for the Forestville area on the day of the occurrence. Therefore, the day ended at approximately 1755.

Pilot Information

The pilot was certified and qualified for the flight, in accordance with existing regulations. The pilot obtained a private helicopter licence in September 2009 and had over 400 flying hours on the Robinson R44.

Aircraft Information

At the time of the accident, C-FNZO had logged 509.7 flight hours since it was manufactured. The technical records indicated that the aircraft was certified and maintained in accordance with existing regulations. There was no evidence found of any airframe failure or system malfunction during the flight, other than the loss of power associated with the wrong type of fuel being added to the tanks.

The weight and centre of gravity were within the prescribed limits at the time of the accident.

The R44's fuel system consists of a main tank on the left and an auxiliary tank on the right. The 2 filler caps are located at the top of the fuselage on each side of the aircraft. The system is designed so that the engine receives fuel from the main tank. Both tanks are interconnected by a

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[3] A flight condition in which the lifting rotor is driven entirely by action of the air

hose. The bottom of the auxiliary tank is higher than the bottom of the main tank and thus, by gravity, the auxiliary tank continuously feeds the main tank.

Transparent stickers [4] with black inscriptions were affixed to the aircraft near the filler caps. The placard for the main tank (Text box 1) indicates the type of fuel required.

FUEL 100 OCT MIN GRADE AVIATION GASOLINE

Text box 1. Placard – R44II POH – Section 2 - Limitations

The placard near the auxiliary tank (Text box 2) indicates that, to ensure full fuel, the main tank should be filled first and topped off after the auxiliary tank is filled.

AUX FUEL 100 OCT MIN GRADE AVIATION GASOLINE TO ENSURE FULL FUEL FILL LEFT TANK FIRST AND TOP OFF AFTER FILLING AUX TANK

Text box 2. Placard – R44II POH – Section 2 - Limitations

Section 4 of the *Robinson R44II Pilot's Operating Handbook* (POH) lists the actions to be performed during the daily inspection [5] and the pre-flight inspection. The inspection tasks include checking the amount of fuel by using the fuel gauges and taking a fuel sample. Section 7 of the POH states that fuel samples must be taken from the 3 drains before the first flight of the day and after refuelling. Fuels are distinguished by their color. The AVGAS 100LL is blue while the Jet A-1 is light yellow.

Pilots do not generally take samples immediately after refuelling. It is considered that the agitation caused by refuelling allows contaminants to disperse and potentially remain in suspension for several minutes. Therefore a sufficient amount of time must elapse before fuel samples are taken after each refuelling. The Robinson Helicopter Company (RHC) stated that it does not set a specific amount of time for sampling, and that, after refuelling, pilots must use their judgment to determine what tasks, if applicable, can be omitted from the pre-flight checklist. There is no checklist for rapid turn-around.

The helicopter was not equipped with a cockpit voice recorder or a flight data recorder; neither is required by regulation. The aircraft was equipped with an emergency locator transmitter (ELT) transmitting on 406 MHz and 121.5 MHz that was installed on the right-hand side of the aircraft. The ELT was not damaged in the accident and did not activate on impact. The 2 skids collapsed on either side of the fuselage on impact. According to RHC, the R44 landing gear is

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4 These stickers, referred to as "placards," are shown in the Robinson R44II POH under Section 2 - Limitations.

5 The DAILY and PREFLIGHT inspections are identical. According to the Robinson Helicopter Company, the term DAILY was added to the POH to satisfy international requirements.

designed to withstand impact forces without collapsing at a rate of descent of 614 feet per minute.

In October 2010, RHC began manufacturing a new aircraft, the R66. It is almost identical to the R44, but is powered by a turbine engine that uses Jet A-1 fuel.

Aerodrome Information

CYFE is a registered aerodrome that has been operated by the town of Forestville since 1997, when it was transferred by Transport Canada. Aerodrome amenities and services are available only during the summer months. CYFE was equipped with a divided tank containing 2 types of fuel: Jet A-1 and AVGAS 100LL. The fuel type labelling consisted of just 1 label at each end of the tank and 2 labels over the fuel pump. For refuelling services, the *Canada Flight Supplement* (CFS) indicates that 15 minutes' advance notice is required. Pilots simply have to dial the phone number listed in the CFS and the employee on duty will be paged. The aerodrome employees are volunteer firefighters from the town of Forestville.

The refueller in question was new, having started working at the aerodrome in November 2010. Most of the refuellings done previously had been for helicopters using Jet A-1 fuel. The refueller had never used AVGAS 100LL to refuel either helicopters or aeroplanes. The training had been accomplished by another, more experienced employee (the instructor). The refueller's training consisted of a demonstration and supervision of 5 to 8 refuellings. The training did not mention that some helicopters use AVGAS. Since his training, the refueller had done 6 to 8 refuellings unassisted.

In November 2010, the fuel supplier trained 2 CYFE employees directly in its facilities in Québec for free. The training lasted several days and included a final evaluation and a certificate. Neither the refueller nor the instructor had received this training. One of the evaluation questionnaires consisted of 10 questions directly related to nozzle refuelling. Two examples are shown in text boxes 3 and 4 below.

The Jet A-1 fuel nozzle is very different from the AVGAS nozzle. State two (2) main characteristics of the Jet A-1 nozzle:. a) Large opening and wide spout b) Colour: black

Text box 3. Questionnaire 1 – Question 2 – Trainer's guide – Evaluation answers

You approach an aeroplane that needs to be refuelled and the pilot says, "Full fuel." List the steps you should take before you start to refuel. a) Confirm what type of fuel the pilot wants. b) Confirm the amount of fuel the pilot wants. c) Check that the nozzle spout and the aeroplane's tank opening match the standard for the desired fuel. (Jet A-1 fuel – Large opening and flat, wide spout; AVGAS – Small opening and small, round spout.)

d) Check that the type of fuel indicated on the aeroplane's fuel label is the same as the type of fuel in the refuelling vehicle.

Text box 4. Questionnaire 1 – Question 3 – Trainer's guide – Evaluation answers

No information was provided to the employees concerning standard procedures to be followed; no aircraft refuelling reference manuals, no fuel emergency manuals, and no how to prepare incident reports, either at CYFE or at Forestville city hall.

Refuelling

In general, a Jet A-1 fuel nozzle, which measures 3 inches in diameter, cannot be inserted into the R44 fuel filler opening, which measures 1½ inches in diameter. However, the Jet A-1 fuel nozzle used to refuel the three R44s in this occurrence measured 1 inch in diameter, which allowed it to be inserted in the fuel filler opening. The nozzle had been changed earlier to refuel Aérospatiale AS350 helicopters, which have fuel filler openings measuring 2.28 inches in diameter. There are over 450 AS350 aircraft registered in Canada. [6]

While there are no fuel-nozzle-dimension standards for aircraft refuelling at Canadian airports, there are airworthiness standards for obtaining type approval and changes to type certificates for normal-, utility-, aerobatic-, and commuter-type aeroplanes. Subchapter 523.973 of the *Canadian Aviation Regulations* (CARs) specifies that for aeroplanes with engines requiring gasoline as the only permissible fuel, the inside diameter of the fuel filler opening must be no larger than 2.36 inches, whereas for aeroplanes with turbine engines, the inside diameter of the fuel filler opening must be no smaller than 2.95 inches. However, there is no standard for helicopters.

Similar occurrences have taken place in recent years, not only with helicopters, but also with piston-engine aircraft. Barely a month after this accident, a similar occurrence was reported: a McDonnell Douglas 500N helicopter was refuelled with AVGAS instead of the Jet A-1 fuel required.

The Transportation Safety Board inspected other installations from the same fuel supplier. A number of documents were available to employees as reference tools, including a reference manual entitled *Aircraft Service Directory* (Appendix A), which lists different types of aircraft and their specific refuelling requirements. Refuellers have access to a chart, including an example: an image showing an employee using a ladder to refuel, the type of fuel marked on a tanker truck, and the volume of the fuel.

Pilot Decision Making

Pilot decision making (PDM) is a critical aspect of flight safety. PDM can be defined as a four-step sequential loop: gathering information, processing information, making a decision

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6 According to the Canadian Civil Aircraft Register

based on the possible options, and acting on that decision. Evaluating the available options involves a subjective evaluation of risks based on experience and knowledge.

Pilots' decisions can be influenced by a wide range of factors such as the perception of the situation and their experience. For example, when a flight is successful, without performing all manufacturer-recommended tasks, pilots may be prone to continue deviating from recommended procedures, therefore increasing their tolerance to risk until they experience negative consequences, which too often are disastrous. Over time, and with experience of uneventful flights, pilots get accustomed to this modified flight procedure, which no longer offers the established safety margin and thus compromises safety.

According to the Rasmussen risk management framework, [7] the real safety limit is usually invisible and people do not know whether the system as a whole is on the brink of disaster or far from it. A shift in work methods, such as making changes to checklists, can continue and evolve over years without mishap—until the real safety limit is reached and an accident occurs.

A Transport Canada advisory circular [8] reminded pilots of the importance of performing a careful pre-flight inspection. The circular recommended that pilots know the total usable fuel on board before the flight and that they drain the tanks to check the quality and colour of the fuel to ensure that Jet A-1 has not been mixed with AVGAS.

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7 Rasmussen, J. (1997). "Risk management in a dynamic society: A modelling problem." *Safety Science* Vol. 27, No. 2/3, pp. 183–213, 1997. Complex sociotechnical system

8 FAA Advisory Circular AC 20-105B JUNE 1998, *Reciprocating Engine Power Loss Accident Prevention and Trend Monitoring*.

Analysis

A number of successful defences have been introduced to address the risks associated with refuelling errors. However, as with all mitigated risks, when these defences are not used, the risk of error increases considerably.

When the helicopters landed at Forestville, the refueller had already started to pull out the Jet A-1 fuel hose to refuel the 3 helicopters. Relying on prior experience, the refueller prepared to refuel the helicopters with Jet A-1 fuel. The training made no mention that some helicopters use AVGAS.

Because the refueller had prepared the hose while waiting for the aircraft, the pilots were lead to believe that the type of fuel required had been confirmed in the phone call. The refueller did not ask any questions, which reinforced the pilots' belief in the refueller's qualifications. None of the pilots gave any instructions, other than to fill the tanks. As the refueller prepared to refuel, the pilots, who were standing by, did not notice the fuel type labels on the pump nor did any of them suspect that they were about to receive Jet A-1 fuel.

The refueller completed the refuelling alone. Consequently, only 1 of the 2 tanks was filled on each aircraft. In addition, because the refueller was unaware of the particulars of refuelling R44s, the manufacturer's recommendations were not followed. Specifically, to fill the main tank first, then the auxiliary tank, as indicated on the placards. Had the refueller used a ladder to refuel the aircraft, the placards located on the fuselage would have been more visible. The pilots did not question the refueller's knowledge of refuelling R44s.

When the invoices were signed, only the low price was observed. Although the pilots had asked for full fuel, nobody noticed that only 1 of the 2 tanks had been filled, and with Jet A-1 fuel, as indicated clearly on the invoices.

The aircraft took off from Forestville at the end of the day. Because the pilots did not hold night ratings, they may have felt pressed for time because they had to land at Québec in daylight. The pilots did not take fuel samples and did not check the fuel quantity gauges, which suggests that the checklist was not followed, or that, in their haste to depart, some items on the list were omitted. The decision to omit certain tasks from habit or experience demonstrates that the pilots did not perceive the increased risk and the resulting potential safety threat. A certain number of accidents have been directly attributable to pilots not fully completing their checklists.

Transport Canada does not set any standards for refueller training or qualifications. However, the refueller would have greatly benefitted from a more detailed training program. Having aircraft refuelling reference material available would have provided additional defences necessary to reduce the risk to aviation safety.

Although RHC is not subject to Subchapter 523.973 of the CARs, the fuel filler openings on the R44 and R66 meet the standards that apply to aeroplanes.

The Jet A-1 fuel nozzle at Forestville had been replaced with a smaller nozzle to allow refuelling of another type of helicopter. A large number of refuelling stations in Canada change the fuel

nozzles. Some use adapters that attach directly to the nozzle, while others change the nozzle itself as needed. Routinely using the same size nozzle for Jet A-1 and AVGAS 100LL means that a defence against inadvertent fuelling errors is eliminated. If the appropriate Jet A-1 nozzle had been used, it would not have been possible to refuel the R44s.

Even though some deficiencies were identified in terms of the defences associated with the risks of fuelling errors, these defences help primarily to reduce risks. The ultimate responsibility rests with pilots, who must ensure that refuellers are aware of the refuelling procedures for their particular aircraft. They must be fully satisfied with the type and volume of fuel they receive. However, better knowledge of refuelling on the part of aerodrome officials [9] and effective training of refuellers would allow them to recognize and be aware of the significance of the risks associated with refuelling operations.

Findings as to Causes and Contributing Factors

1. The inadequate training of the refueller at the Forestville aerodrome directly contributed to the wrong type of fuel being pumped.
2. The lack of supervision by the pilots during the refuelling meant that they did not notice the wrong fuel type being used.
3. The fuel hose had a small nozzle which allowed it to be used to fuel the helicopters with Jet A-1 rather than AVGAS.
4. The pilots omitted parts of the pre-flight inspection which would have permitted them to identify the fuelling error.
5. The wrong fuel type caused the helicopter to lose power and to require an autorotation.

Findings as to Risk

1. The *Canadian Aviation Regulations* (CARs) provide no standards for the diameter of fuel filler opening in helicopters. Consequently, the risk of error increases when different fuel nozzles are used.
2. There are no regulations concerning training requirements for aircraft refuelling at Canadian aerodromes. This fact increases the risk of refuelling errors.
3. Routine use of the same size nozzle for Jet A1 and AVGAS means that a defence against inadvertent fuelling errors is eliminated.

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[9] "Officials" refers to the airport authority, aerodrome staff or the aerodrome manager, depending on the situation.

Safety Action Taken

Transportation Safety Board of Canada (TSB)

On 20 May 2011, a safety advisory was sent to the Director General, Civil Aviation, Transport Canada.

The advisory contained information about the accident and informed the regulatory agency of the safety deficiencies that posed low to moderate risks. The advisory urged the agency to take appropriate corrective action.

Transport Canada

On 28 September 2011, Transport Canada undertook as a safety measure the publication of an article that appeared in *Aviation Safety Letter*, Issue 4/2011.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 31 October 2012. It was released on 6 December 2012.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

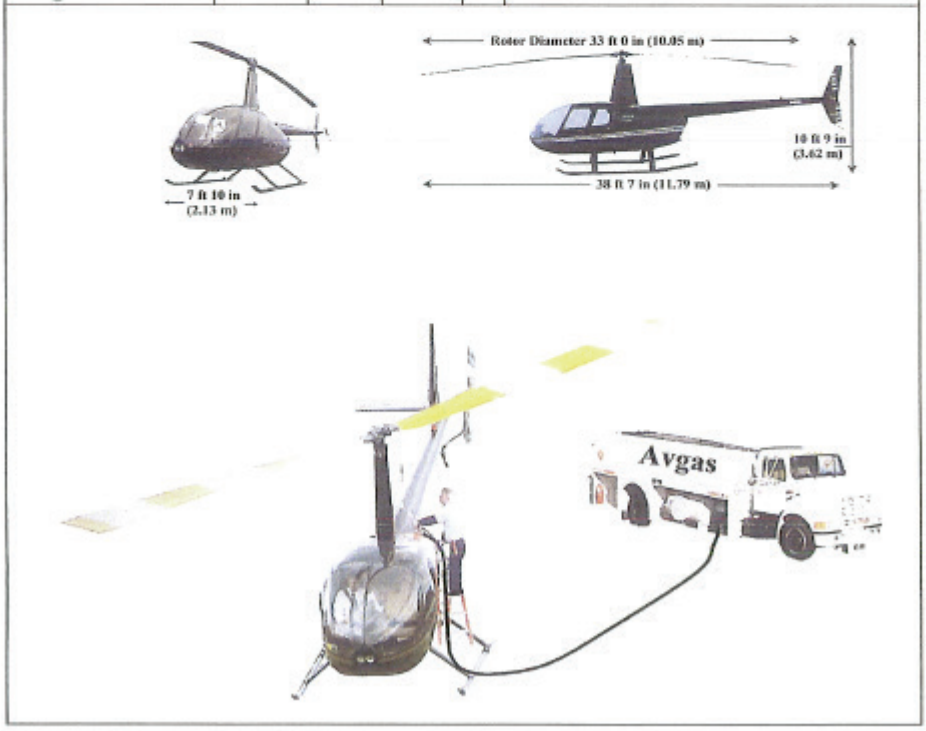
Appendix A: Aircraft Reference Manual

AIRCRAFT SERVICE DIRECTORY

ROBINSON HELICOPTER R44

FUEL		GND POWER	PERFORMANCE			WEIGHTS		
Avgas		24 V/DC	Seating	1 + 3		Empty	1,468	lbs
							655	kgs
30	Gallons		Cruise (max)	110	mph	Takeoff	2,400	lbs
				177	kmh		1,088	kgs
177	Liters		Ceiling	14,000	ft	Landing	2,400	lbs
				4,267	m		1,088	kgs
Gravity Fueling			Range	310	mi			
				499	km			

DIMENSIONS:									
Rotor Diameter	33 / 0	ft / in	10.05	m	Wheel Base	---	ft / in	--	m
Length Overall	38 / 7	ft / in	11.97	m	Skid Track	7 / 0	ft / in	2.13	m
Length W/O Rotor	---	ft / in	---	m					
Height	10 / 9	ft / in	3.62	m					



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