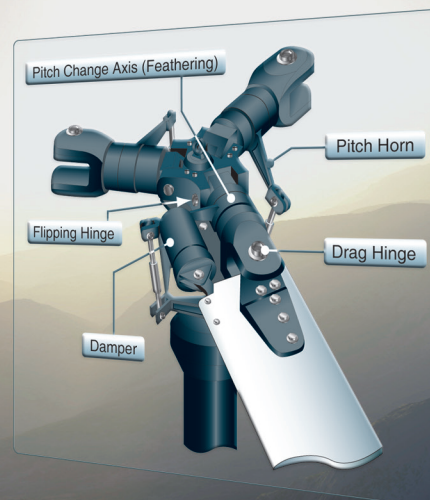
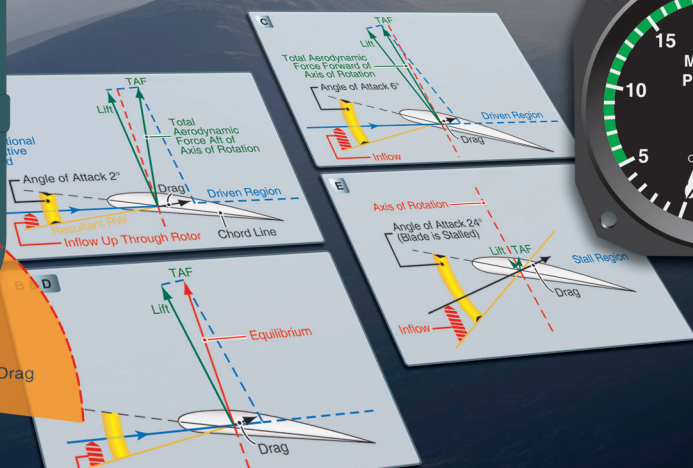
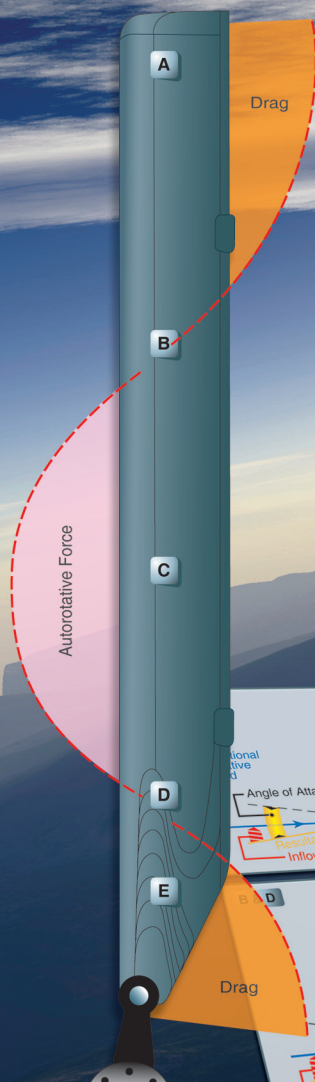


Helicopter Flying Handbook



U.S. Department
of Transportation
**Federal Aviation
Administration**



If altitude is sufficient, some time can be spent in the vortices, to enable the pilot to develop a healthy knowledge of the maneuver. However, helicopter pilots would normally initiate recovery at the first indication of settling with power. Recovery should be initiated at the first sign of vortex ring state by applying forward cyclic to increase airspeed and/ or simultaneously reducing collective. The recovery is complete when the aircraft passes through effective translational lift and a normal climb is established.

Common Errors

1. Too much lateral speed for entry into settling with power.
2. Excessive decrease of collective pitch.

Retreating Blade Stall

In forward flight, the relative airflow through the main rotor disk is different on the advancing and retreating side. The relative airflow over the advancing side is higher due to the forward speed of the helicopter, while the relative airflow on the retreating side is lower. This dissymmetry of lift increases as forward speed increases.

To generate the same amount of lift across the rotor disk, the advancing blade flaps up while the retreating blade flaps down. This causes the AOA to decrease on the advancing blade, which reduces lift, and increase on the retreating blade, which increases lift. At some point as the forward speed increases, the low blade speed on the retreating blade, and its high AOA cause a stall and loss of lift.

Retreating blade stall is a major factor in limiting a helicopter's never-exceed speed (V_{NE}) and its development can be felt by a low frequency vibration, pitching up of the nose, and a roll in the direction of the retreating blade. High weight, low rotor rpm, high density altitude, turbulence and/ or steep, abrupt turns are all conducive to retreating blade stall at high forward airspeeds. As altitude is increased, higher blade angles are required to maintain lift at a given airspeed. Thus, retreating blade stall is encountered at a lower forward airspeed at altitude. Most manufacturers publish charts and graphs showing a V_{NE} decrease with altitude.

When recovering from a retreating blade stall condition, moving the cyclic aft only worsens the stall as aft cyclic produces a flare effect, thus increasing the AOA. Pushing forward on the cyclic also deepens the stall as the AOA on the retreating blade is increased. Correct recovery from retreating blade stall requires the collective to be lowered first, which reduces blade angles and thus AOA. Aft cyclic can then be used to slow the helicopter.

Common Errors

1. Failure to recognize the combination of contributing factors leading to retreating blade stall.
2. Failure to compute V_{NE} limits for altitudes to be flown.

Ground Resonance

Helicopters with articulating rotors (usually designs with three or more main rotor blades) are subject to ground resonance, a destructive vibration phenomenon that occurs at certain rotor speeds when the helicopter is on the ground. Ground resonance is a mechanical design issue that results from the helicopter's airframe having a natural frequency that can be intensified by an out-of-balance rotor. The unbalanced rotor system vibrates at the same frequency or multiple of the airframe's resonant frequency and the harmonic oscillation increases because the engine is adding power to the system, increasing the magnitude (or amplitude) of the vibrations until the structure or structures fail. This condition can cause a helicopter to self-destruct in a matter of seconds.

Hard contact with the ground on one corner (and usually with wheel-type landing gear) can send a shockwave to the main rotor head, resulting in the blades of a three-blade rotor system moving from their normal 120° relationship to each other. This movement occurs along the drag hinge and could result in something like 122° , 122° , and 116° between blades. [Figure 11-6] When one of the other landing gear strikes the surface, the unbalanced condition could be further aggravated. If the rpm is low, the only corrective action to stop ground resonance is to close the throttle immediately and fully lower the collective to place the blades in low pitch. If the rpm is in the normal operating range, fly the helicopter off the ground,



Figure 11-6. Ground resonance.

and allow the blades to rephase themselves automatically. Then, make a normal touchdown. If a pilot lifts off and allows the helicopter to firmly re-contact the surface before the blades are realigned, a second shock could move the blades again and aggravate the already unbalanced condition. This could lead to a violent, uncontrollable oscillation.

This situation does not occur in rigid or semi-rigid rotor systems because there is no drag hinge. In addition, skid-type landing gear is not as prone to ground resonance as wheel-type landing gear since the rubber tires are not present and change the rebound characteristics.

Dynamic Rollover

A helicopter is susceptible to a lateral rolling tendency, called dynamic rollover, when the helicopter is in contact with the surface during takeoffs or landings. For dynamic rollover to occur, some factor must first cause the helicopter to roll or pivot around a skid or landing gear wheel, until its critical rollover angle is reached. (5–8° depending on helicopter, winds, and loading) Then, beyond this point, main rotor thrust continues the roll and recovery is impossible. After this angle is achieved, the cyclic does not have sufficient range of control to eliminate the thrust component and convert it to lift. If the critical rollover angle is exceeded, the helicopter rolls on its side regardless of the cyclic corrections made.

Dynamic rollover begins when the helicopter starts to pivot laterally around its skid or wheel. This can occur for a variety of reasons, including the failure to remove a tie down or skid-securing device, or if the skid or wheel contacts a fixed object while hovering sideward, or if the gear is stuck in ice, soft asphalt, or mud. Dynamic rollover may also occur if you use an improper landing or takeoff technique or while performing slope operations. Whatever the cause, if the gear or skid becomes a pivot point, dynamic rollover is possible if not using the proper corrective technique.

Once started, dynamic rollover cannot be stopped by application of opposite cyclic control alone. For example, the right skid contacts an object and becomes the pivot point while the helicopter starts rolling to the right. Even with full left cyclic applied, the main rotor thrust vector and its moment follows the aircraft as it continues rolling to the right. Quickly reducing collective pitch is the most effective way to stop dynamic rollover from developing. Dynamic rollover can occur with any type of landing gear and all types of rotor systems.

It is important to remember rotor blades have a limited range of movement. If the tilt or roll of the helicopter exceeds that range (5–8°), the controls (cyclic) can no longer command a vertical lift component and the thrust or lift becomes a lateral

force that rolls the helicopter over. When limited rotor blade movement is coupled with the fact that most of a helicopter's weight is high in the airframe, another element of risk is added to an already slightly unstable center of gravity. Pilots must remember that in order to remove thrust, the collective must be lowered as this is the only recovery technique available.

Critical Conditions

Certain conditions reduce the critical rollover angle, thus increasing the possibility for dynamic rollover and reducing the chance for recovery. The rate of rolling motion is also a consideration because, as the roll rate increases, there is a reduction of the critical rollover angle at which recovery is still possible. Other critical conditions include operating at high gross weights with thrust (lift) approximately equal to the weight.

Refer to *Figure 11-7*. The following conditions are most critical for helicopters with counterclockwise rotor rotation:

1. Right side skid or landing wheel down, since translating tendency adds to the rollover force.
2. Right lateral center of gravity (CG).
3. Crosswinds from the left.
4. Left yaw inputs.

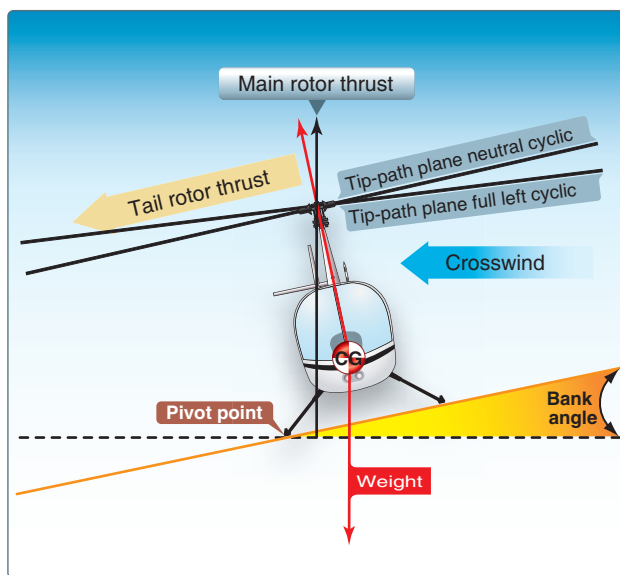


Figure 11-7. Forces acting on a helicopter with right skid on the ground.

For helicopters with clockwise rotor rotation, the opposite conditions would be true.