

**VORTEX RING.****1 Introduction**

1.1 The following paragraphs are a reminder to helicopter pilots of the ever present danger and insidious nature of vortex ring. The usual American term for this condition is 'power settling', a description that sums up the potential predicament for the unwary pilot.

2 The Vortex Ring State

2.1 Vortex ring state is a phenomenon that occurs when the main rotor tip vortices are recycled into the induced airflow. This state can exist when the vertical rate of descent is greater than half the air velocity induced by the rotor and is normally experienced at low forward speeds and significant rates of descent. The effect of this is to produce severe instability of the airflow around the rotor disk with subsequent aerodynamic inefficiencies and loss of rotor thrust.

2.2 Many modern helicopters with high disc loading (high induced flow) will require a relatively high rate of descent before the possibility of vortex ring exists and it may be this factor, combined with greater amounts of power generally available today, that has led to a view that modern helicopters do not develop vortex ring. This is not the case and whilst it can be difficult to induce vortex ring deliberately, the possibility of a vortex ring occurrence always exists if the helicopter is operated in the relevant flight conditions.

3 Conditions for Entry

3.1 Vortex ring becomes a possibility when the airspeed is below about 30 kts, with a rate of descent greater than 300 fpm and with power applied. This can be a very unpredictable process so there may be occasions when, operating beyond these conditions, vortex ring is not encountered. However, the greater the time spent within these conditions, the greater is the chance of encountering the problem. The inaccuracy of helicopter airspeed indications at low airspeeds should also be considered and allowed for, particularly when operating out of wind or with a rate of descent.

4 Symptoms

4.1 The symptoms of vortex ring are typically:

- a. The Incipient Stage:
 - i. Increased vibration and buffet;
 - ii. The onset of small amplitude 'twitches' in roll and yaw;
 - iii. Longitudinal, lateral and directional instability.
- b. The Established Stage:
 - i. A very rapid build up in rate of descent which can exceed 3000 fpm;
 - ii. Reduced effectiveness of cyclic inputs in roll or pitch; and
 - iii. Application of collective pitch having no effect in reducing the rate of descent (possibly increasing it).

4.2 It is possible to pass through the incipient stage very quickly; the warning cues for the pilot may not be obvious. A fully developed vortex ring state may therefore result with very little warning; especially at night, in poor visibility or at high altitude when visual cues are absent. Even when the vortex ring state is fully developed the flight can be very smooth with little or no increase in vibration; the only real clue being the sudden indication of a very high rate of descent.

5 Recovery

5.1 The Incipient Stage

5.1.1 As soon as the incipient stage is recognised, immediate recovery action must be taken. This is best attempted by maintaining the collective position and applying forward cyclic to achieve a nose down attitude, in order to increase airspeed without delay. More power can be applied if required as soon as steadily increasing airspeed is indicated - it is not necessary to wait for the best rate of climb speed. The effectiveness of the incipient stage recovery must be carefully monitored and more positive action taken, as described below, if any signs of slow recovery or established vortex ring become apparent.

5.2 The Established Stage

5.2.1 In order to recover from established vortex ring, the flow state around the rotor must be changed in some way. Application of forward cyclic should increase airspeed but it must be borne in mind that a large amount of cyclic may be required and held for several seconds before a significant pitch attitude and speed change is achieved. It may be necessary to reach a large nose down attitude to obtain positive airspeed. Lowering the collective to reduce power towards auto-rotation is also effective, but forward airspeed must be gained before power is reapplied during recovery. Both methods will result in an inevitably large height loss. The best technique for recovery is to combine both actions positively, then reapply power when steadily increasing airspeed indications are regained. It is not necessary to wait for best rate of climb speed before adding power.

6 Applicability

6.1 All helicopters are susceptible to vortex ring and all helicopters suffer from unreliable airspeed indications when operating below about 30 kts. Flight at low airspeeds, particularly with poor visual cues, must be treated with caution because it only requires a relatively small increase in the rate of descent for there to be a significant probability of vortex ring development.

6.2 Vortex ring can occur at any height above the ground cushion.

6.3 At typical helicopter operating heights, particularly during photographic and surveillance tasks or during steep or vertical approaches, the conditions referred to in paragraph 3 must be avoided since lack of height will make recovery from the condition uncertain. Pilots should therefore always maintain airspeed when turning or descending in high wind conditions. Pilots should therefore always maintain airspeed when turning or descending **and especially when downwind** in high wind conditions.