AVIATION OCCURRENCE REPORT

FUEL EXHAUSTION

KENN BOREK AIR LTD.
DE HAVILLAND DHC-6 TWIN OTTER, C-FPAT
YAKOUN LAKE, BRITISH COLUMBIA
17 JUNE 1997

REPORT NUMBER A97P0169

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.

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Summary

The float-equipped de Havilland DHC-6 Twin Otter, serial number 2, departed Langara at about 1350 Pacific daylight time, with 8 passengers and 2 pilots, for a 35-minute visual flight rules (VFR) flight to Alliford Bay, in the Queen Charlotte Islands on the west coast of British Columbia. About 20 minutes after departure, the forward fuel tank low-level caution light illuminated, even though the forward fuel gauge indicated 310 pounds of fuel. The captain consulted the emergency checklist which indicated that this situation could be caused by a blocked ejector pump, slowing transfer of fuel to the collector cell. The captain continued the flight with no further action since he assessed that gravity feed would be sufficient to ensure proper fuel supply to the engine. About five minutes later, the low fuel pressure caution lights came on and the number 2 engine stopped. The forward fuel gauge indicated about 200 pounds. At this time, the aircraft was near Yakoun Lake, and the captain decided to land there to assess the problem. The aircraft landed without further event, but the number 1 engine also stopped as the captain attempted to taxi to the beach area. The fuel tanks were found to be empty. Another Twin Otter was dispatched to Yakoun Lake by the company to deliver an aircraft maintenance engineer (AME) and two drums of fuel to the downed aircraft and to carry the passengers to their destination. The aircraft was refuelled from the drums and the engines were restarted. The aircraft was later ferried back to Alliford Bay without further incident.

Ce rapport est également disponible en français.

Other Factual Information

The operation on the day of the incident involved flying passengers between the base at Alliford Bay and a fishing lodge at Langara. The pre-flight fuel calculations made by the pilots on the company flight planning form indicated that each flight would consume 340 pounds of fuel; 50 pounds for the start, taxi, and climb, plus 290 pounds for the en route phase. These figures were based on a calculated en route time of 29 minutes and a fuel burn of 600 pounds per hour.

Prior to the first flight, the captain used a dipstick to determine that there was a total of 550 pounds of fuel in the aircraft tanks. The fuel gauge indications matched the dip, however the aft tank gauge was working intermittently. The captain added 600 pounds of fuel and the aircraft departed for Langara. The aircraft then returned to Alliford Bay and the captain added another 600 pounds of fuel. No records of the refuelling were kept, so there was no independent means of verifying the quantity of fuel loaded. The aircraft departed for Langara again, and, because of reports of poor weather, the captain took a longer route along the west coast of the island. The actual en route times for these flights were 39 minutes, 39 minutes, and 43 minutes respectively, considerably longer than the 29 minutes originally flight-planned. Fuel flow readings taken during the flights indicate that the aircraft was burning 600 pounds of fuel per hour.

The aircraft journey logbook entry for the first flight indicated a fuel weight of 850 pounds at departure. The captain reported that the actual fuel weight was 1,150 pounds. With this amount of fuel on board, the actual take-off weight would was 11,095 pounds, which is 95 pounds above the maximum certificated gross weight of the aircraft. On the return flight from Langara, the journey logbook again indicated a fuel weight of 850 pounds, even though no fuel was taken on at Langara. Prior to the second flight from Alliford Bay to Langara, 600 pounds of fuel was added and the journey logbook indicated a fuel weight of 1,200 pounds. The next flight, from Langara to Alliford Bay, was the incident flight, and the journey logbook entry indicates a fuel load of 860 pounds at departure. At the time of the incident, the weight and centre-of-gravity of the aircraft were calculated to have been within prescribed limits.

At the time of the second departure from Langara, the forward fuel gauge was indicating about 450 pounds, but now the aft tank gauge was not working at all. The captain believed that the aft tank contained the same quantity as the forward tank, and he believed that the forward gauge was accurate, since it had been accurate when he checked it in the morning. Fuel was available at another dock at Langara, and the captain was aware that he could refuel there.

The captain was certified, trained, and qualified for the flight in accordance with existing regulations. This was the second day that he had been flying this particular aircraft and he had not noticed any discrepancies with the aircraft on the previous day. The first officer was new to the company and had started working in the Queen Charlotte Island operation four days prior to the incident.

The two standard fuel tanks in the Twin Otter are located in the belly of the fuselage. Normally the forward tank feeds the number 2 engine, while the aft tank feeds the number 1 engine. Each tank comprises four cells connected together, one of which is the collector cell into which fuel is transferred from the other cells through a booster pump operated ejector. A capacitance type fuel quantity indicating system measures the amount of fuel in each cell, and a fuel gauge for each tank displays the fuel quantity in pounds. If electrical power to the fuel indication system is lost, the gauges remain at the same indication displayed when power was lost. Several company AMEs reported that fuel gauge indication problems were common due to the location of the system's wires in the belly of the fuselage and the aircraft operation in salt water.

A physical check of the fuel in the tanks can be made with a fuel quantity dipstick. The dipstick is inserted in the fuel filler neck into cell number 1 of the forward tank, and into cell number 7 of the aft tank. This measurement will only be accurate if the fuel level in each cell of the tank is the same. This requires that the aircraft be level, and that 15 minutes elapse since the engines were operated or since the last refuelling. The dipstick is calibrated in 200-pound increments and is intended to provide an approximate reading of fuel in each tank. Flight Safety International's DHC-6 training manual advises that the dipstick is a secondary means of checking fuel quantity, and it is not intended to replace the fuel gauges. The normal procedure followed by the operator's Twin Otter pilots was to dip the tanks each morning, before the first flight, and compare the readings to the fuel gauge readings.

There are two fuel low-level caution lights, one for each tank. Each caution light is activated by a float switch in its respective collector cell when the fuel in that cell reaches a predetermined level. In level flight, the forward tank low-level light should activate when 75 pounds of useable fuel are remaining. Seventy-five pounds of fuel would provide one engine with sufficient fuel to operate for 15 minutes at cruise power settings. The aft tank low-level caution light did not illuminate during the incident flight, although it should have illuminated when there was 110 pounds of useable fuel remaining.

Kenn Borek Air Ltd. has established a minimum equipment list (MEL) for the DHC-6 aircraft. The MEL allows dispatch of an aircraft with one fuel gauge inoperative provided that the following operating procedures are followed:

a) the problem must be noted in the logbook and deferred by a licenced AME;
b) the quantity of fuel on board the aircraft must be determined before each flight, either through the use of a dipstick, or by filling the tank to capacity;
c) both fuel flow indicators and both low-level caution lights must be operating normally; and,
d) the inoperative fuel quantity gauge must be placarded as such.

The above procedures were not followed on the day of the incident. Some operational penalties are incurred if these procedures are followed. For instance, it is difficult without a working gauge to determine the quantity of fuel on board the aircraft before each flight. The fuel dip will only be accurate after the aircraft has sat idle for at least 15 minutes, causing a delay for each flight. The company chartering the Twin Otter was informed by the operator that the aircraft could carry a payload of 2,700 pounds from Langara to Alliford Bay. This figure was based on a fuel load of 800 pounds. If fuel loads were greater than 800 pounds, a reduction of payload would be required. An examination of the journey logbook entries for the previous month shows that the provisions of the MEL were not used during that time.

The base AME at Alliford Bay rectified the fuel gauge problems after the flight and before the Transportation Safety Board (TSB) was made aware of the incident. He dipped the tank and checked the fuel gauge when the aircraft arrived at Alliford Bay, and noted that both the dip and the gauge were in error, given the known fuel quantity that was loaded into the aircraft at Yakoun Lake. The engineer replaced two electrical cable ends and a connector, and cleaned the connector blocks and plug ends in the fuel quantity indication system. He then checked the system and found it to be accurate.

On 8 July 1997, investigators carried out calibration testing on the occurrence aircraft to

determine the accuracy of the forward fuel tank gauge, the dipstick, and the fuel low-level warning lights. The forward fuel tank was drained, and fuel was measured into the tank. As fuel was added, the fuel gauge reading was compared to the amount of fuel added. At fuel quantities above about 100 pounds, the fuel gauge was found to read about 14% less than the actual fuel in the tank; at lower quantities, the error was from16 to 20%. After adding 407 pounds of fuel to the tank and waiting 30 minutes, the tank was dipped and the fuel quantity dipstick read about 385 pounds. The low fuel caution light was found to function normally.

Analysis

The following table compares the pre-flight fuel calculations to the amount of fuel burned, and it compares the fuel load recorded in the journey logbook to the fuel load calculated from the fuel burn. All of the calculations are based on the figures given above.

Departure/ destination	Planned fuel burn	Actual fuel burn	Fuel load, as recorded in journey log	Fuel load, based on actual fuel burn and captain's statement
Alliford Bay/ Langara	340	440	850	1150
Langara/ Alliford Bay	340	440	850	710
Alliford Bay/ Langara	340	480	1200	870
Langara/ Alliford Bay	340	Fuel exhaustion after 37 minutes flight time (Approx 390 pounds)	860	390

The pilots' pre-flight calculations were somewhat optimistic; however, pre-flight plans are often slightly inaccurate. Of greater concern are the gross errors made in the journey logbook regarding the quantity of fuel on board. These figures are normally based on actual fuel burns or accurate measurements of fuel on board. The quantities listed in the journey logbook for this day were not consistent with known and measured quantities, nor with the fuel calculations that should have been made as the flights progressed. The only other source these figures could have been derived from were the fuel gauge indications, even though only one gauge was functioning. The captain believed that the forward gauge was accurate, and he assumed that the aft tank would be carrying the same amount of fuel. He relied on the forward fuel gauge for all of his fuel load information, but this gauge proved to be inaccurate.

The means of establishing the fuel quantity in this particular operation is problematic. Twin Otters, operating on floats in a salt water environment, have a history of fuel gauge problems. Additionally, the fuel dip should be considered an approximate indication rather than an accurate measurement. The pilots do not fill the tanks to capacity since that would reduce the payload. The only method available to the pilot to reliably establish the fuel quantity on board is to closely monitor the fuel burn during the course of the flights. The amount of fuel that the captain loaded onto the aircraft is not consistent with him having accurately monitored the fuel burn during the flight. According to the captain, he refuelled the aircraft twice, each time adding 600 pounds of fuel; pre-flight planning, however, indicated that 680 pounds would have been required after each round trip. The flights were longer than planned, which should have alerted the captain that more fuel was required. For instance, after the 43-minute flight from Alliford Bay to Langara, the fuel load in the journey logbook was reduced by only 340 pounds of fuel, even though the fuel burn was likely about 480 pounds.

Contributing to this incident were the unserviceability of the aft fuel gauge, the inaccuracy of the forward gauge, and that the MEL procedures for continued operations with an unserviceable fuel gauge were not followed. It is not clear why the procedures were not followed, but the negative operational impact of complying with the MEL procedures may have deterred the captain from entering the defect into the logbook. Had the MEL procedures been followed, the tank would have been filled, or additional fuel dips would have been made, and the low fuel situation would likely have been identified or prevented.

The procedure of dipping the tanks each morning as a means of checking fuel gauge accuracy has limitations that must be understood. The design of the fuel tanks makes the fuel dip technique prone to error. When the dip and the gauge are the same, it is possible that both are equally in error.

The captain decided to land after the number 2 engine stopped because he recognized conflicting information regarding the fuel quantity status and he was unable to resolve the conflict. Rather than attempt to proceed on the single engine, he chose to land at Yakoun Lake, ten minutes short of his destination, and this action likely prevented a serious accident.

Findings

1. The forward fuel gauge was inaccurate, and the aft fuel tank gauge was unserviceable.

2. The procedures required by the MEL to continue operations with an unserviceable fuel gauge were not followed.

3. The pilots did not accurately monitor fuel consumption during flight.

4. The captain relied on the forward fuel gauge and the dipstick for his fuel load information.

5. The captain landed after the number 2 engine stopped because of conflicting information about the fuel quantity.

6. The procedure of dipping the tanks is a secondary method of determining the fuel quantity and gives an approximate reading.

7. The recorded fuel loads found in the journey logbook reflect neither the pilots'

calculations nor the actual fuel onboard.

Causes and Contributing Factors

The aircraft ran out of fuel because the pilots did not establish the fuel quantity onboard before or during flight. Contributing to the incident were the unserviceable and inaccurate fuel gauges, and that the pilots did not accurately monitor fuel burn in-flight or follow applicable MEL procedures.

Safety Action

The company has instituted a procedure at the Alliford Bay operation whereby the pilots must log the amount of fuel loaded into the aircraft, and this entry must be witnessed by another person.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 25 February 1998.