United States Helicopter Safety Team

Our Vision: A Civil Helicopter Community with Zero Accidents

Power Available Limitations

A USHST Airmanship Safety Bulletin (Part 2)

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Demanding more power than the engine(s) can deliver, then continuing to increase the collective can be disastrous. This is especially true at the bottom of an approach, or in an OGE hover at or near the power limits of the machine. The High-Altitude Army Aviation Training Site (HAATS) in Eagle, Colorado, defines *Power Management* as knowing how much power is available for a maneuver and comparing that with an understanding of how much power is required. The United States Helicopter Safety Team (USHST) has determined that inadequate power management and exceeding limitations is the cause of nearly 20 percent of all helicopter accidents every year.

OVER TORQUING OR OVERPITCHING ON AN APPROACH

At the bottom of an approach, if you grab a fair amount of collective to arrest the descent rate, the output of the engine(s) may not be able to maintain rotor RPM. Reciprocating engine powered helicopter pilots for years have referred to this as “overpitching.” In a turbine powered machine in the same situation, chances are you will experience an over torque. This is not a Vortex Ring State (VRS) condition (discussed in Part 1).

In an OGE hover, even a slight descent can lead to a big power rise. As the helicopter descends vertically at one or two hundred feet per minute, the power needed to keep from accelerating downward rises by perhaps two to five percent according to Nick Lappos, a former Sikorsky test pilot and engineer. If the descent continues unchecked, without accelerating forward to obtain some effective translational lift, the vortices created by the rotor will increase and could lead to full VRS.

REACHING A POWER LIMIT

If power limited in a hover, the machine will have trouble reaching effective translational lift for takeoff. If the helicopter has reached its environmental service limit in cruise flight, the helicopter will not climb any higher. Since the engine(s) have reached their limit, increasing the collective will cause the rotor RPM to droop, or slow down. In the turbine engine world, this condition may be referred to as N1 topping. A good analogy is driving your car over a mountain pass. As you drive farther and farther up the mountain, you depress the accelerator pedal more toward the floor. When the accelerator pedal gets to the floor, the car has no additional power and starts to slow down. The car's engine is giving you all the power it has.

A helicopter in this situation will not be able to maintain rotor RPM. If you keep pulling up on the collective to increase thrust, or try to arrest the descent rate, the rotor will droop, and it drags the engine RPM down with it. With any decrease in rotor RPM, an increase in the coning angle will occur. Coning is a very second order effect compared to decreasing rotor RPM. Also, with a decrease in rotor RPM, the tail rotor also slows down, and can lead to a loss of directional control and an uncommanded spin (LTE).

EXPERIENCING A POWER AVAILABLE LIMITATION SITUATION

In an OGE hover, or slow flight above the helicopter's service ceiling, once the rotor RPM decays, the descent increases rapidly because thrust is proportional to RPM squared. At a certain engine and low rotor RPM, depending on the model, the helicopter may become uncontrollable due to blade stall. At this critical point, if there is no maneuver room, the impending result is, at the very least, embarrassing (provided you survive).

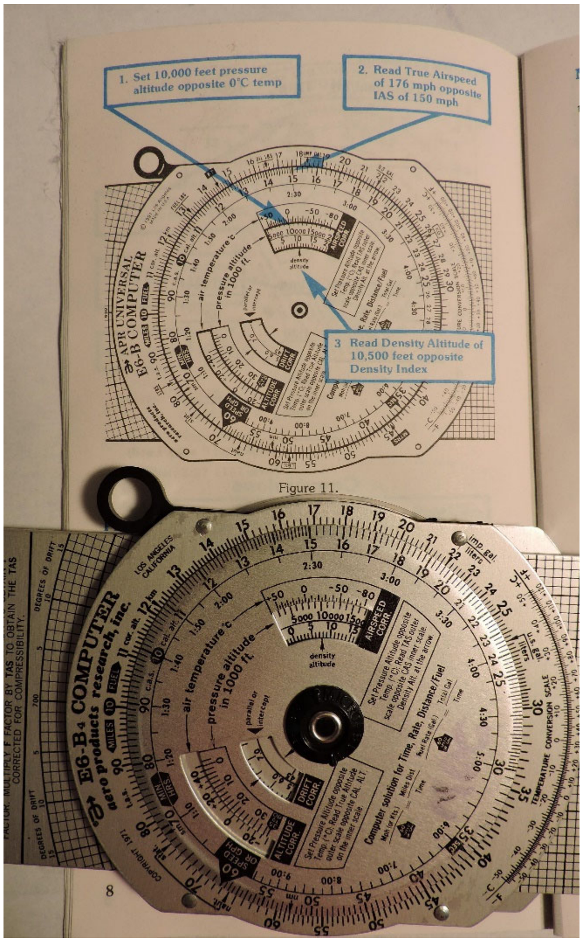
When can you experience a power available limitation situation?

1. Taking off overloaded, or on a hot day, or with high humidity at high altitude, or with a tail wind and not having enough power to clear an obstacle or trees (N1 topping).

2. Coming in too hot (or fast, with the rotor disk tilted aft at a steep angle in relation to the ground), too heavily loaded, or downwind on an approach, then trying to arrest the descent rate at the bottom (overpitching)…with insufficient power to develop high thrust needed to arrest the descent rate.

3. Trying to hover out-of-ground effect at an altitude exceeding the chart limits, or

4. Trying to get over a mountain pass that is above the service ceiling of your helicopter.



HIGH DENSITY ALTITUDE OPERATIONS

Helicopters perform much differently at higher altitudes, high humidity, high outside air temperatures, and at or near maximum gross weight. At altitude and in high temperature the engine will develop less power, while simultaneously, the rotor needs more power to develop the same thrust. As a helicopter climbs higher, the air gets thinner and less lift is produced by the rotor blades. Technically, if the helicopter gets to the altitude, the blades develop 1-g thrust. The problem is that if the pilot slows the helicopter down, the rotor will need more power, and then the rotor RPM decay ensues, and the settling occurs. At altitude, power available is less, and power required is more. The decrease in performance can be so significant that the pilot may not realize he or she is out of power until it's too late. On approach to a landing, the approach angle and subsequent collective input at the bottom of an approach that worked just fine during a solo flight (or with less baggage, cargo, or passengers onboard), or at a lower density altitude, suddenly won't necessarily arrest the helicopter's rate of descent.

LOSS OF CONTROL INFLIGHT

Most pilots, after experiencing a power available limitation situation, are confused by what happened. The first thing most pilots say (providing they survive) is; "I had an engine failure." Not true. In many cases the NTSB sends the engine(s) in for analysis and discovers the engine(s) was operating just fine right up until the point of impact. If video of the incident exists, manufacturers can perform a sound analysis and determine the rotor and/or engine RPM at time of impact. In nearly every case, they determine the rotor or engine RPM is way below the red line. Every one of these accidents could have been completely avoided with a little bit of knowledge and proper prior planning.

TRAIN FOR THE ENVIRONMENT

Logically, to prevent power management accidents we need to start training in the environments we will be tasked to fly. If flying involves high altitude operations, the training should not be exclusively performed at sea level. Most flight training occurs in a controlled environment, either at or near sea level altitudes, at a low gross weight, and with minimum fuel states. We routinely fly with minimum fuel because it gives us safer margins for maneuvers. However, this may be a disservice to new pilots because they are not receiving the training they need to properly operate at the limits of their helicopter's performance envelope. To prepare new pilots for these differences in helicopter performance and handling, flight instructors should conduct a portion of the training flights in different environments at increased gross weights (and at least one flight at maximum gross weight). Special attention should focus on the differences in helicopter performance, control and power management demands from what was planned verses the actual helicopter performance.

PREFLIGHT PLANNING IS ESSENTIAL

Thorough preflight planning is essential to prevent power management accidents and inadvertent VRS. Flight manual performance chart calculations are an integral part of this planning. However, charts vary wildly across manufacturer models. Some manuals are not as detailed as others and may require pilot interpretation of the available charts to match a planned flight environment.

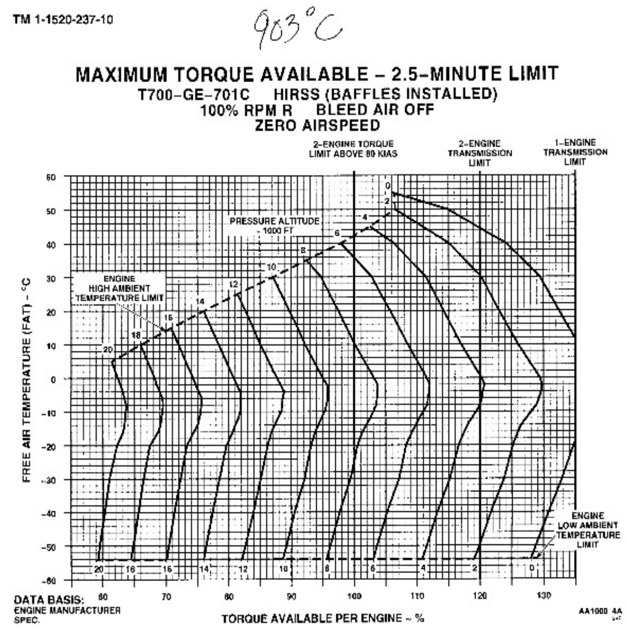


Figure 7A-4. Maximum Torque Available (Sheet 1 of 3)

VERIFY HOVER POWER CHECKS BEFORE EVERY TAKEOFF

When working off airport, expect ambient conditions at an intended area of operation to be different from those planned for. Flight manual performance graphs denote the operation of a brand new or "spec" engine with clean rotor blades, so calculated values must always be verified with an actual hover power check under the ambient conditions that exist at the operating site. Pilots, after loading or reloading passengers and cargo, would be well advised to re-verify those power checks each time before attempting another takeoff.