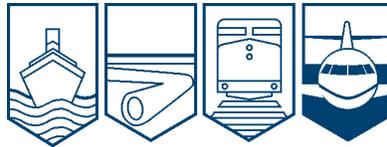


Transportation Safety Board
of Canada



Bureau de la sécurité des transports
du Canada

AVIATION INVESTIGATION REPORT A10C0104



INSUFFICIENT FUEL

**PERIMETER AVIATION
DEHAVILLAND DHC-8-102 C-GWPS
WINNIPEG, MANITOBA
29 JUNE 2010**

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

Insufficient Fuel

Perimeter Aviation
deHavilland DHC-8-102 C-GWPS
Winnipeg, Manitoba
29 June 2010

Report Number A10C0104

Synopsis

The deHavilland DHC-8-102 (registration C-GWPS, serial number 120) operating as flight PAG107 departed from Winnipeg/James A. Richardson International Airport, under instrument flight rules for a scheduled flight to Island Lake, Manitoba. On board were 2 pilots, a flight attendant, and 22 passengers. PAG107 was operating under Subpart 705 - Airline Operations of the *Canadian Aviation Regulations*. At about 1250 Central Daylight Time, during the climb check, the crew determined that the fuel quantity was insufficient for the intended flight. The flight returned to Winnipeg and landed at 1306 without further incident.

Other Factual Information

History of the Flight

While inbound to Winnipeg on the leg preceding the occurrence flight, the crew calculated the fuel required for the next leg to Island Lake. The calculations showed that 4070 pounds of fuel was required for the round trip to Island Lake and back to Winnipeg under instrument flight rules (IFR). This was rounded up to 4200 pounds to account for taxi time at Winnipeg and for ease of fuelling.

At about 1125 ¹, the crew contacted a customer service representative (CSR) at Winnipeg fixed base operator (FBO) ² and provided an estimated time of arrival and the desired fuel load. The crew requested the fuel truck meet the aircraft at the Perimeter Aviation (hereafter referred to as Perimeter) apron to facilitate a quick turnaround.

The CSR wrote the fuel load information on a notepad. This information would normally be passed on to the FBO line foreman; however, as the CSR's attention was diverted to performing other tasks, the fuel load information was not passed on and the task was forgotten. Later, the CSR saw the note but assumed the information had been passed on and took no further action. The information was not transcribed to the log sheet kept at the CSR counter.

The flight arrived at 1138. The fuel remaining at shutdown was 1540 pounds. The crew completed the shutdown check and instrument cross-check, and partially completed the BEFORE START - ENROUTE checklist to the line (see Appendix A - Before Start - Enroute checklist). The "fuel quantity" and "fuel on caution light" checklist items were deferred because the aircraft had not yet been fuelled.

The crew placed the fuel transfer card ³ (see Photo 1) on the glare shield to remind them of the 2 deferred checklist items to be completed before initiating the engine start. Subsequently, they opened the cockpit escape hatch to the vent position, and the fuel transfer card also served as a reminder to close the hatch.

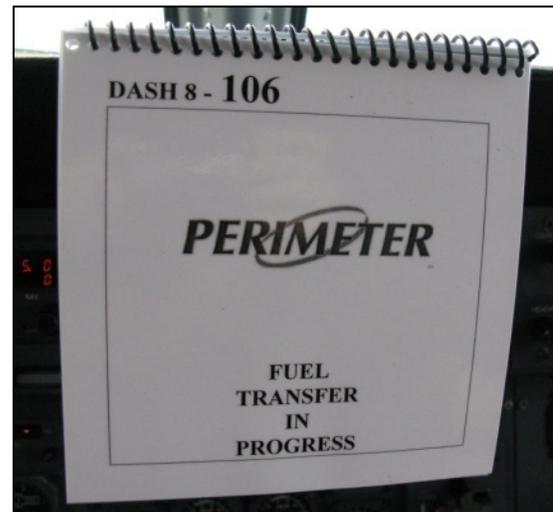


Photo 1. Fuel Transfer Card

The fuel truck met the aircraft at the Perimeter apron just as the aircraft was shutting down. While the passengers disembarked, the fuel truck operator moved the truck into position and connected the fuel hose to the aircraft. The fuel truck operator had not received any information

¹ All times are Central Daylight Time (Coordinated Universal Time minus 5 hours).

² Perimeter Aviation obtained its fuel from a Winnipeg FBO which assigned a fuel truck and operator to remain at the Perimeter Aviation apron.

³ The fuel transfer card is intended to be a highly visible reminder that in-flight fuel transfer is in progress.

about the desired fuel load and expected the flight crew to provide this information before commencing fuelling. The truck operator did not immediately ask the pilots for this information.

The captain left the aircraft and entered the Perimeter hangar. The first officer did a post-flight external inspection before also proceeding to the hangar. Both pilots saw the fuel truck and assumed the fuel truck operator knew the desired fuel load; consequently, they did not reiterate or otherwise communicate their fuel requirements.

Several minutes later, another Perimeter aircraft in need of fuel arrived at the apron. The fuel truck operator tried to locate the PAG107 pilots in the hangar but was unsuccessful. The operator informed the line foreman by radio of the situation. The line foreman instructed the fuel truck operator to disconnect from C-GWPS and fuel the other aircraft. The fuel truck operator did so and then returned to C-GWPS, once again connecting the hose to the aircraft and waiting for fuel load information from the flight crew.

The fuel truck operator made another unsuccessful attempt to locate the crew of PAG107. The fuel truck operator again contacted the line foreman by radio, and was instructed to return to the FBO apron where other aircraft were waiting for fuel. The fuel truck operator proceeded as instructed. Perimeter was not informed that the aircraft had not been fuelled.

Inside the hangar, the PAG107 pilots were performing dispatch duties for the next flight while the aircraft was being unloaded and reloaded with cargo and baggage. Upon their return to the aircraft, the fuel truck and operator were gone and both pilots assumed the aircraft had been fuelled.

Once the passengers had boarded, the crew computed the weight and balance, verifying both were within specified limits. The calculations were made using the weight of the requested fuel load. They then advised the flight attendant to close the cabin door. The captain then closed the escape hatch and removed the fuel transfer card from the glare shield.

Both pilots forgot that the "fuel quantity" and "fuel on caution light" checks were deferred. Neither pilot checked the fuel quantity. They completed the items below the line on the BEFORE START - ENROUTE checklist, started the engines and taxied out. At 1238, PAG107 departed from Runway 18.

While conducting the 10 000-foot climb check, the crew observed that the indicated fuel quantity was 1000 to 1200 pounds, and was less than expected. The crew initially considered the possibility of a malfunction of the fuel quantity indicating system, and then contacted the FBO by radio to verify whether the aircraft had been fuelled. The FBO advised that the aircraft had not been fuelled.

The crew determined they did not have sufficient fuel to safely continue the flight and decided to return to Winnipeg. The aircraft had consumed 640 pounds of fuel during the flight; fuel quantity at shutdown was 900 pounds.

Flight Crew

The flight crew was certified and qualified for the flight in accordance with existing regulations. The captain had about 4500 hours of total flight time, with about 2500 hours on the DHC-8 as pilot-in-command. The first officer had about 5000 hours of total flight time, with about 1000 hours on the DHC-8 as second-in-command.

The crew was off duty the day before the occurrence. Their work and rest schedules are not considered a factor in this occurrence.

Aircraft

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. There were no outstanding defects at the time of the occurrence.

Recorders

The aircraft was equipped with a digital flight data recorder which was sent to the TSB Laboratory for analysis. There were no recorded parameters relating to aircraft fuel state or consumption.

The aircraft was also equipped with a 30-minute cockpit voice recorder. No information was recovered because the aircraft continued operating after the occurrence flight and data was overwritten during subsequent flights.

Weather

The weather is not considered a factor in this occurrence.

Fuel Communications and Documentation

While inbound to Winnipeg, the practice of Perimeter pilots was to contact the FBO CSR by radio and provide their outbound fuel requirements. The CSR practice was to record the fuel request on a notepad. The CSR would then relay the information to the line foreman by intercom or radio, before transcribing the information onto a log sheet and scratching out the notepad entry. The line foreman, in turn, passed the information to the fuel truck operators by radio. Occasionally, the CSR would directly contact the fuel truck operators by radio. Fuel truck radios were not capable of communicating with aircraft.

FBO policy required fuel truck operators to verify the desired fuel load with pilots before fuelling. Sometimes flights were delayed or cancelled without the truck operators being notified. At such times, they would move on to other aircraft needing fuel without notifying Perimeter operations staff that fuelling had not occurred. FBO policies were not documented and were informally communicated to staff.

Until 18 months before the occurrence, fuel truck operators were required to have pilots sign fuel delivery slips. Perimeter's copy was then given to the pilot or left in the cockpit. However, truck operators could not always find pilots to sign the slips. Moreover, some slips were lost or otherwise not forwarded to Perimeter's accounting department. Consequently, this process was

changed so that the fuel slips were sent by the FBO directly to the Perimeter accounting department on a daily basis, eliminating pilot signatures and copies.

Development of Adaptations

People rarely follow rules or instructions precisely. They do so for reasons and in ways that make sense to them given their circumstances, knowledge, and goals.⁴

While policies and standard operating procedures (SOP) are prescribed in order to set boundaries for safe operations, individuals may experiment with the boundaries in order to become more productive or obtain some other benefit. This leads to adaptations of procedures and a shift beyond the prescribed boundaries described in the SOP toward unsafe practices.⁵ Without intervention, the communication of successful adaptations between crew members will tend to lead to their spread throughout an organization.

Checklist Design

One principle of checklist design is operational logic.⁶ Some checklist tasks are dependent on people external to the cockpit, including fuel truck operators. This influence must be taken into account when designing the sequence of steps in a checklist, such that checklist tasks run parallel to external activities.

Operating Policies, Procedures, and Practices

Perimeter uses a Type C operational control system known as pilot self-dispatch. All responsibility for aircraft dispatch decision-making is delegated to the pilot-in-command (PIC). Pilot self-dispatch systems are widely used by commercial air operators across Canada.

Prior to the PIC dispatching the flight, section 6.6.2 of the Perimeter company operations manual (COM) requires flight crew members to calculate the fuel needed and to verify it has been loaded. Tools provided to assist pilots with this requirement are operational flight plans to calculate the required fuel, and the BEFORE START checklist to verify the aircraft fuel quantity.

Section 8.7 of the COM specifies fuel safety procedures and requires the flight crew to supervise aircraft fuel operations. The COM did not specify locations or situations where such supervision was not required. In practice, pilots did not supervise fuel operations at the company's Winnipeg base, where fuelling was conducted by FBO staff who were familiar with the company's aircraft. At locations where fuel personnel were not familiar with the company's aircraft, pilots would supervise the fuel operation. At sub-bases, pilots fuelled the aircraft themselves from company systems.

Section 4.6.3 of the company SOP allows the BEFORE START - ENROUTE checklist to be done down to the line, with the final 5 items done immediately prior to start. The company SOP does

⁴ S. Dekker, *The Field Guide to Understanding Human Error*, Ashgate, 2006.

⁵ J. Rasmussen, "Risk management in a dynamic society: a modeling problem," *Safety Science*, 27 (2-3), 183-213, page 197.

⁶ A. Degani and E. L. Wiener, "Cockpit Checklists: Concepts, Design, and Use," *Human Factors*, 35 (2).

not specifically allow deferral of checklist items, and does not include guidance to pilots on how to ensure a checklist item that has been deferred is completed.

On turnaround flights such as the occurrence flight, Perimeter's DHC-8 crews would conduct the SHUTDOWN - ENROUTE check. With a view to expediting the subsequent departure, crews would then conduct an instrument cross-check and complete the BEFORE START - ENROUTE checklist down to the line. These checks were frequently completed while the aircraft was being unloaded and before it was fuelled. Crew members would then attend to other ground duties outside the cockpit. Later, when ready to start engines, crews would finish the checklist by completing the items below the line. This practice was employed by both line and supervisory pilots.

When the aircraft required fuel, this practice resulted in the fuel quantity check being deferred. Perimeter's DHC-8 pilots employed various undocumented personal practices to remind themselves to conduct this check after the aircraft had been fuelled. Some pilots placed the fuel transfer card on the glare shield, while others placed it on the power levers. At least one pilot would conduct a final walk-around inspection immediately before boarding the aircraft for departure. During the inspection, the pilot would open the external fuel panel to check the fuel quantity and ensure the switches were correctly positioned, and then close and secure the panel.

The cockpit escape hatch can be opened to a vent position to ventilate the cockpit while the aircraft is parked. To ensure the hatch is closed before engine start, the first item on the BEFORE START - ENROUTE checklist is "escape hatch - closed". Some of Perimeter's DHC-8 pilots would occasionally open the hatch either before or after the BEFORE START - ENROUTE checklist had been completed to the line. In such situations, they routinely used the fuel transfer card as a reminder that the hatch needed to be closed before commencing the items below the line.

The following TSB Laboratory report was completed:

LP 090/2010 - FDR Download

Analysis

Influence of Adaptations

The BEFORE START - ENROUTE checklist matched the actual sequence of events occurring during aircraft turnarounds, thereby following the principle of operational logic. However, deferring the fuel quantity check enabled pilots to do the checklist down to the line and slightly reduced the time needed to complete the checklist when the flight was ready for engine start. This adaptation became an accepted practice at the company, and pilots used various methods to ensure they remembered to check the fuel quantity. This practice resulted in checklist usage that no longer followed the operational logic principle.

This adaptation was employed by the PAG107 pilots when they performed the BEFORE START - ENROUTE checklist to the line immediately after completing the shutdown checklist. The pilots then employed another adaptation, using the fuel transfer card as a reminder that the fuel quantity check had been deferred.

Pilot supervision of fuelling is intended to ensure fuelling safety procedures are followed. It also provides the pilots an opportunity to verify the fuel quantity, as required by COM section 6.6.2. In practice, however, Perimeter pilots considered the FBO fuel truck operators in Winnipeg to be familiar with the aircraft and fuelling process. Therefore, pilots did not supervise fuelling operations in Winnipeg. While this adaptation provided them with more time to attend to other duties, it eliminated an opportunity to conduct a fuel quantity check. Moreover, as both crew members saw the fuel truck connected to the aircraft, they had assumed the operator knew the fuel requirement. Upon their return to the aircraft, the absence of the truck confirmed in their minds that the fuel had been uploaded.

Fuel truck operators obtained aircraft fuel requirements through the FBO's processes, which were undocumented and informally communicated. The FBO's informal policies incorporated a defence whereby the fuel truck operator was to confirm the fuel upload with a pilot. In this occurrence, the fuel truck operator arrived at the aircraft not knowing the requested fuel load and did not commence fuelling. The crew assumed their fuel requirements had been communicated to the fuel truck operator and did not discuss the desired fuel load with the fuel truck operator. By the time the operator actively sought the information, both pilots had entered the hangar and could not be found.

After disconnecting, fuelling another aircraft, and reconnecting to C-GWPS, the fuel truck operator eventually concluded the flight was delayed or cancelled, and moved on to service other aircraft as instructed by the line foreman. As was the practice, Perimeter was not notified that the aircraft had not been fuelled. Additionally, the distribution of fuel slips to pilots had been discontinued. In the absence of a requirement for a fuel slip, another opportunity for the crew to verify the fuel upload was lost.

Given the pilots' expectation about the aircraft having been fuelled, the absence of any documentation or communication of the fuel upload, and the deferral of the fuel quantity check, the final defence to ensure the fuel quantity was verified was the fuel transfer card the crew had placed on the glare shield as a reminder. However, the fuel transfer card also served as a reminder to close the escape hatch. When the pilots returned to the cockpit, the card cued them to remember to close the hatch, but the deferred fuel quantity check was forgotten. Once this occurred, the checklist usage practice did not guide them to check the fuel quantity indicators.

Significance of Fuel Shortage

There was insufficient fuel to satisfy IFR reserve requirements for the intended flight. The crew's discovery of the fuel shortage during the 10 000-foot level check and their return to Winnipeg eliminated the risk of fuel exhaustion and the associated consequences.

Findings as to Causes and Contributing Factors

1. The fuel requirements were not passed on to the line foreman or truck operator. Consequently, the aircraft was not fuelled.

2. Perimeter DHC-8 pilots had developed an adaptation of deferring the fuel quantity check, and used various means as a reminder to conduct this check before engine start.
3. Using the adaptation that had become accepted practice, the PAG107 pilots completed the BEFORE START - ENROUTE checklist to the line, and placed the fuel transfer card on the glare shield as a reminder that the fuel quantity check had been deferred.
4. The PAG107 pilots subsequently opened the cockpit hatch for ventilation, and also used the fuel transfer card as a reminder to close the hatch before engine start. Consequently, the card served as a reminder for two unrelated purposes, the incomplete fuel quantity check and the open hatch.
5. Perimeter DHC-8 pilots did not normally supervise fuelling at Winnipeg despite a policy in the company operations manual requiring that they do so. Both pilots saw the fuel truck operator with the hose connected to the aircraft and had an expectation that the aircraft had been fuelled.
6. The crew subsequently closed the cockpit escape hatch and removed the fuel transfer card from the glare shield. Both pilots forgot their intent to use the fuel transfer card as a reminder that the fuel quantity check had been deferred. The fuel quantity was not verified and the flight departed with insufficient fuel.

Safety Action Taken

Perimeter investigated this occurrence in accordance with its safety management system (SMS). The SMS investigation analysis determined the severity of the occurrence as critical and its probability as improbable, resulting in an assessment that the risk presented by the occurrence was low. The company developed a corrective action plan to mitigate the probability of a subsequent similar occurrence.

Short-term corrective action was implemented immediately after the occurrence. On 29 June 2010, the chief pilot issued Perimeter Dash 8 Operation Memo #05-10 to all company DHC-8 pilots. The memo indicated that “doing the ‘Before Start Checklist’ while passengers were deplaning from the inbound flight and then the crew leaving the aircraft” had led to a serious flight irregularity. The memo directed all pilots to cease the practice, and stated that, “effective immediately, the ‘Before Start Checklist’ will only be done when the captain and first officer are in their respective seats and ready for the start.”

Before the occurrence, Perimeter had made arrangements to obtain its fuel from a different supplier. Perimeter expected to have more operational control over the new supplier because it was also a subsidiary of Perimeter’s parent company. Operations with the new fuel supplier commenced on 05 July 2010.

The SMS long-term corrective action plan is to use this occurrence as a case study for Perimeter’s crew resource management (CRM) training program. This was implemented during the company’s most recent CRM course, which was delivered to all Dash 8 pilots and to most of the company’s Metro pilots. The course was monitored by Transport Canada.

This report concludes the Transportation Safety Board’s investigation into this occurrence. Consequently, the Board authorized the release of this report on 04 April 2011.

Visit the Transportation Safety Board’s website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A – “BEFORE START – ENROUTE” Checklist

BEFORE START - ENROUTE

ESCAPE HATCH..... CLOSED
BATT MSTR, MAIN & AUX ON
BUS TIE ON
DC EXTERNAL PWR/APU..... ON & CHKD
PRESSURIZATION SET FOR ___
BLEED AIR..... MIN/OFF
PASSENGER SIGNS ON
EMERGENCY LIGHTS ARM
FLT INST / RADIOS SET, X-CHKD
ENG INTAKE BYPASS DRS..... OPEN
ECU SELECTOR TOP
PARK BRAKE SET/___ (PSI)
POWER LEVERS..... FLT IDLE
CONDITION LEVERS FUEL OFF
TRIMS 3 SET
FUEL QUANTITY ___ LBS
FUEL ON CAUTION LT..... OUT

FLIGHT DECK DOOR..... SECURE
RECIRC FAN OFF
APU BLEED AIR OFF
PROPELLER..... UNTETHERED/CLEAR
ANTI-COLLISION RED