

Transportation Safety Board
of Canada



Bureau de la sécurité des transports
du Canada

**AVIATION INVESTIGATION REPORT
A12P0008**



ENGINE POWER LOSS AND HARD LANDING

**ROYAL CANADIAN MOUNTED POLICE
EUROCOPTER AS 350 B3 (HELICOPTER), C-FMPG
CULTUS LAKE, BRITISH COLUMBIA, 1.5 NM E
17 JANUARY 2012**

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 A12P0008

Engine power loss and hard landing

Royal Canadian Mounted Police
Eurocopter AS 350 B3 (helicopter), C-FMPG
Cultus Lake, British Columbia, 1.5 nm E
17 January 2012

Summary

At 1351 Pacific Standard Time, Air Five, the Royal Canadian Mounted Police Eurocopter AS 350 B3 helicopter (registration C-FMPG, serial number 3082), with only the pilot on board, took off from an open field near Cultus Lake, British Columbia, on the outskirts of the city of Chilliwack. The helicopter slowly travelled nearly 260 feet to the north, and then hovered at about 80 feet above the ground for approximately 30 seconds. Suddenly, a distinct noise and a puff of grey/white vapour from the engine area occurred, followed by a rapid loss of rotor revolutions per minute. The helicopter descended quickly, and within seconds, landed heavily on the snow-covered terrain. Upon impact with the ground, the helicopter fuselage collapsed and the fuel tank ruptured. There was no fire. The helicopter was destroyed, and the pilot was fatally injured. The emergency locator transmitter activated and was detected by the search and rescue satellite system. The accident occurred in daylight at 49°04'13" N and 121°56'08" W, at an elevation of about 650 feet above sea level.

Ce rapport est également disponible en français.

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1.0 Factual information

1.1 History of the flight

On the day of the accident, Air Five, the Royal Canadian Mounted Police (RCMP) Eurocopter AS 350 B3 helicopter departed the Vancouver International Airport (CYVR) at 0906¹ and landed at a Department of National Defence property, about 1.5 nautical miles (nm) east of Cultus Lake, British Columbia, at 0930. At 1145, the helicopter took off and carried out human external transportation system (HETS) training (pictured in Photo 1 and described in section 1.17.2) over open and partially treed terrain. The flight was conducted during periods of intermittent, light snowfall. Approximately 35 minutes later, the helicopter returned to the landing site and was shut down so that the pilot could get some lunch and prepare for the afternoon's training flights.

When the helicopter was shut down for lunch, it was not snowing, and the engine air inlet covers, which were on board, were not installed. During the lunch break, heavy snow started to fall and lasted for approximately 15 to 20 minutes. The pilot did not return to the helicopter to install the engine air inlet covers. At 1315, the pilot decided to cancel the remaining training and return to CYVR. Since shutdown, there appeared to be a significant accumulation of snow on the helicopter; the snowfall, however, had by then diminished to very light or none at all. The temperature was approximately -10°C .

After the helicopter was reconfigured for the flight to CYVR, the pilot entered the cockpit and prepared for start-up. At the same time, 2 ground crew members removed the snow accumulation from the 2 front windscreens. At 1349, the pilot started the helicopter, and the snow was flung off the blades. A significant amount of snow remained on the upper surfaces of the fuselage and tail boom (Photo 2).

After lifting off into a hover, the helicopter climbed to approximately 50 feet above ground level (agl), and slowly travelled up and forward about 260 feet in a straight line before hovering for about 30 seconds at a height of 80 feet agl. Soon afterward, there was a muffled bang and a puff of grey/white vapour from the exhaust area, and the rotor revolutions per minute (rpm) decayed immediately. At the same time, the customary and familiar sounds from the engine rapidly disappeared, and the regular slapping sound of the rotor blades quieted significantly. The helicopter began to descend, turned quickly to the right about 150° , pitched nose-down briefly, and then descended more rapidly. During the final moments of the flight, the helicopter



Photo 1. Human external transportation system (HETS) training flight (Source: RCMP)

¹ All times are Pacific Standard Time (Coordinated Universal Time minus 8 hours).

descended almost vertically, colliding with the terrain in a nose-down, right-side-down attitude. In all, the helicopter had been running for about 3 minutes.

Within 30 seconds of the impact, several ground crew members reached the helicopter. The pilot's helmet had come off, and the pilot was unconscious. The ground crew members extracted the pilot from the cockpit and performed first aid. Although the fuel tanks had ruptured at impact and fuel had spread beneath the wreckage, no fire occurred. The on-



Photo 2. C-FMPG, moments before final take-off (Source: RCMP)

board 406-Mhz (megahertz) emergency locator transmitter (ELT) activated at impact and transmitted a signal to the search and rescue satellite (SARSAT) system. The ELT was later turned off by first responders. Despite rapid onsite paramedic attention and response, the pilot did not regain consciousness and died as a result of severe injuries.

1.2 Injuries to persons

Table 1. Injuries to persons

	Crew	Passengers	Others	Total
Fatal	1	-	-	1
Serious	-	-	-	-
Minor/none	-	-	-	-
Total	1	-	-	1

1.3 Damage to aircraft

Due to the force of the impact with the ground, the right landing skid broke, and the cabin, engine/transmission platform, and main airframe structure collapsed (Photo 3). The internal fuel cell was also shattered by contact with the attached belly hook and sling unit upon ground impact. The tail boom and tail-rotor blades struck the ground, buckling the whole structure. Two of the main-rotor blades were intact and exhibited little damage, whereas the third rotor blade suffered extensive ground-impact damage. The tail-rotor blades were both damaged. One blade showed no damage except for evidence of wood in its striker tab. The other blade was almost completely fractured near its root/hub. The main-rotor and tail-rotor blade damage was characteristic of extremely low rotor rpm at impact. However, there was no mechanical

indication of any pre-accident malfunction of any flight control or rotor drive system on the helicopter that could have contributed to a loss of control of the helicopter.

The pilot's seat was an energy attenuating design, and it had collapsed and deformed the floor.

Engine examination findings are included later in this report.

1.4 Other damage

Trees at the edge of the impact site exhibited damage consistent with vertical shearing of the branches as the fuselage descended toward the ground. There was no indication of either main-rotor or tail-rotor blade



Photo 3. Wreckage (Source: RCMP)

strikes. The soil beneath the helicopter was contaminated with the jet fuel that had emptied from the burst fuel tank. Following removal of the wreckage, soil remediation was carried out.

1.5 Pilot information

Table 2. Pilot information

Canadian pilot licence	Commercial helicopter
Medical expiry date	May 2012
Total flying hours	8900
Hours on type	3000
Hours, last 90 days	67
Hours on type, last 90 days	10
Hours on duty before accident	7
Hours off duty before accident	12

The pilot was certificated and qualified for flight in accordance with existing regulations. The pilot had begun to work for the operator in June 2006, and had met all of its recurrent ground and flight training requirements. The pilot had experience with the AS 350 and several other types in winter conditions similar to the accident day. The pilot was appropriately rested before commencing the duty day on the day of the accident, and was characterized as highly experienced and competent.

1.6 Aircraft information

1.6.1 Eurocopter AS 350 B3 C-FMPG

Table 3. Aircraft information

Manufacturer	Eurocopter (France)
Model	AS 350 B3
Year of manufacture	December 1997
Serial no.	3082
Total airframe time	6995 hours
Engine model	Turbomeca Arriel 2B
Maximum take-off weight	4961 pounds
Recommended fuel	Jet A-1

The helicopter had been operated by the RCMP since new. The investigation determined that it was equipped, modified, and maintained in accordance with existing regulations and approved procedures, and that it was within its weight and centre-of-gravity limits. However, during a review of the various aircraft records for C-FMPG, several different weight-and-balance documents were found, none of which matched the values used by the pilot.

The helicopter air intake had been equipped with a Eurocopter air particle separator (QB0550), more commonly referred to as the sand filter, to protect the engine from ingestion of airborne particles. By design, no part of the air intake system was heated.

The helicopter had a vehicle and engine multifunction display (VEMD) unit. The main purpose for the VEMD was to display engine and system readings and parameters in digital and graphical formats, replacing conventional indicators and gauges. The VEMD integrates additional functions such as engine cycle counting, engine power checks, and engine performance calculations. As well, a maintenance function allows the retrieval of system failures, engine power checks, over-limit records, and previous flight-time data. To a certain degree, the VEMD communicates with the digital engine control unit (DECU), recording specific failures or faults.

1.6.2 Turbomeca Arriel 2B engine

The engine installed in the accident helicopter was a Turbomeca gas turbine Arriel 2B model (serial no. 22007), rated at 747 shaft horsepower. Its fuel flow, among other things, is managed by a DECU, which provides proper engine operation and specification performance, and its main functions are starting, rotor speed control, and operational limits protection. The Arriel engine does not have an automatic re-ignition capability, nor is this required by regulation. Therefore, if the Arriel engine flames out, it will result in a total power loss. See section 1.18.4 for a description of auto-relight systems.

Engine maintenance logs record that the engine had a total of 7779 hours in service since new. The engine was certified and maintained in accordance with existing regulations and approved

procedures. All component lives and cycles were within the engine manufacturer's approved limits.

1.7 Meteorological information

The temperature was not formally recorded at the accident site, but the hourly observation at the Chilliwack Municipal Airport (6 nm north) for 1300 recorded the temperature as -10°C in clear skies. The accident site, being about 600 feet higher, would have been slightly colder. Several vehicles parked at the landing zones had recorded the ambient temperature of approximately -10°C . Video recordings show the sky as being obscured. No accurate visibility measurements were recorded during the take-off.

1.8 Aids to navigation

There is no indication of problems with the available aids to navigation.

1.9 Communications

No difficulties were noted in the quality of radio transmissions.

1.10 Aerodrome information

Not relevant to the occurrence.

1.11 Flight recorders

The helicopter was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation. As a result, valuable flight data were not available to the investigation. The helicopter did, however, have functional and operating global positioning system (GPS) tracking units on board, as well as a satellite-based flight tracking system. Data recovered from these units were consistent with known flight path information.

1.12 Wreckage information

The airframe wreckage was examined, and no indication was found of any pre-accident anomaly or malfunction with the flight controls, the drive train, or other aircraft system that could have contributed to the accident.

Visual examination of the engine inlet section revealed damage to 1 of the compressor blades (Photo 4). The investigation determined that the blade became bent during the loss-of-power event. However, nothing prevented engine test cell runs following the occurrence.



Photo 4. Compressor blades

1.13 Medical and pathological information

There was no indication that the performance of the pilot was degraded by physiological factors or incapacitation. A review of the pilot's recent activities found no indication that fatigue or other human factors contributed to the accident circumstances.

1.14 Fire

There was no fire.

1.15 Survival aspects

The injuries to the pilot resulting from the impact were fatal. Medical information and injury patterns indicate that the pilot was wearing a flight helmet and the full seat restraint and shoulder harness. The deceleration forces associated with the crash were beyond human tolerance.

Overall, the helmet was in good repair and condition, except that the chinstrap locking clip was badly worn. There was also a small indentation on the locking lever, characteristic of impact with a hard object, which was likely the airframe. The direction of the indentation is consistent with the clip being struck downward, in the direction of clip release.

The locking function of the clip was examined, and it was found that the effort required to open the locking lever was about 7 times less than the effort required for a new clip. The locking lever and associated locking post both demonstrated significant wear, consistent with repeated use of the chinstrap lock.

1.16 Tests and research

1.16.1 Engine examination

The engine was removed from the accident helicopter and examined at the Transportation Safety Board (TSB) Regional Wreckage Examination Facility (RWEF). During this examination, the DECU and VEMD were removed and subjected to further examination and analysis.

The engine had suffered some minor external damage to the power output shaft casing, but otherwise was intact and able to be examined in detail. Examinations of the compressor, turbine, and gearbox assemblies revealed that, at the time of impact, the engine was rotating at an rpm considerably less than self-sustaining speed. After the engine was examined at the TSB RWEF, it was sent to an approved engine overhaul facility in Grande Prairie, Texas, where it was examined, run in a test cell, and disassembled under the direct supervision of the United States National Transportation Safety Board (NTSB).

1.16.2 Examinations of the vehicle and engine multifunction display and the digital engine control unit

The accident VEMD was sent to the French aircraft accident investigation agency, Bureau d'Enquêtes at Analyses pour la sécurité de l'aviation (BEA), for examination and to retrieve data for possible failure records. No meaningful VEMD or DECU failure data were captured by the VEMD.

The DECU was examined by Turbomeca under the supervision of the BEA. The retrieved data were analyzed, and the analysis showed that some of the data were corrupted. As a result, no meaningful information could be extracted from the DECU regarding the circumstances of the accident.

1.16.3 Engine test cell run

Preliminary inspection of the engine revealed nothing that would have prevented normal operation, and no contamination was found in the filters before, during, or after the test cell run. In addition to the damage noted on 1 of the axial compressor blades (Photo 4), slight damage was noted on the 6 o'clock position inlet guide vane. Boroscopic examination did not reveal anything remarkable with the centrifugal compressor or the high pressure turbine.

With the exception of the DECU, the engine was run in its accident site condition. It was run for a total of 1 hour and 22 minutes on 2 separate test cells. The results were conclusive; the engine was found to be compliant with all specification tests performed, and nothing was identified to explain the sudden loss of power.

The sole anomaly was the high-pitched whine heard throughout the entire range of operation, but especially prominent between 80% and 90% Ng (gas generator speed). This whine was the result of the bent axial compressor blade, and the sound was so distinct that both pilot and ground crew would have been alerted had such an unusual noise existed at start and take-off. Video records of the last start and take-off capture the normal sounds of engine operation, with no unusual noise.

1.16.4 Engine compressor blade damage

The TSB Laboratory examined the engine compressor components to assess the cause of the blade damage observed during the initial engine examination and the subsequent test cell run.

All of the compressor blades were found bent forward of the vertical plane of rotation normally travelled by the blade tips, but only 1 blade was bent significantly and was visibly obvious.

The Laboratory examination of the noticeably bent compressor blade did not reveal any evidence typical of foreign object damage, such as sharp dents, gouges, tears, or material transfer. The examination did determine that the appearance of the bent blade was similar to that of the blades bent during the water/snow/ice instantaneous ingestion testing for engine certification. Given the similarities in blade damage, the Laboratory report concluded that the damage to the axial compressor blade, as well as the flame-out of the engine, occurred as a result of the ingestion of accumulated snow or ice, or both, into the engine compressor after take-off.

The damage appeared similar to the bending incurred by the axial compressor blade(s) during certification testing when snow and ice was purposely ingested in the engine at maximum continuous power. The bending of the accident compressor blade was somewhat greater than that seen in the test compressor blades, so the TSB concluded that the engine in C-FMPG was operating in a similar, high power condition when the ingestion occurred.

1.16.5 Turbomeca Arriel air consumption

According to the manufacturer, the Turbomeca Arriel 2B gas-turbine engine consumes about 5 pounds of air per second; this translates into an air flow of about 330 feet per second passing into the engine axial compressor disc. If the engine inlet (approximately 5.75 inches in diameter) becomes blocked, it could cause a loss of power.

As well, as a result of the airflow speeds entering the plenum and engine intake, a reduction of air temperature takes place as the air moves through the engine's intake air plenum toward the engine compressor. Turbomeca computation results indicate the temperature at the engine mouth would be around -12°C .

1.16.6 Ministère de la Défense: Arriel engine inlet ice certification tests (1977)

In late 1976 and early 1977, the French ministry of defence carried out a series of tests to certificate the air intake in icing conditions for the Arriel engine installed in the AS 350 helicopter. The tests incorporated several different intake grills, with and without the sand filter unit installed. The tests determined that the intake grill and sand filter unit together provided adequate ice and snow protection with an acceptable and minor loss of engine performance.

1.16.7 Turbomeca: Arriel engine water/snow ingestion tests

1.16.7.1 General

In April 1985, the engine manufacturer (Turbomeca) conducted a series of tests to study the effect of water and snow ingestion on the Arriel 1B engine. The study report (no. 6329) stated that 30 grams of water or snow was sufficient to cause the Arriel 1B engine to flame out, regardless of flight regime. Additionally, the tests revealed that the compressor blades were susceptible to bending as a result of snow ingestion. Further tests by the engine manufacturer determined that more than 40 grams caused a flame-out on the Arriel 1D, and 45 grams caused a flame-out on the Arriel 2B engine.

In 2002, Turbomeca prepared a technical report (Note Technique No. 218-2002) regarding ice ingestion and engine performance tests for the Arriel 2C2 engine, so as to verify compliance with the *Joint Aviation Regulations*² certification requirements. According to the report, the ingestion of approximately 83 grams of ice was required to cause the engine to flame out. As in this investigation, damage was observed on 1 of the axial compressor blades (Photo 5). It was determined that this damage was a direct result of ice ingestion and flame-out. In comparison with the engine blade damage found in C-FMPG (Photo 4), the characteristics are very similar.

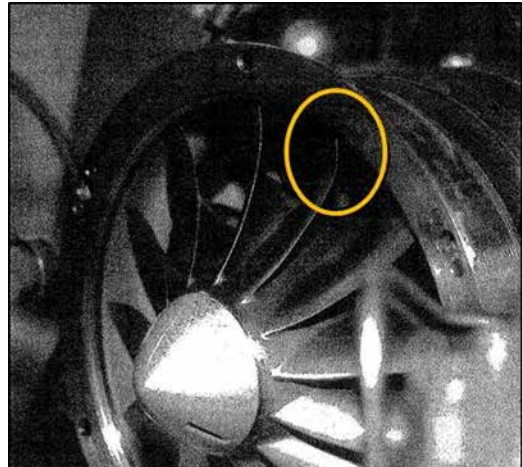


Photo 5. Ice test engine damage

1.16.7.2 Aerospatiale: Service Bulletin 30.04—Ice and Rain Protection (1985)

In 1985, the original manufacturer of the AS 350, Société Nationale Industrielle Aerospatiale (Aerospatiale), issued an ice and rain protection Service Bulletin (SB 30.04) on the subjects of the removable engine cowling grid and drainage of the engine air intake. In particular, SB 30.04 called for:

- modifying the engine inlet screen to make it easier to remove, so as to allow better inspection and cleaning of the plenum; and
- drilling a water drain hole in the bottom of the plenum.

The modifications came about following a number of engine flame-outs that occurred after helicopters had been parked in falling snow. Aerospatiale identified that insufficient cleaning of outer fairings, and possible snow/ice/water accumulation at the bottom of the plenum, were major factors.

It should be noted that, with the sand filter installed, the inlet screen does not incorporate the quick-removal fasteners. Inspection of the plenum can only be accomplished by opening the

² The Joint Aviation Regulations are the European equivalent of the Canadian Aviation Regulations (CARs).

engine compartment. Also, to inspect and clean the sand filter, the inlet screen must be removed, requiring the removal of 20 bolts. This level of disassembly is not work that can be accomplished by a pilot, so the sand filter could not be inspected or cleaned without an aircraft maintenance engineer (AME). This necessity for an AME is impractical for field operations.

1.16.7.3 Tests on basic air intake

In June 1992, Eurocopter France issued Protection of Engine Air Intake AS 350 B/BA/B1 /B2 Against Snow: Summary Document (No. 350A.04.4735), dealing with two 1991 studies into the protection of the engine air intake for flight in falling snow and for helicopters parked on the ground:

- Flight test campaign (February 1991) in natural snow; and
- Test campaign (November 1991) in artificial snow at ETBS (Établissement Technique de Bourges) in Bourges, France.

The tests, done with and without a filter, identified the location of snow or ice accretion in the intake and concluded that the air intake plenum was vulnerable to ice accretion during engine operation in certain snow/ice conditions. The tests showed that substantial ice accretion occurs on the upper rear section of the plenum (Figure 1), resulting from direct impact of the snowflakes in the area followed by a merging/refreezing phenomenon after making contact with the metal air intake wall.

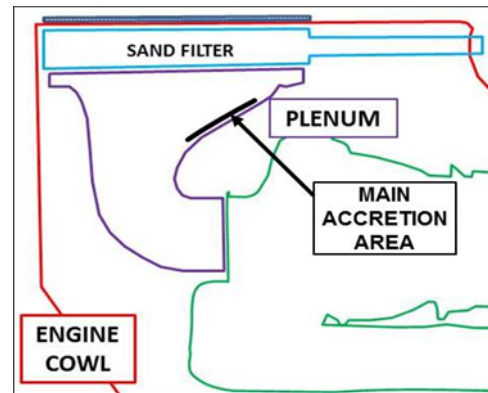


Figure 1. Ice accretion area

1.16.7.4 Engine damage due to ice ingestion

The June 1992 Eurocopter summary report of a January 1990 engine flame-out due to snow/ice ingestion identified that 1 axial compressor blade had been bent during the flame-out event. According to Eurocopter, this damage was “a symptom typical to ingestion of an ice block by the engine,”³ and the cause of the accident was snow accretion in the air intake. This damage is similar to the damage found in C-FMPG’s engine.

The analysis portion of the report stated that snowflake merging/refreezing in some air intake areas may lead to ice accretion, which may be ingested by the engine due to warming, vibration or a combination of both.

In an effort to reduce the risk of engine flame-outs during snow operations, Eurocopter issued a series of service letters and manual amendments dealing with the protection of the AS 350 while being operated in falling snow and during periods of cold weather (Appendix D).

³ Eurocopter, Protection of Engine Air Intake AS 350 B/BA/B1 /B2 Against Snow: Summary Document (June 1992), part 4: Analysis, page 6

1.16.8 Eurocopter Service Letter No. 1270-00-96 (December 2006)

The December 2006 issue of Eurocopter Service Letter (SL) No. 1270-00-96, Protection and Use of Helicopters in Cold Weather and Damp Conditions, warns about proper preparation before flight, stating ⁴ that a turbine engine is "...sensitive to a 'sudden quantity' of water, snow, or ice, because this quantity (even limited) corresponds to a very high instantaneous concentration exceeding its absorption capacities."

As a result of previous incidents of engine flame-outs that occurred shortly after take-off, Eurocopter considered it necessary to remind customers of the basic precautions to be taken in cold conditions (i.e., temperature close to 0°C or below). The SL reiterated that instructions are found in the following sections of the AS 350 helicopter manuals:

- AS 350 RFM, Normal Procedures: Pre-flight Procedures – Use in Cold Weather;
- AS 350 RFM, Limitations: Flight in Icing or Snowy Conditions;
- AS 350 RFM, Supplement SUP 4 – Instructions for Operations in Cold Weather;
- AS 350 Aircraft Maintenance Manual (AMM) – Pre-flight Check in Cold Weather.

Appendix E contains paragraphs quoted directly from the SL (including Eurocopter-added emphasis).

1.16.9 Cold weather operations for the AS 350 B3

Section 2.7 of the AS 350 B3 rotorcraft flight manual (RFM) restricts operations in falling snow. Following that restriction, it states: ⁵ "Note: For preparation before flight, refer to SUP. 4. This Supplement applies to operations with or without a sand filter installed." Supplement SUP.4. states ⁶ the following, in part:

INSTRUCTIONS FOR OPERATION IN COLD WEATHER

5. PREPARATION FOR FLIGHT

[...]

Engine:

- Remove the air intake cover and the exhaust nozzle cover after removing snow from the aircraft surface.
- Remove snow and ice accretion in the vicinity of the air intake, on either side of the screen and inside the engine air intake duct (remove the air intake screen if necessary).
- It is essential that the air intake is clean

⁴ Eurocopter, Service Letter 1270-00-96, Protection and Use of Helicopters in Cold Weather and Damp Conditions (December 2006)

⁵ Eurocopter, *Flight Manual AS 350 B3*, Section 2.7

⁶ Eurocopter, *Flight Manual AS 350 B3*, Supplement SUP.4 (06-18): Instructions For Operation In Cold Weather

Remove air intake grid, manually and visually check for snow and ice inside the air intake duct up to the first stage of the compressor.

In case of icing:

- remove ice using a wooden or plastic scraper.
- carefully wipe the surface using a cloth soaked with isopropyl alcohol.
- inspect drains, unblanked scuppers; check for snow and ice on vent and static ports.

Reinstall air intake grid.

Supplement No. 14—Sand Filter ⁷ in the RFM states, ⁸ in part, “This sand filter installation even when it does not use any P2 bleed air, is also designed to protect the air intake against any potential induction of snow in flight, in falling snow.” With the sand filter installed, there are no restrictions for flight in falling snow.

The instructions in Supplement No. 14 – Sand Filter must be followed in conjunction with the instructions provided in Supplement SUP. 4.

With regard to external checks, Supplement No. 14 states ⁹ the following:

- Engine air intake :

- Remove ice or snow from the air intake grid.
- Open the engine cowling.
- Check for snow, ice or water in the air intake, and particularly under the filter.

1.16.10 P2 bleed air operations

P2 bleed air is air tapped from the engine’s compressor discharge. In this application, the air is used to accelerate ambient air in a venturi to help evacuate debris captured in the filter. During the investigation, informal discussions with Canadian operators of the AS 350 revealed different operational practices for using the P2 bleed air during flight in falling snow. Some operators activated the P2 bleed air in falling snow, while others did not. The RFM Supplement No. 14 states: “The sand filter installation is designed to protect the engine against ingestion of sand or dust. This installation even when it does not use any P2 bleed air, is also designed to protect the air intake against any potential induction of snow in flight, in falling snow.” ¹⁰

The investigation also determined that there is a common misunderstanding with regard to the functioning of the unit. Some operators believed that the hot P2 bleed air is introduced into the filter housing and raises the temperature within. However, this is not the case since the P2 bleed air is introduced only into the venturi tubes at the rear of the filter box, and P2 bleed air does not flow through the vortex tube chamber.

⁷ Applicable to sand filter QB0550 as installed in C-FMPG

⁸ Eurocopter, *Flight Manual AS 350 B3 Supplement SUP.14—Sand Filter* (02 February 2009), part 1: General

⁹ *Ibid.*, part 4: Normal Procedures

¹⁰ *Ibid.*, part 1: General

1.16.11 Eurocopter Information Notice No. 2030-I-00 (January 2009)

In January 2009, Eurocopter issued Information Notice (IN) No. 2030-I-00: Protection and Use of Helicopters in Cold Weather and in Damp Conditions. This IN was essentially a re-issue of SL No. 1270-00-96 (mentioned in section 1.16.8), with some additional information.

Of note, this IN introduced a new alerting protocol on the leading page to facilitate the appropriate distribution of information to pilots, mechanics, or both. Under the subject line of the IN, an alerting box entitled “For the attention of” identifies which group should receive the notice by including a pictogram of either a mechanics wrench or pilot wings (Figure 2).

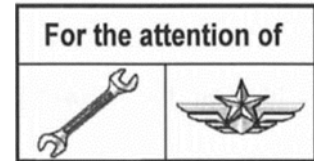


Figure 2. Alerting box

In the introduction of this IN, Eurocopter added ¹¹ the following:

A turbine engine has a good rainwater or falling-snow absorption capacity in continuous operation. On the other hand, the engine is sensitive to a “sudden quantity” of water, snow or ice, because this quantity (even limited) corresponds to a very high instantaneous concentration exceeding its absorption capacities. This can occur because snow and ice can build up in the engine air intakes and plenums when the aircraft is on the ground without the engines operating or when the engine is at a low power setting for an extended period.

In addition, the IN included the requirement to inspect the inside surfaces of the plenum and the surrounding surfaces of the engine cowling. Also, the IN advised ¹² the following:

It is preferable to use heated air or appropriate de-icing fluid to remove ice or snow. Removing ice or snow by chipping or scrapping [sic] can bring a residual amount inside the inlet. In freezing temperatures pay particular attention to sheet ice on the bottom or forward of the inlet.

Eurocopter also announced that the IN would be re-issued periodically to draw attention to the recommendations contained in the IN regarding flight in snowing conditions.

1.16.12 Eurocopter Information Notice No. 2302-I-00 (April 2011)

In April 2011, Eurocopter issued IN 2302-I-00: *Protection and Use of Helicopters in Cold Weather and in Damp Conditions*, which was a re-issue of IN 2030-I-00 and included additional information. In part 2, Eurocopter warned: ¹³ “The quick installation of the blanks is a basic precaution, but their use does not guarantee that no ice will accumulate in the air intake (possible phenomenon of water seepage in the air intake due to rain or molten snow).”

¹¹ Eurocopter, Information Notice 2030-I-00: Protection and Use of Helicopters in Cold Weather and in Damp Conditions (January 2009)

¹² *Ibid.*

¹³ Eurocopter, Information Notice 2302-I-00: Protection and Use of Helicopters in Cold Weather and in Damp Conditions (April 2011), part 2

1.16.13 Summary of manufacturers' information

There has been a large number of studies, warnings, recommendations, and precautions issued since 1985 regarding operations in snow, ice, or rain. The plenum is susceptible to snow/ice accumulation in certain circumstances even with the air intake covers installed. No design modifications have been made that mitigate the risk of ice/snow accumulation during engine start and at low power before take-off. The Arriel engine—like most other small gas turbine engines—is vulnerable to snow, ice, or water ingestion, and a flame-out can occur if the amount of contamination exceeds the engine's capability for continued operation.

1.16.14 Helicopter operations in winter conditions

In Canada, Transport Canada (TC) has published several documents dealing with the safe operation of helicopters in winter conditions. For example, "*When in Doubt...*" (TP 10643), *Aviation Safety Letter* (TP 185), and the *Aviation Safety Vortex* (TP 202) all contain valuable information for winter helicopter operations, and identify that ingested snow and ice accumulation in the engine air intake during ground operations has been the cause of several engine in-flight loss-of-power events.

1.16.15 Previous occurrences involving similar engine power loss

There have been several accidents involving Eurocopter AS 350 helicopters with Arriel engines in which the circumstances and the damage to the axial compressor blades were quite similar to this occurrence. Some of these helicopters were not equipped with filters and were not covered during falling snow while parked. All were parked outdoors.

August 2009: AS 350 B3 helicopter crashed in Chile

The engine disassembly revealed that the axial compressor had 2 blades bent at the tip and leading edge. The report noted that this damage is characteristic of soft foreign-object damage (ice or snow ingestion), which can lead to an engine flame-out.

March 2006: AS 350 B3 helicopter crashed in Sweden

Before the flight, the helicopter had been parked outside in falling snow. After the accident, 3 compressor blades were found to have foreign object damage from impact with a soft object. No further anomalies were found with the helicopter. The Swedish Accident Investigation Board determined that the accident was probably caused by undetected ice buildup—accumulated while the helicopter was parked—being drawn into the engine and causing a flame-out. The report identified, as a contributory factor, that this type of engine is sensitive to water ingress and did not have an auto-ignition system. Two recommendations, RL 2007: 09 R1 and RL 2007: 09 R2, were made¹⁴ by the Swedish Accident Investigation Board, advising that the Swedish Civil Aviation Authority:

¹⁴ Swedish Accident Investigation Board, Report RL 2007:09es, *Aircraft accident to helicopter SE-JHD at Södra Åsjön, K county, on 1.March 2006: Case L-04/06* (09 July 2007)

- In a suitable manner point out to operators of this category of helicopter the importance of ensuring that ice, packed snow and water cannot be drawn into the engine, since even small amounts can cause the engine to stop (*RL 2007: 09 R1*), and to
- Make efforts to have the Auto Ignition System introduced as standard for this type of helicopter (*RL 2007: 09 R2*).

February 1998: AS 350 BA helicopter crashed near Golden, British Columbia

An AS 350 BA helicopter, without a sand filter, crashed ¹⁵ near Golden, British Columbia, following an indication of a loss of main-rotor rpm. The subsequent technical examination of the engine revealed 2 bent compressor blade tips that were assessed as possibly being damaged due to snow or ice ingestion.

Winter 1986: AS 350 B helicopter operating in Marathon, Ontario: engine flame-outs after start

An AS 350 B helicopter operating in Marathon, Ontario, without a sand filter, experienced a series of engine flame-outs after start. The aircraft had been parked outside overnight. During the night, gusting winds forced snow past the intake cover into the aircraft intake. Measures were taken to warm the aircraft by covering the entire aircraft with a large, light parachute-type cover and inserting the hoses from a Herman Nelson heater to provide ambient heating of the aircraft. The helicopter was swept clean, and all critical surfaces were cleared to prevent snow ingestion. On 3 separate engine starts, shortly after the engine reached full rpm, the engine flamed out. It is believed that moisture remained in the intake after heating the aircraft, that the cold intake air during the engine start turned it to slush on the plenum, and that the hardening slush then partially broke away, causing the flame-out. An ice layer, with a piece missing, was evident in the plenum. The piece of slush that had broken away was approximately the size of half of a medium dinner plate. There was no apparent damage to the engine.

Other manufacturers have had similar problems, but in addition to issuing safety bulletins, they made design changes, such as auto-ignition systems, to mitigate the risk to helicopter operators (section 1.18.4).

1.17 Organizational and management information

1.17.1 RCMP Air Services Branch

Although the RCMP Air Services Branch (ASB) is registered as a state aircraft operator, it is classified by TC as a *Canadian Aviation Regulations (CARs) Subpart 604* private operator.

The RCMP ASB is comprised of 19 air sections across Canada, with a combined fleet of 42 aircraft. The Vancouver Air Section is the largest RCMP air section. At the time of the accident, the Vancouver Air Section operated 3 rotary-wing and 3 fixed-wing aircraft.

¹⁵ TSB Aviation Investigation Report A98P0037

1.17.2 *Human external transportation system*

HETS is a system used by the RCMP to transport personnel on a long line (about 100 feet) hanging below the helicopter. TC considers these operations to be Class D external loads (Appendix G). The system allows personnel to be deployed into or extracted out of confined areas. It can be used to put personnel onto building tops, onto boats, into treed areas, onto steep mountainsides, etc. It also makes retrieving personnel from these areas possible. The pilot operates the helicopter using vertical reference techniques (that is, by leaning out of the side of the helicopter and looking down to the end of the line and personnel below) when positioning these human loads.

Other operators, particularly commercial operators, carry out similar operations for mountain rescue.

Class D operations require the air operator to use a multi-engine helicopter that is capable of hovering with 1 engine inoperative at the existing weight and altitude. However, with an exemption from TC, an air operator may use a single-engine helicopter or a multi-engine helicopter where they are unable to comply with 1-engine-inoperative requirements. These exemptions have been granted to Class D rescue, law enforcement, and firefighting bodies, provided they comply with the Commercial Air Service Standards.

1.17.3 *RCMP maintenance*

1.17.3.1 *General*

Each ASB air section is staffed by local AMEs operating independently. Supervision of all ASB maintenance rests with the office of the Chief Aircraft Maintenance Engineer (CAME) in Ottawa.¹⁶ Under this office are the offices of quality assurance (QA), the regional supervisor east, the regional supervisor west, and technical records and library.

1.17.3.2 *Maintenance instruction documents*

A review of the RCMP ASB maintenance manuals at the time of the accident revealed that both current and out-of-date versions of several different publications in different formats were in circulation. The investigation determined that there were significant differences among the different formats, including references to other nonexistent or out-of-date documents.

1.17.3.3 *100-hour inspection sheets*

One of the standard maintenance practices employed by the RCMP is to conduct regular aircraft inspections every 100 hours of service. For the AS 350 B3 helicopter, the inspection sheet was compiled from the Eurocopter master servicing manuals and from the inspection programs for the ancillary equipment installed on C-FMPG. During the investigation, 3 different versions of the check sheet were found in circulation: 1 from 2008, 1 from 2009, and 1 from 2010. The 2010 version contained several requirements not included in the 2009 version, and all 3 versions referred to manuals that had been renamed or reorganized. Furthermore, the *Maintenance*

¹⁶ In civilian aviation operations, this office is normally called the director of maintenance.

Control Manual (MCM) dated 31 March 2010 contained the 2008 check sheet. In addition, a working copy of the check sheet sent from Ottawa in January 2012 referred to an even earlier, 2006 version.

The AMEs at the Vancouver Air Section, however, carried out the work required by the ASB check sheets, and supplemented those inspections by referring directly to the manufacturer's instructions and carrying out those requirements separately. Accordingly, the required maintenance was performed correctly from a technical perspective and in a timely manner, albeit with some unnecessary duplication. As well, it appears that the other individual ASB sections across Canada carried out maintenance in a similar manner and that the RCMP fleet was well maintained.

1.17.4 Helicopter weight and balance

A large mathematical error of more than 20 inches in calculating the centre of gravity for external load operations had been made, and the error was replicated in the series of weight-and-balance amendment sheets dated 03 January 2012. The error showed that the helicopter was at least 7 inches outside the forward limit, when in fact it was not; however, the weight calculation was correct. This significant error went undetected before the occurrence.

1.17.5 Air Services Branch internal distribution of information

The investigation determined that Eurocopter IN 2302-I-00 was received by the ASB in Ottawa shortly after issue, where it was reviewed by the QA section before being forwarded to the various ASB maintenance sections. The operations branches were not informed about IN 2302-I-00, despite the fact that the Eurocopter alert box (Figure 2) indicated that the information was also intended for pilots. The RCMP rotary-wing chief pilot also received IN 2302-I-00; however, that information was not passed on to other ASB section pilots.

A survey of the RCMP pilots in the other ASB sections across Canada revealed that none of them had seen IN 2302-I-00 before the accident.

1.17.6 Air Services Branch safety management system

In accordance with the guidelines of CARs Subpart 604, ASB Ottawa established a safety management system (SMS). As part of its SMS, the ASB made attempts to identify possible hazards to the operation. The RCMP had a hazard reporting process documented in its operating manual. However, the effectiveness of the ASB's reporting process was never formally assessed. In addition, there were no documented risk assessments carried out to examine the suitability of the AS 350 B3 for the missions typically carried out by the RCMP.

1.17.7 Transport Canada oversight

The most recent TC inspection of the RCMP ASB maintenance program was carried out in May 2008 as a Program Validation Inspection (PVI). During the PVI, TC examined selected ASB functional area systems and procedures in maintenance operations to determine the degree of conformance to CARs and TC-approved ASB manuals and documents. From the PVI, TC made the following 2 non-conformance findings regarding the MCM:

1. Approved maintenance organization (AMO) internal audits were not being accomplished as required.
2. The MCM was incomplete.

As a result, the PVI concluded that the qualification approval process did not meet the requirements of the applicable CARs, and determined that enhanced monitoring of the AMO was necessary.

1.18 Additional information

1.18.1 Helicopter engine power-loss landings

If a single-engine helicopter experiences a power loss, the pilot must quickly react to conserve main-rotor rpm (rrpm). In many cases, it requires that the pilot immediately enter autorotation. Autorotation is defined as the condition of flight where the main rotor is driven by aerodynamic forces, with no power being delivered by the engine. During an autorotation, the cyclic is used to control the airspeed, and the collective is used to control the lift produced by the main rotor (i.e., rrpm).

Airspeed is the primary control for rate of descent during an autorotation. Proper control of the rate of descent is critical to the safe execution of an autorotative landing. During the autorotative landing phase, the helicopter's forward speed and rate of descent are reduced by flaring the aircraft (increasing the nose-up pitch attitude) until the desired touchdown speed is achieved. The main rotor's kinetic energy is then used to minimize the helicopter's rate of descent just before touchdown. As forward speed declines, so does the effectiveness of the flare, which may result in high rates of descent just before touchdown.

The collective is used to manage rrpm in autorotative flight, and rrpm must be maintained within the normal power-off range. In autorotative flight, if the rrpm decreases below the normal range, the collective must be reduced. If rrpm continues to decrease, the angle of attack of the main-rotor blades will eventually increase to the point that they will begin to stall. If the blades enter a stall condition, lift will decrease and drag will increase causing the helicopter's rate of descent to increase rapidly, which further exacerbates the stall condition, eventually leading to a loss of helicopter control. As a result, it is critical that pilots avoid a main-rotor blade-stall condition by remaining within the normal power-off rrpm range. If all of the rotor blades stall, it may be impossible to regain a safe rotor speed to carry out the remainder of the autorotation to landing.

If a total engine power loss occurs in hovering flight, it can be much harder to maintain and control rrpm in order to ensure a safe landing. If the helicopter is hovering close to the ground, an emergency landing can often be carried out by slowly increasing the collective pitch lever to cushion the landing, timing the application of collective to ensure that touchdown occurs before the rotor decreases too much. The pilot must maintain rrpm within the power-off limits to be able to maintain flight control effectiveness and to prevent main-rotor stall, but it will result in excessive rates of descent for some flight conditions.

1.18.2 Airspeed-height envelope

The principle of the airspeed-height envelope (AHE) ¹⁷ is unique to helicopter operations. The AHE is normally incorporated into the basic RFM, and depicts the combinations of altitude and airspeed (determined during certification using the manufacturer's test pilots) that would allow a safe autorotation in the event of an engine failure. The AHE is not a limitation in the RFM; its sole purpose is to identify those flight regimes which present the greatest risk in the event of an engine power loss. The chart is predicated on the assumption that the pilot is proficient in engine-out landings on hospitable terrain.

The AHE describes the area within which there may not be enough energy available for the pilot to be able to perform a safe landing after an engine failure. The AHE shows the low hover point at 8 feet, and the high hover boundary is variable (325 feet to 650 feet) depending on altitude and aircraft weight.

The shaded area of the AHE (Figure 3 and Appendix B) identifies airspeed and altitude-avoid combinations (Z). If the helicopter is being operated within that area, pilots should not expect to establish full autorotation and carry out a successful landing.

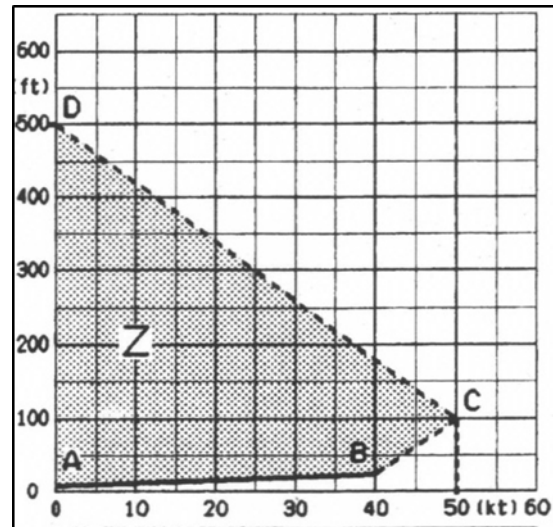


Figure 3. Simplified airspeed-height envelope (AHE) chart (image: Eurocopter, *Flight Manual AS 350 B3 (97-40)*, page 3)

1.18.3 Transport Canada aircraft certification requirements

1.18.3.1 Single-engine operations

Single-engine helicopters certificated under Chapter 527 of the *Airworthiness Manual* require a height-velocity diagram to be included in the RFM to document areas within the flight envelope where a safe landing may not be possible following an engine failure. Single-engine helicopters routinely operate within this area, particularly during aerial work operations with external loads. Prohibition of operations within the shaded area of the height-velocity diagram for single-engine helicopters may require operators to purchase twin-engine aircraft capable of adequate single-engine performance following an engine failure.

The risks associated with low-altitude flight in single-engine helicopters have been identified in previous TSB investigations, most notably in that of the fatal accident of a Bell 206 helicopter in Cranbrook, British Columbia, in May 2008. ¹⁸ The Cranbrook accident shares 3 common factors with this occurrence: the helicopter was operating in the avoid zone of the AHE, the engine lost power suddenly, and the subsequent impact forces on collision with the ground were unsurvivable.

¹⁷ Also known as the “height-velocity envelope” or “height-velocity diagram”

¹⁸ TSB Aviation Investigation Report A08P0125

1.18.3.2 Winter operations

TC's type certificate data sheet no. H-83 for the AS 350 B3 model rotorcraft includes *Airworthiness Manual 527.1093b*(1)(ii) and (iii) [Change 527-3] in its basis of certification, which states¹⁹ in part:

- b) (1) It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling);
[...]
- (ii) In falling, blowing, and recirculating snow without adverse effect on engine operation; or
- (iii) Where clearance for flight in snow has not been sought, the engine tolerance to snow shall be demonstrated...

These criteria would also include AWM 527.1301-1 (cold soak requirements) as a matter of course for issuance of a type certificate. There is no separate approval for winter operations; however, failure to meet these criteria would result in significant operational limitations.

1.18.4 Auto-ignition and continuous ignition systems

Several small turbine-engine manufacturers have equipped their engines with automatic ignition systems or continuous ignition systems. These systems are designed to reignite the fuel in the event of the combustion being extinguished due to a momentary change in the fuel-to-air ratio. They are particularly effective when there is no time for a pilot to restart the engine, such as when a helicopter is at an altitude and speed where rotor rpm cannot be maintained without power (i.e., shaded area Z in Figure 3 and Appendix B), or when an aeroplane is in a critical phase of flight, such as low level on departure. The auto-relight systems are armed but dormant until the engine flames out. There is time for the aircraft to yaw during the loss and re-establishment of power, but the time when there is no power is insignificant, and pilots are usually able to continue flight. Continuous ignition systems are usually activated during operation when the engine is susceptible to flame-out, as, for example, during icing conditions. Engines that are equipped with a continuous ignition system relight in a very short time, and pilots are often unaware of the flame-out.

In 2001, TC issued Airworthiness Directive (AD) CF-2001-03R1 (Appendix C in this report), which included the requirement for auto-relight systems for the Bell 206-series helicopter. This AD followed a 2000 Bell Helicopter Information Letter (206-00-80) that stated²⁰ the following:

In 1988, Bell Helicopter Textron revised all Bell 206 series Flight Manuals to define the approved engine inlet configuration applicable to each Bell 206 helicopter for flight in falling or blowing snow.

¹⁹ Canadian Aviation Regulations (CARs), *Airworthiness Manual*, Normal Category Rotorcraft – Induction System Icing Protection, 527.1093**b**(1)(ii) and (iii) [Change 527-3]

²⁰ Bell Helicopter Textron, Information Letter 206-00-80 (12 January 2000), Flight Operations in Falling or Blowing Snow

Since issuing these Flight Manual revisions, Bell Helicopter has learned of certain incidents where engine flameouts occurred shortly after takeoff during operations where the operator failed to clear snow/ice from the engine inlet following a snowfall or after extended ground idling in conditions of falling and blowing snow.

After consultation with the engine manufacturer, Rolls-Royce Allison, we have decided to add the engine automatic re-ignition kit to the approved winterization kit to configure the helicopters for operations in winter conditions.

This Information Letter is issued to advise operators of Bell 206A and Bell 206B helicopters that Flight Manuals are being revised to add the engine re-ignition kit to the mandatory configuration for flight in falling or blowing snow.

1.18.5 Human external transportation system operations

The accident aircraft had been carrying out HETS training, in accordance with CARs Part VII, Subsection 22, Aerial Work Standards (Appendix G in this report). When these Standards were drafted, single-engine helicopters were permitted to conduct emergency rescues, provided that the engine was equipped with an automatic relight system in case of engine failure due to a momentary disruption of fuel or airflow. However, many operators used the AS 350 helicopter type, and in an effort to recognize helicopter availability, an exemption to the auto-relight requirement was included in the Standard. This exemption allowed the RCMP to choose the AS 350 B3 helicopter, which did not have an auto-relight system.

HETS operations require the helicopter to operate in the avoid area of the AHE chart for significant periods of time. In addition to the standard risk of operating in this avoid area, persons being carried beneath the helicopter when it is engaged in HETS operations are at high risk any time there is an engine power loss. This risk is significantly higher when the helicopter is being operated in the avoid zone of the AHE, as a power loss in that regime of flight would most likely result in a high rate of descent and impact with terrain. Pilots are trained to release any external load when there is an engine power loss. Therefore, in a power-loss scenario involving a single-engine helicopter, the pilot must also be concerned about the person below on the long line while taking urgent emergency action to land the helicopter without engine power. For that reason, the risks associated with a power loss while conducting HETS are greatly reduced by the use of multi-engine helicopters.

1.19 Useful or effective investigation techniques

1.19.1 Structural analysis of airframe and seat damage

In collaboration with TSB Laboratory specialists, airframe structural engineers from Eurocopter France examined and analyzed the mechanical damage to the airframe to assess the forces upon impact, primarily with the intention of evaluating the performance of the pilot seats and floor attachment design.

Originally, the occurrence helicopter's pilot seats were the conventional AS 350 helicopter bucket seats installed by Eurocopter. The helicopter was subsequently fitted with 2 energy-

attenuating pilot seats rated at 25 g.²¹ The occupied right-hand pilot seat was severely damaged during the occurrence (Photo 6). By design, the seat absorbs vertical impact energy by progressively collapsing and deforming (stroking). The seat back fitting on both sides of the seat had yielded in this manner, leaving characteristic fracture and distortion evidence. As well, the floor and support beams beneath the seat had buckled significantly, adding to the bending forces imposed on the seat attachment fittings and floor tracks.

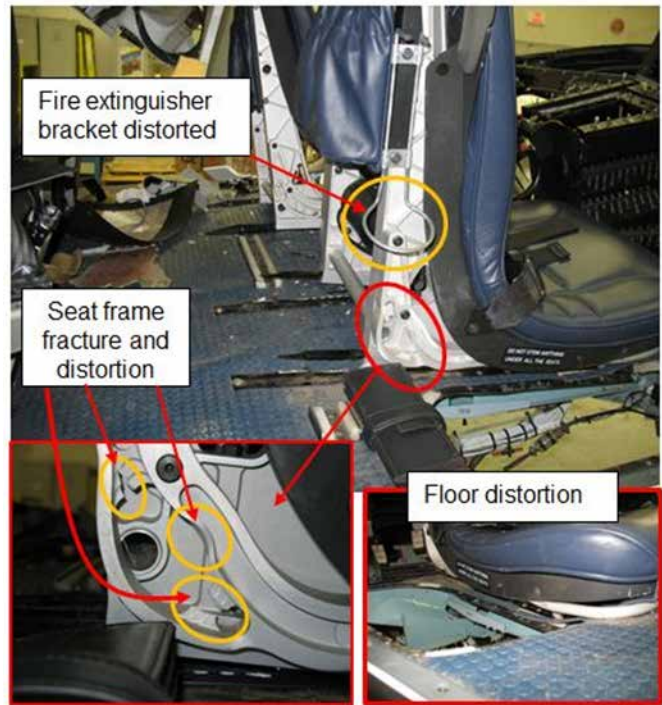


Photo 6. Seat and floor damage

The investigation determined that the accident helicopter struck the ground with a vertical velocity of 16.4 metres per second (m/s), which exceeded the designed structural capacity of the airframe. Even after the landing gear skids absorbed about 2 m/s, the airframe experienced a vertical velocity of 14.5 m/s. Mathematical modeling of the helicopter structural deformation revealed that the impact load factors on the airframe were between 15 g and 20 g forward, and between 40 g and 50 g downward.

Once the *g*-force attenuation limit of the pilot seat was reached, the *g* forces were then transmitted to the pilot, since the seat had by then stroked to its limit, making contact with the cockpit floor below it. Furthermore, the forward and downward *g*-force vectors must be combined to arrive at the total impact force transferred to the pilot. In this accident, the design certification basis for the seat was grossly exceeded, and the pilot experienced impact forces in the order of 35 g downward and 17 g forward, values which far exceed human tolerance.

1.19.2 Snow accumulation and plenum temperature trial

The TSB, in concert with the RCMP ASB, and with technical support from Eurocopter Canada Limited (ECL), carried out an environmental simulation trial on an identical AS 350 B3 helicopter in mid-February 2012.

In preparation for the trial, 4 temperature probes and a digital recording device were attached to the engine inlet plenum. As well, 2 laser temperature guns were used to monitor various external engine and airframe temperatures. The helicopter was first started in clear conditions, and then run on the ground at flying rotor rpm for 15 minutes. During this time, the engine temperatures were monitored and recorded, both with the sand filter P2 bleed air off, and with

²¹ The normal measure of *g*-load on an object is the load factor, or *g* (gravity), which is the ratio of the force experienced under acceleration to the force that would exist if the object was at rest on the surface of the earth.

it activated. The temperature at the inlet face of the sand filter stabilized at near-0°C with the engine running, yet it dropped by 0.9°C when P2 bleed air was turned ON and rose again to slightly above zero when P2 bleed air was turned OFF. The helicopter was then shut down normally. The engine was then run again to confirm the function of the temperature recorder and, after about 10 minutes, the engine was shut down.

The team created a snowfall environment for the test helicopter using a large capacity, commercial snow-making machine. After the helicopter was shut down, the snow machine began to lay snow onto the helicopter, and for the next 90 minutes, the temperatures in the plenum and engine compartment were recorded every 5 minutes. After 90 minutes, the accumulated snow had built up to an amount similar to that seen on the accident helicopter before start. With the outside air temperature remaining at -10°C throughout the test, this process closely replicated the conditions on the day of the accident (Photo 7).



Photo 7. Snow trial with AS 350 B3 ([Source: RCMP](#))

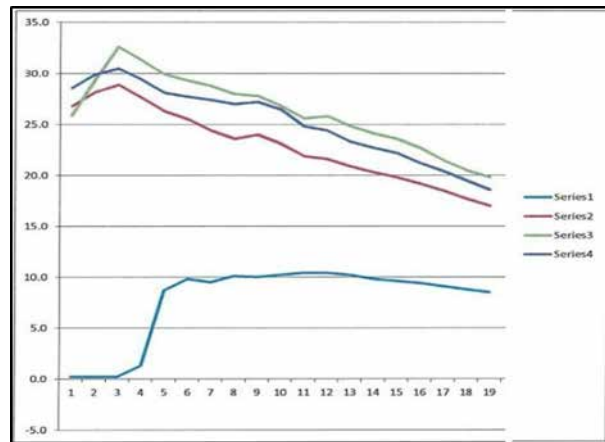


Figure 4. Temperature in plenum and filter

During the trial, it was noted that, in the cold outside air, the inlet grill and sand filter unit at the top of the engine cowling did not cool down after engine shutdown. Instead, following engine shutdown, the temperatures increased quickly from 0.2°C at shutdown to 10°C, dropping only to 8.5°C at the 90-minute mark. Similarly, the temperatures inside the plenum itself, after peaking to about 33°C, fell to no lower than 17°C during the test. Figure 4 shows the temperature drop in °C over 19 increments of 5 minutes. During testing, an opening appeared in the snow layer on the top of the engine cowling and engine intake grill. This opening was created by rising hot air from the engine, which passed up the plenum and out of the intake, causing a small area of melting in the layer of snow that had formed.

After the artificial snowfall had stopped, the engine cowling was opened to inspect for snow or ice accumulation on the underside surface of the sand filter, or inside the engine plenum; none was found. However, water stains down the plenum were seen, and a small amount of water had drained out of the plenum bottom drain hole, just in front of the engine compressor.

1.19.3 Sampling of AS 350 operators' winter operations

After confirming the findings of the snow accumulation and plenum temperature trial, the TSB held an AS 350 operators' briefing and information gathering meeting. About 8 operators from

the BC coast attended. None were aware that ice could form in the plenum between the filter and the engine. Also, while some were aware of the manufacturer's instructions to reduce the risk of ice accumulation in the plenum during low power, none of the attending operators were applying the RFM directives with regard to cleaning and drying the intake system. The operators noted that the task was impractical for field operations.

2.0 Analysis

2.1 General

The accident investigation revealed no indication of a pre-existing mechanical defect in the helicopter or its engine. In addition, the pilot was certificated and qualified for the flight, and there were no indications that the pilot's performance was in some way degraded due to physiological factors such as fatigue. In this occurrence, the facts support the conclusion that there was an engine power loss due to a sudden change in air/fuel ratio. Accordingly, this analysis will focus on the design-related and operational factors that played a role in this occurrence.

2.2 Exposure to inclement weather

There have been a number of engine power-loss accidents associated with ice/snow/water ingestion involving the AS 350 over the past 25 years. The design of the Turbomeca Arriel engine is such that, if the right conditions exist, such as during snow and rain, it may not be possible to prevent the accumulation of water and/or snow/ice in the air intake system before take-off. While aircraft covers are designed to protect the aircraft from the elements, there may still be an opportunity for moisture to enter the plenum on the AS 350. The risks associated with soft ice ingestion were well understood by Eurocopter and Turbomeca, and they had provided procedures and instructions to reduce these risks.

The available protective covers for the airframe and the engine air intake were not installed when the helicopter was shut down or when heavy snow began falling. In addition, preparation of the helicopter for flight, by removal of the accumulated snow from the airframe or the air intake, was not carried out. The AS 350 B3 rotorcraft flight manual (RFM) requires removal of all snow, ice, or water from the engine intake system before start. However, in this occurrence, those instructions were not carried out. Water accumulated in the engine air intake plenum, which allowed soft ice to build up after start.

Although Information Notice (IN) 2302-I-00 was not circulated to Royal Canadian Mounted Police (RCMP) pilots, the critical information was in the RFM supplements. It was determined that AS 350 operators may not be fully complying with the RFM procedures and appear to lack understanding of the hazards and consequences associated with snow, ice, or water contamination in the filter and plenum. This conclusion highlights the importance of ensuring that critical safety information is clearly understood and passed to the appropriate people. One means to do this is to conduct an annual safety briefing before commencing winter operations. If critical safety-related maintenance and operational information is not properly disseminated and risk management strategies are not applied, pilots and passengers travelling on those aircraft will be at increased risk.

According to Eurocopter, the quick installation of the intake covers is a basic precaution, but their use does not guarantee that no ice will accumulate in the air intake (possible as a result of water seepage in the air intake, due to rain or molten snow). Even with the engine covers in place, there is a risk of engine flame-out when the aircraft has been standing outside and

exposed to conditions in which moisture that may not be detected by the pilot can collect in the engine inlet filter components. The investigation also determined that in at least 1 case, despite installation of the covers and measures taken to remove snow that got past the covers, an engine flame-out due to ice ingestion was not prevented.

The procedures to remove snow, ice, and water from the intake system are impractical for field operations. However, if AS 350 operators and pilots do not recognize the risk of water, snow and ice accumulation in the plenum before engine start, and do not fully follow the manufacturer's instructions, there is an increased risk that passengers and pilots will be exposed to an engine flame-out shortly after take-off during winter operations.

2.3 Engine start and operation

Tests and previous accidents have shown that under certain winter conditions, the air flow into the engine progressively deposits ice or slush contamination onto the rear wall of the intake plenum, thereby creating a buildup of snow/ice/water mixture (soft ice), which eventually detaches and strikes the inlet axial compressor disc, bending blades, interfering with the airflow, and causing the engine to shut down.

In testing, residual heat following an engine shutdown was enough to cause a narrow opening to appear at the forward edge of a snow-covered intake grill (Figure 5). The high airflow through the air inlet would then have begun to progressively erode the snow layer rearwards, increasing the aperture size and causing the airflow to gradually change (Figure 6). As the size of the opening on the grill increased, the airflow pattern would have likely started to form recirculating eddy currents on the rear face of the plenum, increasing in intensity as the opening grew. The intake air contained moisture—from both the atmosphere and the melting snow layer on top of the grill—and probably became colder due to pressure reduction in the plenum resulting in slush gathering on the rear face of the plenum (Figure 6). This soft ice buildup phenomenon is not unheard of—it is the very contamination development seen in the French certification tests described previously in this report. The only significant contributing factor not present in the test regimes, however, was the increasing surface area of the air intake as a result of the snow layer eroding gradually in the airflow stream. At some stage in this process, the airflow pattern likely changed to impinge on the accumulation deposited on the rear face of the plenum, and perhaps in combination with vibration, caused the deposit to separate from the plenum surface and be sucked into the engine inlet (Figure 7 and Figure 8).

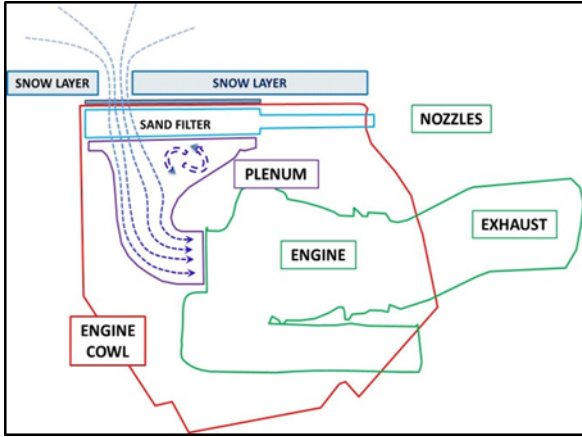


Figure 5. Airflow at engine start

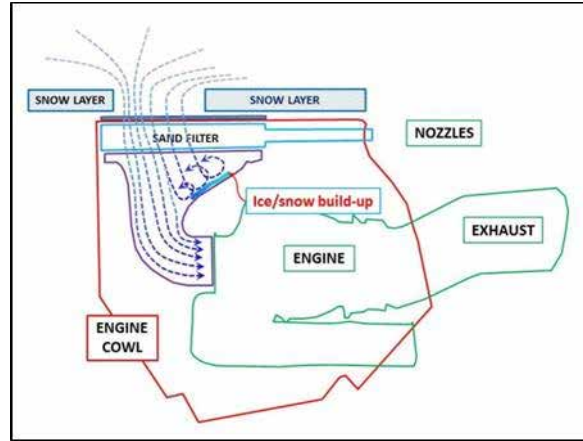


Figure 6. Airflow snow buildup

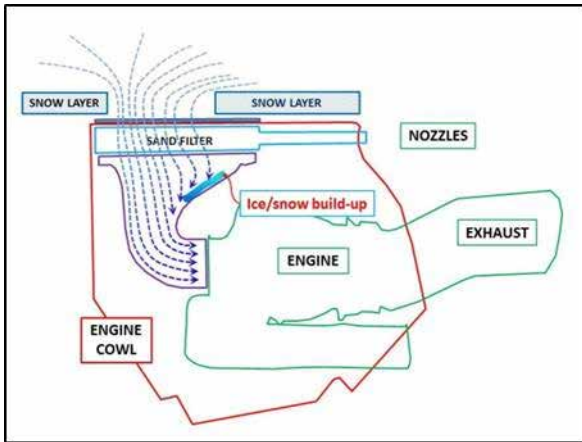


Figure 7. Airflow impinges on snow deposits

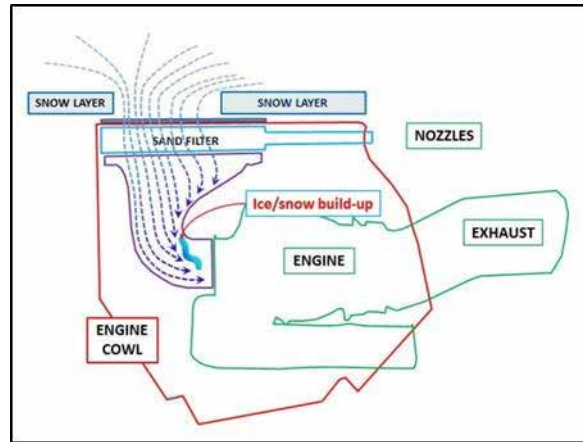


Figure 8. Airflow snow/ice dislodged

2.4 Loss of engine power

There is a significant amount of research demonstrating that gas turbine engines cannot tolerate ingestion of significant amounts of water, snow, or ice. Tests show that engine flame-outs can be expected after ingestion of as little as 40 grams of soft ice. The AS 350 is not equipped with any system to melt or prevent soft ice buildup, such as heated surfaces in the plenum. In addition, these engines are not equipped with any type of automatic engine relight capability, nor is it required by regulation. As a result, the AS 350 is susceptible, under certain conditions, to the buildup of soft ice in the engine plenum, which can cause the Turbomeca Arriel engine to flame out if the ice is ingested.

The tests carried out prove that the temperature in the plenum remained well above freezing before the engine start, and that snow or ice would not exist there at that time. However, during the start and once the engine is running, the temperature would quickly drop well below freezing. This drop in temperature would create ideal conditions for water particles to freeze. Because of the difference in temperature, any water particles would quickly form a soft slushy water/ice mixture. The rear slope of the plenum was susceptible to collecting this contaminant. A significant amount had collected, and more than 83 grams of it was likely released into the engine. This slushy mixture matches the consistency of engine contamination required to create

the damage to the compressor impeller that was found following the occurrence. Based on the circumstances of this occurrence and the well-documented history of engine flame-outs associated with water, snow, or ice ingress, the investigation determined that the cause of the loss of engine power was a sudden change in the critical air/fuel ratio as a result of soft ice ingestion. While it is impossible to know for sure how much soft ice was ingested by the engine, the damage to the compressor blades suggests that the amount of soft ice striking the blades was larger than the amount seen in the certification tests.

2.5 Accident flight envelope

The vast majority of the brief occurrence flight was spent in the higher risk avoid zones of the airspeed-height envelope (AHE), as identified in the RFM. When the helicopter experienced a loss of engine power, which occurred while hovering at approximately 80 feet agl, the helicopter would not have had sufficient altitude or time to fully enter autorotative flight. As a result, the pilot would have had little opportunity to preserve main-rotor rpm (rrpm), and a high rate of descent would have developed rapidly. As the helicopter descended, the rapid decay in rrpm resulting from the engine power loss reduced the effectiveness of the flight controls, leading to an impact with terrain that was beyond human tolerances.

2.6 Management oversight

The investigation discovered several discrepancies related to out-of-date Air Services Branch (ASB) maintenance publications. While it was determined that the maintenance procedures were being carried out in accordance with the manufacturer-approved procedures, there was an increased risk that required steps would be omitted, since ASB publications did not reflect the approved procedures. If company manuals are not kept up to date with the manufacturer-approved maintenance procedures, there is an increased risk that critical maintenance tasks will not be carried out.

The decision to operate the AS 350 was not supported by an in-depth analysis of mission-related risks and probable outcomes associated with an engine power loss. The risk of soft ice accretion associated with cold weather operations was not well appreciated by the operator, and the steps to inspect and clean the air intake system as outlined in the RFM were not practical for field operations.

No additional risk-management steps were taken to identify hazards associated with human external transportation system (HETS) operation using a single-engine helicopter, particularly during winter. If detailed risk assessments are not carried out when introducing a new aircraft type into an operation, there is an increased risk that any associated hazards will be undetected.

2.7 Auto-ignition systems

Aircraft certification for winter operations does not specifically require that engines be equipped with relight systems, despite the fact that several aircraft types have demonstrated susceptibility to engine flame-outs during snow and icing conditions. The risk of flame-outs on the AS 350 due to snow and/or ice ingestion has been previously documented, and resulted in 2 recommendations by the Swedish Accident Investigation Board.

While many aircraft manufacturers have changed their designs to incorporate relight systems, there is no such system on AS 350 with Turbomeca engines. While at high-altitude cruise, these engines can be restarted by the pilot. The lack of auto-ignition systems for single-engine helicopters like the AS 350 places pilots and passengers at increased risk of an accident following an engine power loss at low altitude due to snow, water, and/or ice ingestion.

2.8 Human external transportation system operations

HETS operations necessitate that a helicopter operate in the avoid area of the AHE chart for significant periods of time. While operating in the avoid area of the AHE envelope, pilots and passengers of those aircraft are at increased risk in the event of an engine power loss. This risk is particularly critical for single-engine helicopters, which lack the redundancy of another engine to help ensure a safe landing. Single-engine helicopters were allowed by TC, and used by the RCMP, to carry out HETS training and operations. As a result, pilots and passengers transported externally were at increased risk for injury or death in the event of a power loss.

3.0 Findings

3.1 Findings as to causes and contributing factors

1. The available protective covers for the airframe and the engine air intake were not installed when the helicopter was shut down or when heavy snow began to fall. In addition, preparation of the helicopter for flight, by removal of the accumulated snow from the airframe or the air intake, was not carried out as required by the rotorcraft flight manual.
2. Water accumulated in the engine air intake system, and ice or compacted snow built up in the engine air intake plenum after start. The helicopter experienced a complete loss of engine power resulting from a sudden change in air/fuel ratio caused by ingestion of the contaminant.
3. The helicopter's power loss occurred at an altitude and airspeed that did not permit an autorotation, which led to a rapid loss of main-rotor rpm and an extremely high rate of descent.
4. As the helicopter descended, the rapid decay in main-rotor rpm resulting from the engine power loss reduced the effectiveness of the flight controls, leading to an impact with terrain that was beyond human tolerances.

3.2 Findings as to risk

1. If an aircraft has been exposed to conditions in which moisture that may not be detected by the pilot can collect in the engine inlet filter components, then there is a risk of engine flame-out even with the engine covers in place.
2. Compliance with the requirements for making sure that the air intake system is dry is impractical for field operations. Nevertheless, unless AS 350 operators fully follow the manufacturer's instructions, there is an increased risk that passengers and pilots will be exposed to an engine flame-out shortly after take-off during winter operations.
3. Exemptions that allow Shuman external transportation system operations by single-engine helicopters engaged in law enforcement, fire-fighting and rescue in the avoid area of the airspeed-height envelope place pilots and passengers at increased risk in the event of an engine power loss.
4. If detailed risk assessments are not carried out when introducing a new aircraft type into an operation, there is an increased risk that associated hazards will go undetected.
5. If critical safety-related maintenance and operational information is not properly disseminated and risk management strategies not applied, pilots and passengers travelling on those aircraft will be at increased risk.

6. The lack of auto-ignition systems for single-engine helicopters like the AS 350 places pilots and passengers at increased risk for accidents following an engine power loss at low altitude due to snow, water, and/or ice ingestion.
7. If company manuals are not kept up to date with the manufacturer-approved maintenance procedures, there is an increased risk that critical maintenance tasks will not be carried out.

4.0 *Safety action*

4.1 *Safety action taken*

4.1.1 *Royal Canadian Mounted Police*

Following the occurrence, the Royal Canadian Mounted Police (RCMP) issued replacement chinstraps and locking clips for all of its in-service flight helmets, and implemented a biennial replacement program. The RCMP also implemented a more frequent replacement schedule (10 years to 7 years) for the helmets than the manufacturer's recommended replacement schedule.

All pilots were reminded of the importance of using the covers in all forms of precipitation and exposure to temperatures near freezing. New covers offering a better seal were purchased for all helicopters.

A reminder highlighting the requirements and regulations for clean (uncontaminated) aircraft was sent out to all pilots immediately after the accident.

Both chief pilots are now providing all pilots with "Cold Weather and Warm Weather Operations" briefings at the beginning of each season, reviewing critical aspects in relation to the operational environment and aircraft flown.

Both chief pilots have since been subscribed to the publications for fixed- and rotary-wing aircraft in the RCMP fleet, to ensure that all pertinent information is disseminated to pilots in a timely, efficient, and documented manner.

The rotary-wing chief pilot issued a temporary directive on 10 February 2012 for pilots to carefully review all of the RFMs for correct content at the next available opportunity. An annual review of the RFM and other manuals was planned for introduction, to ensure that the information within them is accurate and up to date.

A complete safety risk profile involving all stakeholders was completed on the human external transportation system program. All stakeholders were educated on the flight envelope and aircraft limitations within which these operations take place.

Forms were amended to ensure proper and thorough reviews were conducted on all service bulletins (SBs) and to include flight operations input when required.

All RCMP check sheets were verified, and any aircraft within the RCMP fleet that had been signed out with reference to, and in accordance with, any of the invalid sheets were not considered airworthy until they were re-signed out in accordance with the correct aircraft maintenance manual criteria. A maintenance information letter (MIL) was sent out to all sections on 23 February 2012, directing that the sections no longer use the RCMP check sheets.

The RCMP Air Services Branch (ASB) in Ottawa has implemented a shared-drive computer system that contains all manuals, procedures, practices, and policies for RCMP fleet maintenance and flight operations.

On 29 February 2012, a revised MIL (no. 030R), was issued, instructing aircraft maintenance engineers (AMEs) to verify that existing aircraft were inspected in accordance with the aircraft manufacturers' requirements.

Furthermore, the ASB has implemented a procedure to directly notify the rotary-wing chief pilot of all pertinent Eurocopter operational information, as well as the fixed-wing chief pilot of all pertinent fixed-wing aircraft manufacturers' operational information.

4.1.2 *Transport Canada*

Transport Canada (TC) has initiated a review of the engine inlet design in accordance with sections 527.1091 and 527.1093 of chapter 527 of the *Airworthiness Manual*, with respect to normal category rotorcraft, the RFM limitations, pre-flight inspection requirements, and other identified operational concerns. This review is a National Aircraft Certification project requiring international coordination that may take a considerable amount of time to resolve.

TC has published Civil Aviation Safety Alert (CASA) 2013-03²² regarding the AS 350, to raise operator awareness of the problem with moisture collection in the plenum chambers of this aircraft. The CASA includes a strong caution to avoid the shaded area of the height velocity curve wherever possible.

4.1.3 *Eurocopter*

Eurocopter issued Safety Information Notice 2645-S-30 in the fall of 2013, applicable to AS 350, AS 550, and EC 130, regarding ice and rain protection (see Appendix F).

The notice refers to sudden engine flame-out in flight occurring shortly after take-off, due to snow and ice accumulation in the engine air intake plenum and to the snow/ice mixture suddenly being ingested by the engine.

The notice states:²³ "When an area close to the engine air intake or the air intake itself is not cleaned on the ground, an instantaneous volume of water, snow or ice may detach. The design of the engine air intakes (including those equipped with a sand filter) does not ensure correct engine operation in these conditions."

The notice goes on to say that additional warnings will be added to the RFM highlighting the procedures for cold weather operations.

²² Transport Canada, Civil Aviation Safety Alert (CASA) 2013-03, Potential for AS 350/EC 130 Engine Inlet (Plenum) Icing (11 June 2013)

²³ Eurocopter, Safety Information Notice No. 2645-S-30: Ice and Rain Protection: Recommendations in case of snow/ice accumulation in and around the engine air intakes (31 October 2013)

4.2 Board safety concern

There are about 532 Eurocopter AS 350 and EC 130 helicopters being operated by 132 operators in Canada. The EC 130 is essentially an evolution of the AS 350, and has the same engine air intake design.

This investigation found that ice or compacted snow built up in the AS 350's engine air intake plenum after start and the helicopter experienced a complete loss of engine power resulting from a sudden change in air/fuel ratio caused by ingestion of the contaminant. The helicopter's power loss occurred at an altitude and airspeed that did not permit an autorotation, leading to a rapid loss of main-rotor rpm, an extremely high rate of descent, and impact with the ground that was not survivable.

The engine inlet of the AS 350 is susceptible to ice formation when the plenum, contaminated with snow, ice, or liquid water, is cooled to below freezing temperatures during start-up and low-power engine operations. Ice forming in the plenum may then break free and cause (soft) foreign object damage and/or engine flame-out. This phenomenon can occur during take-off when high power is initially selected, resulting in a sudden power loss and a possible loss of control of the aircraft, as took place in this occurrence.

According to Transport Canada, this phenomenon seems to be a particular risk for helicopters equipped with filters where ice can collect below and behind the filters and dislodge suddenly into the plenum, momentarily disrupting the airflow and causing a flame-out. However, ice formation may occur in these helicopter types where the plenum itself is not clear of snow or water before start-up and the outside air temperature is relatively low.

The manufacturer recommends the installation of protective covers on the airframe and the engine air intake when the helicopter is parked outside. While these measures will mitigate the risk of ice or snow collection, they will not totally eliminate the possibility that moisture will collect in the engine inlet filter and plenum in certain weather and operational conditions.

For these reasons, the AS 350 B3 Flight Manual Supplement 9-4: Instructions For Operations in Cold Weather, Preflight section, states in part: "...visually inspect for snow and ice inside the air intake duct...Note It is imperative that the air intake be cleaned..."²⁴

Canadian regulations require that the manufacturer's instructions be complied with fully. Transport Canada advises that it is imperative that the engine inlet (plenum) of the AS 350/EC 130-type helicopter be free of all snow, ice, and liquid water before starting up in cold weather operations and/or snowy conditions. However, compliance with these instructions for the inspection and cleaning of the engine inlet (plenum) of the AS 350/EC 130-type helicopter cannot be done without elevating and supporting the engine cowling or, where installed, removing and reinstalling the grill that covers the filter. These tasks cannot easily be accomplished in field operations, which significantly limits operators' ability to operate in some weather conditions.

²⁴ Eurocopter, *Flight Manual AS 350 B3 Supplement 9-4: Instructions For Operations in Cold Weather*, Preflight section

Therefore, the Board is concerned that, in certain cold weather conditions, when the manufacturer's instructions are not fully followed, AS 350 and EC 130 helicopters are at increased risk for engine flame-out shortly after take-off.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 12 March 2014. It was officially released on 28 May 2014.

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.

Appendices

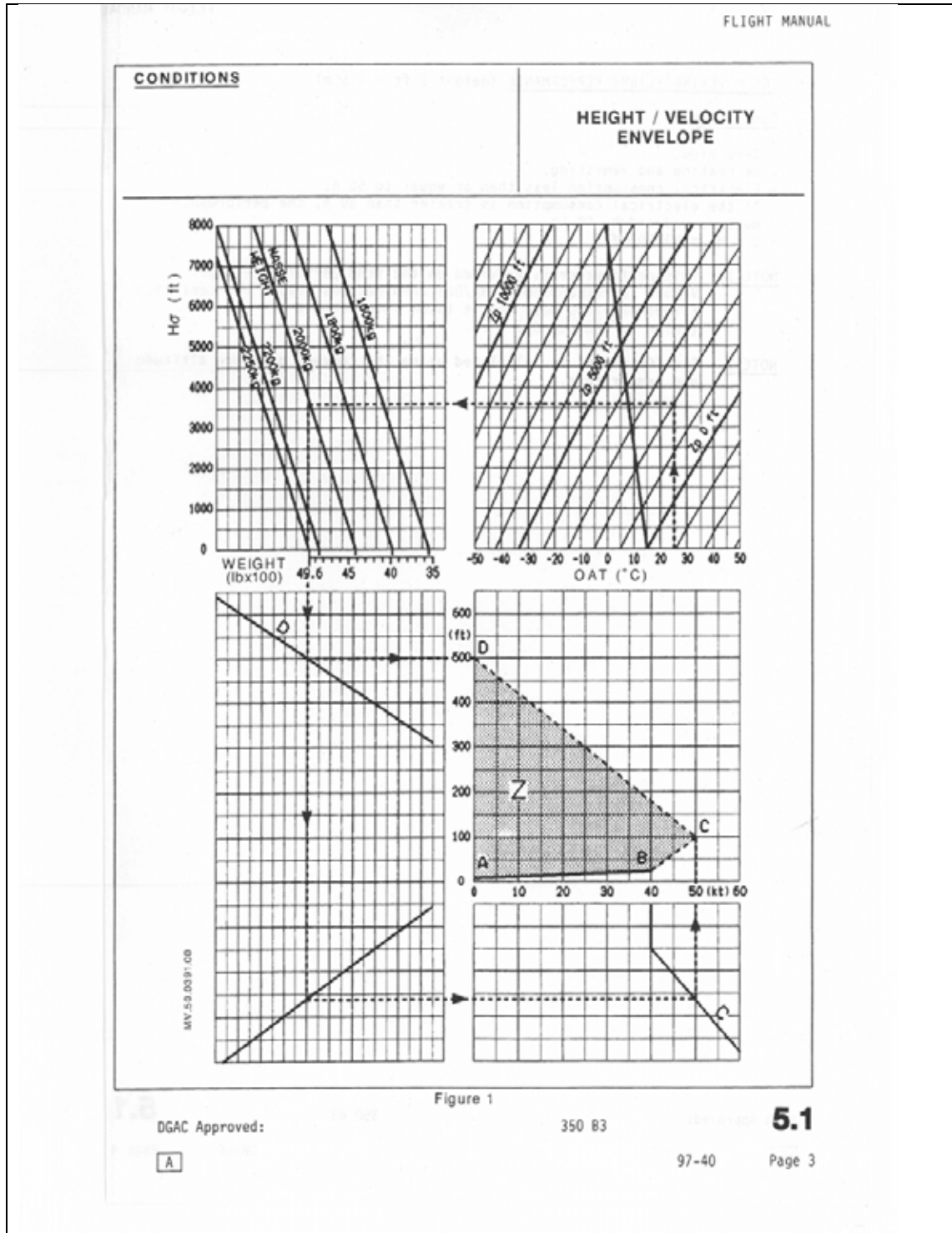
Appendix A – List of laboratory reports

The following TSB Laboratory reports were completed:

- LP 014/2012 – VEMD Download
- LP 097/2012 – Axial Compressor Blade Examination
- LP 186/2012 – Fire Extinguisher Mounting Bracket

These LP reports are available from the Transportation Safety Board of Canada upon request.

Appendix B – AS 350 rotorcraft flight manual charts for airspeed-height envelope²⁵



*Appendix C – Transport Canada Airworthiness Directive CF-2001-03R1
(excerpt)*

Issue Date
28 May 2001

Number: CF-2001-03R1

Subject: Bell 206A/B - Particle Separator/Intake Deflector

Effective: 28 February 2001 (the effective date of Airworthiness Directive (AD) CF-2001-03).

Revision: Supersedes AD CF-2001-03 issued 22 January 2001.

Applicability: All Bell Helicopter Textron Canada (BHTC) Model 206A and B series helicopters.

Compliance: Not later than 30 September 2001, unless already accomplished.

Background: In 1989, the Federal Aviation Administration (FAA) issued Airworthiness Directive (AD) 89-10-11R1 applicable to the Bell 206A and 206B models requiring the installation of the Bell Helicopter particle separator and intake deflector system for operation in falling or blowing snow. In Canada a large number of helicopters which were equipped with winterization kits consisting of reverse scoops and auto relight (re-ignition) systems, were granted an exemption to this AD in the form of an Alternate Means of Compliance (AMOC). The original issue of this AD superseded FAA AD 89-10-11R1 and mandated the installation of an auto relight system in addition to the kits installed previously as per FAA AD 89-10-11R1.

This revision has been issued to correct the compliance date and remove reference to the 206B3 model as this is only a marketing designator. Other minor editorial changes have also been made.

Corrective Actions:

The following equipment shall be installed when conducting flight operations in falling or blowing snow:

1. For Model 206A and 206B:
 - (a) Engine (Automatic) Re-Ignition Kit No. 206-706-038;
 - (b) Deflector Kit – Engine Air Induction System; and
 - (c) Snow Particle Separator - Engine Air Induction System.

2. Alternatively, for the Model 206A Helicopter only:

- (a) Engine (Automatic) Re-Ignition Kit No. 206-706-038; and
- (b) Snow Winterization - Air Induction System.

Appendix D – List of compiled snow, ice, and water-ingestion tests and documentation

- *Rotary Flight Manual (RFM)*: added Cold Weather Operating Instructions: Preparation for Flight (see section 1.16.14)
- *Aircraft Maintenance Manual (AMM)*: added instructions for Cold Weather Preparation Inspection
- *Aerospatiale Service Letter (SL) No. 662.30.84 (February 1985)*: Reminder about precautions after unsheltered parking under snowing conditions (specifically, intake cleaning and RFM/AMM instructions)
- *Aerospatiale Service Bulletin No. 30.04 (December 1985)*: Retrofit removable air intake grill and plenum drain hole
- *Aerospatiale SL No. 743.05.86 (February 1986)*: Preparation for Flight after Parking under Snow
 - As a result of a few accidents during winter 1985 that were due to insufficient snow removal, reminds of the importance of intake cleaning before takeoff
 - Refers to SB No. 30.04
- *Aerospatiale SL No. 784.05.86 (December 1986)*: Preparation for Flight After Parking in Falling Snow
 - Issued after several accidents in winter 1985/1986 as a result of improper snow removal after parking in falling snow
 - Refers to AMM instructions (Work Card 05-21-00-605), including mandatory cleaning of the air intake
- *Eurocopter SL No. 1036-05-91 (March 1991)*: Preparation for Flight following aircraft parking in snow and/or in cold weather
 - Prompted by recent accident caused by insufficient snow removal on AS 350 helicopters
 - Reminds of AMM instructions in Work Card 05-21-00-605 and SL 662.30.84, both requiring inspection of the air intake, and refers to Aerospatiale SB No. 30.04
- *Aerospatiale SL No. 784-05-86 (December 1991) REISSUED*: Preparation for Flight After Parking in Falling Snow
 - Issued after several accidents in winter 1985/1986 as a result of improper snow removal after parking in falling snow
 - Refers to AMM instructions (Work Card 05-21-00-605), including mandatory cleaning of the air intake
- *Aerospatiale SL No. 1094-00-91 (January 1992)*: Flight in Falling Snow

- Prompted by recent engine flame-outs caused by snow accretion on AS 350 helicopters
- Reminds of visibility limitations in snow
- Eurocopter SL No. 1142-00-92 (November 1992): Flight in Falling Snow
 - Advises that installing the snow filter (SB 71.04) or sand filter (SB 71.11) eliminates the inflight visibility restrictions in falling snow
- Eurocopter SL No. 1270-00-96 (May 1996): Protection and Operation of Helicopters in Snowy Conditions
 - Issued after several engine flame-outs after operating or parking in falling snow, and reminds of the basic precautions when preparing a helicopter parked under snow
 - Refers to RFM– Instructions for Cold Weather: Preparation for Flight, and AMM – Pre Flight Check in Cold Weather
 - Instructs to clear snow off helicopter and remove blanking covers from air intake
- Eurocopter SL No. 1270-00-96 REISSUED (June 1996): Protection and Operation of Helicopters in Snowy Conditions
- Eurocopter SL No. 1270-00-96 REISSUED (October 1996): Protection and Operation of Helicopters in Snowy Conditions
- Eurocopter SL No. 1270-00-96 REISSUED (December 1998): Protection and Operation of Helicopters in Snowy Conditions
- Eurocopter SL No. 1270-00-96 REISSUED (January 2001): Protection and Operation of Helicopters in Snowy Conditions
- Eurocopter SL No. 1270-00-96 REISSUED (November 2002): Protection and Use of Helicopters in Cold Weather and Damp Conditions
- Eurocopter SL No. 1270-00-96 REISSUED (December 2006): Protection and Use of Helicopters in Cold Weather and Damp Conditions (see section 1.16.10)
- Eurocopter In No. 2030-I-00 (January 2009): Protection and Use of Helicopters in Cold Weather and in Damp Conditions
- Eurocopter In No. 2302-I-00 (April 2011): Protection and Use of Helicopters in Cold Weather and in Damp Conditions

Appendix E – Paragraphs from Eurocopter Service Letter No. 1270-00-96: Protection and use of helicopters in cold weather and in damp conditions ²⁶

1. Precautions for parking in the open

It is advisable to always install the air intake and exhaust pipe blanks on a helicopter parked in the open.

This is **mandatory** for a helicopter parked in **cold weather**, likely to be exposed to **snow or rain fall** during all or part of the parking period.

After arriving on a parking area in cold weather in falling snow or rain, it is recommended to install the **air intake blank rapidly following engine shutdown**.

The exhaust pipe blank can be installed subsequently, as soon as the exhaust pipe temperature is acceptable.

2. Pre-flight precautions

If the helicopter has been parked in the open in cold weather in falling snow or rain, and whether it is equipped with specific engine air intake snow protection or not (snow filter or sand filter or multipurpose air intake), **the following steps must be taken:**

- a. Carefully remove the snow or ice from the helicopter, in particular around the air intakes (especially from the engine air intake).
- b. Remove the engine air intake blank then remove any snow and ice that may have accumulated on the air intake and the air intake screen or the filter system (if the helicopter is thus equipped).
- c. Check the inside of the engine air supply system; it may be necessary to remove a screen or filter or cowling (according to the type of helicopter). Any accumulation of snow or ice must be removed.
- d. Before closing or reinstalling the engine air supply system, perform a complete check using an electric lamp where necessary (in case of poor light conditions or back light) and if necessary by looking from different angles to have a complete view of the engine air intake system.
- e. Check that there is no snow or ice on the air vents, the static ports, the drains and scuppers. Any snow or ice must be removed.
- f. It may be necessary to warm the area to remove the ice. A hot air blower can be used. In this case, all the water from thawing must be wiped off thoroughly to prevent an accumulation of water and the risk of subsequent refreezing.
- g. In particular, there must be no accumulation of water in the engine air supply system (screen or filter) which could freeze again subsequently.

These operations must be performed **at the last moment before engine starting**.

3. Additional precautions before takeoff

If the helicopter is not equipped with specific engine air intake snow protection (no snow filter or sand filter or multipurpose air intake), and in the following cases, **the engine air intake must be checked again before takeoff**:

- a. In **light or moderate** falling snow or sleet conditions, if the waiting or taxiing phase is **long** (as an indication: more than 20 minutes for a Super Puma).
- b. In **blown or heavy-falling** snow or sleet conditions, regardless of the taxiing or waiting phase. Heavy snowfall conditions are characterized by a horizontal visibility of less than 400 meters. In these conditions, the takeoff must be performed quickly after checking the engine air supply system and very quickly after starting the engine(s), taking into account of course the minimum engine or MGB oil temperature limits possibly specified in the Flight Manual for the helicopter concerned.

4. Precautions in flight

Even after complying with the precautionary measures above, the crew must give their full attention to the inflight operating procedures in icing or snowy atmospheric conditions, as reminded below:

- a. Comply with the VFR flight limitations, sufficient visibility for visual flight rules.
- b. Comply with the Flight Manual regarding the restrictions or flight limitations in icing conditions or in falling snow. Some helicopters are equipped with specific options which waive compliance with these restrictions or limitations.
- c. If the helicopter is equipped with multipurpose air intakes, and for flight in icing conditions or in snow, the bullets must be kept closed until the engines are fully shut down. This is to prevent flame-out or damage to the engine.

Appendix F – Eurocopter Safety Information Notice No. 2645-S-30



No. 2645-S-30

SAFETY INFORMATION NOTICE

SUBJECT: ICE AND RAIN PROTECTION

Recommendations in case of snow/ice accumulation in and around the engine air intakes



AIRCRAFT CONCERNED	Version(s)	
	Civil	Military
AS350	B, BA, BB, B1, B2, B3, D	L1
AS550		A2, C2, C3, U2
EC130	B4, T2	

EUROCOPTER has participated in investigations concerning an accident which occurred following sudden engine flame-out in flight.

The investigations revealed that the engine flame-out occurred shortly after take-off and was due to a snow and ice accumulation in the engine air intake plenum, and the snow/ice mixture suddenly being ingested by the engine. The aircraft had been shutdown after a previous flight and the inlet covers had not been used. Several centimeters of snow accumulated on the upper surface of the sand filter prior to engine start. The snow was not removed from the upper surface of the particle separator and the engine air intake was not inspected prior to engine start.

A turbine engine has a good rainwater or falling-snow absorption capacity in continuous operation. However, the engine is sensitive to the absorption of an instantaneous volume of water, snow or ice, because this quantity (even if it is limited) can exceed the instantaneous absorption capacity of an operating engine.

When operated in accordance with the Flight Manual, the engine air intakes are designed to prevent - in flight or on the ground with the engine running (rotor spinning or not) - an accumulation which could lead to this type of engine flame-out.

When an area close to the engine air intake or the air intake itself is not cleaned on the ground, an instantaneous volume of water, snow or ice may detach. The design of the engine air intakes (including those equipped with a sand filter) does not ensure correct engine operation in these conditions.

EUROCOPTER would like to remind you that the check of the engine air intakes is required in all Ecureuil Flight Manuals. In order to underline the importance of this check, EUROCOPTER will progressively introduce the modifications below in all the Ecureuil Flight Manuals.

The following condition will be added to the forbidden conditions in section 2 "Limitations": "Engine starting when snow or ice accumulations are in or around the engine air intake".

The following "Warning" will be added to the "Pre-flight check" part of section 4, in the "Sand Filter" and "Use in cold weather" supplements:

"WARNING: Ice or snow accumulations that remain in or around the engine air intake may be ingested and can cause a sudden in-flight engine failure".

The pre-flight check will be adapted as follows:

"Engine air intake.....Clean - No foreign objects or accumulations of ice or snow in or around the engine air intake and no stagnant water at the drain hole".

"Exhaust cover.....Removed".

The following complementary information will be added in the "Use in cold weather" supplement:

- General: This supplement details the procedures to be followed when the aircraft is operated in cold weather (OAT $\leq 0^{\circ}\text{C}$) and/or when the aircraft is or could be exposed to falling or blowing snow.
- NOTE: In falling or blowing snow conditions the engine air intake should be checked at the end of the exterior checks. The further checks before engine starting should then be performed without major delay.

EUROCOPTER also reminds you that after arriving on a parking area in cold weather and snowy conditions or falling rain, it is recommended that you install the engine air intake cover rapidly after engine shutdown.

Appendix G – Regulations and Standards for Class D external load operations²⁷

Helicopter Class D External Loads

702.21 (1) Subject to subsection (2), no air operator shall operate a helicopter to carry a helicopter Class D external load unless

(a) the helicopter is a multi-engined helicopter that meets the transport category engine-isolation requirements of Chapter 529 of the *Airworthiness Manual* and that is capable of hovering with one engine inoperative at the existing weight and altitude;

(b) the air operator is authorized to do so in its air operator certificate; and

(c) the air operator complies with the *Commercial Air Service Standards*.

(2) An air operator may operate a helicopter other than a helicopter described in paragraph (1)(a) to carry a helicopter Class D external load if the air operator

(a) is authorized to do so in its air operator certificate; and

(b) complies with the *Commercial Air Service Standards*.

Helicopter Class D External Loads

722.21 (1) The standards for authorization to operate a helicopter to carry a Class D helicopter external load are:

(a) the helicopter is equipped to permit direct radio intercommunication among crew members;

(b) the personnel carrying device is airworthiness approved for the carriage of human external loads;

(c) the load is jettisonable if it extends below the landing gear;

(d) the air operator has applicable one engine inoperative performance charts for the operating weight and density altitude at which the Class D external load operation is to be conducted. Performance charts may take account of windspeed providing windspeed is 10 knots or more;

(e) the air operator's Company Operations Manual includes operational requirements, operational procedures and air operator employee qualification and training requirements.

(2) The standards for authorization to operate a helicopter to carry a Class D helicopter external load using a single-engine helicopter or a multi-

²⁷ Canadian Aviation Regulations (CARs), Part VII – Commercial Air Services, Subpart 2 – Aerial Work, 702.21 (1) – Helicopter Class D External Loads, and *Commercial Air Service Standards* (CASS), Standard 722 – Aerial Work, 722.21 – Helicopter Class D External Loads

engine helicopter unable to comply with one engine inoperative requirements are:

(a) where the load does not extend below the landing gear:

(i) the helicopter is equipped to permit direct electronic or visual communication among crew members;
(amended 1998/09/01; previous version)

(ii) the personnel carrying device is airworthiness approved for the carriage of human external loads;

(iii) the helicopter is turbine powered and equipped, where approved for the type, with an auto-ignition system and a detector system to warn flight crew members of excessive ferrous material in the engine(s);

(iv) only flight crew members and persons essential during flight are carried; and

(v) the air operator's Company Operations Manual includes operational requirements, operational procedures and air operator employee qualification and training requirements;

(b) where the load extends below the landing gear:

(i) the helicopter is equipped to permit direct radio intercommunication among crew members;

(ii) the personnel carrying device is airworthiness approved for the carriage of human external loads;

(iii) the load is jettisonable;

(iv) the helicopter is turbine powered and equipped, where approved for the type, with an auto-ignition system and a detector system to warn flight crew members of excessive ferrous material in the engine(s);

(v) only flight crew members and persons essential during flight are carried;

(vi) persons are transported externally between geographical points only to the nearest suitable landing site;

(vii) the authorization is for the purpose of law enforcement operations, forest fire suppression operations, urban fire-fighting operations or rescue operations;

(viii) the air operator has a formal written agreement from the user of the service and the agreement stipulates that only suitably trained and qualified persons will be assigned; and

(ix) the air operator's Company Operations Manual includes operational requirements, operational procedures and air operator employee qualification and training requirements.

(3) Authorization may be granted for deviation from the standards of 722.21 (1) and (2) for the Production of Commercial Motion Pictures and Television filming provided:

- (a) the aircraft is operated within approved limitations;
- (b) a co-ordinated plan for each complete operation is developed;
- (c) all persons involved are knowledgeable of equipment to be used and pre-flight briefed; and
- (d) only flight crew members and persons essential during flight are carried.

(4) Where helicopter Class D External Load Operations are to be conducted for the purpose of providing a rescue service the following standards shall apply.

(a) Pilot Experience

Pilots-in-command for rescue service operations shall have achieved:

- (i) at least 2,000 hours total helicopter pilot flight time;
- (ii) at least 200 hours on the aircraft type which the pilot is to fly on initial assignment to rescue operations and at least 25 hours on types to be used thereafter;
- (iii) at least 1,000 hours experience in the operational area if rescue services are to be conducted in Designated Mountainous Areas 1 or 2 as defined in the *Designated Airspace Handbook* (TP 1820); and
- (iv) have completed training for Class D load operations in accordance with section 722.76.

(b) Rescue Service Operations Control

A close working relationship is required between the air operator and the emergency response user organization to ensure coordinated proficiency and mission safety. Terms of reference shall be documented in a written agreement and will define the following:

- (i) responsibility of pilot-in-command and rescue specialist(s);
- (ii) required operational capabilities and scope of operation;
- (iii) coordinated rescue mission standard operating procedures;
- (iv) mission authorization and control process, including communication procedures; and
- (v) coordinated air operator and emergency response user agency training program on at least an annual basis.