AVIATION INVESTIGATION REPORT
A02C0143

LOSS OF ENGINE POWER AND FORCED LANDING

BLUE WATER AVIATION SERVICES
DE HAVILLAND DHC-2 MK1 BEAVER C-FEYQ
SASAGINNIGAK LAKE, MANITOBA 10 NM S
28 JUNE 2002

Aviation Investigation Report

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Summary

The float-equipped de Havilland DHC-2 Beaver aircraft, registration C-FEYQ, serial number 465, operated by Blue Water Aviation Services, departed Bissett, Manitoba, at approximately 0910 central daylight time (CDT). The aircraft's load comprised the pilot, three passengers, passenger baggage, and two 16-foot canoes strapped to the float strut assemblies, one on each float. The purpose of the flight was to transport canoeists to Sasaginnigak Lake approximately 38 miles north of Bissett. The trip was estimated to take 22 to 24 minutes. Approximately 18 minutes into the flight, the engine low fuel pressure warning light illuminated, and the engine began to lose power. The pilot switched tanks from the centre fuel tank to the front tank and began to manually operate the fuel wobble pump. The engine sputtered a few times, but did not regain power. The aircraft was descending over land at this point and the pilot was forced to put the aircraft down through trees into a rocky outcrop area. The aircraft overturned during touchdown and the pilot and three passengers exited the aircraft uninjured. The aircraft was spotted several hours later by an overflying aircraft. There was no emergency locator transmitter (ELT) on board the aircraft. A helicopter was dispatched and the pilot and passengers were transported to a nearby hospital for observation. The accident occurred during the daylight hours at 0930 CDT.

Ce rapport est également disponible en français.

Other Factual Information

The pilot held a valid Canadian commercial pilot licence, rated for land and sea operations. According to Transport Canada and company documentation, the pilot was qualified and fit to perform the flight.

The weather observation for Bissett at 0900 central daylight time (CDT)[1] was as follows: surface temperature 28°C, temperature at 1000 feet 30°C, and winds less than 10 knots out of the south.

This was the pilot's third flight of the day. It was company policy to fly external loads early in the morning when the temperatures were cooler. The first flight was flown approximately four hours earlier with three passengers and one externally strapped canoe. The temperature at that time was approximately 18°C, or 10 degrees cooler than at the time of the occurrence trip. The second flight consisted of three legs. The first leg was flown with freight only, the second leg empty, and the third leg with four passengers and baggage. The pilot reported no performance problems with the aircraft on either of these two flights at cooler temperatures. Company operations personnel reported that an external load trip would not normally be scheduled to depart in high ambient temperature conditions. The temperature at the time of departure for the occurrence flight was unusually high. The occurrence flight would have been the pilot's last external load flight that day.

Prior to the occurrence flight, the pilot put approximately 50 litres (13.25 US gallons) of fuel into the centre tank, which was nearly empty. The front fuel tank already contained approximately 113 litres (30 US gallons) from the previous flight. The pilot's normal practice was to burn fuel from the centre tank first, then switch to the front tank for landing. At a fuel burn rate of approximately 25 US gallons per hour (gph), the pilot estimated that he had a duration of about 32 minutes of flight time on the centre tank, or enough fuel to handle the outbound leg of the trip. After the occurrence, the average fuel burn rate for segments of the first two flights of the day was calculated from log book entries to be between 22 and 28 US gph, or close to the 25 US gph stated in the aircraft flight manual. The flight up to the time of the engine power loss was flown entirely on the centre fuel tank.

On this type of flight, the pilot would normally climb to a minimum cruising altitude of 2500 feet above sea level (asl). Because of the high ambient air temperature and the increased drag caused by the canoes tied onto the aircraft's floats, the pilot levelled off at 1700 feet asl, 700 feet above ground level (agl), and set the engine power to a normal cruise power setting of 28 inches of manifold pressure and 1800 rpm. At this power setting, the engine temperatures were normal and the carburettor heat was in the yellow range with no reported loss of aircraft altitude. The lower cruising altitude was selected so as not to prolong the use of climb power and risk overheating the engine; it was at that altitude when the engine lost power. The design service ceiling of the float equipped DHC-2 Mk 1 Beaver is 15 750 feet asl. Carrying external loads on an aircraft increases the aerodynamic drag in flight, adversely affecting aircraft performance.

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[1] All times are CDT (Coordinated Universal Time [UTC] minus five hours) unless otherwise noted.

The company's operations manual, Section 3.14.1, prohibits the carriage of passengers when external loads are being carried, unless authorized in the aircraft's Type Certificate or Supplemental Type Certificate (STC). The Type Certificate for the DHC-2 Beaver contains direction and limitations governing the carriage of external loads, but it does not authorize the carriage of passengers when external loads are being carried. The company did not hold an STC for the DHC-2 Beaver. No documentation was found indicating an exemption to 3.14.1 of the company's operations manual had been approved or was in effect. There is no known STC that allows the external carriage of two canoes on the aircraft.

Canadian Aviation Regulation (CAR) 703.25 prohibits the carriage of external loads with passengers onboard, unless otherwise authorized in the aircraft's Type Certificate or STC. There is, however, an exemption to CAR 703.25 published in the *Commercial and Business Aviation Advisory Circular*, No. 0209 (CBAAC 0209, formally CBAAC 0152R - See Appendix A). The exemption was issued by Transport Canada, after representation from industry, to allow operators to carry external loads and passengers simultaneously without having these authorities.

The CBAAC 0209 Advisory Circular is made up of two documents, the Advisory Circular and the exemption to CAR 703.25 document. In the "purpose" statement of the Advisory Circular it states:

> This exemption will permit operators to carry passengers and an external load, without authorization in the Type Certificate or in a supplemental Type Certificate (STC), provided that certain conditions are met.

In the "Purpose and Application" statement of the exemption to CAR 703.25 document it states:

> The purpose of this exemption is to allow Canadian air operators to carry external loads on their float equipped aeroplanes without authorization in the aeroplane type certificate or in a supplemental type certificate. This exemption does not apply to operators that have been authorized in the aeroplane type certificate or supplemental type certificate to carry external loads.

CBAAC 0209 requires that operators meet certain conditions if they wish to operate under this exemption, and requires that the company's operations manual be amended to indicate that the operator is conducting external load operations in accordance with the conditions of the exemption. A review of company and Transport Canada documentation indicated that none of the conditions of CBAAC 0209 had been met.

Interviews with several Transport Canada inspectors in the Prairie and Northern Region and the Ontario Region revealed varying and substantially different interpretations as to how the exemption (CBAAC 0209) was applied. Specifically there was confusion as to when the aircraft Type Certificate governed the carriage of external loads and when the conditions of CBAAC 0209 governed carriage of external loads. There was concern among the inspectors that CBAAC 0209 contained no finite restrictions regarding weight, quantity, and dimensions, creating the potential for operators to carry large, non-aerodynamic external loads that could exceed the performance capabilities of their aircraft. They believed that the wording in CBAAC 0209 was ambiguous in its application and that it would be unreasonable to expect operators to have a uniform understanding of the exemption and its application with the current wording.

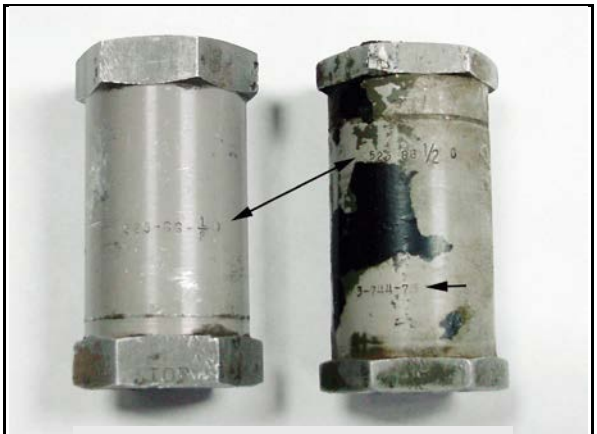
The investigation revealed that most of the company's senior operations personnel and the pilot in command had a limited knowledge and understanding of existing regulations governing the carriage of external loads. The carriage of external loads with passengers was common practice at the company and the pilot had done so in the

past. One of the requirements of CBAAC 0209 is that formal and documented training be conducted on the carriage of external loads. Some company training had been done, but it was neither formal nor documented. The training information available from the company's operations manual and training program was incomplete and not in accordance with the normal operating practices of the company or the requirements of the CARs.

CBAAC 0209 does not permit operators to exceed the performance capabilities of their aircraft. It requires, when passengers plus external loads are carried, that the maximum take-off weight of the aircraft be reduced by twice the weight of the external load. On the occurrence aircraft, the pilot was aware that the external load and high outside temperatures would affect aircraft performance and he limited the load in an ad hoc manner. It was calculated that at the time of take-off, the aircraft was 350 to 400 pounds below its maximum take-off weight of 5090 pounds.

An examination of the wreckage was done approximately one week after the occurrence. As the first indication of an anomaly was the illumination of the fuel pressure warning light, the aircraft's fuel system was examined in detail. The fuel delivery system in the DHC Beaver is a suction feed system, with the engine driven fuel pump drawing fuel from the fuel tanks in the belly of the aircraft. The aircraft had been inverted since the day of the accident and most of the fuel that had been in the aircraft had either drained out or evaporated. The fuel that was recovered was free of water and contamination. The engine and airframe fuel system screens were removed and found to be clean and free of obstructions. The fuel tanks and fuel lines were found to be free from foreign obstructions and the fuel selector valve was found to operate normally. The fuel selector valve was found selected to the forward tank.

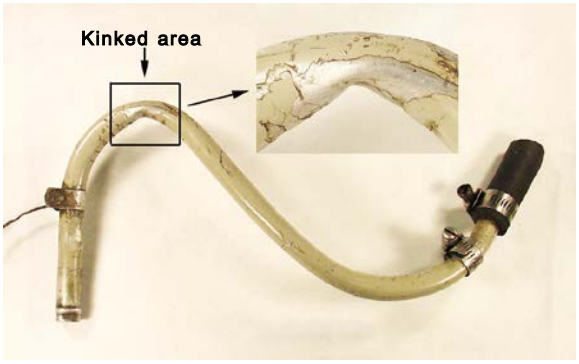
During the examination of the aircraft, two anomalies were noted in the fuel delivery system. The first anomaly involved one of the two inline fuel system check valves (see Figure 1). The check valves were stamped with the same body number (525 GG ½ D), but only one valve was stamped with the original component manufacturer's part number (P/N) 3-744-75. The valve without the original component manufacturer's P/N stamp appeared to be of a different design. The internal flapper door on this valve had a stiffer return spring and the flapper door was found to contact the internal wall of the valve, preventing the door from opening fully. This check valve was installed in the main fuel line between the inlet and outlet lines connected to the wobble pump.



Both valves were tested at the component manufacturer's facility in Irvine, California. The minimum flow requirement for the P/N 3-744-75 valve is 110 cubic centimeters per minute (cc/min) with a flow rate of 5 inches of solvent. The flow rate for the approved P/N 3-744-75 valve was measured at 132 cc/min with the flow beginning at approximately 4 inches of solvent. The flow rate for the non-approved valve was measured at 36 cc/min with the flow eventually beginning at 5 inches of solvent, after waiting a few seconds.

The second anomaly was a significant kink in a section of the aluminum main engine fuel feed line (P/N C2P1017), mounted directly behind the engine oil cooler temperature regulating valve. The valve controls the flow of oil through the cooler. The kink was located on a bend in the line and had reduced the size of the line to

approximately ½ of its original diameter. The fuel line was located in a protected area of the fuselage and would not have been damaged from impact forces. As a result, the kink was believed to be damage caused during an unspecified maintenance action at some unknown time prior to the occurrence (see Figure 2).



The aircraft was not equipped with an optional electric fuel boost pump. The engine-driven fuel pump was removed and later flow-checked at an engine overhaul facility; the pump output pressure was below limits. It was not believed that the lower fuel pressure setting would have resulted in the engine power loss; however, the lower pump output pressure would have reduced the suction on the main engine feed line. The operator indicated that earlier in the season the aircraft's fuel pressure gauge was reading high, and that the wobble pump handle was moving up and down by itself. The operator reduced the fuel pump pressure, which seemed to cure the problem of the handle moving up and down.

During the 2001/02 winter season, a major 800-hour inspection of the aircraft was carried out. The airframe time was 19 705.8 hours, and the inspection was signed as completed on 01 May 02. During the inspection, a fuel primer line, located in the area of the kinked main engine fuel feed line, was replaced and EDO 4580 floats were reinstalled. The aircraft was inspected again on 24 June 02, four days prior to the occurrence, during a scheduled 100-hour maintenance inspection. During that inspection the fuel sumps were drained and the screens were cleaned. The survival kit was signed out as being inspected and the emergency locator transmitter (ELT) was re-certified. No record of the inline fuel check valves being replaced was found.

The pilot could not locate the ELT in the aircraft after the accident. An examination of the wreckage revealed that the ELT mounting bracket straps were bent over and flattened against the ELT mounting tray. The ELT mounting tray and straps were in a protected part of the fuselage and would not have been damaged by the impact. The company could not explain why or when the ELT was removed from the aircraft, but indicated that the flattening of the mounting bracket straps could have occurred during the replacement of the elevator cables at the 800-hour inspection.

CAR 605.39 (2) (b) allows an aircraft to be operated without a serviceable ELT for a period of up to 30 days, providing certain conditions are met. One condition is that the operator "displays on a readily visible placard within the aircraft cockpit, for the period of removal of the ELT from the aircraft, a notice stating that the ELT has been removed and setting out the date of removal". There was no entry in the log book to indicate that the ELT had been removed from the aircraft, nor was the aircraft placarded to indicate that the aircraft was operating without an ELT.

The company's operations manual does not state what items are covered in the required training on the use of emergency equipment, in particular, knowledge about access to and use of the ELT in an emergency.

Analysis

The pilot indicated that prior to his fuelling the centre tank, the tank contained an unknown minimal amount of fuel. Using a minimum value of 50 litres (13.25 US gallons) of fuel added by the pilot prior to the flight, and a

flight time of approximately 18 minutes to the time of the power loss, it was calculated that the engine would need to burn a minimum of 44 US gph to empty the centre tank. Because the average fuel burn rate on segments of the first two flights of the day was calculated to be close to the stated aircraft flight manual rate of 25 US gph, a fuel burn rate of 44 US gph was unlikely. Therefore, illumination of the fuel pressure warning light and subsequent loss of engine power was not a result of the centre fuel tank running dry.

The only two anomalies found in the fuel delivery system that could account for the loss of engine power was a restriction in the inline fuel check valve at the wobble pump location and a kink in the main engine fuel feed line. A restriction in the check valve at the wobble pump location would probably not result in an engine power loss, as fuel can still be drawn through the internal check valves in the wobble pump, providing an additional path of fuel to the engine. However, the path would have resulted in additional line losses due to the additional routing and check valves. The prior problem with the wobble handle moving up and down indicates that the inline fuel check valve was restricted to the extent that fuel was being drawn through the wobble pump to compensate for the restriction. The subsequent lowering of the fuel pump pressure likely lowered the flow of fuel through the check valve to a point where the fuel did not have to be bypassed through the wobble pump.

The main fuel line was in an airframe compartment just aft of the engine firewall and behind the oil cooler temperature regulating valve. This area of the compartment was subjected to high temperatures during this flight, as the oil cooler would have been flowing at high capacity to dissipate heat from the hot engine oil. The result would have been heating of the fuel line and the fuel flowing through it. The kink in the fuel would have restricted the flow of fuel through the line causing a localised drop in fuel pressure at the narrowest point (venturi effect).

Because of the location of the fuel tanks, there is very little head pressure in the tank to force the fuel forward. As well, suction in the fuel line was lower than normal because of the adjustment to the engine-driven fuel pump. As the tank level decreased and the fuel line temperature rose, it is likely a fuel vapour lock occurred. The boiling point of the fuel at the location of the kink would have been lowered because of the drop in pressure caused by the venturi effect. The kink, located at a bend in the line, would also have induced a turbulence in the fuel where the fuel flow over the bend would have separated from the internal wall of the line, downstream of the kink. As the fuel passing over this low pressure area was heated by the hot air being dissipated from the oil cooler, the fuel likely reached a temperature at which it vaporized.

With the vaporization of the fuel, the engine-driven pump would have eventually cavitated, resulting in illumination of the fuel pressure warning light and loss of engine power. The hand-operated wobble pump would have been ineffective as the wobble pump was located downstream of the vapour lock and would have quickly lost its prime. Changing to the front tank would initially have had little effect on the operation of the engine, as the fuel could not have been sucked forward from the tank until the vapour lock cleared and either the engine-driven or hand-operated wobble pump regained its prime. A stiffer-than-normal return spring in the inline fuel check valve could also have delayed the repriming of the pumps.

It is not known when or how the kink in the fuel line was made. Because of the severity of the kink, it is unlikely that the aircraft had been operating for very long in this condition, because a power loss would likely have happened earlier under similar conditions.

The aircraft performance was degraded by the high outside air temperature and the drag of the externally loaded canoes. Because of the degraded performance and the pilot's concern about the engine operating temperature, the pilot was forced to level off at a lower than normal cruising altitude. This reduced the likelihood of a successful forced landing and the time available to restart the engine after it stopped.

The information presented in the CBAAC 0209 Advisory Circular and in the exemption to CAR 703.25 document, if not contradictory is, at least, ambiguous. The "purpose" paragraph in the CBAAC 0209 Advisory Circular says that Type Certificate and STC authorization is not required to carry passengers with an external load. The "purpose and application" statement in the exemption to CAR 703.25 document also says that Type Certificate and STC authorization is not required to carry external loads, but makes no reference to the carriage of passengers. The exemption document goes on to say that if an operator already has an STC or Type Certificate approval to carry external loads, the exemption does not apply. The ambiguous wording, and the degree of variance in how it is interpreted by Transport Canada inspectors, may contribute to an operator's inadequate understanding of its requirements and application.

The exemption to CAR 703.25 was not applicable to the de Havilland Beaver because carriage of external loads on the Beaver aircraft is governed by the information in the aircraft Type Certificate. If company personnel believed that the exemption did apply to their operation, they had not amended the operations manual to include the conditions listed in CBAAC 0209, which also precluded them from taking advantage of it. Because it was common practice by the company to carry external loads with passengers, the pilot believed that it was acceptable, and expected of him, to do so.

Because CBAAC 0209 contains no quantity and dimensional limitations, there is no regulatory defence in place to prevent an operator from attempting to carry large, non-aerodynamic external loads and subsequently exceeding the performance capabilities of their aircraft.

Findings as to Causes and Contributing Factors

1. The main engine fuel feed line had been damaged and kinked at some unknown time prior to the occurrence, which restricted the flow of fuel through the line.

2. The damage to the fuel line was not discovered during regular maintenance inspection checks of the aircraft, which allowed a potentially serious problem to go unchecked.

3. The area of the kink in the fuel line was in a hot area behind the engine oil cooler, which likely led to a fuel vapour lock situation resulting in a loss of engine power.

4. The aircraft was equipped with a non-approved fuel check valve that did not meet the manufacturer's flow specifications. The fuel check valve not only presented a restriction in the fuel delivery to the engine, but was equipped with a stiffer valve plate return spring, which could delay the restarting of the engine if a fuel tank were to be run dry.

5. The aircraft's load and the ambient weather conditions limited the cruising altitude for the flight. This reduced the likelihood of a successful forced landing and the time available to restart the engine after it stopped.

Findings as to Risk

1. *Commercial and Business Aviation Advisory Circular* (CBAAC) 0209 does not place any finite restrictions for the carriage of external loads. There is a risk that operators may attempt to carry

large, non-aerodynamic external loads and subsequently exceed the performance capabilities of their aircraft.

2. Canadian Aviation Regulation (CAR) 703.25 exempt aircraft are less restricted in their carriage of external loads than are non-exempt aircraft. This exposes exempt aircraft to a higher level of risk than non- exempt aircraft.

3. Although the downed aircraft was found in a relatively short time, the absence of an ELT decreased the occupants' chances of a prompt rescue.

4. The company was operating as if the exemption to CAR 703.25 was in effect for the company, although it was not; thus, the pilot thought that his aircraft was approved to carry the load involved, which resulted in a decreased level of aircraft performance.

5. The aircraft was not equipped with an optional fuel boost pump. A boost pump, if in use, could have prevented a vapour lock situation, or, once selected on, could have cleared a vapour lock.

Other Findings

1. The wording of the exemption to CAR 703.25 is ambiguous. If not clarified and quantified, it is likely that industry and Transport Canada officials will continue to misinterpret its application and purpose.

2. The pilot did not know or detect, prior to the flight, that the emergency locator transmitter (ELT) was missing.

Safety Action

The examination and testing of the inline fuel check valves indicated that one valve did not meet the original component manufacturer's flow specifications, and as such was unapproved. Transport Canada has sent a letter to the airframe manufacturer requesting their position on this potential safety issue and what corrective action will be taken. The aircraft manufacturer's airworthiness department has taken the issue of the unapproved inline fuel check valve under advisement.

Transport Canada has also established an Internal Working Group to review the issues surrounding the carriage of external loads.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 21 May 2003.

*Visit the Transportation Safety Board's Web site (**www.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 – CBAAC 0152R

COMMERCIAL AND BUSINESS AVIATION
ADVISORY CIRCULAR

No. 0152R
2000.05.05

Carriage of Passengers and External Loads

PURPOSE

This *Commercial and Business Aviation Advisory Circular* (CBAAC) informs floatplane operators of an exemption to section 703.25 of the *Canadian Aviation Regulations* (CARs). This exemption will permit operators to carry passengers and an external load, without authorization in the Type Certificate or in a Supplemental Type Certificate (STC), provided that certain conditions are met.

This CBAAC replaces CBAAC 0152 dated 1999.03.02. This revision reflects a change to the Procedures and Recommended Practices for Carrying External Loads as well as the expiry date noted on page two of the exemption.

REFERENCES

CAR 703.25 *(Carriage of External Loads)*

DISCUSSION

CAR 703.25 only authorizes carriage of an external load with passengers on board when it is authorized in the Type Certificate or in a STC. After several representations from industry, Transport Canada, Civil Aviation has issued an exemption to permit operators of floatplanes to carry passengers and an external load, without having these authorities. The exemption contains conditions that operators must meet, and guidance material to assist them in meeting these conditions. (Note that changes have been made to the Procedures and Recommended Practices since the previous CBAAC.)

ACTION

Operators who wish to take advantage of this exemption must satisfy all the conditions, and amend the Company Operations Manual accordingly.

M.R. Preuss
Director
Commercial & Business Aviation

Commercial & Business Aviation Advisory Circulars (CBAAC) are intended to provide information and guidance regarding operational matters. A CBAAC may describe an acceptable, but not the only, means of demonstrating compliance with existing regulations. CBAACs in and of themselves do not change, create any additional, authorize changes in, or permit deviations from regulatory requirements.

www.tc.gc.ca/CivilAviation/commerce/circulars/AC0152r.htm