The H-V Diagram: Clarifying Some Misconceptions

The helicopter height-velocity diagram—or simply, the H-V diagram or H-V curve—has seemingly always been an easy tool with which a pilot can check his/her aircraft performance capabilities. Published by the manufacturer of each aircraft model, it plots height above surface versus indicated airspeed with several dubious “cross-hatched” or “shaded” areas where “AVOID” is usually clearly written. Operating within the “AVOID” area of the H-V diagram, according to the FAA’s Rotorcraft Flying Handbook, may not allow enough time for the critical transition from powered flight to autorotation, hence the H-V diagram’s other, more colorful name, the “Dead Man’s Curve.”

Unfortunately, this simple tool for pilots has turned into a continuing source of confusion for many others, including regulators and developers of guidance material. Predominantly because of differing terminologies used by manufacturers, inconsistent use of terms used in the regulations, and by the very nature of the regulatory process itself, whereby changes are made piecemeal and as a result, in an inconsistent fashion, the interpretation of the meaning of the H-V diagram has changed to a point where it is not consistent with its original intent. Recently, after some initial requests by HAI, the FAA’s Rotorcraft Directorate and Flight Standards Service volunteered to develop a letter that clarifies much of the H-V inconsistencies. After over a year of work, an outstanding product was completed. Prior to reviewing the results of the FAA’s work, an examination of H-V and some of its associated issues are in order.

Figure 1 illustrates a typical H-V diagram. The curve, each developed as a result of manufacturer’s test flights, is in accordance with either Federal Aviation Regulation (FAR) 27 (normal category helicopters) or FAR 29 (transport category helicopters). FAR Part 27.79 states that if there is any combination of height and forward speed (including hover) under which a safe landing cannot be made after an engine failure, a limiting height-speed envelope must be established for that condition, throughout the ranges of the following: 1. Altitude, from standard sea level conditions to the maximum altitude capability of the rotorcraft, or 7,000 feet, whichever is less. 2. Weight, from the maximum weight (at sea level) to the lesser weight selected by the applicant for each altitude covered in 1. For helicopters, the weight at altitudes above sea level may not be less than the maximum weight or the highest weight allowing hovering out of ground effect, whichever is lower. The applicable power failure conditions are

(1) For single-engine helicopters, full autorotation; (2) For multiengine helicopters, one engine inoperative (where engine isolation features insure continued operation of the remaining engines), and the remaining engines at the greatest power for which certification is requested.

In order to develop the H-V diagram, the aircraft is loaded to maximum gross weight and worst center of gravity. At this point, the test pilots autorotate from the different combinations of altitude and airspeed. The curve is developed with two main sections, the left side representing low speed performance of the aircraft in autorotation and the right side representing the high-speed portion of the H-V curve. The left side is further broken down into an upper and lower section. Each area is developed a little differently. The lower section assumes the pilot is performing a takeoff, and the pilot enters an autorotation one second after disengaging the engine. The upper section assumes the helicopter is in cruise flight and a two second delay between engine cutoff and entering the autorotation is introduced. These delays are to roughly replicate typical pilot's reactions in the two flight regimes. The right, high-speed side typically deals solely with pilot reaction time, because flying fast and low greatly limits reaction time in case of an engine failure.

The FAA, in its February 2002 letter, speaks to four certification standards, and how the H-V diagram should apply. These certification levels are FAR 27 (single engine), FAR 29 (single engine), FAR 27 (twin engine), and FAR 29 (multi-engine). As far as FAR 27 singles are concerned, the FAA states: “The H-V diagram is performance information and resides in the performance section of the flight manual. It is advisory in nature and is provided for pilot planning purposes.” As planning material, the pilot can now make intelligent choices about which combinations of altitude and airspeed to use for a particular mission. Many FAR 27 missions require flying in the shaded area of the H-V, but an aware
pilot with the proper information about H-V will know how to react if something goes wrong with the aircraft. If the H-V curve information were intended as limitations, they would be placed in the limitations section of the flight manuals. The FAA continues: "The preamble material associated with virtually every iteration of the H-V regulations make it very clear that the intention has always been to permit operation inside the H-V for smaller, utility-type helicopters."

For single engine helicopters certificated under Part 29, these aircraft (usually older, mid-weight class) have been grandfathered into Category B performance rules. According to the FAA, the H-V diagram for this small group of aircraft is a limitation only when configured to carry more than nine passengers. For all other cases, the H-V is intended for performance information only.

The third certification category addressed by the FAA deals with twin engine FAR Part 27 aircraft. These helicopters are limited to 7000 pounds maximum gross weight and seven passengers. "The gross weight and passenger limits . . . are purposefully limited commensurate with the philosophy that this certification category provides a lower level of safety than transport category aircraft which are also certificated to Category "A" performance standards." Since all models in this category have been designed and approved to Category "A", these aircraft have a "single engine H-V" which is performance information and not a limitation.

Multi-engine FAR Part 29 aircraft, the fourth category addressed by the FAA in its H-V letter, have had the H-V standards softened over time through relieving amendments. There are three groupings of these aircraft: 1) those weighing less than 20,000 pounds with passenger seating for nine or less; 2) those weighing less than 20,000 pounds with more than nine passenger seats; and 3) those weighing more than 20,000 pounds.

With respect to the first grouping, the present standard allows for the removal of the H-V limitation for aircraft weighing less than 20,000 pounds if passenger seating is nine or less. For older aircraft, where the H-V is a limitation in the original flight manual, a Supplemental Type Certificate (STC) or kit supplement typically defines a nine (or less) passenger-seating configuration that also moves the H-V to performance. For the second grouping, operating rules would likely require Category "A" performance if an aircraft configured for ten or more passengers were to be used for scheduled air carrier operations. It is important to note however, that there is ample evidence that this grouping of aircraft can be operated to avoid the H-V, while still achieving an 8:1 clearance plane criteria that is recommended for heliport design. Recent testing by several manufacturers show that pilot technique can be varied to safely and consistently achieve the required climb gradient. For the third grouping, the aircraft must be operated under Category "A" performance requirements regardless of passenger configuration. It should be emphasized that an H-V diagram does not actually exist when operating under Category "A" performance requirements, as long as the pilot flies the published procedures.

In its summary, the FAA states "aircraft certification requirements have purposely been modified in recent years to change the H-V from a limitation to performance information for most aircraft. The regulatory stance is that this information is advisory in nature unless it is a limitation. There are no operating regulations that specifically restrict flight within the H-V unless it is in the limitation section of the Rotorcraft Flight Manual. Category "A" would likely be mandated under such a scenario, which would therefore negate concerns associated with operations within the H-V. The aircraft certification and operating regulations are consistent."

These clarifications to many long held misunderstandings by regulators can be very critical in the future development of vertical flight infrastructure. Heliport development, in many cases, has been held hostage to the whims of advisory material drafters and those who approve heliport sites, because of the insistence on H-V being a limitation. As a result, potential heliport sites were limited due to misunderstood airspace constraints. Additionally, as instrument approach procedure development is becoming more and more common, H-V has had the potential to limit this growth, again due solely to the misunderstanding of H-V as a performance indicator and not as a limitation. The recent efforts of the FAA Rotorcraft Directorate and Flight Standards Service in analyzing and creating a "for-the-record" clarification will go far in ensuring that vertical flight infrastructure development will not be impeded to the extent that seemed likely only several months ago.

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