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Enter At Own Risk

The height-velocity diagram may be only advisory in nature, but the pilot who does not treat it with due respect is flirting with disaster.

by
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All helicopter flight manuals contain a similar warning. It is known by many names: Limiting height-speed envelope; avoid area; and dead man's curve are just a few. The generally accepted term is height-velocity (HV) diagram which, in itself, does not suggest anything hazardous. The fine print that accompanies the HV diagram is normally a mild admonition to "avoid operation in the shaded area." A typical HV diagram is shown in Figure 1.

A casual study of the diagram does not indicate the potential dangers of ignoring the advice given. After all, it is only *advisory*, hence its usual placement in the performance section of the flight manual. For some aircraft types the diagram appears in the limitations section; but this is not strictly correct as it is not a limitation on, or prohibited area of, operations.

Manufacturers are required to produce HV diagrams as part of the aircraft certification process. The actual regulation states among other requirements, "If there is any combination of height and forward speed (including hover) under which a safe landing cannot be made under the applicable power failure condition … a limiting height-speed envelope must be established (including all pertinent information) for that condition. …"

The applicable power condition referred to means complete and sudden power loss on one engine with the remaining engine(s), if you have any, operating at maximum power. The regulation also requires the envelope to cover all weights up to maximum takeoff weight at altitudes up to at least 7,000 feet.

Development of an HV diagram is a very high risk and expensive operation. The manufacturer will wish to produce

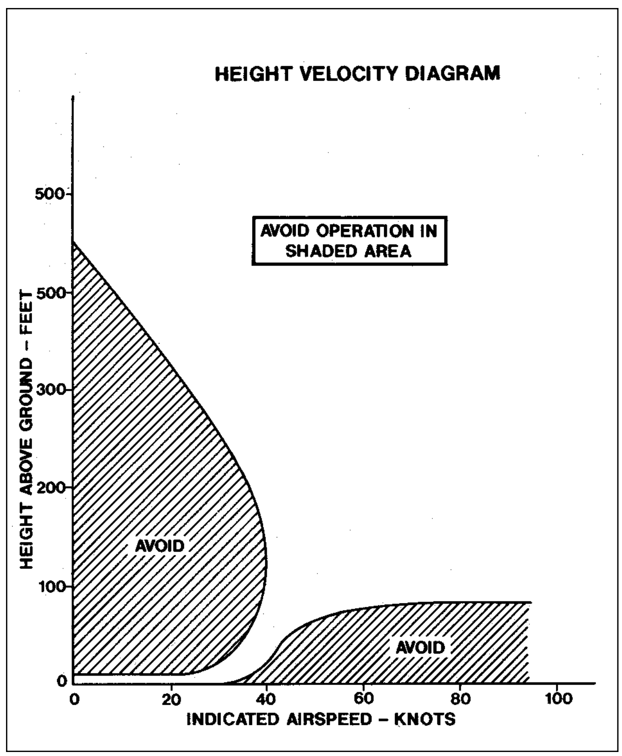

Figure 1

the smallest "avoid area" possible which in turn will require test flights to the very edge of the safe landing envelope. Unsafe landing will, by definition, result in some damage to the aircraft, and possibly to the crew and passengers also. For these reasons, HV testing is normally left until the end of the certification program, the oldest development aircraft is used, and there is a certain amount of "short straw drawing" in the test pilots' office.

Before commencing HV testing, the test pilot will become totally familiar with the autorotational characteristics of the aircraft. This will include rotor decay rates, handling qualities during transition from powered to autorotative flight and optimum flare heights, attitudes and rates. The test aircraft will be instrumented to record critical parameters, notably vertical and longitudinal accelerations, and loaded to the correct weight. Supporting personnel, including fire and rescue services, will be briefed on their part of the tests.

The flying to develop the HV diagram will involve dozens, and even hundreds, of data points. The aircraft will be flown to its absolute limits, with respect to vertical and horizontal accelerations, in an attempt to establish the smallest possible "unsafe" areas. Occasionally, limits will be exceeded and there will be a pause in the program while the aircraft is repaired or replaced.

At the end of the program, the certification authority will require the manufacturer to prove the HV diagram. This process involves spot checks of certain points along the edge of the avoid areas. It is carried out by an experienced test pilot after a comprehensive familiarization with the aircraft and its autorotational characteristics.

The net result, as shown in the flight manual, is the product of extensive testing and checking. But what does it mean for the average helicopter pilot?

First and foremost is the fact that, if you have an engine failure while operating in the avoid area, you will damage the aircraft in the ensuing landing. The extent of damage will depend on how far over the line you are and may result in injury to you and your passengers. For example, engine failure during a high hover taxi ("high" means greater than five feet in most machines) will damage the landing gear (or skids) but hopefully not much else, always assuming you eliminate yaw and drift before touchdown. More dramatic is an engine failure while hovering at 100 feet.

Another feature of HV diagrams is that, unlike other performance data in the flight manual, there is no margin for error. They have been developed according to the capabilities of someone who is probably the best pilot in that particular machine. The chances of anyone other than a test pilot doing better are about the same as winning the lottery. Hence, in all probability, an engine failure that may be in the "safe" area, but close to the line, will probably result in an accident. This has been proven on several occasions by overzealous instructors seeking a more demanding emergency simulation for their students.

There are a few simple rules for dealing with the HV diagram, however, that can help all helicopter pilots avoid disaster:

Rule 1. If at all possible, *do not fly in the avoid areas:* keep your hover and air taxi height as low as possible (three to four feet is normally ample). Consider whether it is really necessary to hover at 200 feet to take that picture. Think about going higher or adding airspeed. Avoid low passes because they allow no room for error.

Rule 2. Do not take liberties with avoid area boundaries. You would be amazed if you knew how little margin there is before the bottom drops out of your world. Your insurance company will not thank you for failed attempts to advance this area of aviation research.

Rule 3. If you must operate in the avoid area, give yourself the best chance of minimizing injury in the event of an engine failure. Seat in good condition to absorb impact forces? Harness tight and secure? How about a helmet on your next sling load job?

As with many other aspects of aviation operations, misconceptions and misleading advice abound about the HV diagram. Here are a few to bear in mind:

"It only applies to maximum weight operations" — not so. Some parts of the avoid areas are defined by pilot reaction irrespective of weight. The problem is that you do not know where they are and what margin, if any, exists for reduced vertical velocities at lighter weights in other areas. See Rule 2 before contemplating flight in these areas at any weight.

"High hovers and air-taxiing are safe in strong wind" — only true in very strong (greater than 40 knots in the diagram) winds and even then there is a complication. Remember that the HV diagram relates to indicated airspeed, but when the engine stops at 100 feet and 40 knots indicated, *ground* speed becomes a major consideration. Construction of the HV diagram involves use of flare effects wherever possible. If airspeed equals windspeed, then that flare effect is not available — unless you wish to touchdown going backwards.

"The high hover limit point (450 feet in the diagram) is the minimum height. I should fly downwind" — not so. The HV diagram only holds true for a landing in the direction of flight following power failure. Minimum recommended downwind height is dictated by the autorotational performance and handling of the particular aircraft type. There is no direct correlation between the two issues.

The HV diagram has been provided to warn pilots of a potential danger. If you must operate within this area, such as during sling load operations, then give yourself the best chance of surviving the inevitable crash landing if the engine stops. Keep in mind that you enter the avoid area at your own risk. ♦

[This article is reprinted from the Australian CAA's Aviation Safety Digest *in the interest of sharing safety information with the worldwide aviation community. — Ed.]*

Crew Confusion Leads to Trouble

Lack of teamwork results in an uncoordinated response to an inflight emergency.

The mission had been to fly to a field about 55 minutes away, pick up passengers, and return to home base. While the pilot planned the flight, the copilot preflighted the aircraft. A fuel sample was not taken, and the aircraft was overdue for an engine runup and daily inspection.

Although required, there was no pre-mission coordination between the crew members concerning duties in the event of an emergency.

The first leg of the flight was planned and, except for a slight fluctuation in EGT, aircraft performance was satisfactory. The copilot, apparently to reduce fuel consumption, decreased engine speed to between 6,400 and 6,500 rpm.

The helicopter was refueled at the passenger pickup point. The return flight was delayed more than two hours while the crew awaited arrival of the passengers. When the passengers finally arrived, the departure was made without a passenger briefing.

A VFR flight plan was filed. Weather at the destination was 800 feet overcast with 10 miles visibility. When the aircraft was 14 miles east of the destination, a ground controlled approach was requested. The aircraft was 10 miles out in level flight at 4,000 feet when the pilot took the controls and began to fly on instruments. The ground controlled approach was initiated and the aircraft entered a cloud layer at 1,800 feet. At this point, a prelanding check was made, and the landing light was extended but not turned on.

As the aircraft cleared the bottom of the cloud layer, the rpm warning system activated; N_2 rpm and rotor rpm dropped to 6,000 and 300 respectively (needles joined). The pilot lowered the collective without rolling the throttle off and began a left run toward a forced landing area. He then made a Mayday call and decided to try to increase engine rpm using the increase/decrease switch. Simultaneously, the copilot moved the fuel control governor switch to the emergency position. The resulting engine overspeed was in excess of 7,000 rpm, and the rotor overspeed was in excess of 400 rpm.

The aircraft responded with an immediate nose-up attitude and right yaw. The pilot increased collective pitch and retarded the throttle to decrease engine and rotor rpm. Without waiting for acknowledgement from the pilot, the copilot returned the governor switch to the automatic position. Engine and rotor rpm decreased and stabilized at 6,000 rpm and 300 rpm, respectively, with the collective full down and throttle full on.

At a height of 300 to 400 feet, the helicopter's airspeed was 40 knots and decreasing. The pilot lowered the nose of the aircraft and the airspeed stabilized at 40 knots. Approximately 20 to 30 feet above the ground, the pilot decelerated but did not apply power until ground contact was made. The aircraft approached the ground in a nose-high attitude with about 20 knots of forward airspeed.

Touchdown was hard. Collective was increased and the aircraft became airborne again, then pitched forward. The main rotor blades hit the ground three times, and the transmission was displaced. The aircraft came to rest in an upright position, substantially damaged.

The 28-year-old pilot had accumulated almost 800 rotary wing flight hours. More than 700 of these were in Bell 212s. The 22-year-old copilot had almost 300 rotary wing flight hours, with more than 200 in the Bell 212. The performance of both pilots was satisfactory during the post-accident flight evaluations. However, both displayed weaknesses in the knowledge of emergency procedures, use of the checklist and the performance of autorotation. Neither knew the correct procedure for manual operation of the throttle with the governor switch.

During the ill-fated flight, the pilot had permitted the copilot to reduce N_2 rpm to considerably less than 6,600 rpm, supposedly to conserve fuel. The aircraft had been refueled before start for the return leg of the mission, but the estimated time en route was only one hour. The need for fuel/range management, therefore, was irrelevant to safe accomplishment of the mission. A further reduction of N_2 may have inadvertently occurred later in the flight, causing the rpm warning system to activate. There was no evidence to confirm a materiel malfunction.

An approach with lower than appropriate power was made because the pilot and copilot incorrectly assessed a low engine/rotor rpm indication as a low-side governor failure, and failed to respond to the suspected emergency correctly. Following the onset of the emergency, the pilot began to remedy the condition by increasing N_2 rpm. The copilot placed the governor switch in the emergency position while the throttle was in the full-on position without telling the pilot. When the pilot tried to compensate for the resulting engine/rotor overspeed by adding collective and rolling off the throttle, the copilot reversed his earlier action and returned the governor switch to the automatic position, causing further confusion.

The cumulative effect of these actions may have overloaded the pilot to such a degree that he was unable to complete the approach and landing without damaging the aircraft. The pilot initiated the deceleration phase of the approach at too low an altitude (about 25 feet) to fully realize an appreciable reduction in forward speed and sink rate before touchdown was imminent. As a result, he was late in applying control inputs necessary to arrest the rate of descent and achieve a near-level attitude on landing.

Although the copilot cannot be faulted for misinterpreting a probable reduced N_2 condition as a low-side governor failure, he should not have cycled the governor switch into and out of the emergency position without the pilot's knowledge. The pilot did not brief the copilot before the flight regarding duties and responsibilities in the event of an emergency. Also, when the pilot began to remedy what he thought was a reduced N_2 condition, he did not coordinate his actions with the copilot.

The operator had an excellent training program in writing. However, it was not being enforced. Training in the use of appropriate publications, weather, emergency procedures and other flight-related subjects was not provided on a regular basis.

Stress and its relationship to crew member performance, as well as the types of errors that lead to creation of a high stress situation, should be discussed at safety meetings.

Managers must ensure that personnel are able to perform assigned jobs. Less experienced pilots must be continually monitored, evaluated and trained as necessary to ensure they are capable of coping with inflight emergencies. Aviator judgment should be evaluated as an area of special interest during standardization evaluations and training flights.

Managers should emphasize to their pilots the importance of crew briefings prior to flight, proper crew coordination, and aviation professionalism in general. ♦

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