

ERA14TA096; Houlton, ME

How many helicopters were based at Houlton?

**In my 12 years, 3 months assigned to Houlton; we started with a MD-500C, then an OH-6A along with an EC-120B, followed by a BH-407 (Dept. of State modifications) and finally the AS350B3 (N578AE). We had 578AE for about two years at the time of the mishap.*

How many pilots/mechanics?

**From Nov 2002 to Jan 2008, myself and one other pilot; no mechanics employed, we contracted maintenance out on a job-by-job basis. We used Beals Aircraft Service at KHUL and New Hampshire Helicopters at KPSM. In Jan 2008, two other pilots came to the unit and the CBP maintenance contractor assigned one mechanic. I believe it was 2009 when two more pilots came in and put us at 5 pilots. The maintenance contractor placed a second mechanic at the operation during this time period. In 2013 our 6th pilot came on board and a 3rd mechanic. At the time of the mishap, six pilots & three mechanics were at the air branch.*

Were there any preexisting mechanical issues with the helicopter that you knew of?

**This aircraft was transferred to the Houlton Air Branch from the National Capital Region Air Branch. When it arrived the T/R blades were immediately replaced. One blade had what appeared to be fiberglass or paint damage on its surface near the inboard, or root, area. The damaged looked like a thick paint or fiberglass layer was 'balled up' into numerous mounds on the surface. I believe both the T/R swashplate assembly and the pitch change links were replaced due to excessive wear.*

In addition to these, when the aircraft arrived in Houlton, the throttle assembly and solenoid were found to be seized. This rendered the throttle inoperative with the FADEC in manual mode. The solenoid would not retract following a FADEC failure, or an intentional switching the FADEC to manual (during training scenarios & maintenance test flights). The throttle assembly was disassembled, cleaned and adjusted/rigged. I do not recall if the solenoid was replaced.

We had a low frequency vibration issue that took about five months to solve. The investigation into the vibration started in Aug 2013 and reached an apparent resolution in Jan 2014, the mishap month. I have included the presentation we made to document the vibration history, troubleshooting and corrective actions. Within the file, there is a discussion of the DECU (digital engine control unit) causing the NR/NF to vary significantly, and contributing to the vibration. The DECU is one of two components that comprise the FADEC (full authority digital engine control). The HMU (hydro-mechanical unit) is the other component.

Was there a tool control program? If so, please describe.

**Yes; the maintenance contractor required all tooling to be inventoried and kept in a specific location (bin, shelf, cabinet etc.). Government & personal tools were kept in a shadowed toolbox. All tools had to be signed out and had to be signed in as part of the job working standard and returning the aircraft back to service. I cannot say that I observed the mechanics following the tool control program 100% of the time. As with every group of humans, things 'slide by' on occasion.*

Were there any warnings before the "bang" or "explosion"?

**No, I saw nothing during the mishap flight that would indicate a problem with the engine. However, the Customs & Border Protection Officers on duty at the Houlton Port of Entry when the mishap occurred reported to the agency mishap investigators (Agency being CBP Office of Air & Marine) that when the helicopter passed over the port of entry on final approach to the airport, the engine sounded 'abnormal' and 'different'. Also, a border patrol agent patrolling the airport, adjacent to the US-Canada border reported the same type of 'abnormal' engine sound as the helicopter passed over head.*

From where did the explosion sound come?

**I perceived it to be from the engine or main gearbox compartment.*

What, if any, were your initial thoughts as to what happened?

**The copilot was doing NVG iterations; on the third one (the one when the mishap occurred), I thought he was too 'tail low' as he came through the hover to land. {I nudged the cyclic forward and cautioned him about the attitude} When the explosion occurred on takeoff, I initially wondered if the T/R had contacted the runway. I immediately dismissed this as there was no yaw, and the 'bang' did not sound as though it came from as far back as the T/R.*

Following the explosion, what was the sound volume compared to what you were used to?

**I estimate that within two seconds after the explosion the noise level had increased to a point that made the communication system barely audible. The noise grew so fast, and to such a level that when the audible NR activated, I initially could not discern which audible warning was going off.*

Was the type of sound abnormal? If so, what kind of sound did you hear?

**The normal noise is a somewhat high pitched 'whine' from the transmission; at least that is what I liken the sound to. The noise after the explosion was the same type of noise, just much louder.*

Why wasn't there an immediate landing?

**1) When the emergency occurs, the PF's immediate task is to control the aircraft; the PNF is to start the troubleshooting & evaluation of the problem. 2) The PF [the copilot] stopped the takeoff around 15 feet AGL; at only a couple of seconds into the scenario before the control problems began, neither pilot had the ability to know what the nature of the problem was, and therefore know if the helicopter could safely maneuver to an immediate landing. 3) Once the PNF [the PIC] took the flight controls, the aircraft control problems were of such magnitude that the helicopter could not be put in a reasonably normal attitude (skids level) to allow the pilot to roll the throttle to idle.*

What is the difference between a constant and an intermittent rotor rpm horn?

**The rotor RPM, or NR, warning functions with two different audible warnings; the low rotor warning and the high rotor warning. The low NR warning is a steady, or continuous, relatively low pitch tone that sounds when the NR is below 360 rpm. The high NR warning is an intermittent or broken tone, of a higher pitch than the low NR tone, which activates when the NR is greater than 410 rpm.*

The AS350-B3 has a third audible warning tone that activates when any engine power parameter (on the FLI or first limitation indicator) exceeds the maximum continuous power level for more than 1.5 seconds. This power warning tone is a steady, continuous tone as well.

While flying, did you hear any sounds of engine rpm or rotor rpm increase/decrease?

**Only during the mishap evolution. The engine & rotor sounds rapidly increased after the explosion; and then steadily decreased once the power turbine (NF) shed its turbine blades, effectively removing the power which drove the rotors. This was during the last 20 – 30 seconds of the mishap evolution.*

Did you see any instrument indications of engine rpm or rotor rpm increase/decrease?

**NO. As I tried to analyze the emergency after the explosion, I glanced inside the cockpit briefly and noticed the FLI presentation was below the maximum continuous index. I was not able to observe the other system indications on the VEMD because I had to focus my attention outside and on controlling the aircraft.*

Were there any vibrations after the explosion? If so, describe.

**Yes, two to three seconds after the explosion, as the later identified over speed progressed and the control problems ensued, the aircraft entered a severe vertical vibration.*

Did the vibrations continue throughout the rest of the flight?

**Yes; all the way through to about the last 20 seconds of the evolution.*

How did the passing of helicopter control occur from SIC to PIC?

**As the vertical vibration started, I grabbed the controls and stated "I have the control". At that time, I believe I saw the copilot (through my peripheral vision) raise his hands. I do not recall if he said anything.*

Is it possible both pilots were on the controls at the same time? If not, why not?

**I do not believe so; there was no resistance to the control inputs I made. Sometime in the middle of the evolution, the vibration reminded me of a 'pilot induced oscillation' I encountered in the past. For a brief second, I wondered if both of us were attempting to make collective inputs. I stated "let go of the controls". The copilot immediately lifted his hands to show me he was not on the controls. Additionally during the first portion of the evolution, I heard the copilot make the 'Mayday' call to the border patrol Law Enforcement Communications Specialist. He would have used the foot switch at his crew position.*

Describe the helicopter's flight characteristics after the explosion?

**The vertical vibration became very significant in the first few seconds. Then the aircraft began to yaw excessively and enter bank and pitch excursions. The 'excursions' seemed to increase in magnitude when I made corrective control inputs. The bank excursions reached 30-45 degrees; the yaw excursions seemed to be no more than 20 degrees. I did not perceive the pitch excursions to exceed 10 degrees.*

To what do you attribute the increased flight excursions after the explosions?

**I believe the rotor system's extreme over speed condition produced transonic and supersonic regions across the rotor disc; across airfoils that are not designed for supersonic flight. This condition would seriously deteriorate the main rotor blades ability to produce lift; the shock waves from supersonic airflow would also decrease the rotor blades efficiency.*

What occurred approaching the snow bank; why land after the snow bank?

**The transmission noise began to subside and I regained full aircraft control. I estimate this happened about 150 yards from the snow bank. The helicopter's altitude was about 15' at ETL airspeed. The helicopter had just come through an event where aircraft controllability was marginal; control inputs seemed to aggravate the attitude excursions. I did not believe it prudent to 'rashly' manipulate the flight controls and commit the aircraft to a ground impact. Also, the approximate 150 yard distance between the aircraft and the snow bank was asphalt; I elected to put the aircraft down on several inches of snow, covering a grassy field instead. I had control of the aircraft, and I made a deliberate, controlled shallow approach to a point well past the asphalt and snow bank.*

With a governor failure what happens with the fuel flow?

**The governor has three components: HMU, Fuel Metering Unit and DECU. If any of the three fail, the red 'GOV' illuminates. The Eurocopter AS350 Instruction Manual for B3 variants, and Eurocopter Service Letter 1702-71-05 both state that a governor failure (red 'GOV' light) will cause a seizure of the fuel metering valve, freezing the fuel flow to the engine. Therefore; if the governor fails, illuminating the red 'GOV' light, the fuel flow to the engine can only be modified by the pilot manipulating the throttle twist grip. There is also an acceleration controller in the fuel metering unit that prevents engine surges when the pilot increases the fuel flow in manual mode. The twist grip was not moved during this mishap, until successfully completing the emergency landing at the end of the evolution. Evidence for this is the amber 'TWIST GRIP' light never illuminated. After the explosion, the fuel flow rapidly increased without pilot input.*

What ways can an engine overspeed be pilot-induced?

**When operating in manual mode on the FADEC, the pilot can manipulate the twist grip and collective in an uncoordinated manner and over speed the engine. Asynchronous movement of the collective will affect the NR more readily than the engine. Also, when conducting autorotation training, it is possible for the pilot to inadvertently energize the twist grip solenoid lock and rotate the twist grip past the 'VOL', or flight detent, when recovering the engine speed to terminate the training maneuver. Note that the mishap helicopter, N578AE, had a modified twist grip which included an automatic solenoid. This prevents an inadvertent activation. See NTSB accident report LAX03GA145.*

What ways can an engine overspeed be non-pilot-induced?

**A mechanical failure in the HMU or fuel metering unit, or some type of failure in the DECU. See Turbomeca Service Letter 2362/05/AR2B/23; Turbomeca Service Bulletin 292 71 2180; NTSB accident reports LAX05GA231 & FTW02LA247.*

When did you first become aware of the possible existence of fire? How?

**As the aircraft approach the ground during the emergency landing; I saw the orange glow on the snow around the helicopter. The red 'FIRE' light did not activate.*

When the collective was lowered was there any change in sound?

**No. I fully lowered the collective as the skids contacted the ground; there were no sound changes.*

Was the engine operating upon touchdown?

**I do not believe so. There were no sounds coming from the engine as I completed the emergency landing.*

If so, how do you know?

**Not applicable.*

At what point do you feel the engine started shedding blades? Why?

**When the helicopter began to 'calm down'. The Arriel 2B engine is designed so the NF blades will shed when the NF speed reaches 143% to 150% of the nominal speed. This equates to 558 - 585 rpm NR/NF.*

What type of NVGs did you use?

**ITT F4949 ANVIS 9.*

What kind of sight restriction(s) occur with that make of NVG?

**There are no restrictions to vision apart from the limitations associated with every set of ANVIS 9 NVGs. The person's field of view is 40 degrees and the best visual acuity obtained can be at least 20/40. The field of view is mitigated by constant, proper scanning and head movement. When properly adjusted you can look under the NVGs to see the instrument panel and cockpit; your peripheral vision combined with proper scanning allows you to identify lighted obstructions and aircraft. Depth perception is the only decreased visual factor. The NVGs had no negative impact on my vision during the mishap flight.*

What kind of NVG training have you received?

**I completed the U.S. Border Patrol Initial NVG qualification course in 2000. Ten days and I believe 15 hours of NVG flight training, with a final check ride.*

What was the extent of helo make and model training received?

**After the agency reorganized into CBP Office of Air & Marine, on Oct 1, 2005, the specific airframe transition training on NVGs was only three hours of NVG flight training.*

How often does recurrent training occur and by whom?

**The Border Patrol Air Operations manual required 45 day currency and an annual NVG academic test, and check ride. After becoming CBP, OAM; a 60 day currency was required with an annual test and check ride as well. I believe in Jan 2013, CBP, OAM decided to conduct NVG operations in accordance with FAR Part 91 & 61, exclusively. There never has been (at least in my tenure) a central NVG recurrent training course. NVG currency and proficiency was left up to each field unit, and largely each individual pilot.*

Who schedules recurrent training?

**The unit instructor pilot, training officer or supervisor.*

What kind of emergency procedures training occurs while wearing NVGs?

**Operating as the Border Patrol, all emergencies were trained under NVGs. Operating as CBP, OAM, no emergency procedures training utilizing NVGs were allowed.*

What kind of simulator training occurs?

**The Border Patrol incorporated training in high performance, single engine Cessna simulators. CBP OAM did not utilize any fixed-wing, or rotor-wing flight simulators.*

Does simulator training occur with NVGs?

**No. See above response.*

Any additional thoughts?

**This was not merely a governor failure when the sequence of events were: An explosion of some sort; a near instantaneous engine over speed that was accompanied by an engine chip light, fuel pressure light and door light. The fuel pressure light sensor is located between the low pressure pump and the high pressure pump, inside the HMU. If the fuel pressure inside the HMU dropped low enough to illuminate the warning light, how could the fuel flow to the engine increase at all, whether 'pilot induced' or not? There is a diaphragm inside the HMU called the 'constant delta pressure diaphragm'. Turbomeca has issued a service letter addressing rupture of the constant delta pressure diaphragm in the HMU of Arriel 2B and 2F engines. A rupture of this diaphragm causes an uncontrollable engine over speed. The HMU on N578AE was not torn down for inspection, at least in the U.S.*

**There is also a Turbomeca Service Bulletin (issued 30 days after N578AE's mishap) addressing a problem with the co-joined fuel drain lines from the combustion chamber and the HMU. It was discovered that when the engine compressor was washed, the soap solution would enter the HMU through the co-joined drain lines; this caused corrosion on the rotating (driven) parts inside the HMU. These parts (including the low pressure fuel pump and high pressure fuel pump) are driven by the accessory gearbox and drive (module 1). This accessory gearbox has two chip detectors. The first fault recorded by the VEMD was the 'stepper motor' gear in the HMU. When the OAM investigators removed the chip detectors, there was a large metal piece on one of the detectors. This was verified by the branch Director of Air Operations and one other pilot assigned to the air branch. The Director told me there were several pictures taken of the chip detector.*

**The 'DOOR' light illuminated because of the forces applied to the airframe during the over speed. The four lights on the Caution & Warning Panel illuminated simultaneously a couple of seconds after the explosion occurred. Six out of the eight center belly pan were sprang open from the forces.*

**My copilot, Director and myself asked several questions of the OAM safety office after they produced their report for the agency's leader, the Assistant Commissioner of OAM. The questions were responded to, but not with any documentation of the factual information. We made a FOIA request to see the facts from which OAM drew their conclusions about this mishap. OAM ignored the request and did not respond, or even acknowledge the request. I will provide the questions we came up with for OAM to clarify and document their facts.*

1. If this was a governor failure, why was the aircraft on fire?

- 2. Why was the fire located in the forward part of the engine, the compressor section?*
- 3. Why was the aircraft noise reported as 'abnormal' when it flew over witnesses, who were federal law enforcement officers familiar with the 'normal sound of this aircraft'?*
- 4. Why did the fuel pressure light and engine chip light illuminate? If the position is that the PIC misidentified the lights, what four lights were illuminated?*
- 5. What was the 'bang' or 'explosion' at the start of the evolution?*
- 6. What caused the vertical vibrations and lack of aircraft controllability? Why were the vibrations severe enough to spring the baggage compartment doors, illuminate the 'DOOR' light, pop open the copilot's door and forcibly open six belly panel latches?*
- 7. If the FADEC was in 'mixed mode' (that mode being in 'auto' and the twist grip out of the 'VOL' detent); how did the PIC access the high side of the governor when the acceleration controller in the fuel metering unit prevents engine surging? Why wasn't the amber 'TWIST GRIP' light and amber "GOV" light illuminated? Why was the red 'GOV' light on when it is not supposed to be on in the mixed mode?*
- 8. How can you come to conclusions and identify 'contributing factors' without knowing what caused the mishap evolution to begin with?*
- 9. What facts led to the conclusion that both pilots were fighting over the controls? If this were the case, how did the copilot remain on the controls and use his foot switch to transmit a Mayday call; use his hand to close the door?*
- 10. What facts led to the conclusion that the NVGs blocked the PIC's view of the caution & warning panel; considering the PIC could identify four lights on the CWP and the copilot stated 'several' lights were illuminated on the CWP? Again, if the PIC misidentified the CWP lights, what lights were on?*
- 11. If the failure occurred approximately 10' off the ground; if it was just a governor failure and the over speed was caused by lowering the collective, why didn't the aircraft descend and contact the ground?*