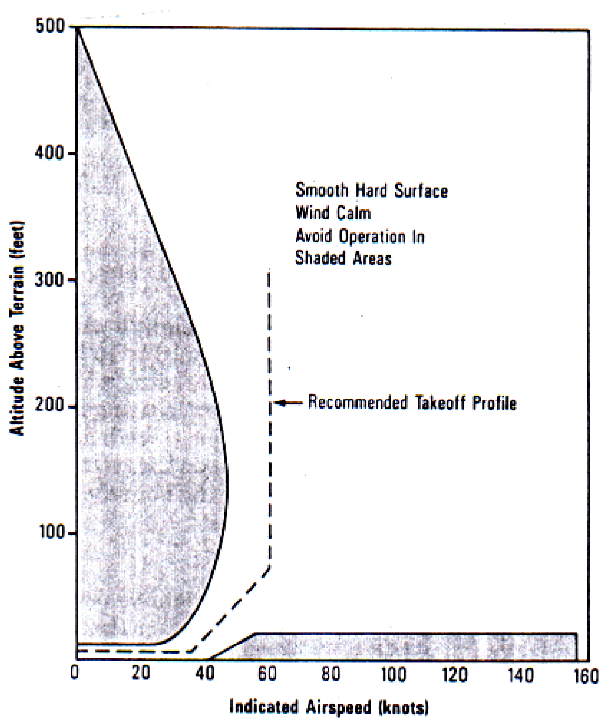
COPING WITH A POWER FAILURE

INSIDE THE DEADMAN'S CURVE

All good helicopter pilots--especially those who fly single-engine helicopters--are aware of the serious consequences of an engine failure while flying low and slow. Manufacturers put their best recommendation of the low-and-slow region to avoid in operator's manuals as height-velocity diagrams--or the Deadman's Curve. A sample curve (for the MD 500D) is shown below.

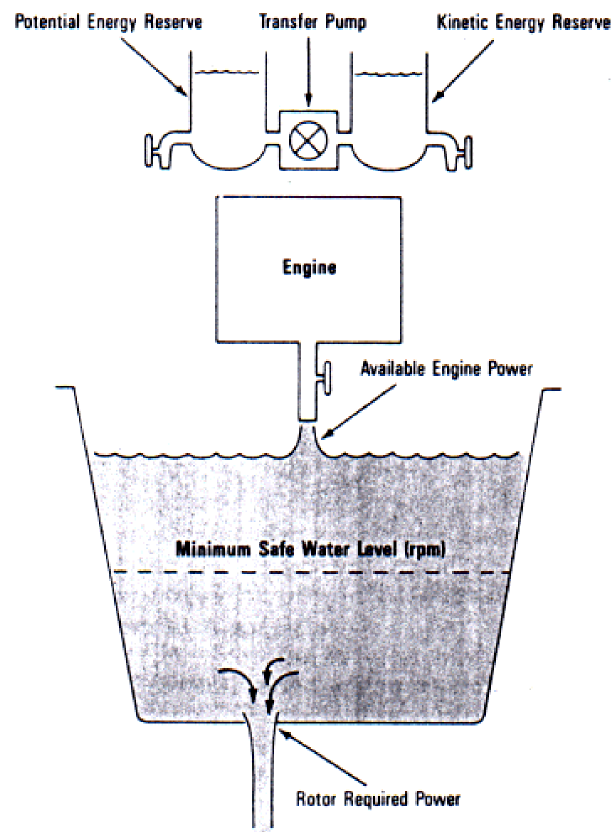


There are some situations, however, when the pilot must ignore these recommendations and enter the warning areas if he is to do the kind of job that only helicopters can do. In those rare instances, when a power failure occurs inside the Deadman's Curve, a crash is to be expected. How much damage is done depends on how well the pilot has managed his meager energy reserves.

Saving rpm

The object of energy management in this situation is to keep the rotor speed up as long as possible so it can be used to develop thrust to cushion the crash.

For the purpose of illustration, rotor rpm can be compared to the water level in a leaky bucket. The size of the leak corresponds to the power required.



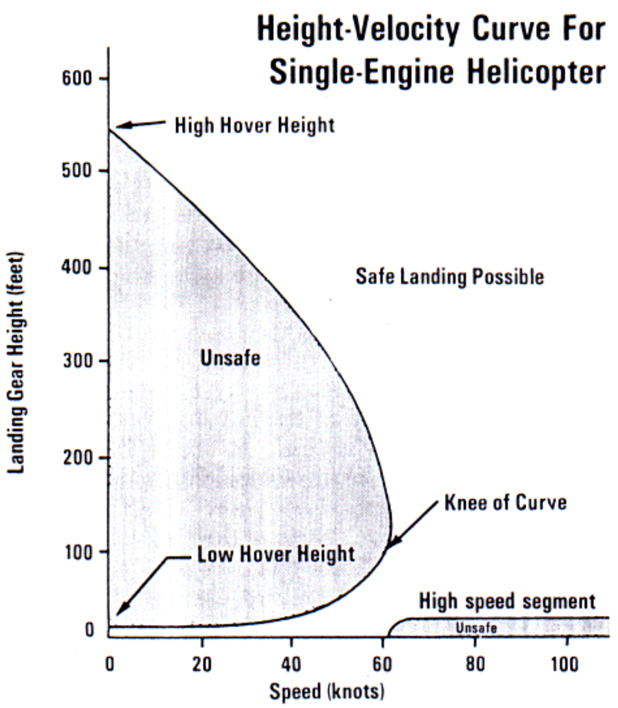
Normally, the water being pumped in by the engine exactly balances the loss of water leaking out, but when this source fails, there are two reserves that can be called on. The first is the potential energy corresponding to the height above the ground and the second is the kinetic energy corresponding to forward speed.

Neither reserve comes automatically to the rescue. Each requires quick pilot reaction to bring it on line before the rotor would stall is asked to produce thrust equal to the weight of the helicopter.

Power failure at high hover

In hover, of course, the forward-flight kinetic energy reserve tank is empty, so the pilot must initially do whatever he can with his potential energy.

For guidance, let us look at the techniques that assure successful landing from the point marked "High Hover Point."



From this point, the management of energy has two objectives. The first is achieved by rapidity dropping the collective pitch. This does two things. It reduces the power extracted from the rotor, thus saving precious rotor speed, and it gets the helicopter going down through the air toward an autorotative condition.

The second objective is to build up some forward speed. Even though the transfer of energy from the potential energy reserve to the kinetic energy reserve in not 100% efficient, it has an overall benefit in reducing the power required. Even in autorotation, the rotor requires about as much power as in level flight. However, instead of coming from the engine, the power is supplied by using the potential energy or altitude. For most helicopters, a speed of about 60 knots is the speed for minimum power and thus also the speed for minimum rate of descent.

Upon reduction of collective pitch, the rotor will flap down and forward. While one might think that this is a powerful means of pitching the helicopter nose-down and accelerating it forward, the rotor thrust will initially be low and both the ability to pitch the helicopter forward and to accelerate it forward will be degraded.

The low control power will be especially noticeable on helicopters with teetering rotors. These rotors will happily flap in response the cyclic pitch commands but little pitching moment will be applied to the fuselage until rotor thrust builds up as the helicopter approaches autorotation. Helicopters with hingeless rotors or with offset flapping hinges will not suffer as much loss of control but their ability to accelerate forward initially will be no better.

The final flare

Even before getting into autorotation or to the speed for minimum sink rate, the pilot should be able to make a cyclic flare to take advantage of his newly acquired forward-flight kinetic energy to develop a rotor thrust higher than the gross weight. This thrust, tilted back in the cyclic flare, will kill off both the forward speed and the vertical speed to the point where the landing gear can cope with both.

During the first part of the flare, a slight rotor overspeed might be obtained, which will help develop the rotor thrust required to cushion the touchdown, The "High Hover Height" is the minimum altitude at which the pilot can accomplish all this without bending anything.

A bit of speed helps

For a power failure with some forward speed along the upper boundary, the pilot has a head start toward achieving the desired flight conditions and so can go through the process faster. Thus, he requires less altitude--as reflected in the shape of the height-velocity diagram. If his speed is beyond the nose of the curve, he should be able to make a satisfactory touchdown from any altitude more than a few feet above the ground.

At low altitude, the pilot's reactions are also influenced by how much speed he has. A successful landing from the "Low Hover Height"--which is usually with the landing gear 10 or 15 feet off the ground--can be made by maintaining a level attitude and letting the helicopter settle, using collective only to soften the final impact. With forward speed, the use of a cyclic flare to keep the rotor speed up is possible. This explains why the boundary goes up with speed.

High-speed segment

The high-speed segment of the height-velocity diagram simply calls attention to the fact that when flying low and fast, it is no time for anything to go wrong. Combat pilots flying nap-of-the-earth might have to fly in this region but most others can easily avoid it.

The rotor has an automatic reaction characteristic that is both good and bad in this situation. As it loses rpm following an engine failure, it will flap nose-up. This pitches the helicopter up and gets it started into a climb--but it might also slam the tail into the dirt if the ground clearance was too small to start with.

The crash situation

So far we have discussed making successful landings from outside the Deadman's Curve but the question we started with was "What should the pilot do if the power failure occurs inside the manufacturer's height-velocity diagram?"

His primary objective should be to hit in a level attitude to take maximum advantage of the energy-absorbing characteristics of the landing gear and fuselage belly. To accomplish this, he should try to do--as nearly as possible--what he would do if he were just outside the boundary at that speed. That is, from the upper portion of the diagram, drop collective, try to gain some forward speed, and then make a cyclic flare followed by a leveling maneuver just before touching down.

If the rotor thrust is still low after the collective reduction and the pushover to pick up speed, the ability to do the final cyclic flare will be degraded because of the low control power. And, the impact might be more on the nose than on the landing gear.

For this reason, the descent from low heights and low speeds within the Deadman's Curve should avoid extreme nose-down attitudes. From this low corner of the curve, settle in; only using collective at the last moment to get as much thrust as the rotor can develop without stalling.

Obviously, these recommendations are full of "ifs" and "buts" depending on the exact situation and in the final analysis, I can only say "Good Luck."

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