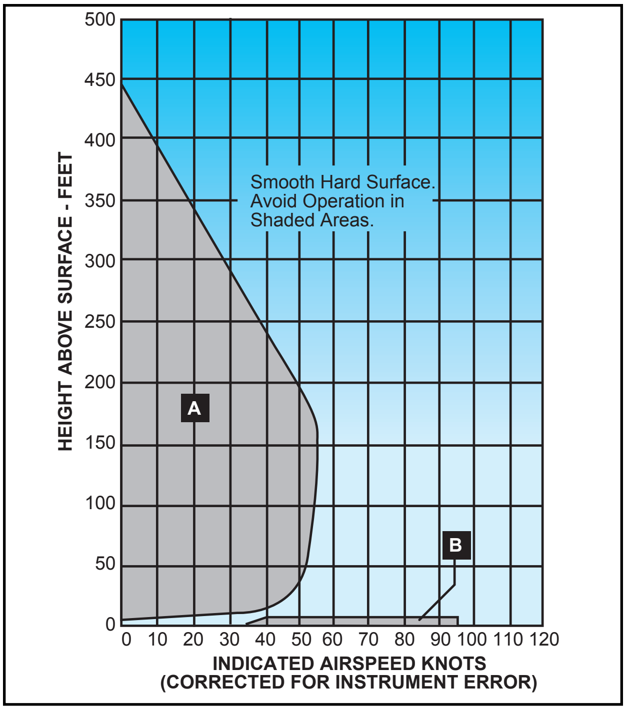

Figure 11-2. By carefully studying the height/velocity diagram, you will be able to avoid the combinations of altitude and airspeed that may not allow you sufficient time or altitude to enter a stabilized autorotative descent. You might want to refer to this diagram during the remainder of the discussion on the height/velocity diagram.

You should avoid the low altitude, high airspeed portion of the diagram (section B), because your recognition of an engine failure will most likely coincide with, or shortly occur after, ground contact. Even if you detect an engine failure, there may not be sufficient time to rotate the helicopter from a nose low, high airspeed attitude to one suitable for slowing, then landing. Additionally, the altitude loss that occurs during recognition of engine failure and rotation to a landing attitude, may not leave enough altitude to prevent the tail skid from hitting the ground during the landing maneuver.

Basically, if the helicopter represented by this H/Vdiagram is above 445 feet AGL, you have enough time and altitude to enter a steady state autorotation, regardless of your airspeed. If the helicopter is hovering at 5 feet AGL(or less) in normal conditions and the engine fails, a safe hovering autorotation can be made. Between approximately 5 feet and 445 feet AGL, however, the transition to autorotation depends on the altitude and airspeed of the helicopter. Therefore, you should always be familiar with the height/velocity diagram for the particular model of helicopter you are flying.

THE EFFECT OF WEIGHT VERSUS DENSITYALTITUDE

The height/velocity diagram depicts altitude and airspeed situations from which a successful autorotation can be made. The time required, and therefore, altitude necessary to attain a steady state autorotative descent, is dependent on the weight of the helicopter and the density altitude. For this reason, the H/Vdiagram for some helicopter models is valid only when the helicopter is operated in accordance with the gross weight vs. density altitude chart. Where appropriate, this chart is found in the rotorcraft flight manual for the particular helicopter. [Figure 11-3]

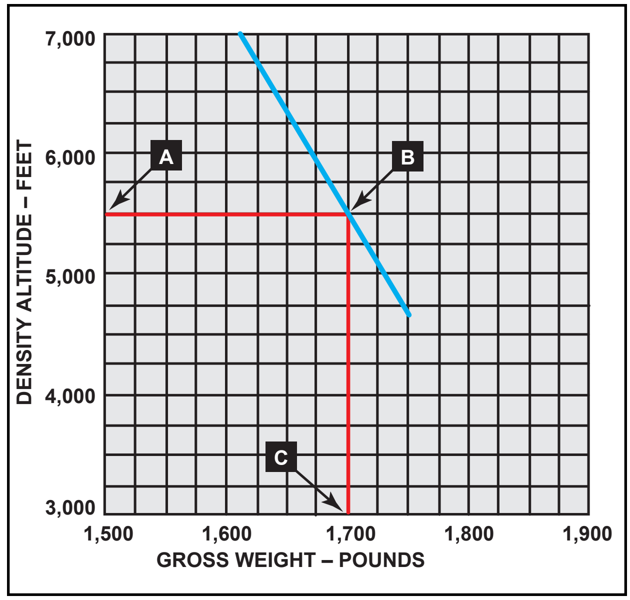

Figure 11-3. Assuming a density altitude of 5,500 feet, the height/velocity diagram in figure 11-2 would be valid up to a gross weight of approximately 1,700 pounds. This is found by entering the graph at a density altitude of 5,500 feet (point A), then moving horizontally to the solid line (point B). Moving vertically to the bottom of the graph (point C), you find that with the existing density altitude, the maximum gross weight under which the height/velocity diagram is applicable is 1,700 pounds.

The gross weight vs. density altitude chart is not intended as a restriction to gross weight, but as an advisory to the autorotative capability of the helicopter during takeoff and climb. You must realize, however, that at gross weights above those recommended by the gross weight vs. density altitude chart, the H/Vdiagram is not restrictive enough.

VORTEX RING STATE (SETTLING WITH POWER)

Vortex ring state describes an aerodynamic condition where a helicopter may be in a vertical descent with up to maximum power applied, and little or no cyclic authority. The term “settling with power” comes from the fact that helicopter keeps settling even though full engine power is applied.

In a normal out-of-ground-effect hover, the helicopter is able to remain stationary by propelling a large mass of air down through the main rotor. Some of the air is recirculated near the tips of the blades, curling up from the bottom of the rotor system and rejoining the air entering the rotor from the top. This phenomenon is common to all airfoils and is known as tip vortices. Tip vortices consume engine power but produce no useful lift. As long as the tip vortices are small, their only effect is a small loss in rotor efficiency. However, when the helicopter begins to descend vertically, it settles into its own downwash, which greatly enlarges the tip vortices. In this vortex ring state, most of the power developed by the engine is wasted in accelerating the air in a doughnut pattern around the rotor.

In addition, the helicopter may descend at a rate that exceeds the normal downward induced-flow rate of the inner blade sections. As a result, the airflow of the inner blade sections is upward relative to the disc. This produces a secondary vortex ring in addition to the normal tip-vortices. The secondary vortex ring is generated about the point on the blade where the airflow changes from up to down. The result is an unsteady turbulent flow over a large area of the disc. Rotor efficiency is lost even though power is still being supplied from the engine. [Figure 11-4]

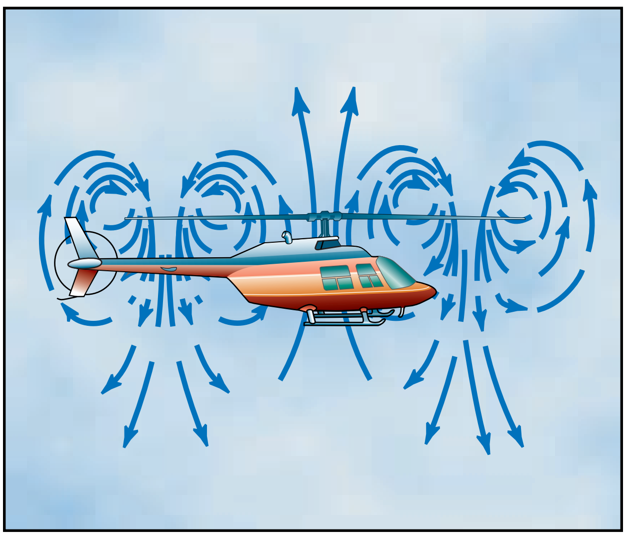

Figure 11-4. Vortex ring state.

A fully developed vortex ring state is characterized by an unstable condition where the helicopter experiences uncommanded pitch and roll oscillations, has little or no cyclic authority, and achieves a descent rate, which, if allowed to develop, may approach 6,000 feet per minute. It is accompanied by increased levels of vibration.

A vortex ring state may be entered during any maneuver that places the main rotor in a condition of high upflow and low forward airspeed. This condition is sometimes seen during quick-stop type maneuvers or during recoveries from autorotations. The following combination of conditions are likely to cause settling in a vortex ring state:

1. A vertical or nearly vertical descent of at least 300 feet per minute. (Actual critical rate depends on the gross weight, r.p.m., density altitude, and other pertinent factors.)

2. The rotor system must be using some of the available engine power (from 20 to 100 percent).

3. The horizontal velocity must be slower than effective translational lift.

Some of the situations that are conducive to a settling with power condition are: attempting to hover out of ground effect at altitudes above the hovering ceiling of the helicopter; attempting to hover out of ground effect without maintaining precise altitude control; or downwind and steep power approaches in which airspeed is permitted to drop to nearly zero.

When recovering from a settling with power condition, the tendency on the part of the pilot is to first try to stop the descent by increasing collective pitch. However, this only results in increasing the stalled area of the rotor, thus increasing the rate of descent. Since inboard portions of the blades are stalled, cyclic control is limited. Recovery is accomplished by increasing forward speed, and/or partially lowering collective pitch. In a fully developed vortex ring state, the only recovery may be to enter autorotation to break the vortex ring state. When cyclic authority is regained, you can then increase forward airspeed.

For settling with power demonstrations and training in recognition of vortex ring state conditions, all maneuvers should be performed at an elevation of at least 1,500 feet AGL.

To enter the maneuver, reduce power below hover power. Hold altitude with aft cyclic until the airspeed approaches 20 knots. Then allow the sink rate to increase to 300 feet per minute or more as the attitude is adjusted to obtain an airspeed of less than 10 knots. When the aircraft begins to shudder, the application of additional up collective increases the vibration and sink rate.

Recovery should be initiated at the first sign of vortex ring state by applying forward cyclic to increase airspeed and simultaneously reducing collective. The recovery is complete when the aircraft passes through effective translational lift and a normal climb is established.

RETREATING BLADE STALL

In forward flight, the relative airflow through the main rotor disc is different on the advancing and retreating side. The relative airflow over the advancing side is higher due to the forward speed of the