SOUTH AFRICAN CIVIL AVIATION AUTHORITY

*Section/division* **Accident and Incident Investigations Division** Form Number: CA 12-57

# LIMITED OCCURRENCE INVESTIGATION REPORT – FINAL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Reference Number** | CA18/2/3/10422 | | | | | | |
| **Classification** | Accident | **Date** | 19 February 2024 | | **Time** | 1140Z | |
| **Type of Operation** | Aerial Works – Game Culling (Part 137) | | | | | | |
| **Location** | | | | | | | |
| Place of Departure | Doornhaag Farm near Vryburg, North West Province | | Place of Intended Landing | | Elandsheuwel Farm near Potchefstroom, North West Province | | |
| Place of Occurrence | 5.3 nm south-east of Potchefstroom Aerodrome (FAPS) in Elandsheuwel Farm, North West Province | | | | | | |
| GPS Co-ordinates | Latitude | 26° 44' 40.3" S | Longitude | 27° 11' 15.0" E | Elevation | 4 641 feet | |
| **Aircraft Information** | | | | | | | |
| Registration | ZT-RBZ | | | | | | |
| Make; Model; S/N | Robinson; R44 Raven II (Serial Number: 0873) | | | | | | |
| Damage to Aircraft | Substantial | | Total Aircraft Hours | | 2 245.2 | | |
| **Pilot-in-command** | | | | | | | |
| Licence Type | Commercial Pilot Licence (CPL) | | Gender | Male | Age | 29 | |
| Licence Valid | Yes | Total Hours | 2 605.5 | Total Hours on Type | | 2 300 | |
| Total Hours 30 Days | 76.8 | Total Flying on Type Past 90 Days | | 102.9 | | | |
| **People On-board** | 1+2 | **Injuries** | 0 | **Fatalities** | 0 | **Other (on ground)** | 0 |
| **What Happened** | | | | | | | |

On Monday, 19 February 2024 at approximately 1140Z, a pilot and two passengers on-board a Robinson helicopter R44 Raven II with registration ZT-RBZ were involved in a game culling operation at Elandsheuwel Farm near Potchefstroom Aerodrome (FAPS), North West province. The flight was conducted under visual meteorological conditions (VMC) by day and under the provisions of Part 137 of the Civil Aviation Regulations (CAR) 2011 as amended.

According to the pilot, he completed a pre-flight inspection with no anomalies found. He refuelled the helicopter with 49.9 litres (L) of AVGAS, which brought the total fuel in both tanks to 117.3L. The helicopter took off from Doornhaag Farm near Vryburg to Elandsheuwel Farm, situated 142 nautical miles (nm) south-west of Doornhaag Farm in the same province. The intention of the flight was to conduct a game culling and capturing operation. The flight duration from Doornhaag Farm to Elandsheuwel Farm was 90 minutes.

Upon arrival at Elandsheuwel Farm, three of the four helicopter doors were removed; only the right rear door was left intact. Thereafter, the pilot and the passengers commenced with the game culling and capture operation. Whilst repositioning the helicopter, approximately 50 minutes into the operation at 50 feet (ft) above ground level (AGL) and at a forward speed of 30 knots (kt), the helicopter’s low rotor revolutions per minute (RPM) warning horn sounded, followed by the warning light which illuminated on the instrument panel. The main rotor RPM dropped from 102% to 87%. The pilot increased throttle and lowered the collective to regain speed but was out of time. The helicopter landed hard and the main rotor blades severed the tail boom. The helicopter rested in an upright position next to a fence. None of the occupants was injured.


**Figure 1:** The helicopter after it had stopped. (Source: Pilot)

**Figure 2:** The severed tail of the helicopter. (Source: Pilot)

ZT-RBZ

DATA | CG | SUMMARY

| | Weight | Longitudinal | | Lateral | |
|---|---|---|---|---|---|
| | (lb) | Arm (in) | Moment (in-lb) | Arm (in) | Moment (in-lb) |
| Empty | 1546 | 107,9 | 166820,8 | 170425,3 | 263477473 |
| Pilot | 180 | 49,5 | 8910 | 12,2 | 2196 |
| Pilot baggages | 0 | 44 | 0 | 11,5 | 0 |
| Co-pilot | 180 | 49,5 | 8910 | -10,4 | -1872 |
| Co-pilot baggages | 0 | 44 | 0 | -11,5 | -0 |
| Pax 1 | 180 | 79,5 | 14310 | -12,2 | -2196 |
| Pax 1 baggages | 0 | 79,5 | 0 | -12,2 | -0 |
| Pax 2 | 0 | 79,5 | 0 | 12,2 | 0 |
| Pax 2 baggages | 0 | 79,5 | 0 | 12,2 | 0 |
| Sling | 0 | 93,9 | 0 | 0 | 0 |
| **Zero fuel** | **2086** | **95,4** | **198950,8** | **126306,6** | **263475601** |
| Main tank 15.0 US gal | 90,1 | 106 | 9555,9 | -13,5 | -1217 |
| Aux tank 5.0 US gal | 30 | 102 | 3065,1 | 13 | 390,6 |
| **Take-off** | **2206,2** | **95,9** | **211571,8** | **119424,7** | **263474774,6** |

No crew doors are installed
Only the right passenger door is installed

**Table 1:** Weight and balance sheet. (Source: Pilot)

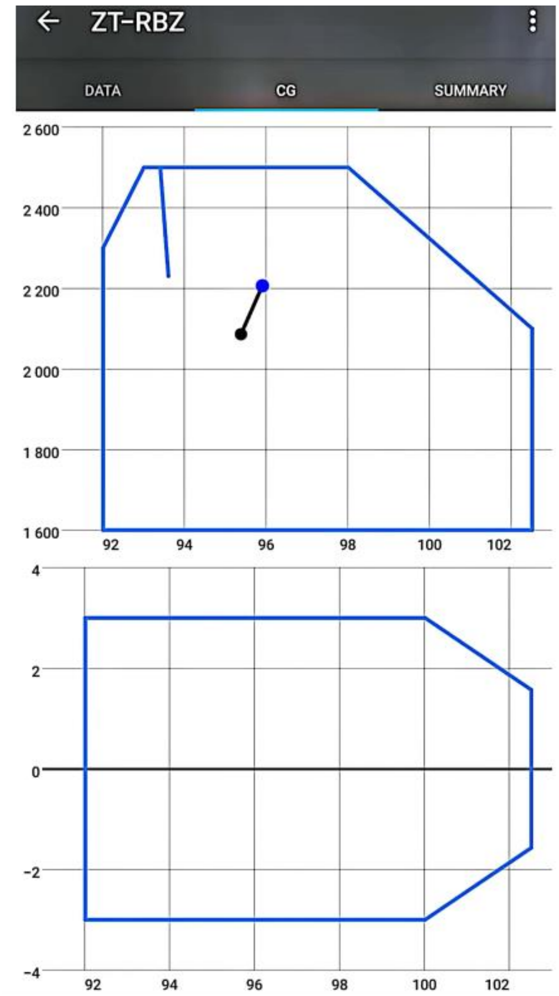



**Chart 1**: The Centre-of-gravity chart. (Source: Pilot)

According to the South African Weather Service (SAPS), the meteorological aerodrome report (METAR) at 1200Z that was issued for Potchefstroom Weather Station (the closest weather station to the accident site) was as follows:

Visibility: >10km
Cloud: No clouds
Current temperature: 32.0ºC
Dew point temperature: 17ºC
Wind direction and speed: 110º 3kt
Pressure reduced to mean sea level: Q1023 hPa

Fuel Calculations
According to the pilot, the aircraft had approximately 87L of Avgas at the beginning of the game culling and capture operation; the fuel consumption was 29.5L per hour. Approximately 57.5L of fuel remained in the tanks after the hard landing. The helicopter had sufficient fuel for the operation.

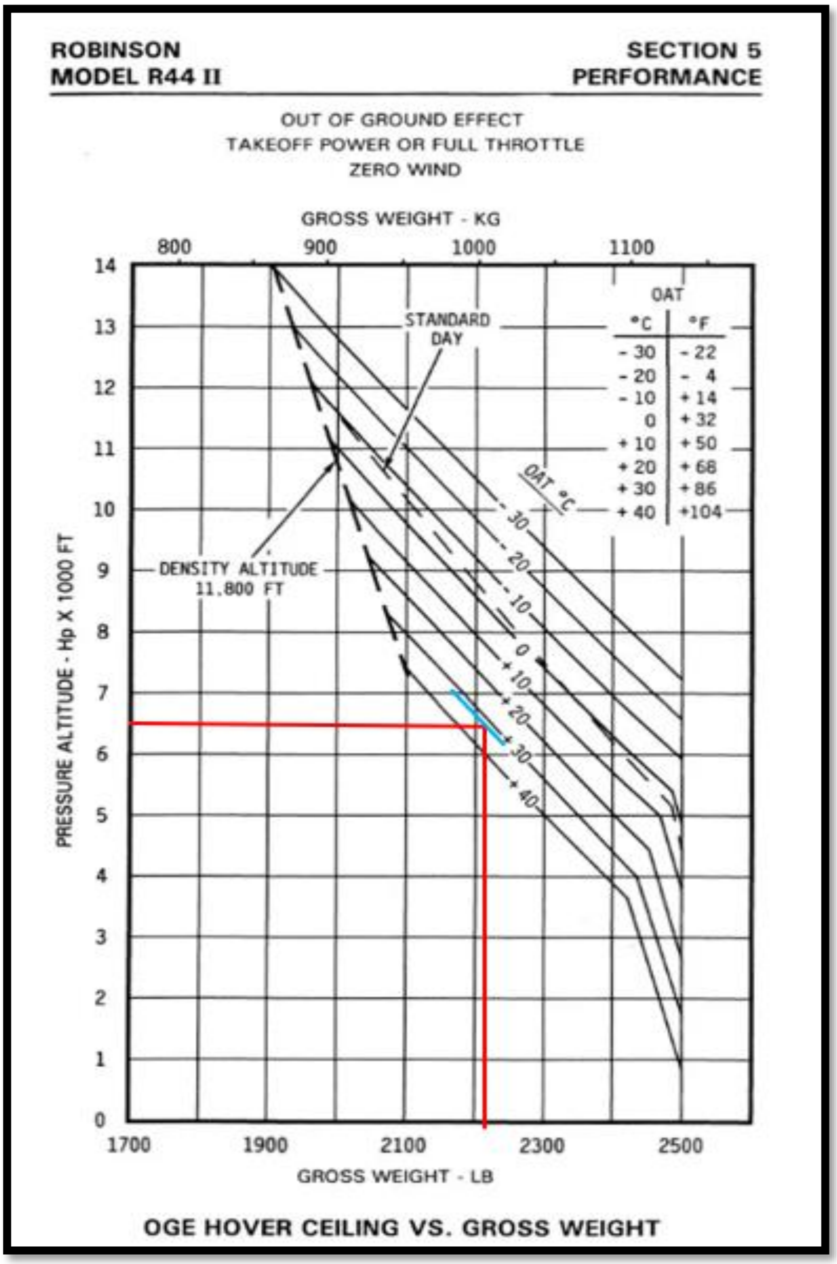
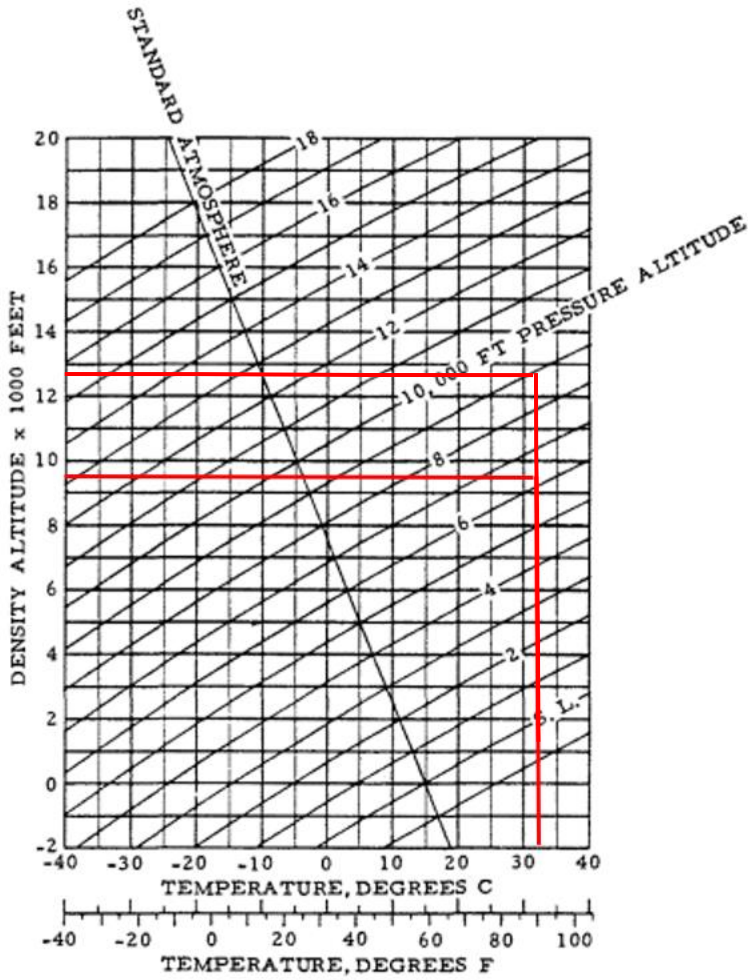



**Chart 2:** Out-of-ground effect (OGE) hover vs. gross weight. (Source: Pilot's Operating Handbook)

Considering the out-of-ground effect (Chart 2) vs. gross weight (Table 1), the pilot calculated the weight of the helicopter at 2 206.3 pounds (lbs) and the temperature at 32ºC at the time of the flight. The helicopter could hover at a pressure altitude of approximately 6 500 ft.

**ROBINSON**
**MODEL R44**

**SECTION 5**
**PERFORMANCE**




**DENSITY ALTITUDE CHART**

**Chart 3:** Density altitude chart. (Source: Pilot's Operating Handbook)

Density Altitude Calculations:
The above density altitude chart was used to determine the density altitude. When plotted against the pressure altitude of 6 500 lbs and the temperature of 32ºC, the density altitude was determined to be approximately 9 600 ft.

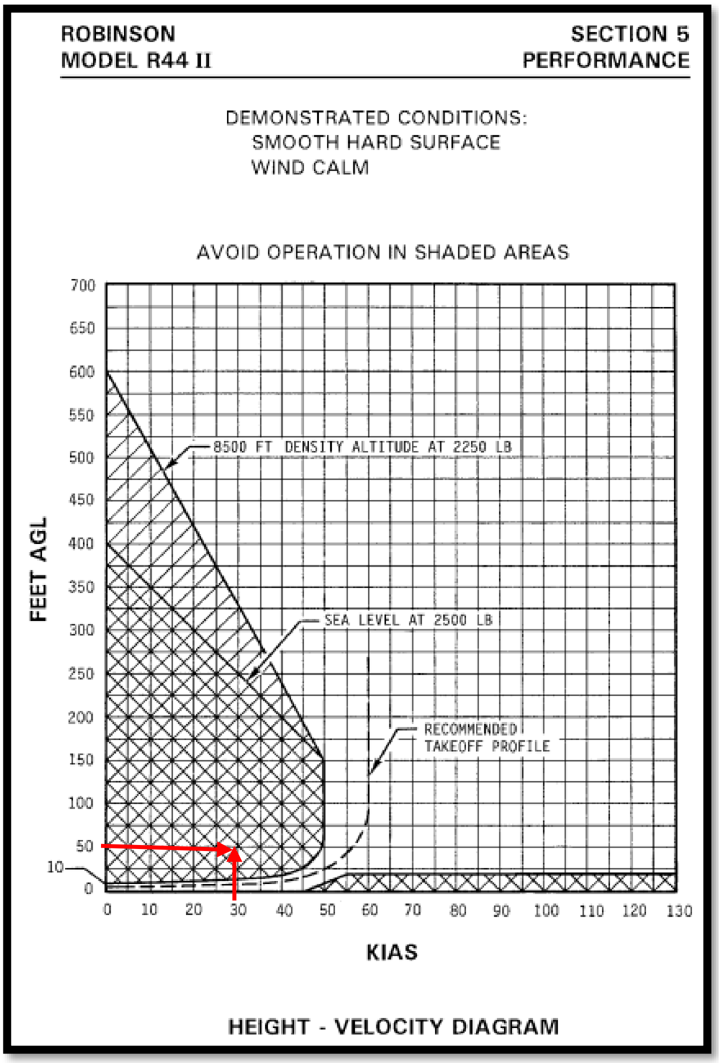



**Chart 4**: Velocity vs height. (Source: R44 Pilot's Operating Handbook)

During take-off, pilots pay attention to avoid the shaded area (shown in Chart 4). Moreover, the rate of climb must be limited to a maximum 500 feet per minute ( ft/min) below 100 ft above ground level (AGL) to limit loss of rotor speed in the event of power failure. The Pilot's Operating Handbook (POH) states that the shaded area in Chart 4 should be avoided. The height velocity (Chart 4) calculations were in the shaded area when the helicopter was being repositioned at 50ft AGL at a speed of 30 kt.

**LIMIT MANIFOLD PRESSURE - IN. HG**

| MAXIMUM CONTINUOUS POWER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PRESS ALT-FT | OAT-°C | | | | | | | |
| | -30 | -20 | -10 | 0 | 10 | 20 | 30 | 40 |
| SL | 22.6 | 22.9 | 23.2 | 23.5 | 23.8 | 24.1 | 24.4 | 24.7 |
| 2000 | 22.2 | 22.5 | 22.8 | 23.1 | 23.4 | 23.7 | 24.0 | 24.2 |
| 4000 | 21.8 | 22.2 | 22.5 | 22.8 | 23.1 | 23.4 | 23.7 | 23.9 |
| 6000 | 21.4 | 21.8 | 22.1 | FULL THROTTLE | | | | |
| FOR MAX TAKEOFF POWER (5 MIN), ADD 1.6 IN. | | | | | | | | |

**Figure 3:** Limit manifold pressure. (Source: POH)

According to the POH, the maximum allowable take-off weight is 2 400 lbs. The weight and balance provided by the pilot was 2 206.2 lbs, which was within limits.

With the outside air temperature of 32ºC and the elevation of 4 641 ft (Chart 2), the pressure altitude was determined to be 6 500 ft. The pressure altitude was outside the limit manifold pressure chart which requires full throttle in inches of mercury (In Hg). For maximum take-off power (Chart 4), one needs to add 1.6 In Hg to the calculated full throttle.

The pilot stated that the pressure manifold during the flight was at 23 In Hg, which was below the full throttle power. This meant that the power required for the flight exceeded the power available. Therefore, the helicopter did not have enough power to sustain the flight and, thus, experienced low rotor RPM. The POH states that 23 In Hg is in the amber range. For maximum take-off power, the helicopter required approximately 22 In Hg or below to enable the pilot to add 1.6 In Hg to the full throttle to reach 24 In Hg.

According to the POH, "*full throttle indicates the engine is near full throttle. The governor will be ineffective because it cannot increase the throttle to maintain RPM. Lower the collective as required to extinguish the light.*

***Safety Notice 24***
*When the rotor stalls, it does not do so symmetrically because any forward airspeed of the helicopter will produce a higher airflow on the advancing blade than on the retreating blade. This causes the retreating blade to stall first, allowing it to dive as it goes aft while the advancing blade is still climbing as it goes forward. The resulting low aft blade and high forward blade become a rapid aft tilting rotor disc sometimes referred to as "rotor blow-back". Also, as the helicopter begins to fall, the upward flow of air under the tail rotor surfaces tends to pitch the aircraft nose down. The two effects, combined with aft cyclic by the pilot attempting to keep the nose from dropping, will frequently allow the rotor blades to blowback and chop off the tail boom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of rotor blades, rotor teeter stops will not prevent the boom chop. The resulting boom chop, however, is academic, as the aircraft and its occupants are already doomed by the stalled rotor before the chop occurs.*

| Findings |
|---|
| 1. The pilot was initially issued a Commercial Pilot Licence (CPL) Helicopter on 17 December 2020. The licence was renewed on 17 December 2023 with an expiry date of 31 December 2024.<br><br>2. The pilot had a Class 1 aviation medical certificate that was issued on 24 November 2023 with an expiry date of 30 November 2024 with no restrictions. The pilot was medically fit to conduct the flight.<br><br>3. The last mandatory periodic inspection (MPI) conducted on the helicopter was on 26 January 2024 at 2 211.6 Hobbs hours. The helicopter was issued a Certificate of Release to Service (CRS) on 26 January 2024 with an expiry date of 25 January 2025 or at 2 309.84 Hobbs hours, whichever occurs first. The helicopter accrued 33.6 hours since the last MPI.<br><br>4. The helicopter had a valid Certificate of Airworthiness (C of A) which was initially issued on 31 January 2018. The C of A was last renewed on 1 February 2024 with an expiry date of 28 February 2025. The helicopter's Certificate of Registration (C of R) was issued to the owner on 22 November 2017.<br><br>5. The aircraft maintenance organisation (AMO) that was responsible for the maintenance of the helicopter had a valid certificate of approval that was issued on 31 October 2023 with an expiry date of 30 November 2024.<br><br>6. The operator had a valid Air Operating Certificate (AOC) and the helicopter was listed on the operation specifications (OpSpecs) that was issued on 31 January 2024 with an expiry date of 31 January 2025.<br><br>7. The pilot repositioned the helicopter when it was 50ft AGL at a speed of 30 kt, which is in the shaded area of the velocity height diagram. This resulted in loss of rotor speed.<br><br>8. According to the density altitude chart, the required power exceeded the power available; this resulted in a drop in the rotor RPM. The pilot elected to perform a forced landing (and did not recover the RPM by rolling the throttle, lowering the collective and applying aft cyclic as required in the POH). The main rotor blades reached a critical stall region which caused them to drop and sever the tail boom. |
| **Probable Cause(s)** |
| Loss of rotor RPM during manoeuvre, followed by the main rotor stall which caused them (main rotor) to sever the tail boom and, thus, the resultant hard landing. |
| **Contributing Factor(s)** |
| Failure to consider the effects of high-density altitude.<br><br>Operating in the shaded area of the velocity height diagram range which is prohibited. |
| **Safety Action(s)** |
| None. |
| **Safety Message and/or Safety Recommendation/s** |
| Pilots who operate in areas of high altitude must always ensure that the effects of high-density altitudes are considered before commencing flight. |

In the interest of safety, it is recommended that the manufacturer updates the safety notices and add game and culling operations to be read together with Safety Notices 10, 24 and 34 because flights during these types of operation had, in the past, resulted in serious injuries and damage to aircraft.

**About this Report**

*The decision to conduct a limited investigation is based on factors including whether the cause is known and the evidence supporting the cause is clear, the level of safety benefit likely to be obtained from an investigation and that will determine the scope of an investigation. For this occurrence, a limited investigation has been conducted, and the Accident and Incident Investigations Division (AIID) has relied on the information submitted by the affected person/s and organisation/s to compile this limited report. The report has been compiled using information supplied in the initial notification, as well as from follow-up desktop enquiries to bring awareness of potential safety issues to the industry in respect of this occurrence, as well as possible safety action/s that the industry might want to consider in preventing a recurrence of a similar occurrence.*

*All times in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.*

***Purpose***

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011 and ICAO Annex 13, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not apportion blame or liability.*

**Disclaimer**

*This report is produced without prejudice to the rights of the AIID, which are reserved.*

**This report is issued by:**

**Accident and Incident Investigations Division**
**South African Civil Aviation Authority**
**Republic of South Africa**

# Safety Notice SN-10

Issued: Oct 82 Rev: Feb 89; Jun 94

## FATAL ACCIDENTS CAUSED BY LOW RPM ROTOR STALL

A primary cause of fatal accidents in light helicopters is failure to maintain rotor RPM. To avoid this, every pilot must have his reflexes conditioned so he will instantly add throttle and lower collective to maintain RPM in any emergency.

The R22 and R44 have demonstrated excellent crashworthiness as long as the pilot flies the aircraft all the way to the ground and executes a flare at the bottom to reduce his airspeed and rate of descent. Even when going down into rough terrain, trees, wires or water, he must force himself to lower the collective to maintain RPM until just before impact. The ship may roll over and be severely damaged, but the occupants have an excellent chance of walking away from it without injury.

Power available from the engine is directly proportional to RPM. If the RPM drops 10%, there is 10% less power. With less power, the helicopter will start to settle, and if the collective is raised to stop it from settling, the RPM will be pulled down even lower, causing the ship to settle even faster. If the pilot not only fails to lower collective, but instead pulls up on the collective to keep the ship from going down, the rotor will stall almost immediately. When it stalls, the blades will either "blow back" and cut off the tailcone or it will just stop flying, allowing the helicopter to fall at an extreme rate. In either case, the resulting crash is likely to be fatal.

No matter what causes the low rotor RPM, the pilot must first roll on throttle and lower the collective simultaneously to recover RPM **before** investigating the problem. It must be a conditioned reflex. In forward flight, applying aft cyclic to bleed off airspeed will also help recover lost RPM.