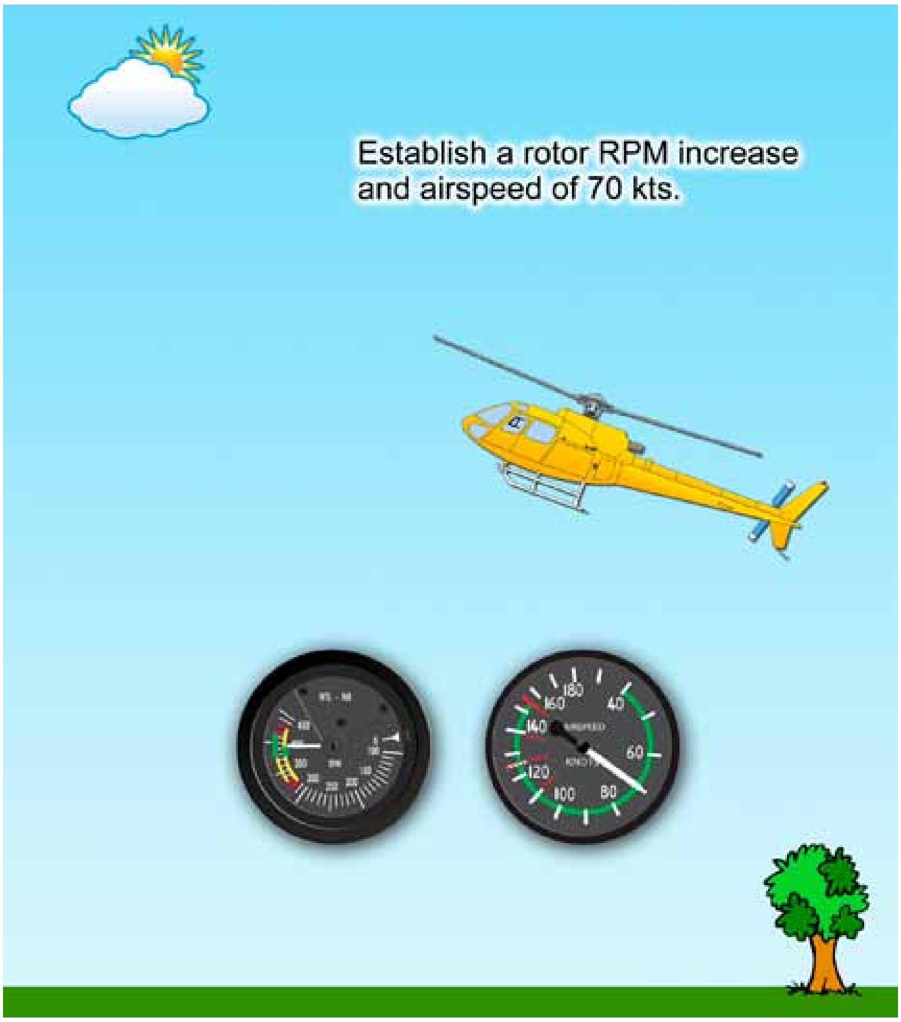
All Helicopters Autorotate the same, RIGHT?

NED DAWSON

One of the most important skills to possess as a pilot of a single engine helicopter is the ability to perform a successful autorotation after an engine failure. This skill set cannot be obtained by simple study, but must be practiced to a point where the actions taken in the helicopter become muscle memory or a motor skill. The Eurocopter AS350 AStar has become one of the most widely used aircraft in the world and the chances are that at one point or another most pilots will operate this airframe in their career. Eurosafety's GLEN WHITE provides an insight into flying the AS350 without an engine.


Establish a rotor RPM increase and airspeed of 70 kts.

THE AUTO

The variables that must be addressed during an autorotative descent require the pilot more to feel the proper action as opposed to methodically address each individual action. If you were to write out each thought, control input, and adjustment from the time the engine reduced in power to the 15 seconds later when the helicopter is safely on the ground, it would fill a page. To develop this mental and physical skill-set, helicopter pilots need to be armed with the proper knowledge of the aerodynamics of their specific model of helicopter.

The basic principles to execute an engine-off landing hold true in all models of helicopters. Airspeed, rotor RPM (RRPM), flare and cushion are all manipulated in order to land the aircraft safely. Each type of helicopter, however, has differing techniques and parameters to achieve that landing without substantial damage to the airframe or persons on board. The flare height of 40 ft in a Robinson R22 would not work well in an Agusta A119 which requires a 150 ft flare height.

Pilots develop their autorotational mental and muscle memory in the aircraft they first learn to fly. Since most of the autorotations performed by a pilot in his or her career occur when first learning to fly, it is this helicopter's autorotational characteristics with which they are most comfortable. This pilot then often goes on to teach engine-off procedures for approximately another 800 hours of his or her career. These ingrained preconceptions of how an autorotation is flown are the most important aspects to address when any pilot transfers helicopter types.

As pilots fly different helicopters, it is important that they mentally address the actual need to change. When learning a new model, pilots sit in ground school and are taught all the parameters of that helicopter's autorotational profile. So the proper numbers are now in their thought process. But then take that same pilot and place him or her in the cockpit of the helicopter and roll the engine off. Even though they have been taught the proper actions, there is a mental wrestling match being performed during the maneuver between the previously learned motor skill and the new numbers and "picture" they need to acquire. Sometimes, when under pressure, the pilot will subconsciously search for the familiar and apply incorrect information or technique to a situation. Acknowledging this pitfall helps to greatly increase the speed at which the pilot gains proficiency in the new model.

ASTAR

The Eurocopter AS350 AStar or Écureuil is one of the most widely used helicopters in the world and the chances are that at some point in their career most pilots will operate this airframe. When performed correctly, the autorotational characteristics of the AS350 are very mild. When performed incorrectly the same maneuver can be far more dramatic.

The first item to address in any helicopter, particularly the AS350, is to ensure that autorotational RPM is correctly set. At least 50% of all our clients' AStars have the RPM set too low.

The procedure to check the NR in the AS350 is very simple and outlined in section 8 of the rotorcraft flight manual (RFM). The method to perform this test and the chart to plot the results are located under a variant of the wording, depending on the model of AS350, of "Low pitch stop setting". The RFM includes a test sheet which can be copied and taken in the helicopter to record the parameters.

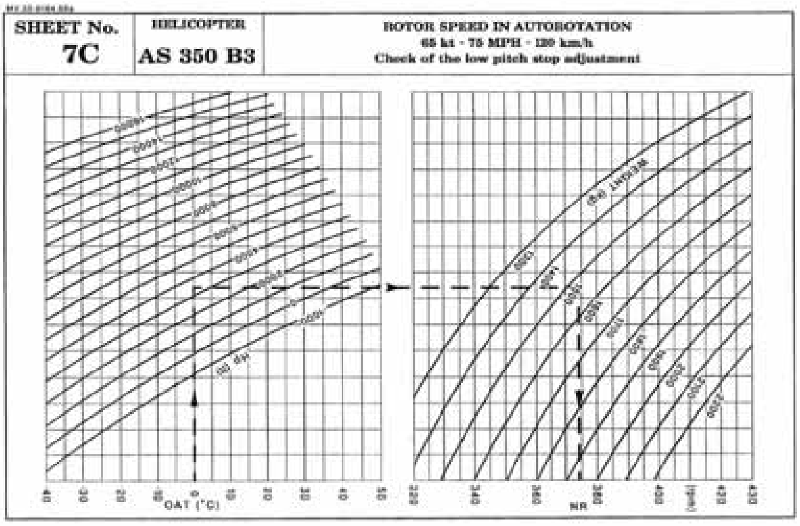
This test is more easily performed when the helicopter is very light. In a heavier ship, the proper NR will be closer to the upper limit of the range and will require more vigilance to not overspeed the rotor.

The test requires the helicopter be flown to a predetermined pressure altitude, (the RFM recommends below 5,000 ft) and at this altitude the outside air temperature is noted. The helicopter is then flown to a higher altitude, generally greater than 500 ft above the predetermined test altitude, to allow the establishment of a steady state autorotation when passing the test altitude.

While leaving the fuel flow control lever (FFCL) or throttle in the flight position, the pilot then lowers the collective to the low pitch stop, ensuring the NR does not exceed the red line at 430 RPM (424 in earlier models of AS350). If the collective needs to be adjusted to stop an overspeed, the test is over and the down stop bolt needs to be adjusted after the flight.

If the RRPM is within the allowed range (360 to 430 (424)), the airspeed is adjusted to 65 kts. As the helicopter passes through the test altitude the NR is noted and the data collected is plotted on the chart in Section 8 of the RFM. The RRPM is then corrected by adjusting the down stop bolt located under the floor of the aircraft cabin. One turn of the bolt is approximately 10 RRPM.

So then the obvious question is, "Why are so many AS350's autorotational RPM set too low"? The answer is quite simple. When the pilot lowers the collective and enters autorotation the FFCL or throttle is still in the flight position. If the down stop bolt is set too high, or in other words if the collective is set too high of a pitch, the RRPM would decrease if the engine were not in the flight position. Since the FFCL or throttle is in the flight position NR cannot decrease below equivalent engine speed.



Graphs such as these give a pilot a good indication of where you should be operating and where you shouldnt.

So many operators think, "Well, it's in the green – that's good enough". But it's the engine that is driving the NR into the green range, not the airflow through the rotor. The proper autorotational RRPM must be set slightly higher than the operational (driven) RRPM.

With NR correctly adjusted, the aircraft is now set up to allow the pilot to perform an autorotation, either actual or simulated, with the RRPM required to safely land the helicopter. As in any helicopter, the collective is lowered to achieve autorotation and keep the RRPM in the green arc. A low RRPM horn sounds if the NR drops below 360 (335 in earlier models) and in the AS350B2 onwards, a high RRPM horn is activated above 410.

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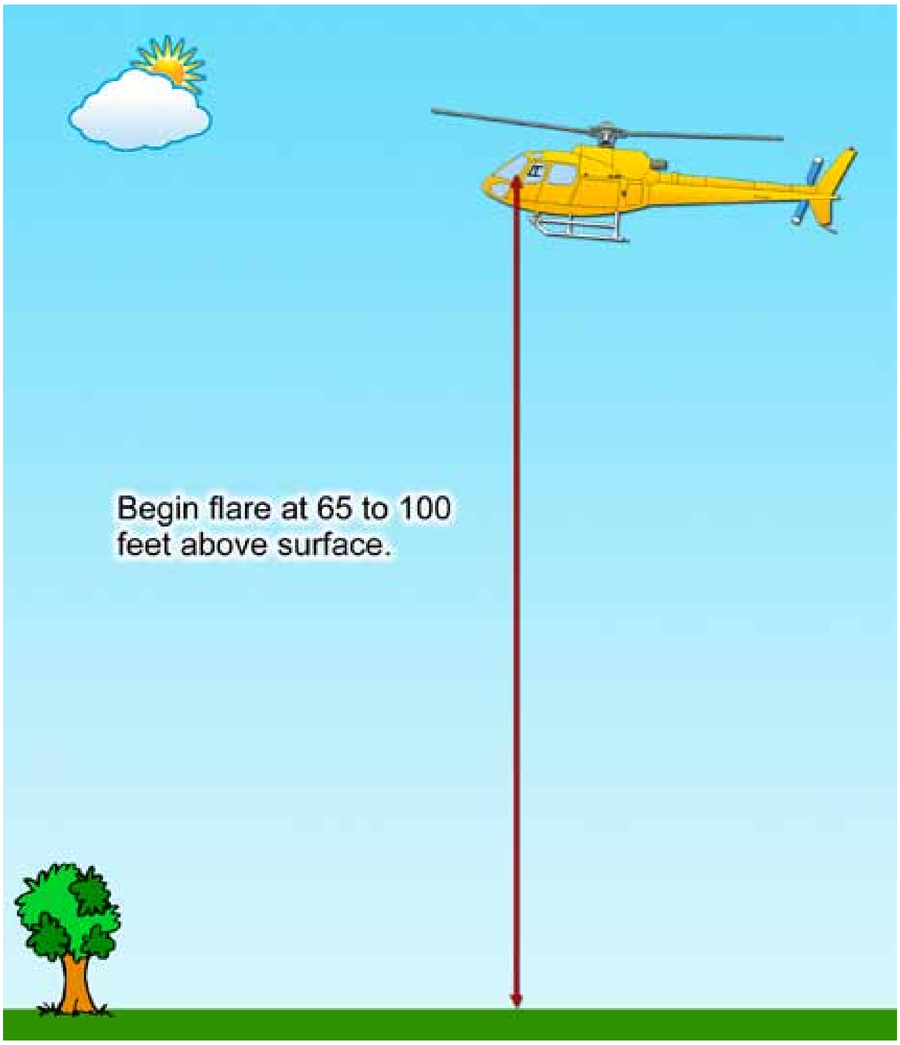
CONTROL

The rotorcraft flight manuals recommend an airspeed of 65 kts for all the AS350 variants with the exception of the EC130B4 which recommends a Vy of 70 kts minus 1 kt per 1,000 ft. Although the RFM does not publish an extended glide path procedure, the standard procedure of increasing KIAS and decreasing NR within limits works the same in the AS350 as with other makes of helicopter.

These recommended airspeeds work very well if held consistently to the flare height. The speed carried at the flare substantially affects the RRPM inertia build and the descent rate once in the flare. The RRPM inertia difference for airspeeds of either 65 kts or 60 kts is dramatic. The problem is that the majority of pilots will have a tendency to slightly decrease their airspeed (usually 5 kts) at approximately 200 ft above the ground as the sight picture of the earth's

As we flare higher the pilot will need to be more vigilant of collective input toward the bottom end of the autorotation, but will have a shorter ground run. As we flare lower (65 ft minimum) the greater the work load and the longer the ground run will result.



surface comes rushing at them rapidly. As the horizon is rising up the screen, there is an unintended easing back of the cyclic to subconsciously maintain the sight picture.

The fix for this is very simple – maintain a 70 kts airspeed. This helps the autorotation in two areas. First, if the pilot inadvertently decreases the airspeed by 5 kts prior to the flare, the aircraft is still at the recommended airspeed. If the airspeed is held at 70 kts to the flare there is still the needed inertia. Second, most AS350 airspeed indicators do not have a 65 kts tick – there is a 60 and a 70 kt line. So holding the airspeed on the 70 kts marking is easier than holding it in a blank space.

During the manipulation of the airspeed the aircraft is maneuvered into the wind and a landing area is chosen. If a turn is needed, the AS350 (like many other makes of helicopters), the airspeed tends to decrease and the RRPM increases. Adjustment of the collective and pitch attitude is needed during the turn. A trick to stay ahead of the RRPM is by feeling the pressure felt between you and your seat. If the pressure increases (indicating an increase in G-force) the RRPM would increase. As this pressure is felt, raise the collective – this will keep you ahead of the NR needs. Once the pressure decreases, lower the collective to prevent an under-speed of the NR.

FLARE

The flare portion of the autorotation is initiated to decrease the helicopter's forward airspeed and increase rotor inertia. The time needed to decelerate the aircraft is accomplished through the height of the flare. If the flare is initiated too low, because of the high descent rate the aircraft will make hard contact with the ground if a dramatic pitch pull is not introduced. This dramatic pitch pull consumes RRPM rapidly and since the aircraft has not been given time to slow in forward airspeed must either be landed with the high forward speed or must be held off the ground as deceleration occurs. Because a large amount of the inertia was consumed to rapidly arrest the rate of descent in the low flare, the needed RRPM may not be available.

The civilian AS350 RFM emergency procedures recommend a flare height of 65 ft in all variants except the EC130B4 which recommends a flare height of 70 ft. The flare height dramatically affects the RRPM at touchdown and the speed at which the helicopter is traveling at ground contact. Due to their prior experience in smaller helicopters, many pilots feel this initial flare height is too high, and the tendency is for the pilot to flare lower than ideal. If a low flare is made in the AS350 models, the bottom end of the auto becomes very dramatic and results in an increase in ground travel at touchdown.

The military AS350 RFM recommends a flare height of 120 ft. When the Australian Defense Force upgraded their AS350B airframes to the AS350BA for roles in the Australian Army Aviation Corps and Royal Australian Navy there was concern regarding autorotational performance with a focus on minimum run on speed.

Between May 1998 and August 1998 testing was performed on the autorotational characteristics of the AS350BA and published in a report by Major AJ (Barney) Langley, AAAvn and Captain CGY Breeden, RAEME. The results from this testing indicated the least amount of collective was required at the landing phase of the autorotation with a flare height of 100 ft. The testing also showed that at flare heights above 100 ft the collective management at the bottom of the autorotation became more difficult. When the flares were lowered to 80 and 65 ft the tendency was for the pilot to have to rush to get the aircraft through the flare and leveling portions of the autorotation.

Utilizing this information in the operation of the AStar models we can conclude that the proper recommended flare height should be between 65 and 100 ft. As we flare higher the pilot will need to be more vigilant of collective input toward the bottom end of the autorotation, but will have a shorter ground run. As we flare lower (65 ft minimum) the greater the work load and the longer the ground run will result.

The amount of flare needed depends on many aspects including wind, temperature, altitude and available area for the ground run. The rate at which the flare is introduced will affect the speed at which the RRPM increases and reduces the rate of descent. When the flare is introduced higher above the ground, time is available to adjust the flare attitude at a slower rate in order to establish a controlled increase in RRPM, and to decrease the descent rate. If the flare is introduced at a lower height above the surface, the control input must be more rapid in order to build the RRPM to the needed inertia (while maintaining RRPM within limits) and rapidly reduce the descent rate.

Atmospheric wind speed will affect the amount of flare needed to build RRPM. The stronger the wind, the less flare is needed to achieve proper RRPM. To provide for the perfect flare angle,

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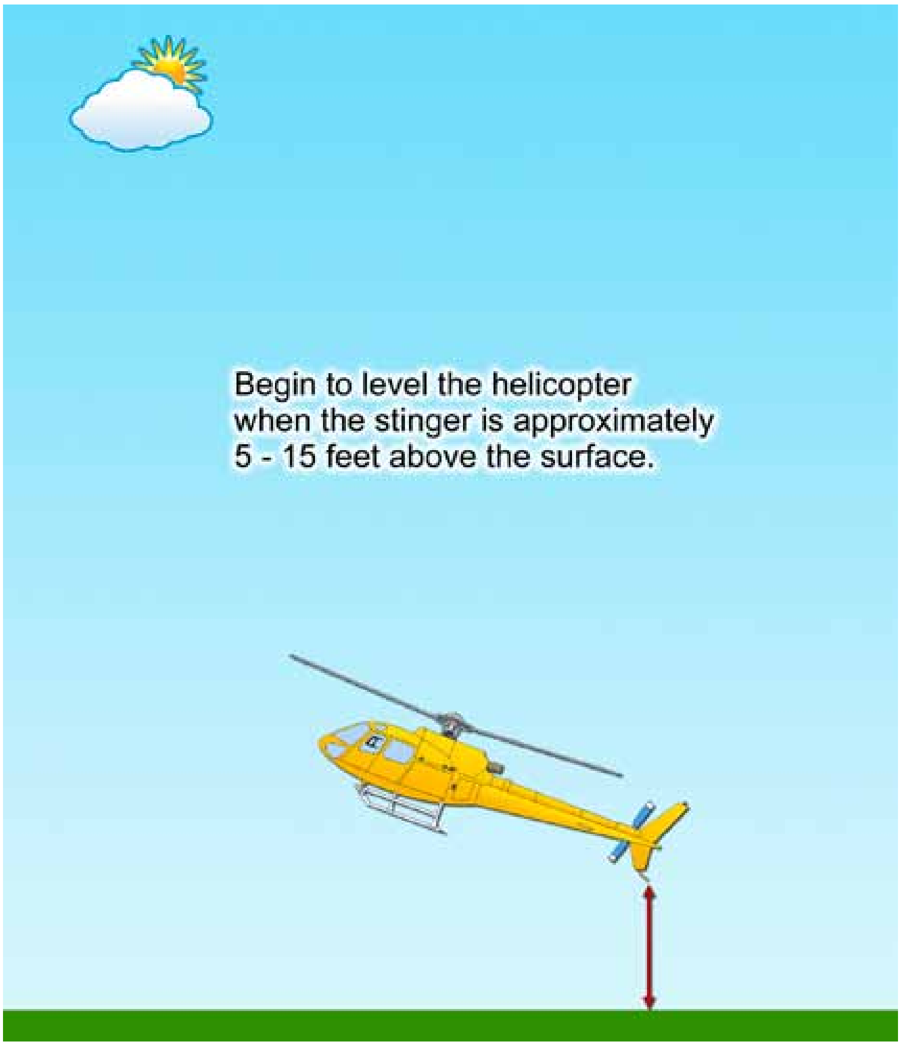
Depending on the amount of flare established, the pilot’s seat will vary in height above the surface when this tail height is achieved. As the helicopter is leveled, a small amount of collective input is used.



Begin to level the helicopter
when the stinger is approximately
5 - 15 feet above the surface.

the NR gauge is utilized. The flare is initiated until an angle is reached which creates a slow rise in NR, while the aircraft continues to descend. If the NR remains stationary or drops, then the flare is at too low an angle or the induced rate of the flare is too slow. If the NR rises rapidly or needs to be controlled with the collective, the flare is at too great an angle or the induced rate of the flare is too rapid. Control inputs during the flare should not be thought of as one steady movement, but rather a series of movements used to find the proper flare angle. Once this flare angle is found, it is held until the level is initiated.

During the descent, if the RRPM is adjusted properly, a small amount of collective is needed to maintain the NR in the green range of the gauge. To achieve the ideal flare/RRPM conditions, this small amount of collective is lowered simultaneously during the flare entry. This creates a build in the NR without ballooning the aircraft and provides for more collective during touchdown.

To be able to achieve this perfect flare angle the RRPM needs to be rigged properly, or this rise in RPM cannot be accomplished without ballooning the aircraft. This occurs because when the NR autorotational RRPM is set low (the collective down stop bolt has the collective resting at too high of a position). It is the same as checking in too much collective during the auto and not releasing it.

During an actual engine failure the RRPM created during the flare becomes even more important, since the landing area generally is smaller and/or the terrain is rough. The goal during the flare in an actual engine failure would be to bring the RRPM to the red line to allow for more inertia for landing. During autorotational training, repeatedly taking the RRPM to the red line would eventually cause an overspeed. The goal during training should be to comfortably take the RRPM into the yellow range of the gauge to induce the mind-set of RRPM increase.

LEVEL

The approximate distance between the pilot’s seat and the tail of the aircraft is 30 feet. When the flare is initiated the pilot must be cognizant of the amount of helicopter that is now closer to the ground. The leveling of the helicopter occurs when the tail of the aircraft is between 5 and 15 feet above the surface. Depending on the amount of flare established, the pilot’s seat will vary in height above the surface when this tail height is achieved. As the helicopter is leveled, a small amount of collective input is used.

Because the transmission is tilted 3 degrees forward, if the helicopter is landed with the skids level, the aircraft will accelerate during touchdown. The proper attitude for touchdown is landing on the heels of the skids without dragging the stinger on the ground. The stinger on the AS350

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Like any skill, it takes study and practice to achieve and maintain proficiency. The 15 seconds between engine failure and ground contact leave little room for analysis, and requires the pilot to have a strong muscle memory of the proper actions.

models is designed to be able to make repeated ground contact without damage to the aircraft as long as the contact is not severe. The stinger on the EC130B4 is more pliable and designed to bend when ground contact is direct, in order to protect the fiberglass construction of the fenestron keel. During autorotational training, hard contact with the stinger on the EC130B4 should be avoided.

A common misconception is that when conducting the collective pull, or cushion, it is one steady raising of the collective. Generally the collective increase is slow at first, and then varies with touchdown. Much like the collective being manipulated inconsistently during a normal landing, the collective must also be adjusted as needed to make an autorotational landing (just usually in the opposite direction). As the helicopter descends to the surface, the collective is manipulated to provide a smooth and slow touchdown.

Once full contact is made with the ground (the skids are now level), the cyclic is displaced slightly aft and the collective is lowered to help decelerate the aircraft. Care must be taken when lowering the collective not to adjust the pitch too rapidly. When the collective is lowered, friction between the helicopter and the surface increases – thereby increasing deceleration. Since the entire cabin of the AS350 (excluding the EC130B4) is forward of the front crosstube, the aircraft can pitch over – particularly if the landing is made on soft ground.

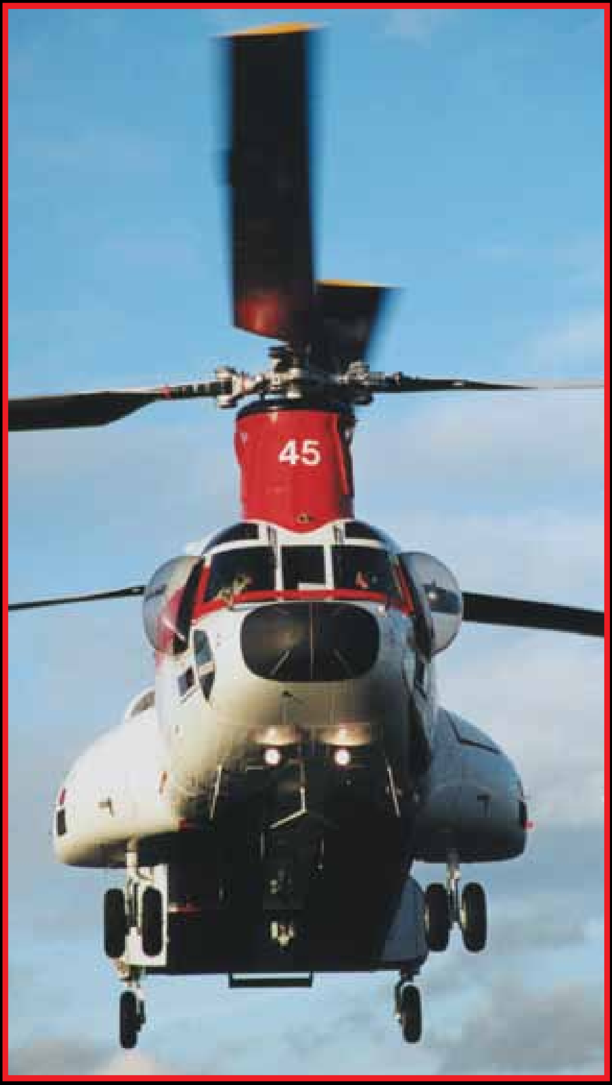
POWER RECOVERY

The unfortunate reality in our industry today is that most autorotational training is conducted to a power recovery. This ingrains incorrect muscle memory for the procedures just prior to ground contact and provides for no guidance on the actual landing of the helicopter. When a pilot performs repeated power recovery autorotations a muscle memory is developed, that when the collective is introduced at level, the power from the engine is being reapplied. This application of collective during a power recovery is constant and only increases to a low pitch since power from the engine is now turning the rotors. With this muscle memory during an actual engine failure or during a training full down autorotation, the pilot will have a tendency to not apply proper collective and make a hard impact.

CONCLUSION

Like any skill, it takes study and practice to achieve and maintain proficiency. The 15 seconds between engine failure and ground contact leave little room for analysis, and requires the pilot to have a strong muscle memory of the proper actions. Just as when flying the aircraft in any other profile we can look down at our hands and they seem to move without any conscious thought process. We need to also develop these skills for our autorotational landings. Either that, or we have 15 seconds to figure it out! ■

We Fly



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