

Faulty Approaches and Landings

Landing involves many precise, time-sensitive, and sequential control inputs. When corrected early, small errors are often not noticeable. On the other hand, uncorrected errors may place the airplane and occupants in an undesirable state. Since pilot training normally includes exposure to landing deviations and their appropriate remedies, this section covers several common landing imperfections.

Low Final Approach

When the base leg is too low, insufficient power is used, landing flaps are extended prematurely, or the velocity of the wind is misjudged, the airplane may be well below the proper final approach path. In such a situation, the pilot would have to apply considerable power to fly the airplane (at an excessively low altitude) up to the runway threshold. When it is realized the runway cannot be reached unless appropriate action is taken, power should be applied immediately to maintain the airspeed while the pitch attitude is raised to increase lift and stop the descent. When the proper approach path has been intercepted, the correct approach attitude is reestablished and the power reduced and a stabilized approach maintained. [Figure 9-30] The pilot should not increase the pitch attitude without increasing the power because the airplane decelerates rapidly and may approach the critical AOA and stall. In addition, the pilot should not retract the flaps since this causes a sudden decrease in lift and causes the airplane to sink more rapidly. If there is any doubt about the approach being safely completed, it is advisable to execute an immediate go-around.

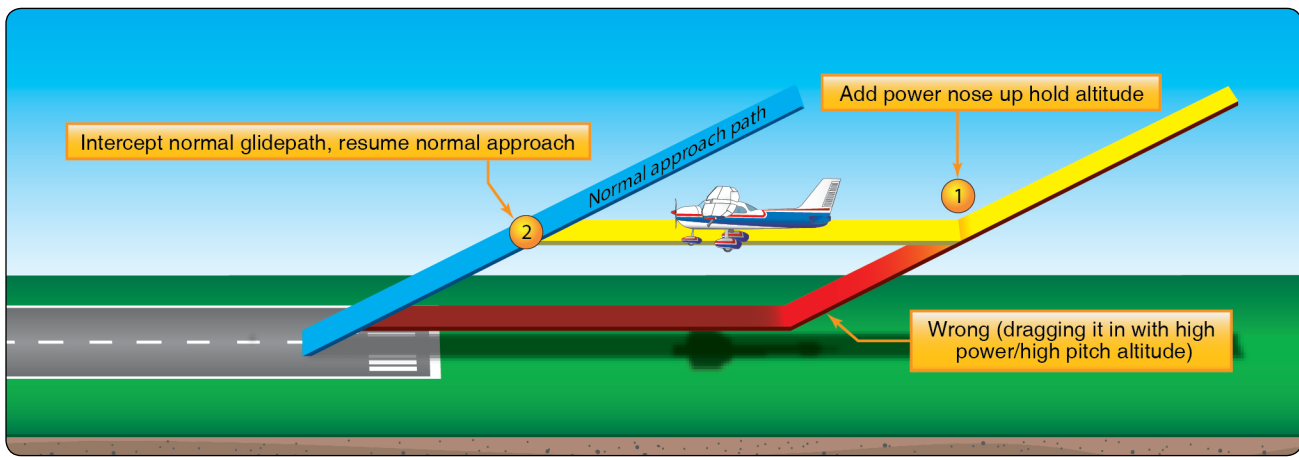


Figure 9-30. Right and wrong methods of correction for low final approach.

High Final Approach

When the final approach is too high, the pilot may lower the flaps as required. Further reduction in power may be necessary, while lowering the nose simultaneously to maintain approach airspeed and steepen the approach path. [Figure 9-31] Alternatively, the pilot could use a forward slip to increase the descent angle and rate of descent while maintaining proper approach speed. Since a sink rate in excess of 800–1,000 feet per minute (fpm) is considered excessive, either technique avoids the high sink rates that would occur if the pilot dives the airplane toward the aiming point. Since a high sink rate continued close to the surface makes it be difficult to slow to a proper rate prior to ground contact, it is not a good idea to dive toward the aiming point. Therefore, when intercepting the proper approach path from above, the pilot adjusts the power as required to maintain a stabilized approach. A go-around should be initiated if the sink rate becomes excessive.

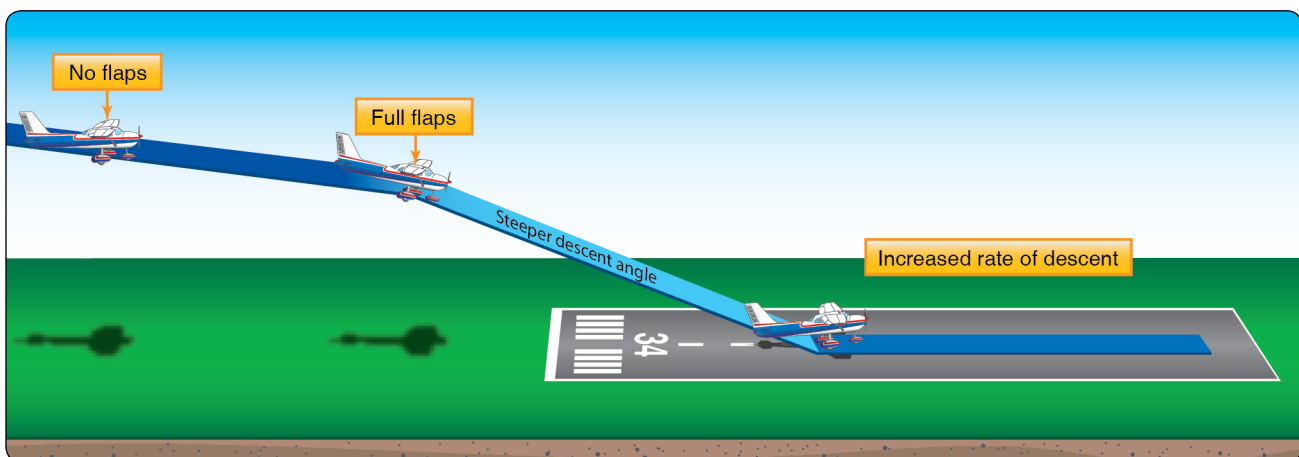


Figure 9-31. Change in glidepath and increase in descent rate for high final approach.

Slow Final Approach

On the final approach, when the airplane is flown at a slower than normal airspeed, the pilot's judgment of the rate of sink (descent) and the height of round out is difficult. During an excessively slow approach, the wing is operating near the critical AOA and, depending on the pitch attitude changes and control usage, the airplane may stall or sink rapidly, contacting the ground with a hard impact.

Whenever a slow speed approach is noted, the pilot should apply power to accelerate the airplane and increase the lift to reduce the sink rate and to prevent a stall. This is done while still at a high enough altitude to reestablish the correct approach airspeed and attitude. If too slow and too low, it is best to execute a go-around.

Use of Power

Power can be used effectively during the approach and round out to compensate for errors in judgment. Power may be added to accelerate the airplane, to increase lift without increasing the AOA, and to slow the descent to an acceptable rate. The increased propwash over the wing behind the propeller(s) also provides an immediate boost in lift that also helps slow the descent rate. If the proper landing attitude is attained and the airplane is only slightly high, the landing attitude is held constant and sufficient power applied to help ease the airplane onto the ground. After the airplane has touched down, the pilot closes the throttle so the additional thrust and lift are removed and the airplane remains on the ground.

High Round Out

Sometimes when the airplane appears to temporarily stop moving downward, the round out has been made too rapidly and the airplane is flying level, too high above the runway. Continuing the round out further reduces the airspeed and increases the AOA to the critical angle. This results in the airplane stalling and dropping hard onto the runway. To prevent this, the pitch attitude is held constant until the airplane decelerates enough to again start descending. Then the round out is continued to establish the proper landing attitude. This procedure is only used when there is adequate airspeed. It may be necessary to add a slight amount of power to keep the airspeed from decreasing excessively and to avoid losing lift too rapidly.

When the proper landing attitude is attained, the airplane is approaching a stall because the airspeed is decreasing and the critical AOA is being approached, even though the pitch attitude is no longer being increased. [Figure 9-32]

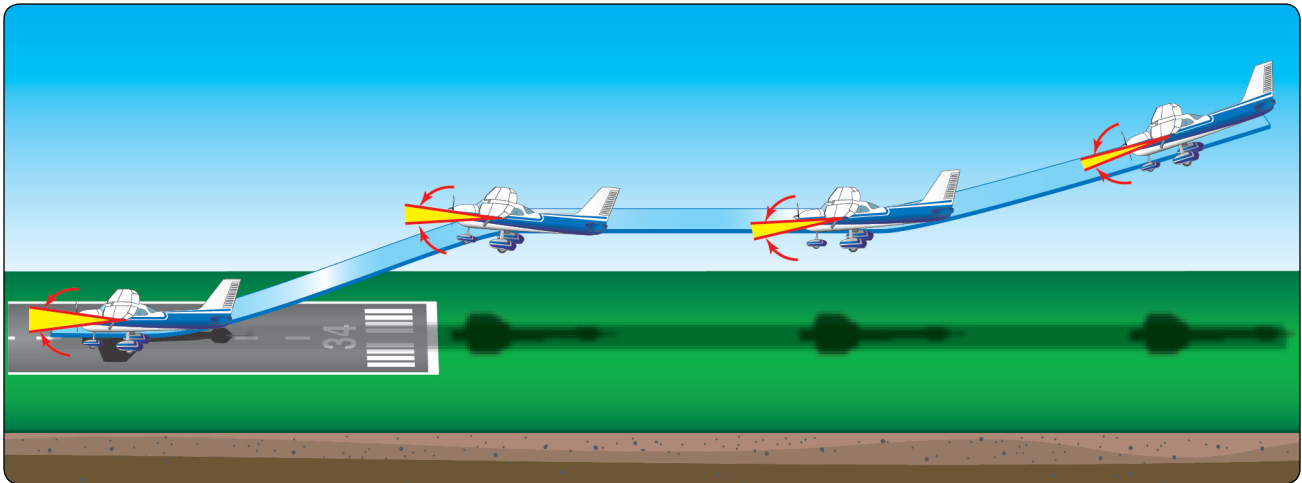


Figure 9-32. *Rounding out too high.*

Although back-elevator pressure may be relaxed slightly, the nose should not be lowered to make the airplane descend when fairly close to the runway unless some power is added momentarily. The momentary decrease in lift that results from lowering the nose and decreasing the AOA might cause the airplane to contact the ground with the nose-wheel first and may result in nose gear damage or collapse.

It is recommended that a go-around be executed any time it appears the nose needs to be lowered significantly or that the landing is in any other way uncertain.

Late or Rapid Round Out

Starting the round out too late or pulling the elevator control back too rapidly to prevent the airplane from touching down prematurely can impose a significant load on the wings and cause an accelerated stall.

Suddenly increasing the AOA and stalling the airplane during a round out is a dangerous situation since it may cause the airplane to land extremely hard on the main landing gear and then bounce back into the air. As the airplane contacts the ground, the tail is forced down very rapidly by the back-elevator pressure and by inertia acting downward on the tail.

Recovery from this situation requires prompt and positive application of power prior to occurrence of the stall. This may be followed by a normal landing if sufficient runway is available—otherwise the pilot should execute a go-around immediately.

If the round out is late and uncorrected, the nose-wheel may strike the runway first, causing the nose to bounce upward. Do not attempt to force the airplane back onto the ground; execute a go-around immediately.

Floating During Round Out

If the airspeed on final approach is excessive, it usually results in the airplane floating. [Figure 9-33] Before touchdown can be made, the airplane may be well past the desired landing point and the available runway may be insufficient. When diving the airplane on final approach to land at the proper point, there is an appreciable increase in airspeed. The proper touchdown attitude cannot be established without producing an excessive AOA and lift. This causes the airplane to gain altitude or balloon.

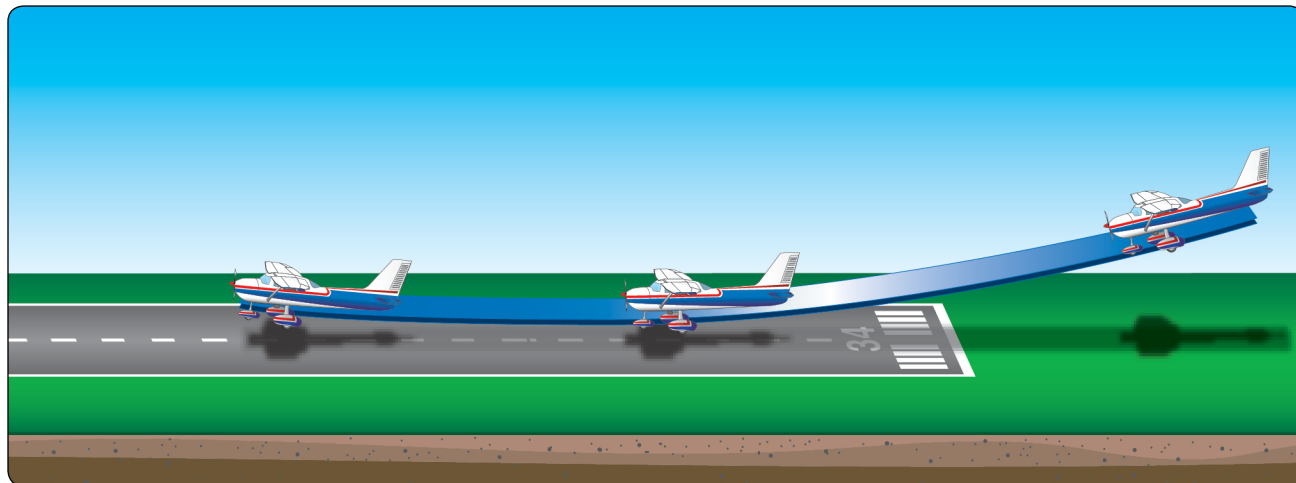


Figure 9-33. *Floating during round out.*

Any time the airplane floats, judgment of speed, height, and rate of sink needs to be especially acute. The pilot should smoothly and gradually adjust the pitch attitude as the airplane decelerates to touchdown speed and starts to settle, so the proper landing attitude is attained at the moment of touchdown. The slightest error in judgment and timing results in either ballooning or bouncing.

The recovery from floating is dependent upon the amount of floating and the effect of any crosswind, as well as the amount of runway remaining. Since prolonged floating utilizes considerable runway length, it should be avoided especially on short runways or in strong crosswinds. If a landing cannot be made on the first third of the runway, or the airplane drifts sideways, execute a go-around.

Ballooning During Round Out

If the pilot misjudges the rate of sink during a landing and thinks the airplane is descending faster than it should, there is a tendency to increase the pitch attitude and AOA too rapidly. This not only stops the descent, but actually starts the airplane climbing. This climbing during the round out is known as ballooning. [Figure 9-34] Ballooning is dangerous because the height above the ground is increasing and the airplane is rapidly approaching a stalled condition. The altitude gained in each instance depends on the airspeed or the speed with which the pitch attitude is increased.

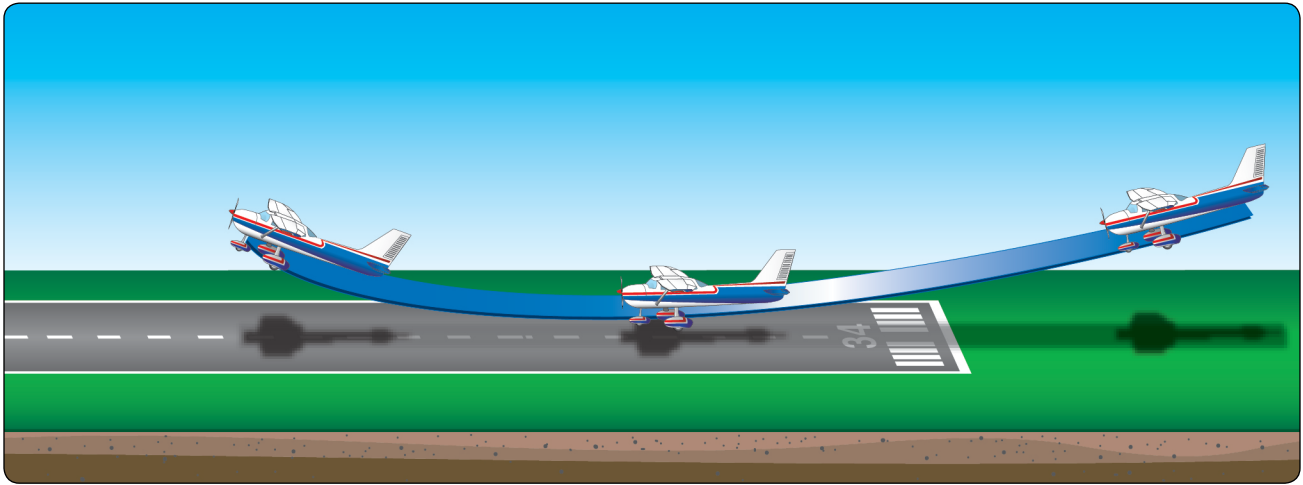


Figure 9-34. *Ballooning during roundout.*

Depending on the severity of ballooning, the use of throttle is helpful in cushioning the landing. By adding power, thrust is increased to keep the airspeed from decelerating too rapidly and the wings from suddenly losing lift, but throttle should be closed immediately after touchdown. Torque effects vary as power is changed, and it is necessary to use rudder pressure to keep the airplane straight as it settles onto the runway.

The pilot needs to be extremely cautious of ballooning when there is a crosswind present because the crosswind correction may be inadvertently released or it may become inadequate. Because of the lower airspeed after ballooning, the crosswind affects the airplane more. Consequently, the wing has to be lowered even further to compensate for the increased drift. It is imperative that the pilot makes certain that the appropriate wing is down and that directional control is maintained with opposite rudder. If there is any doubt, or the airplane starts to drift, the pilot should execute a go-around.

When ballooning is excessive, it is best to execute a go-around immediately and not attempt to salvage the landing. Power should be applied before the airplane enters a stalled condition.

Bouncing During Touchdown

When the airplane contacts the ground with a sharp impact as the result of an improper attitude or an excessive rate of sink, it tends to bounce back into the air. Though the airplane's tires and shock struts provide some springing action, the airplane does not bounce like a rubber ball. Instead, it rebounds into the air because the wing's AOA was abruptly increased, producing a sudden addition of lift. [Figure 9-35]

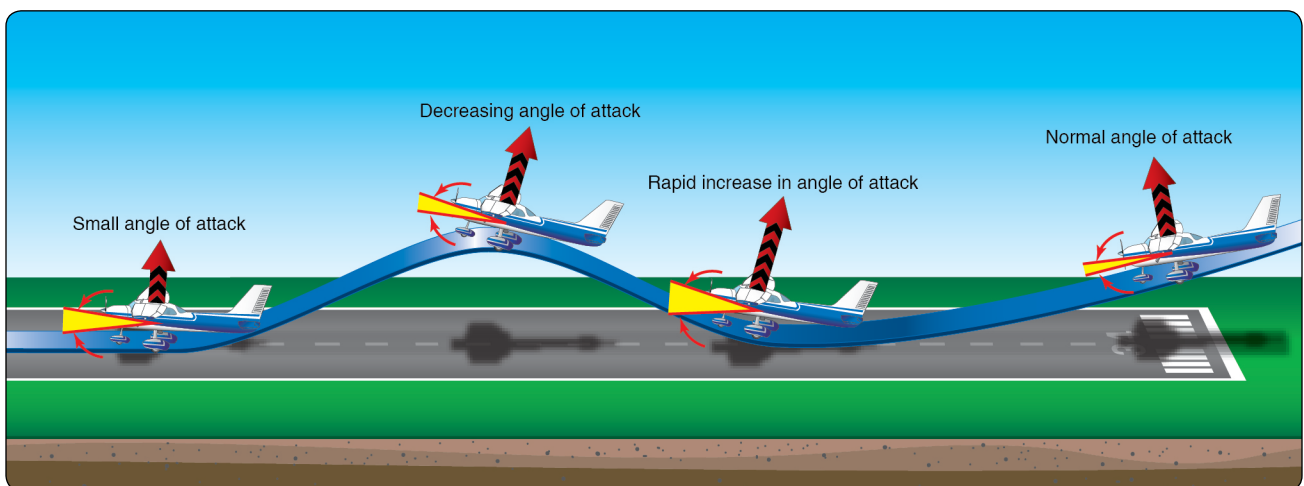


Figure 9-35. *Bouncing during touchdown.*

The abrupt change in AOA is the result of inertia instantly forcing the airplane's tail downward when the main wheels contact the ground sharply. The severity of the bounce depends on the airspeed at the moment of contact and the degree to which the AOA or pitch attitude was increased.

Since a bounce occurs when the airplane makes contact with the ground before the proper touchdown attitude is attained, it is almost invariably accompanied by the application of excessive back-elevator pressure. This is usually the result of the pilot realizing too late that the airplane is not in the proper attitude and attempting to establish it just as the second touchdown occurs.

The corrective action for a bounce is the same as for ballooning and similarly depends on its severity. When it is very slight and there is no extreme change in the airplane's pitch attitude, a follow-up landing may be executed by applying sufficient power to cushion the subsequent touchdown and smoothly adjusting the pitch to the proper touchdown attitude.

In the event a very slight bounce is encountered while landing with a crosswind, crosswind correction needs to be maintained while the next touchdown is made. Since the subsequent touchdown is made at a slower airspeed, the upwind wing has to be lowered even further to compensate for drift.

Extreme caution and alertness should be exercised any time a bounce occurs, but particularly when there is a crosswind. Pilots should not release the crosswind correction. When one main wheel of the airplane strikes the runway, the other wheel touches down immediately afterwards, and the wings become level. Then, with no crosswind correction as the airplane bounces, the wind causes the airplane to roll with the wind, thus exposing even more surface to the crosswind and increasing any drift.

When a bounce is severe, the safest procedure is to execute a go-around immediately. The pilot should not attempt to salvage the landing. Apply full power while simultaneously maintaining directional control and lowering the nose to a safe climb attitude. The go-around procedure should be continued even though the airplane may descend and another bounce may be encountered. Landing from a bad bounce should not be attempted, since airspeed diminishes very rapidly in the nose-high attitude, and a stall may occur before a subsequent touchdown can be made.

Porpoising

In a bounced landing that is improperly recovered, the airplane comes in nose first, initiating a series of motions imitating the jumps and dives of a porpoise. [Figure 9-36] The improper airplane attitude at touchdown may be caused by inattention, not knowing where the ground is, miss-trimming, or forcing the airplane onto the runway.

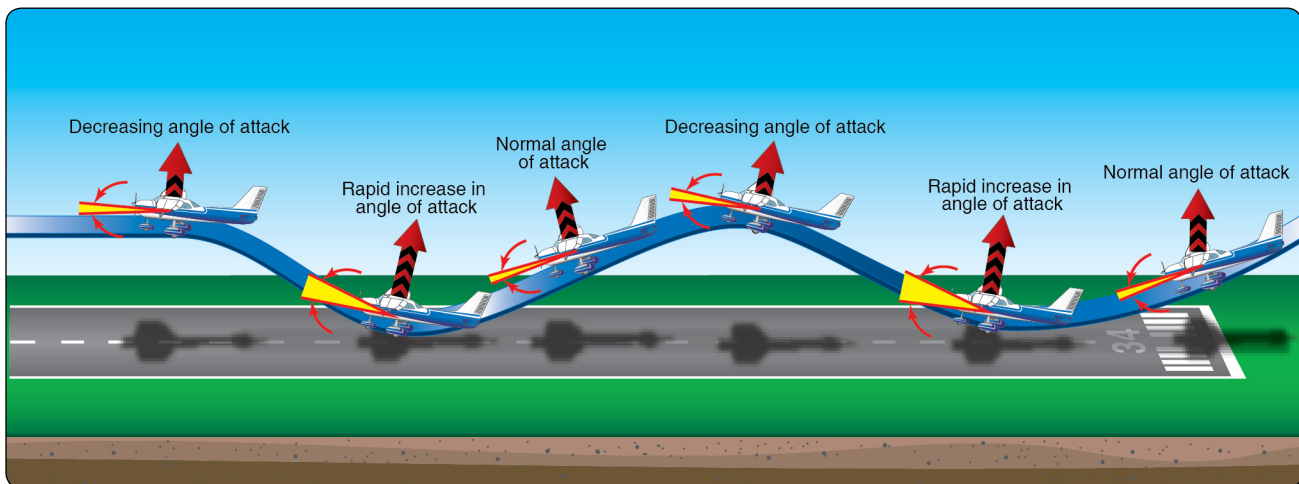


Figure 9-36. *Porpoising.*

Ground effect decreases elevator control effectiveness and increases the effort required to raise the nose. Not enough elevator or stabilator trim can result in a nose low contact with the runway and a porpoise develops.

Porpoising can also be caused by improper airspeed control. Usually, if an approach is too fast, the airplane floats and the pilot tries to force it on the runway when the airplane still wants to fly. A gust of wind, a bump in the runway, or even a slight tug on the control wheel sends the airplane aloft again.

The corrective action for a porpoise is the same as for a bounce and similarly depends on its severity. When it is very slight and there is no extreme change in the airplane's pitch attitude, a follow-up landing may be executed by applying sufficient power to cushion the subsequent touchdown and smoothly adjusting the pitch to the proper touchdown attitude.

When pilots attempt to correct a severe porpoise with flight control and power inputs, the inputs are often untimely may increase the severity of each successive contact with the surface. These unintentional and increasing pilot-induced oscillations may lead to damage or collapse of the nose gear. When porpoising is severe or seems to be getting worse, the safest procedure is to execute a go-around immediately by applying full power while simultaneously maintaining directional control and lowering the nose to a safe climb attitude.

Wheelbarrowing

When a pilot permits the airplane weight to become concentrated about the nose-wheel during the takeoff or landing roll, a condition known as wheelbarrowing occurs. Wheelbarrowing may cause loss of directional control during the landing roll because braking action is ineffective, and the airplane tends to swerve or pivot on the nose-wheel, particularly in crosswind conditions. One of the most common causes of wheelbarrowing during the landing roll is a simultaneous touchdown of the main and nose-wheel with excessive speed, followed by application of forward pressure on the elevator control. Usually, the situation can be corrected by smoothly applying back-elevator pressure.

Wheelbarrowing does not occur if the pilot achieves and maintains the correct landing attitude, touches down at the proper speed, and gently lowers the nose-wheel while losing speed on rollout. However, if wheelbarrowing is encountered and runway and other conditions permit, it is advisable to promptly initiate a go-around. If the pilot decides it's safer to stay on the ground rather than attempt a go-around when directional control is lost, close the throttle and adjust the pitch attitude smoothly but firmly to the proper landing attitude.

Hard Landing

When the airplane contacts the ground during landings, its vertical speed is instantly reduced to zero. Unless provisions are made to slow this vertical speed and cushion the impact of touchdown, the force of contact with the ground could cause structural damage to the airplane.

The purpose of pneumatic tires, shock absorbing landing gear, and other devices is to cushion the impact and to increase the time in which the airplane's vertical descent is stopped. The importance of this cushion may be understood from the computation that a 6-inch free fall on landing is roughly equal to a 340 fpm descent. Within a fraction of a second, the airplane gets slowed from this rate of vertical descent to zero without damage.

During this time, the landing gear, together with some aid from the lift of the wings, supplies whatever force is needed to counteract the force of the airplane's inertia and weight. However, the lift decreases rapidly as the airplane's forward speed is decreased, and the force on the landing gear increases by the impact of touchdown. When the descent stops, the lift is practically zero, leaving the landing gear alone to carry both the airplane's weight and inertia force. The load imposed at the instant of touchdown may easily be three or four times the actual weight of the airplane depending on the severity of contact.

Touchdown in a Drift or Crab

At times, it is necessary to correct for wind drift by crabbing on the final approach. If the round out and touchdown are made while the airplane is drifting or in a crab, it contacts the ground while moving sideways. This imposes extreme side loads on the landing gear and, if severe enough, may cause structural failure.

The most effective method to prevent drift is the wing-low method. This technique keeps the longitudinal axis of the airplane aligned with both the runway and the direction of motion throughout the approach and touchdown. There are three factors that cause the longitudinal axis and the direction of motion to be misaligned during touchdown: drifting, crabbing, or a combination of both.

If the pilot does not take adequate corrective action to avoid drift during a crosswind landing, the main wheels' tire tread offers resistance to the airplane's sideward movement with respect to the ground. Consequently, any sideward velocity of the airplane is abruptly decelerated, as shown in *Figure 9-37*. This creates a moment around the main wheel when it contacts the ground, tending to overturn or tip the airplane. If the upwind wingtip is raised by the action of this moment, all the weight and shock of landing is borne by one main wheel. This concentration of forces may cause tire failure or structural damage.

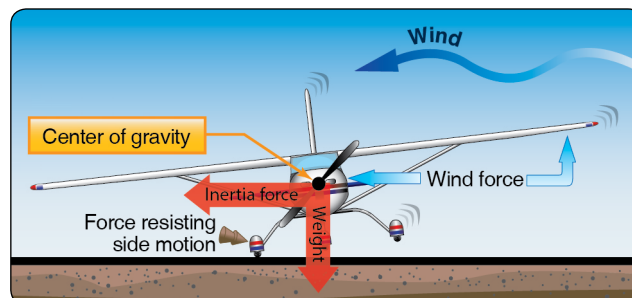


Figure 9-37. *Drifting during touchdown.*

Not only are the same factors present that are attempting to raise a wing, but the crosswind is also acting on the fuselage surface behind the main wheels, tending to yaw (weathervane) the airplane into the wind. This often results in a ground loop.

Ground Loop

A ground loop is an uncontrolled turn during ground operation that may occur while taxiing or taking off. However, an airplane is especially vulnerable to this occurrence during the after-landing roll. A ground loop may result if the pilot fails to control an initial swerve. Drift or weathervaning may cause the initial swerve. Careless use of the rudder, an uneven ground surface, or a soft spot that retards one main wheel of the airplane may also cause a swerve. In any case, the initial swerve tends to make the airplane ground loop, whether it is a tailwheel-type or nose-wheel type. [Figure 9-38]

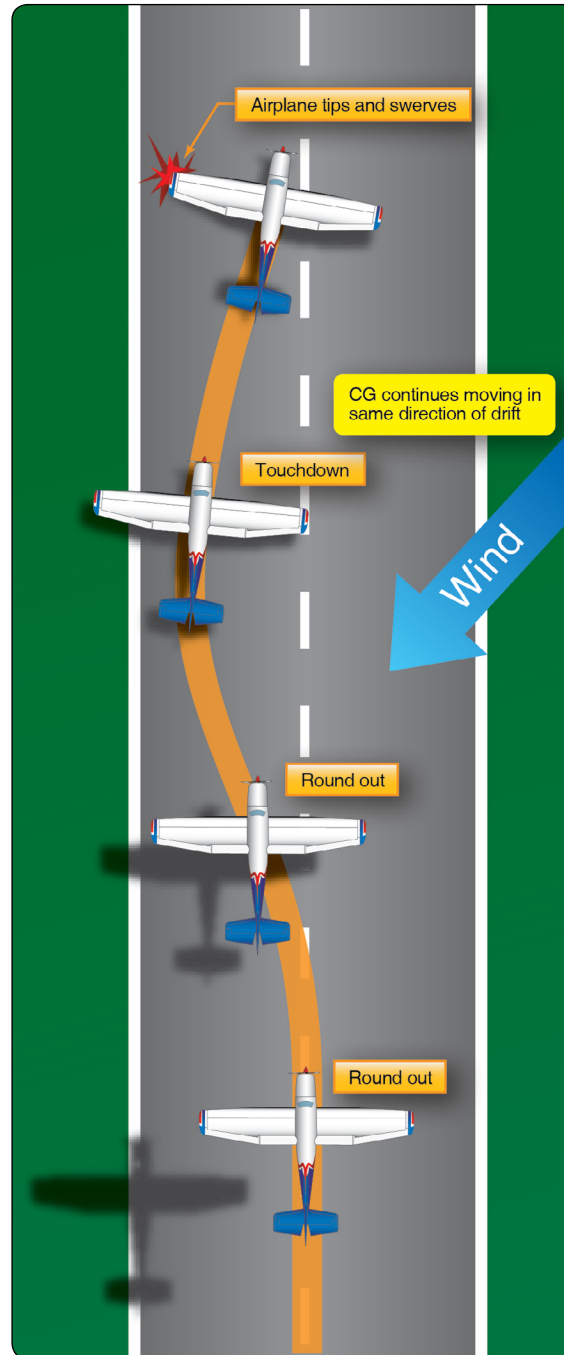


Figure 9-38. *Start of a ground loop.*

Nose-wheel type airplanes are somewhat less prone to ground loop than tailwheel-type airplanes. Since the center of gravity (CG) is located forward of the main landing gear on these airplanes, any time a swerve develops, centrifugal force acting on the CG tends to stop the swerving action.

If the airplane touches down while drifting or in a crab, apply aileron toward the high wing and stop the swerve with the rudder. Brakes are used to correct for turns or swerves only when the rudder is inadequate. Exercise caution when applying corrective brake action because it is very easy to over control and aggravate the situation.

If brakes are used, sufficient brake is applied on the low-wing wheel (outside of the turn) to stop the swerve. When the wings are approximately level, the new direction should be maintained until the airplane has slowed to taxi speed or has stopped.

In nose-wheel airplanes, a ground loop is almost always a result of wheelbarrowing. A pilot should be aware that even though the nose-wheel type airplane is less prone than the tailwheel-type airplane, virtually every type of airplane, including large multiengine airplanes, can be made to ground loop when sufficiently mishandled.

Wing Rising After Touchdown

When landing in a crosswind, there may be instances when a wing rises during the after-landing roll. This may occur whether or not there is a loss of directional control, depending on the amount of crosswind and the degree of corrective action.

Any time an airplane is rolling on the ground in a crosswind condition, the upwind wing is receiving a greater force from the wind than the downwind wing. This causes a lift differential. Also, as the upwind wing rises, there is an increase in the AOA, which increases lift on the upwind wing, rolling the airplane downwind.

When the effects of these two factors are great enough, the upwind wing may rise even though directional control is maintained. If no correction is applied, it is possible that the upwind wing rises sufficiently to cause the downwind wing to strike the ground.

In the event a wing starts to rise during the landing roll, the pilot should immediately apply more aileron pressure toward the high wing and continue to maintain direction. The sooner the aileron control is applied, the more effective it is. The further a wing is allowed to rise before taking corrective action, the more airplane surface is exposed to the force of the crosswind. This diminishes the effectiveness of the aileron.

Hydroplaning

Hydroplaning is a condition that can exist when an airplane has landed on a runway surface contaminated with standing water, slush, or wet snow. Hydroplaning can have serious adverse effects on ground controllability and braking efficiency. The three basic types of hydroplaning are dynamic hydroplaning, reverted rubber hydroplaning, and viscous hydroplaning. Any one of the three can render an airplane partially or totally uncontrollable anytime during the landing roll.

Dynamic Hydroplaning

Dynamic hydroplaning is a relatively high-speed phenomenon that occurs when there is a film of water on the runway that is at least one-tenth of an inch deep. As the speed of the airplane and the depth of the water increase, the water layer builds up an increasing resistance to displacement, resulting in the formation of a wedge of water beneath the tire. At some speed, termed the hydroplaning speed (V_p), the water pressure equals the weight of the airplane, and the tire is lifted off the runway surface. In this condition, the tires no longer contribute to directional control and braking action is nil.

Dynamic hydroplaning is related to tire inflation pressure. Data obtained during hydroplaning tests have shown the minimum dynamic hydroplaning speed (V_p) of a tire to be 8.6 times the square root of the tire pressure in pounds per square inch (PSI). For an airplane with a main tire pressure of 24 PSI, the calculated hydroplaning speed would be approximately 42 knots. It is important to note that the calculated speed referred to above is for the start of dynamic hydroplaning. Once hydroplaning has started, it may persist to a significantly slower speed depending on the type being experienced.

Reverted Rubber Hydroplaning

Reverted rubber (steam) hydroplaning occurs during heavy braking that results in a prolonged locked-wheel skid. Only a thin film of water on the runway is required to facilitate this type of hydroplaning. The tire skidding generates enough heat to cause the rubber in contact with the runway to revert to its original uncured state. The reverted rubber acts as a seal between the tire and the runway and delays water exit from the tire footprint area. The water heats and is converted to steam, which supports the tire off the runway.

Reverted rubber hydroplaning frequently follows an encounter with dynamic hydroplaning, during which time the pilot may have the brakes locked in an attempt to slow the airplane. Eventually the airplane slows enough to where the tires make contact with the runway surface and the airplane begins to skid. The remedy for this type of hydroplaning is to release the brakes and allow the wheels to spin up and apply moderate braking. Reverted rubber hydroplaning is insidious in that the pilot may not know when it begins, and it can persist to very slow groundspeeds (20 knots or less).

Viscous Hydroplaning

Viscous hydroplaning is due to the viscous properties of water. A thin film of fluid no more than one-thousandth of an inch in depth is all that is needed. The tire cannot penetrate the fluid and the tire rolls on top of the film. This can occur at a much lower speed than dynamic hydroplaning, but requires a smooth or smooth acting surface, such as asphalt or a touchdown area coated with the accumulated rubber from previous landings. Such a surface can have the same friction coefficient as wet ice.

When confronted with the possibility of hydroplaning, it is best to land on a grooved runway (if available). Touchdown speed should be as slow as possible consistent with safety. After the nose-wheel is lowered to the runway, moderate braking is applied. If deceleration is not detected and hydroplaning is suspected, raise the nose and use aerodynamic drag to decelerate to a point where the brakes become effective.

Proper braking technique is essential. The brakes are applied firmly until reaching a point just short of a skid. At the first sign of a skid, release brake pressure and allow the wheels to spin up. Directional control is maintained as far as possible with the rudder. Remember that in a crosswind, if hydroplaning occurs, the crosswind causes the airplane to simultaneously weathervane into the wind, as well as slide downwind.

Chapter Summary

Accident statistics show that a pilot is more at risk during the approach and landing than during any other phase of a flight. There are many factors that contribute to accidents in this phase, but an overwhelming percentage of these accidents result from a lack of pilot proficiency. This chapter presents procedures that, when learned and practiced correctly, are key to attaining proficiency. Additional information on aerodynamics, aircraft performance, and other aspects affecting approaches and landings can be found in the Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25, as revised). For information concerning risk assessment as a means of preventing accidents, refer to the Risk Management Handbook (FAA-H-8083-2, as revised). Both of these publications are available at www.faa.gov/regulations_policies/handbooks_manuals/aviation/.