COPING WITH A POWER FAILURE

CRITICAL TAKEOFFS

A takeoff--whether of an airplane or helicopter--is almost always a routine, unexciting event. The exception is when an engine loses power right in the middle of it--a possibility that influences both the aircraft's design and the manner of its operation to assure maximum safety.

When approving helicopters as transports, the Federal Aviation Administration (FAA) has two categories of rules. The main difference is that Category A rules require that the helicopter have a "stay-up" capability (essentially the ability to climb at least 100 fpm in forward flight after the failure of one engine) while Category B rules do not. Automatically, this means that only multi-engined helicopters can qualify as Category A and all single-engine helicopters are in Category B.

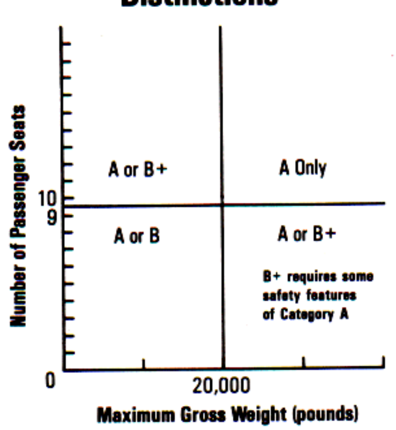
The advantage of Category A certification is that these helicopters are permitted to make takeoffs and landings using such challenging heliports as city-center rooftops and to fly en route over areas that have no emergency landing sites. Category B transports, on the other hand, are restricted to flying a route/altitude pattern in such a manner that at any point, an immediate safe landing can be made in case of engine failure.

The FAA has set rules governing which multi-engine helicopters can be certificated in which category. The first figure illustrates the distinctions, based on maximum gross weight and number of passenger seats. Usually, manufacturers consider it a competitive advantage to obtain Category A certification even on the smaller multi-engine helicopters. Many twin-engine designs have been certificated as Category A at one gross weight and Category B at a higher gross weight.

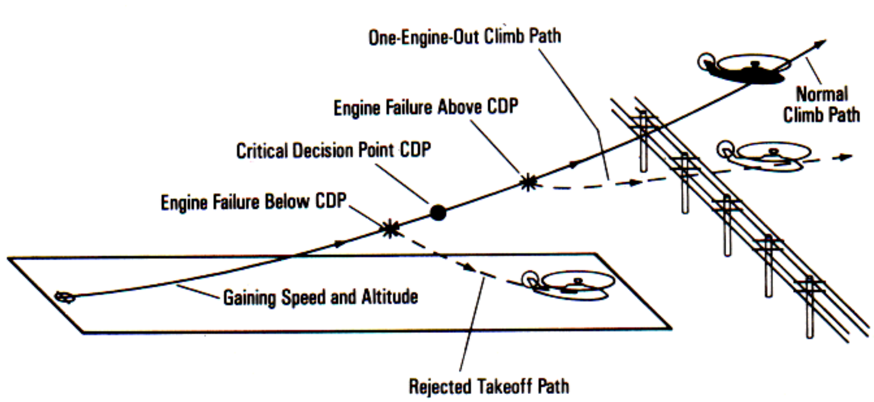
Safe takeoffs

The right procedure for Category A helicopters depends on the type of heliport. The figure below shows both normal and rejected takeoffs for a relatively large heliport. In this case, the pilot's takeoff objective should be quick acceleration to the speed where the power demand is low enough that a climb of 100 fpm could be maintained if one engine were to go out. The higher the takeoff weight, altitude, and temperature, the higher will be the minimum climb speed, which is known as the "takeoff safety speed" or V_{TOSS}. The point along the flight path from which V_{TOSS} can be achieved without coming closer to the ground than 35 feet is called the "critical decision point" (CDP).

Multiengine Certification Distinctions



Operation from a Large Heliport



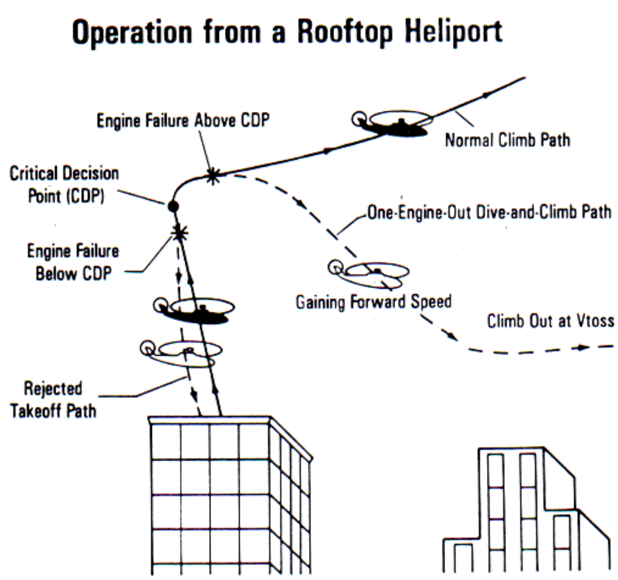
Below the CDP, a power failure is handled as a rejected takeoff by flaring and landing straight ahead. The total distance from the original takeoff spot to the final stopping place will depend on where along the flight path the CDP is located. Thus, in turn, depends on the gross weight of the helicopter and the effects of altitude and temperature on the maximum power that can be obtained from the remaining engine(s).

A heliport that is large enough to handle a rejected takeoff of a fully-loaded helicopter on a cold day may be too small on a hot day. In this case, payload will have to be offloaded to maintain the same degree of safety. This is not unique to transport helicopters. Fixed-wing transports occasionally face the same circumstances.

If the power failure occurs beyond the CDP, the helicopter can fly to another location or return to its takeoff spot in a more-or-less normal flight pattern.

Rooftop operations

Operation from a very small heliport such as a rooftop is shown below.



This situation requires that a rejected takeoff be terminated back at the original takeoff spot. For this reason, the takeoff flight plan must be vertical--or slightly backing up--to keep the heliport in view so that up the CDP the pilot can get back down to the same place he just left. If the power failure occurs above CDP, he can trade altitude for speed and go into forward flight while maintaining a clearance from the roof of 15 feet vertically and 35 feet horizontally.

The vertical climb to the CDP means there must be no unsafe region in the helicopter's height-velocity diagram (or Deadman's Curve) up to this height. For a given helicopter, this usually means that the allowable gross weight for rooftop operations is less than when operating from large, ground-level areas. This of course, has a bearing on the economics of the operation, if with the same helicopter, fewer paying customers can be flown from a rooftop.

Since the loss of only one engine has to provided for, the more engines the helicopter has, the less penalty there will be for rooftop operations.

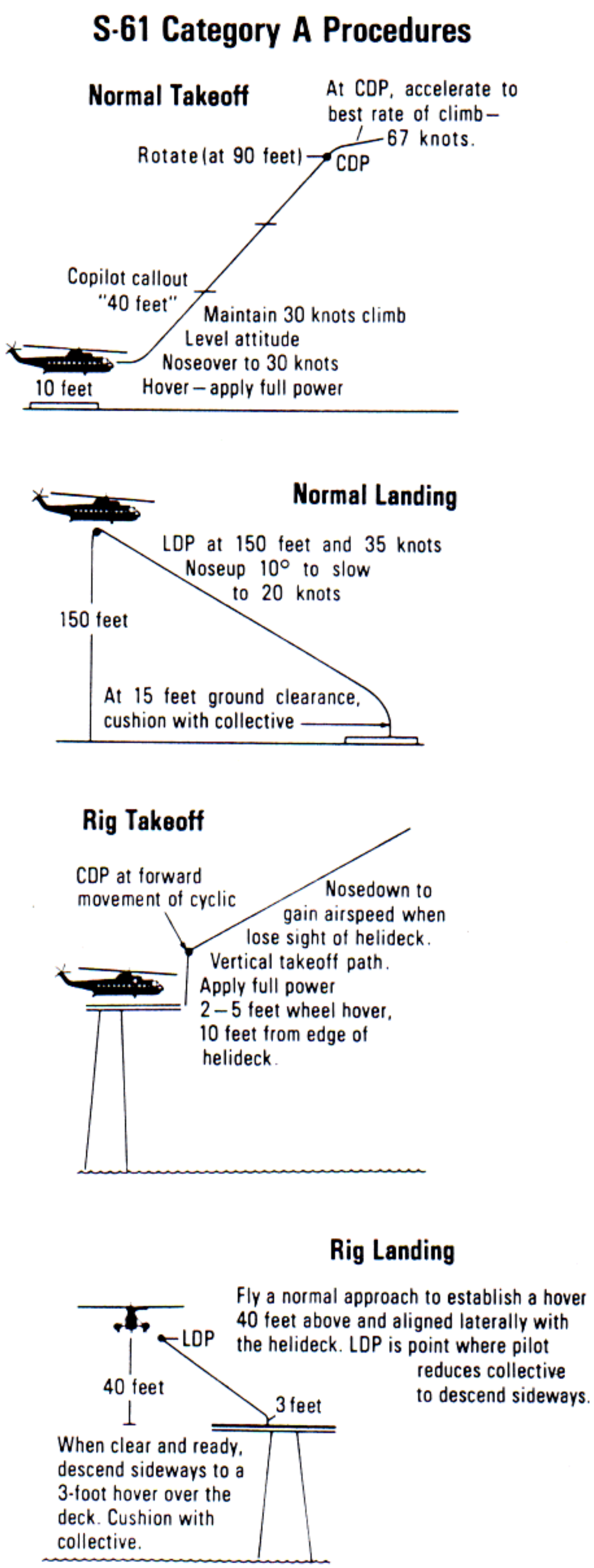
Oil-rig takeoffs

Another takeoff site similar to a rooftop but at the same time different is the helipad on an oil-drilling platform. This is usually 100 or more feet above the sea, which means that the helicopter is in the "avoid" region of the operator's manual height-velocity diagram as soon as it leaves the helipad.

If the helicopter is amphibious or equipped with emergency floatation gear adequate to accomplish a safe emergency ditching on open water, the FAA allows momentary flight through the avoid region. Part of the rational for this waiver is that the height-velocity diagram established for emergency touchdowns on solid ground is conservative when applied to a well-equipped helicopter ditching in water. Thus, these helicopters can use a forward flight takeoff as from a large helipad. If, however, the sea is too rough for ditching or the helicopter is not approved for water landings, the vertical takeoff as from a rooftop should be used.

The next figure shows the Category A

takeoff and landing procedures for the Sikorsky S-61 as used in the North Sea.



Heavy takeoffs

Takeoffs at high gross weight or at high altitudes (or under any other condition where the power available is just barely enough to hover in ground effect) puts the pilot's faith to a test.

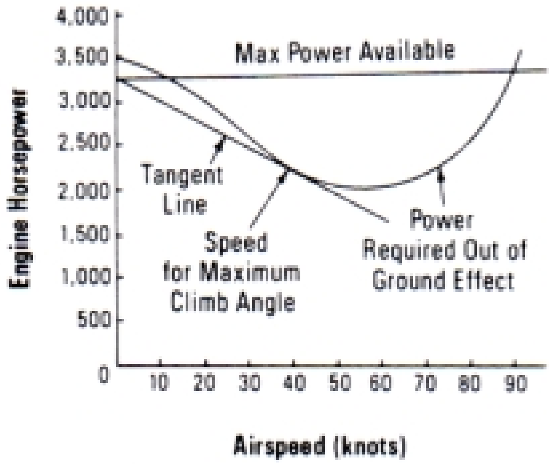
The fact that it takes less power to fly forward than to hover can be used to get a heavily loaded helicopter into the air. In some circumstances, it can make a running takeoff from a runway or cleared field, just like an airplane. In other places, however, it has to get at least a little clearance above the ground to avoid stubbing its toe.

The U.S. Army has done extensive testing to find the best way to clear a nearby 50-foot obstacle. In setting up the tests, the Army covered the full range of takeoffs. The baseline case is when a helicopter is light enough to allow it to climb straight up. The other limit is when the machine is so heavy that it can just barely hover in ground effect.

For the latter case, illustrated below, the Army recommended procedure is as follows:
1) Hover in ground effect and note the pitch angle the fuselage makes with the ground.
2) Tilt the helicopter forward to accelerate it into forward flight, using cyclic pitch to keep the ship low to take advantage of ground effect and keeping the power up to its limit with collective pitch until the transitional flight vibration disappears.
3) Rotate back to hover attitude to initiate climb.
4) Hold this speed (usually about 30 knots) and attitude until the 50-foot obstacle is cleared.
5) Increase speed to the best rate of climb.

If the obstacle just isn't that 50-foot tree line, but a distant mountain ridge, the best rotation speed is the speed for maximum angle of climb. This can be determined graphically from the plot of power required and available as shown on the figure on the next page.

Determining Overload-Takeoff Speed For Maximum Climb Angle



Since a pilot in this situation is unlikely to be able to make this analysis, the Army suggests that he use one rotation speed for all obstacles: for example, 28 knots for the UH-1C. He can get an inkling of whether he will be successful or not by seeing how high he can hover, which depends on the individual helicopter. For instance, Army tests show that if a UH-1C can hover at a 15-foot skid height, it will take 300 feet to clear a 50-foot obstacle, but if its maximum hover height is only four feet, at least 600 feet will be required.

Another consideration in overload or high-altitude operation is the possibility of inducing blade stall by sudden overcontrol of cyclic or collective pitch. An experienced operator has told me, “A pilot who handles the controls smoothly in critical hover conditions will be able to lift considerably more load than a pilot who is rough on the controls.”

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