FINAL REPORT

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In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 23 Sept 2007, appointed Mr. Graham Liddy as the Investigator-in-Charge to carry out a Field Investigation into this Serious Incident and prepare a Synoptic Report.

Aircraft Type and Registration:	Robinson R44 EI-TOY
No. and Type of Engines:	1 x Lycoming O-540-F185
Aircraft Serial Number:	1294
Year of Manufacture:	2003
Date and Time (UTC):	23 Sept 2007 @ 11.27 hrs
Location:	UCD Belfield, Dublin
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 0
Injuries:	Crew - Nil Passengers - Nil
Nature of Damage:	None
Commander's Licence:	CPL (H)
Commander's Details:	Male, aged 41 years
Commander's Flying Experience:	1,600 hours, of which 650 hours were on type
Notification Source:	Dublin ATC Watch Manager
Information Source:	AAIU Field Investigation

SYNOPSIS

The helicopter had just taken off on a short flight. The engine started to run rough and lose power. As the helicopter was over a large open area, but surrounded by a built-up area, the pilot lowered the collective pitch lever and initiated an autorotation. During the autorotation descent the engine stopped completely. The pilot successfully performed a power-off autorotation and landed the helicopter without damage. The Investigation found that carburettor icing was the probable cause of the event.

FINAL REPORT

1. FACTUAL INFORMATION

1.1 History of the Flight

Prior to the flight, the helicopter was refuelled at a small heliport at Leopardstown, Co Dublin. The helicopter then took off with only the Pilot on board. The intended flight was to Weston Aerodrome, to pick up the owner of the helicopter. The flight from Leopardstown to Weston is about 14 nm, much of it close to, or over, the built up suburbs of south Dublin. About 2 nm from Leopardstown, as the helicopter was routing over the large campus of University College Dublin (UCD) at Belfield, at approx 1,000 ft, the engine started to run rough and to lose power. As the helicopter was over a large open area, the Pilot decided to reduce power, by lowering the collective, and prepared for a power-on autorotation onto the campus. He called Dublin ATC to report that he had a problem. During the descent the engine stopped completely. The Pilot continued the autorotation and landed the helicopter, without damage, on a grass playing field in the campus.

Dublin ATC alerted the emergency services who quickly arrived at the scene. ATC also notified the AAIU. The Pilot was taken to a local hospital for examination, but was discharged shortly thereafter, and he returned to the helicopter. Upon his return, he met the AAIU Investigation, which had arrived on scene in the meantime.

1.2 Subsequent Events

The Pilot informed the Investigation that he suspected that contaminated fuel might have been the problem. One member of the Investigation went to the heliport and took fuel samples from the fuel bowser. The main and auxiliary fuel tanks of the helicopter were both more than half full. The helicopter, after an initial examination, was found to have no obvious defect. The Investigation sealed the helicopter's engine bay and arranged for the helicopter to be brought to Weston by truck, under Garda escort. This move was completed by the evening of the event.

1.3 Met Information

Met Éireann supplied the following meteorological information for the Belfield area for the time of the incident:

General Situation:	A low pressure system south of Iceland maintained a southwest to west southwest airflow over the area. A weak cold front passed through the area around the time in question. The tephigrams showed a sharp inversion between 780 hPa and 810 hPa
Wind:	SFC 240 14kt 1000 ft 240 25kt
Weather:	ISOL –RA
Visibility:	10km+
Cloud:	FEW 018 SCT 050 BKN 250
Temperature/Dew-Point:	SFC 1100Z 16/11 deg C 1200Z 17/09 deg C 500 ft 16/09 deg C 1000 ft 15/08 deg C

Note: There was a mountain wave SIGMET valid for the area at the time of the incident, which indicated MAX VSP 550 FPM BTN FL050/160.

1.4 Investigation

Visual examination of the fuel sample taken from the bowser showed no indications of contamination. Further samples were also taken from the helicopter's fuel tanks and fuel filter. All these samples were sent to a laboratory for analysis and were found to conform to the required standards for Avgas and to be free of contamination.

Investigation of the helicopter's air and fuel filters found both filters to be clean. The fuel flow to the engine was found to be adequate. There was no blockage in the air supply to the engine. The spark plugs were removed and examined. These were found to be very clean, and according to the logbook, they had been replaced some 2 months before the event.

Having found no defect or explanation for the event, it was decided to start the engine. The engine started easily and ran at idle without problems. After a period of ground running it was decided to engage the rotors and then to hover the helicopter. After some 15 minutes the hover was terminated. Again the engine had performed flawlessly. The helicopter was then prepared for flight. A half hour flight was then flown, with the Investigator-in-Charge on board. No problems or power fluctuation were noted throughout.

However, the Investigation noted that during this flight, with no carburettor heat selected, the carburettor temperature remained in the danger arc, albeit at the high end of the arc. Furthermore, even a small manual application of carburettor heat selection brought the carburettor temperature back into the safe zone, by a significant amount, almost immediately. The Investigation also noted that any significant reduction of the collective pitch lever also caused the carburettor temperature to move out of the danger zone. The reason for this is explained below in Section 1.5. The Investigation noted that the weather conditions, especially with regard to temperature and humidity were generally similar to those on the day of the engine stoppage.

1.5 Automatic Carburettor Heating System

In the carburetted engine version of the R44 (such as EI-TOY), the carburettor heat can be selected to "ON" manually at any time. This is done by pulling up on a knob at the base of the instrument pedestal. Later versions of the R44 (including EI-TOY) are equipped with a linkage between the collective pitch lever and the carburettor heat knob. As the collective lever is lowered, the carburettor heat knob is pushed up (i.e. carburettor heat "ON") via a friction linkage to the collective lever. The purpose of this feature is to ensure that carburettor heat is applied automatically when the collective lever is lowered and the engine power is reduced. A reduction of power increases the susceptibility of an engine to carburettor icing (see **Figure 1**). This safety feature automatically applies carburettor heat when the pilot lowers the collective pitch lever, thereby reducing power, during the approach to land. A power loss due to carburettor icing at such a low altitude phase of a flight would preclude setting up an autorotation, with serious consequences.

1.6 Other Information

The pilot of EI-TOY subsequently stated that he believed that a carburettor fault might have caused the engine stoppage. Notwithstanding the successful tests, the Investigation had the carburettor removed and sent to an approved carburettor overhaul facility for testing and strip examination. No defect was found.

While this inspection was taking place an overhauled carburettor was fitted to EI-TOY, to enable the helicopter to continue in service. Some four hours flying after this carburettor was fitted, starting problems were experienced. The replacement carburettor was removed and found to have a leaking float. The original carburettor had been inspected for this specific fault and no fault was found. The Investigation noted that since 2006, the float design has been modified by filling them with foam. Both the original and the replacement floats fitted to EI-TOY were manufactured before this modification.

In discussion with the Investigation, the helicopter owner stated that there had been considerable debate, within the small group of pilots who flew EI-TOY, regarding the use of carburettor heat. He recalled that the incident pilot did not support significant use of carburettor heat.

2. ANALYSIS

2.1 The Investigation plotted the ambient temperature and humidity for the day of the incident, using the Met Éireann data, on the standard carburettor-icing diagram, as shown on Figure 1. This shows that the temperature/dew point conditions were such that the helicopter was operating in the zone where moderate carburettor icing could be expected at cruise power or severe icing at descent power, and very close to the zone where serious icing could be expected at any power setting. The fact that the helicopter was operating in a light configuration with only one pilot and approximately 60% of fuel capacity, would have meant that a relatively low power setting would be required in the cruise, thereby further increasing the susceptibility to carburettor icing. Furthermore the presence of mountain wave, and its associated large vertical movements in the local air mass, could have produced localised conditions which may have moved the local environment into the Serious Icing - At Any Power Setting - zone.

2.2 The absence of any defect on the helicopter and the flawless performance of the engine during the subsequent tests are also classic indications of a carburettor-icing event. The Investigation considers that the probable cause of the rough running and loss of power was caused by the onset of carburettor icing. The subsequent rapid lowering of the collective lever for the autorotation would have resulted in a large application of carburettor heat, by the automatic system described above. The sudden influx of heat would have melted the ice in the carburettor and the water, thus produced, would then have passed through the induction system and into the cylinders. This would suppress the ignition in the cylinders and cause the engine to stop completely. There is a particular problem with helicopter engines in that, when the engine starts to loose power and the collective is lowered, the synchronisation between the engine and the rotors is lost (the rotors turn faster than the relative engine speed). This causes the freewheel unit[1] to disengage the main and tail rotors from the engine. In this condition there is no windmill or rotational forces available to continue engine rotation during a brief cessation of the combustion process. In the absence of such a force, the engine stops rapidly and will not pick-up (restart) by itself.

2.3 The Investigation found that the spark plugs were very clean. The use of carburettor heat invariably causes some fouling on the plugs. The absence of such fouling is indicative that carburettor heat was rarely used in this helicopter since the plugs were renewed two months before the incident.

[1] The purpose of the freewheel is to disconnect the engine from the main rotor in the event of a sudden engine seizure or stoppage. Thus a failed engine does not have a braking effect on the main rotors and the pilot can successfully land the helicopter by means of an autorotation.

2.4 Discussion

Carburettor icing is a common problem in the ambient climatic conditions experienced in Ireland, and has been cited as the cause of many accidents in AAIU Reports, particularly helicopters. There appears to be a common perception that carburettor icing is only encountered in low temperature conditions. In reality, the formation of carburettor icing is function of both temperature and relative humidity. Thus carburettor icing can occur at temperatures as high as +30ºC if the humidity is sufficiently high (as shown in Figure 1). The probability of carburettor icing is increased as the power setting of the engine is reduced. This is due to the increased pressure drop experienced on the downside of the carburettor butterfly valve (which closes progressively as the power is reduced), and the associated adiabatic temperature drop.

Fuel injection engines are significantly less prone to icing (induction system icing in the case of injected engines). This is because fuel is not introduced into the intake airflow in the area of the butterfly valve and thus the additional temperature drop, associated with the loss of the latent heat of vaporisation of the fuel, is absent, and the temperature drop is less severe. The Investigation recognises that there are additional capital costs in the purchase of injection-engined variants (the Robinson R44 is also supplied with a injected-engine version). However, in light of the frequency of carburettor accidents and incidents, the Investigation believes that prospective purchasers of helicopters in Ireland should consider the option of purchasing piston engine helicopters fitted with injection engines.

3. CONCLUSIONS

(a) Findings

1. No defect was found that could account for the loss of power or engine stoppage.
2. The ambient conditions were conducive to the formation of ice in the carburettor.
3. The engine bore evidence of limited use of manual carburettor heating selection.
4. The evidence of the incident is consistent with a carburettor icing event

(b) Cause

The probable cause of this incident was the formation of ice in the carburettor.

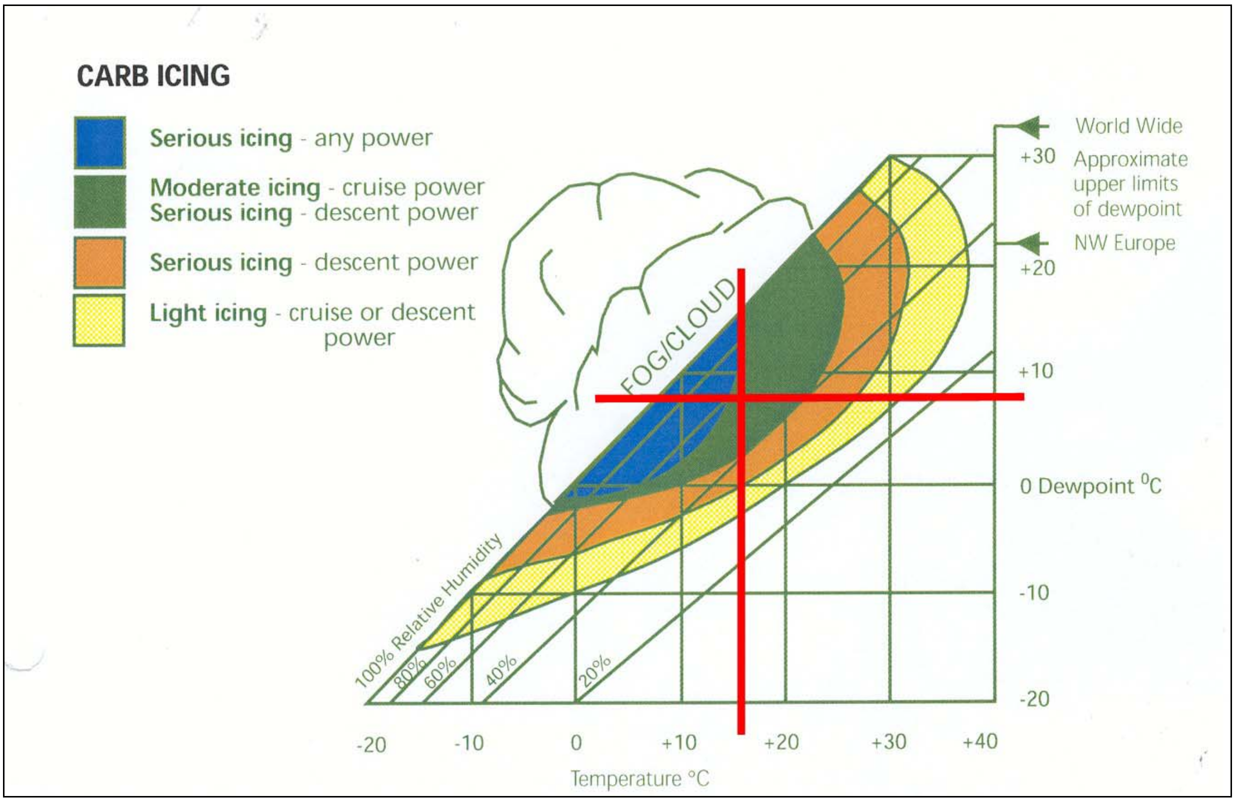
(c) Contributory Cause

Limited or non-use of carburettor heating was a contributing factor.

4. SAFETY RECOMMENDATIONS

This Investigation does not sustain any Safety Recommendations.

Figure 1



This figure shows the plot of the temperature and dew point in the Belfield area, at 1,000 ft, at the time of the incident, superimposed on the standard chart for carburettor icing. The data indicates that the helicopter was operating in the Moderate Icing – at cruise power - Zone and close to the boundary of the Serious Icing - at any power setting – Zone.

- END -