

Chapter 6

Helicopter Attitude Instrument Flying

Introduction

Attitude instrument flying in helicopters is essentially visual flying with the flight instruments substituted for the various reference points on the helicopter and the natural horizon. Control changes, required to produce a given attitude by reference to instruments, are identical to those used in helicopter visual flight rules (VFR) flight, and pilot thought processes are the same. Basic instrument training is intended to be a building block toward attaining an instrument rating.



Flight Instruments

When flying a helicopter with reference to the flight instruments, proper instrument interpretation is the basis for aircraft control. Skill, in part, depends on understanding how a particular instrument or system functions, including its indications and limitations (see Chapter 3, Flight Instruments). With this knowledge, a pilot can quickly interpret an instrument indication and translate that information into a control response.

Instrument Flight

To achieve smooth, positive control of the helicopter during instrument flight, three fundamental skills must be developed. They are instrument cross-check, instrument interpretation, and aircraft control.

Instrument Cross-Check

Cross-checking, sometimes referred to as scanning, is the continuous and logical observation of instruments for attitude and performance information. In attitude instrument flying, an attitude is maintained by reference to the instruments, which produces the desired result in performance. Due to human error, instrument error, and helicopter performance differences in various atmospheric and loading conditions, it is difficult to establish an attitude and have performance

remain constant for a long period of time. These variables make it necessary to constantly check the instruments and make appropriate changes in the helicopter's attitude. The actual technique may vary depending on what instruments are installed and where they are installed, as well as pilot experience and proficiency level. This discussion concentrates on the six basic flight instruments. [Figure 6-1]

At first, there may be a tendency to cross-check rapidly, looking directly at the instruments without knowing exactly what information is needed. However, with familiarity and practice, the instrument cross-check reveals definite trends during specific flight conditions. These trends help a pilot control the helicopter as it makes a transition from one flight condition to another.

When full concentration is applied to a single instrument, a problem called fixation is encountered. This results from a natural human inclination to observe a specific instrument carefully and accurately, often to the exclusion of other instruments. Fixation on a single instrument usually results in poor control. For example, while performing a turn, there is a tendency to watch only the turn-and-slip indicator instead of including other instruments in the cross-check. This fixation on the turn-and-slip indicator often leads to a loss of altitude through poor pitch-and-bank control. Look at each



Figure 6-1. In most situations, the cross-check pattern includes the attitude indicator between the cross-check of each of the other instruments. A typical cross-check might progress as follows: attitude indicator, altimeter, attitude indicator, vertical speed indicator, attitude indicator, heading indicator, attitude indicator, and so on.

instrument only long enough to understand the information it presents, and then proceed to the next one. Similarly, too much emphasis can be placed on a single instrument, instead of relying on a combination of instruments necessary for helicopter performance information. This differs from fixation in that other instruments are included in a cross-check, but too much attention is placed on one particular instrument.

During performance of a maneuver, there is sometimes a failure to anticipate significant instrument indications following attitude changes. For example, during level off from a climb or descent, a pilot may concentrate on pitch control, while forgetting about heading or roll information. This error, called omission, results in erratic control of heading and bank.

In spite of these common errors, most pilots can adapt well to flight by instrument reference after instruction and practice. Many find that they can control the helicopter more easily and precisely by instruments.

Instrument Interpretation

The flight instruments together give a picture of what is happening. No one instrument is more important than the next; however, during certain maneuvers or conditions, those instruments that provide the most pertinent and useful information are termed primary instruments. Those which back up and supplement the primary instruments are termed supporting instruments. For example, since the attitude indicator is the only instrument that provides instant and direct aircraft attitude information, it should be considered primary during any change in pitch or bank attitude. After the new attitude is established, other instruments become primary, and the attitude indicator usually becomes the supporting instrument.

Aircraft Control

Controlling a helicopter is the result of accurately interpreting the flight instruments and translating these readings into correct control responses. Aircraft control involves adjustment to pitch, bank, power, and trim in order to achieve a desired flight path.

Pitch attitude control is controlling the movement of the helicopter about its lateral axis. After interpreting the helicopter's pitch attitude by reference to the pitch instruments (attitude indicator, altimeter, airspeed indicator, and vertical speed indicator (VSI)), cyclic control adjustments are made to affect the desired pitch attitude. In this chapter, the pitch attitudes depicted are approximate and vary with different helicopters.

Bank attitude control is controlling the angle made by the lateral tilt of the rotor and the natural horizon, or the movement of the helicopter about its longitudinal axis. After interpreting the helicopter's bank instruments (attitude indicator, heading indicator, and turn indicator), cyclic control adjustments are made to attain the desired bank attitude.

Power control is the application of collective pitch with corresponding throttle control, where applicable. In straight-and-level flight, changes of collective pitch are made to correct for altitude deviation if the error is more than 100 feet, or the airspeed is off by more than 10 knots. If the error is less than that amount, a pilot should use a slight cyclic climb or descent.

In order to fly a helicopter by reference to the instruments, it is important to know the approximate power settings required for a particular helicopter in various load configurations and flight conditions.

Trim, in helicopters, refers to the use of the cyclic centering button, if the helicopter is so equipped, to relieve all possible cyclic pressures. Trim also refers to the use of pedal adjustment to center the ball of the turn indicator. Pedal trim is required during all power changes.

The proper adjustment of collective pitch and cyclic friction helps a pilot relax during instrument flight. Friction should be adjusted to minimize overcontrolling and to prevent creeping, but not applied to such a degree that control movement is limited. In addition, many helicopters equipped for instrument flight contain stability augmentation systems or an autopilot to help relieve pilot workload.

Straight-and-Level Flight

Straight-and-level unaccelerated flight consists of maintaining the desired altitude, heading, airspeed, and pedal trim.

Pitch Control

The pitch attitude of a helicopter is the angular relation of its longitudinal axis to the natural horizon. If available, the attitude indicator is used to establish the desired pitch attitude. In level flight, pitch attitude varies with airspeed and center of gravity (CG). At a constant altitude and a stabilized airspeed, the pitch attitude is approximately level. *[Figure 6-2]*

Attitude Indicator

The attitude indicator gives a direct indication of the pitch attitude of the helicopter. In visual flight, attain the desired pitch attitude by using the cyclic to raise and lower the nose



Figure 6-2. The flight instruments for pitch control are the airspeed indicator, attitude indicator, altimeter, and vertical speed indicator.

of the helicopter in relation to the natural horizon. During instrument flight, follow exactly the same procedure in raising or lowering the miniature aircraft in relation to the horizon bar.

There is some delay between control application and resultant instrument change. This is the normal control lag in the helicopter and should not be confused with instrument lag. The attitude indicator may show small misrepresentations of pitch attitude during maneuvers involving acceleration, deceleration, or turns. This precession error can be detected quickly by cross-checking the other pitch instruments.

If the miniature aircraft is properly adjusted on the ground, it may not require readjustment in flight. If the miniature aircraft is not on the horizon bar after level off at normal cruising airspeed, adjust it as necessary while maintaining level flight with the other pitch instruments. Once the miniature aircraft has been adjusted in level flight at normal cruising airspeed, leave it unchanged so it gives an accurate picture of pitch attitude at all times.

When making initial pitch attitude corrections to maintain altitude, the changes of attitude should be small and smoothly applied. The initial movement of the horizon bar should not exceed one bar width high or low. [Figure 6-3] If a further adjustment is required, an additional correction of one-half bar normally corrects any deviation from the desired altitude. This one-and-one-half bar correction is normally the maximum pitch attitude correction from level flight attitude.

After making the correction, cross-check the other pitch instruments to determine whether the pitch attitude change is sufficient. If additional correction is needed to return to altitude, or if the airspeed varies more than 10 knots from that desired, adjust the power.

Altimeter

The altimeter gives an indirect indication of the pitch attitude of the helicopter in straight-and-level flight. Since the altitude should remain constant in level flight, deviation from the desired altitude indicates a need for a change in pitch attitude and power as necessary. When losing altitude, raise the pitch attitude and adjust power as necessary. When gaining altitude, lower the pitch attitude and adjust power as necessary. Indications for power changes are explained in the next paragraph.

The rate at which the altimeter moves helps to determine pitch attitude. A very slow movement of the altimeter indicates a small deviation from the desired pitch attitude, while a



Figure 6-3. The initial pitch correction at normal cruise is one bar width or less.

fast movement of the altimeter indicates a large deviation from the desired pitch attitude. Make any corrective action promptly, with small control changes. Also, remember that movement of the altimeter should always be corrected by two distinct changes. The first is a change of attitude to stop the altimeter movement; the second is a change of attitude to return smoothly to the desired altitude. If altitude and airspeed are more than 100 feet and 10 knots low, respectively, apply power in addition to an increase of pitch attitude. If the altitude and airspeed are high by more than 100 feet and 10 knots, reduce power and lower the pitch attitude.

There is a small lag in the movement of the altimeter; however, for all practical purposes, consider that the altimeter gives an immediate indication of a change, or a need for change in pitch attitude. Since the altimeter provides the most pertinent information regarding pitch in level flight, it is considered primary for pitch.

Vertical Speed Indicator (VSI)

The VSI gives an indirect indication of the pitch attitude of the helicopter and should be used in conjunction with the other pitch instruments to attain a high degree of accuracy and precision. The instrument indicates zero when in level flight. Any movement of the needle from the zero position shows a need for an immediate change in pitch attitude to return it to zero. Always use the VSI in conjunction with the altimeter in level flight. If a movement of the VSI is detected, immediately use the proper corrective measures to return it to zero. If the correction is made promptly, there is usually little or no change in altitude. If the needle of the VSI does not indicate zero, the altimeter indicates a gain or loss of altitude.

The initial movement of the vertical speed needle is instantaneous and indicates the trend of the vertical movement of the helicopter. A period of time is necessary for the VSI to reach its maximum point of deflection after a correction has been made. This time element is commonly referred to as instrument lag. The lag is directly proportional to the speed and magnitude of the pitch change. When employing smooth control techniques and small adjustments in pitch attitude are made, lag is minimized, and the VSI is easy to interpret.

Overcontrolling can be minimized by first neutralizing the controls and allowing the pitch attitude to stabilize, then readjusting the pitch attitude by noting the indications of the other pitch instruments.

Occasionally, the VSI may be slightly out of calibration. This could result in the instrument indicating a slight climb or descent even when the helicopter is in level flight. If the instrument cannot be calibrated properly, this error must be

taken into consideration when using the VSI for pitch control. For example, if a descent of 100 feet per minute (fpm) is the vertical speed indication when the helicopter is in level flight, use that indication as level flight. Any deviation from that reading would indicate a change in attitude.

Airspeed Indicator

The airspeed indicator gives an indirect indication of helicopter pitch attitude. With a given power setting and pitch attitude, the airspeed remains constant. If the airspeed increases, the nose is too low and should be raised. If the airspeed decreases, the nose is too high and should be lowered. A rapid change in airspeed indicates a large change in pitch attitude, and a slow change in airspeed indicates a small change in pitch attitude. There is very little lag in the indications of the airspeed indicator. If, while making attitude changes, there is some lag between control application and change of airspeed, it is most likely due to cyclic control lag. Generally, a departure from the desired airspeed, due to an inadvertent pitch attitude change, also results in a change in altitude. For example, an increase in airspeed due to a low pitch attitude results in a decrease in altitude. A correction in the pitch attitude regains both airspeed and altitude.

Bank Control

The bank attitude of a helicopter is the angular relation of its lateral axis to the natural horizon. To maintain a straight course in visual flight, keep the lateral axis of the helicopter level with the natural horizon. Assuming the helicopter is in coordinated flight, any deviation from a laterally level attitude produces a turn. [Figure 6-4]

Attitude Indicator

The attitude indicator gives a direct indication of the bank attitude of the helicopter. For instrument flight, the miniature aircraft and the horizon bar of the attitude indicator are substituted for the actual helicopter and the natural horizon. Any change in bank attitude of the helicopter is indicated instantly by the miniature aircraft. For proper interpretation of this instrument, imagine being in the miniature aircraft. If the helicopter is properly trimmed and the rotor tilts, a turn begins. The turn can be stopped by leveling the miniature aircraft with the horizon bar. The ball in the turn-and-slip indicator should always be kept centered through proper pedal trim.

The angle of bank is indicated by the pointer on the banking scale at the top of the instrument. [Figure 6-5] Small bank angles, which may not be seen by observing the miniature aircraft, can easily be determined by referring to the banking scale pointer.



Figure 6-4. The flight instruments used for bank control are the attitude, heading, and turn indicators.

Pitch-and-bank attitudes can be determined simultaneously on the attitude indicator. Even though the miniature aircraft is not level with the horizon bar, pitch attitude can be established by observing the relative position of the miniature aircraft and the horizon bar.

The attitude indicator may show small misrepresentations of bank attitude during maneuvers that involve turns. This precession error can be detected immediately by closely cross-checking the other bank instruments during these maneuvers. Precession is normally noticed when rolling out of a turn. If, upon completion of a turn, the miniature aircraft is level and the helicopter is still turning, make a

small change of bank attitude to center the turn needle and stop the movement of the heading indicator.

Heading Indicator

In coordinated flight, the heading indicator gives an indirect indication of a helicopter’s bank attitude. When a helicopter is banked, it turns. When the lateral axis of a helicopter is level, it flies straight. Therefore, in coordinated flight when the heading indicator shows a constant heading, the helicopter is level laterally. A deviation from the desired heading indicates a bank in the direction the helicopter is turning. A small angle of bank is indicated by a slow change of heading; a large angle of bank is indicated by a rapid change of heading. If a turn is noticed, apply opposite cyclic until the heading indicator



Figure 6-5. The banking scale at the top of the attitude indicator indicates varying degrees of bank. In this example, the helicopter is banked approximately 15° to the right.

indicates the desired heading, simultaneously ensuring the ball is centered. When making the correction to the desired heading, do not use a bank angle greater than that required to achieve a standard rate turn. In addition, if the number of degrees of change is small, limit the bank angle to the number of degrees to be turned. Bank angles greater than these require more skill and precision in attaining the desired results. During straight-and-level flight, the heading indicator is the primary reference for bank control.

Turn Indicator

During coordinated flight, the needle of the turn-and-slip indicator gives an indirect indication of the bank attitude of the helicopter. When the needle is displaced from the vertical position, the helicopter is turning in the direction of the displacement. Thus, if the needle is displaced to the left, the helicopter is turning left. Bringing the needle back to the vertical position with the cyclic produces straight flight. A close observation of the needle is necessary to accurately interpret small deviations from the desired position.

Cross-check the ball of the turn-and-slip indicator to determine if the helicopter is in coordinated flight. [Figure 6-6] If the rotor is laterally level and pedal pressure properly compensates for torque, the ball remains in the center. To center the ball, level the helicopter laterally by reference to the other bank instruments, then center the ball with pedal trim. Torque correction pressures vary as power changes are made. Always check the ball after such changes.

Common Errors During Straight-and-Level Flight

1. Failure to maintain altitude
2. Failure to maintain heading
3. Overcontrolling pitch and bank during corrections
4. Failure to maintain proper pedal trim
5. Failure to cross-check all available instruments

Power Control During Straight-and-Level Flight

Establishing specific power settings is accomplished through collective pitch adjustments and throttle control, where necessary. For reciprocating-powered helicopters, power indication is observed on the manifold pressure gauge. For turbine-powered helicopters, power is observed on the torque gauge. (Although most Instrument Flight Rules (IFR)-certified helicopters are turbine powered, depictions within this chapter use a reciprocating-powered helicopter as this is where training is most likely conducted.)

At any given airspeed, a specific power setting determines whether the helicopter is in level flight, in a climb, or in a descent. For example, cruising airspeed maintained with cruising power results in level flight. If a pilot increases the power setting and holds the airspeed constant, the helicopter climbs. Conversely, if the pilot decreases power and holds the airspeed constant, the helicopter descends.



Figure 6-6. Coordinated flight is indicated by centering of the ball.

If the altitude is held constant, power determines the airspeed. For example, at a constant altitude, cruising power results in cruising airspeed. Any deviation from the cruising power setting results in a change of airspeed. When power is added to increase airspeed, the nose of the helicopter pitches up and yaws to the right in a helicopter with a counterclockwise main rotor blade rotation. [Figure 6-7] When power is reduced to decrease airspeed, the nose pitches down and yaws to the left. [Figure 6-8] The yawing effect is most pronounced in single-rotor helicopters, and is absent in helicopters with counter-rotating rotors. To counteract the yawing tendency of the helicopter, apply pedal trim during power changes.

To maintain a constant altitude and airspeed in level flight, coordinate pitch attitude and power control. The relationship between altitude and airspeed determines the need for a change in power and/or pitch attitude. If the altitude is constant and the airspeed is high or low, change the power to obtain the desired airspeed. During the change in power, make an accurate interpretation of the altimeter, then counteract any deviation from the desired altitude by an appropriate change of pitch attitude. If the altitude is low and the airspeed is high, or vice versa, a change in pitch attitude alone may return the helicopter to the proper altitude and airspeed. If both airspeed and altitude are low, or if both are high, changes in both power and pitch attitude are necessary.

To make power control easy when changing airspeed, it is necessary to know the approximate power settings for the

various airspeeds at which the helicopter is flown. When the airspeed is to be changed by any appreciable amount, adjust the power so that it is over or under that setting necessary to maintain the new airspeed. As the power approaches the desired setting, include the manifold pressure in the cross-check to determine when the proper adjustment has been accomplished. As the airspeed is changing, adjust the pitch attitude to maintain a constant altitude. A constant heading should be maintained throughout the change. As the desired airspeed is approached, adjust power to the new cruising power setting and further adjust pitch attitude to maintain altitude. The instrument indications for straight-and-level flight at normal cruise and during the transition from normal cruise to slow cruise are illustrated in Figures 6-9 and 6-10. After the airspeed stabilizes at slow cruise, the attitude indicator shows an approximate level pitch attitude.

The altimeter is the primary pitch instrument during level flight, whether flying at a constant airspeed or during a change in airspeed. Altitude should not change during airspeed transitions, and the heading indicator remains the primary bank instrument. Whenever the airspeed is changed by an appreciable amount, the manifold pressure gauge is momentarily the primary instrument for power control. When the airspeed approaches the desired reading, the airspeed indicator again becomes the primary instrument for power control.



Figure 6-7. Flight instrument indications in straight-and-level flight with power increasing.



Figure 6-8. Flight instrument indications in straight-and-level flight with power decreasing.



Figure 6-9. Flight instrument indications in straight-and-level flight at normal cruise speed.



Figure 6-10. Flight instrument indications in straight-and-level flight with airspeed decreasing.

To produce straight-and-level flight, the cross-check of the pitch-and-bank instruments should be combined with the power control instruments. With a constant power setting, a normal cross-check should be satisfactory. When changing power, the speed of the cross-check must be increased to cover the pitch-and-bank instruments adequately. This is necessary to counteract any deviations immediately.

Common Errors During Airspeed Changes

1. Improper use of power
2. Overcontrolling pitch attitude
3. Failure to maintain heading
4. Failure to maintain altitude
5. Improper pedal trim

Straight Climbs (Constant Airspeed and Constant Rate)

For any power setting and load condition, there is only one airspeed that gives the most efficient rate of climb. To determine this, consult the climb data for the type of helicopter being flown. The technique varies according to the airspeed on entry and whether a constant airspeed or constant rate climb is made.

Entry

To enter a constant airspeed climb from cruise airspeed when the climb speed is lower than cruise speed, simultaneously increase power to the climb power setting and adjust pitch attitude to the approximate climb attitude. The increase in power causes the helicopter to start climbing and only very slight back cyclic pressure is needed to complete the change from level to climb attitude. The attitude indicator should be used to accomplish the pitch change. If the transition from level flight to a climb is smooth, the VSI shows an immediate upward trend and then stops at a rate appropriate to the stabilized airspeed and attitude. Primary and supporting instruments for climb entry are illustrated in *Figure 6-11*.

When the helicopter stabilizes at a constant airspeed and attitude, the airspeed indicator becomes primary for pitch. The manifold pressure continues to be primary for power and should be monitored closely to determine if the proper climb power setting is being maintained. Primary and supporting instruments for a stabilized constant airspeed climb are shown in *Figure 6-12*.

The technique and procedures for entering a constant rate climb are very similar to those previously described for a constant airspeed climb. For training purposes, a constant



Figure 6-11. Flight instrument indications during climb entry for a constant-airspeed climb.

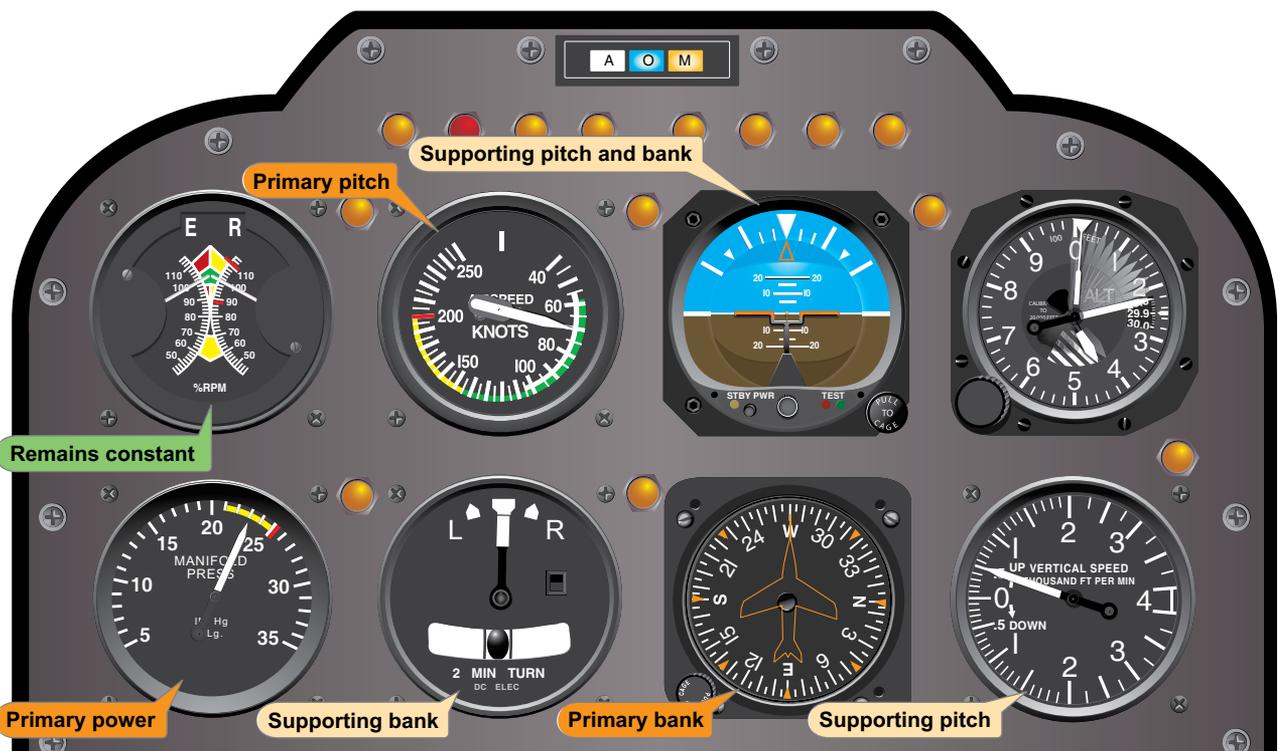


Figure 6-12. Flight instrument indications in a stabilized constant-air-speed climb.

rate climb is entered from climb airspeed. Use the rate appropriate for the particular helicopter being flown. Normally, in helicopters with low climb rates, 500 fpm is appropriate. In helicopters capable of high climb rates, use a rate of 1,000 fpm.

To enter a constant rate climb, increase power to the approximate setting for the desired rate. As power is applied, the airspeed indicator is primary for pitch until the vertical speed approaches the desired rate. At this time, the VSI becomes primary for pitch. Change pitch attitude by reference to the attitude indicator to maintain the desired vertical speed. When the VSI becomes primary for pitch, the airspeed indicator becomes primary for power. Primary and supporting instruments for a stabilized constant rate climb are illustrated in *Figure 6-13*. Adjust power to maintain desired airspeed. Pitch attitude and power corrections should be closely coordinated. To illustrate this, if the vertical speed is correct but the airspeed is low, add power. As power is increased, it may be necessary to lower the pitch attitude slightly to avoid increasing the vertical rate. Adjust the pitch attitude smoothly to avoid overcontrolling. Small power corrections are usually sufficient to bring the airspeed back to the desired indication.

Level Off

The level off from a constant airspeed climb must be started before reaching the desired altitude. Although the amount

of lead varies with the type of helicopter being flown and pilot technique, the most important factor is vertical speed. As a rule of thumb, use 10 percent of the vertical velocity as the lead point. For example, if the rate of climb is 500 fpm, initiate the level off approximately 50 feet before the desired altitude. When the proper lead altitude is reached, the altimeter becomes primary for pitch. Adjust the pitch attitude to the level flight attitude for that airspeed. Cross-check the altimeter and VSI to determine when level flight has been attained at the desired altitude. If cruise airspeed is higher than climb airspeed, leave the power at the climb power setting until the airspeed approaches cruise airspeed, and then reduce it to the cruise power setting. The level off from a constant rate climb is accomplished in the same manner as the level off from a constant airspeed climb.

Straight Descents (Constant Airspeed and Constant Rate)

A descent may be performed at any normal airspeed the helicopter can attain, but the airspeed must be determined prior to entry. The technique is determined by the type of descent, a constant airspeed or a constant rate.

Entry

If airspeed is higher than descending airspeed, and a constant airspeed descent is desired, reduce power to a descent power setting and maintain a constant altitude using cyclic pitch control. This slows the helicopter. As the helicopter



Figure 6-13. Flight Instrument Indications in a Stabilized Constant-Rate Climb.

approaches the descending airspeed, the airspeed indicator becomes primary for pitch and the manifold pressure is primary for power. Holding the airspeed constant causes the helicopter to descend. For a constant rate descent, reduce the power to the approximate setting for the desired rate. If the descent is started at the descending airspeed, the airspeed indicator is primary for pitch until the VSI approaches the desired rate. At this time, the VSI becomes primary for pitch, and the airspeed indicator becomes primary for power. Coordinate power and pitch attitude control as previously described on page 6-10 for constant rate climbs.

Level Off

The level off from a constant airspeed descent may be made at descending airspeed or at cruise airspeed, if this is higher than descending airspeed. As in a climb level off, the amount of lead depends on the rate of descent and control technique. For a level off at descending airspeed, the lead should be approximately 10 percent of the vertical speed. At the lead altitude, simultaneously increase power to the setting necessary to maintain descending airspeed in level flight. At this point, the altimeter becomes primary for pitch, and the airspeed indicator becomes primary for power.

To level off at an airspeed higher than descending airspeed, increase the power approximately 100 to 150 feet prior to reaching the desired altitude. The power setting should be that which is necessary to maintain the desired airspeed in level flight. Hold the vertical speed constant until approximately 50 feet above the desired altitude. At this point, the altimeter becomes primary for pitch and the airspeed indicator becomes primary for power. The level off from a constant rate descent should be accomplished in the same manner as the level off from a constant airspeed descent.

Common Errors During Straight Climbs and Descents

1. Failure to maintain heading
2. Improper use of power
3. Poor control of pitch attitude
4. Failure to maintain proper pedal trim
5. Failure to level off on desired altitude

Turns

Turns made by reference to the flight instruments should be made at a precise rate. Turns described in this chapter are those not exceeding a standard rate of 3° per second as indicated on the turn-and-slip indicator. True airspeed determines the angle of bank necessary to maintain a standard rate turn. A rule of thumb to determine the approximate angle

of bank required for a standard rate turn is to use 15 percent of the airspeed. A simple way to determine this amount is to divide the airspeed by 10 and add one-half the result. For example, at 60 knots approximately 9° of bank is required ($60 \div 10 = 6$, $6 + 3 = 9$); at 80 knots approximately 12° of bank is needed for a standard rate turn.

To enter a turn, apply lateral cyclic in the direction of the desired turn. The entry should be accomplished smoothly, using the attitude indicator to establish the approximate bank angle. When the turn indicator indicates a standard rate turn, it becomes primary for bank. The attitude indicator now becomes a supporting instrument. During level turns, the altimeter is primary for pitch, and the airspeed indicator is primary for power. Primary and supporting instruments for a stabilized standard rate turn are illustrated in *Figure 6-14*. If an increase in power is required to maintain airspeed, slight forward cyclic pressure may be required since the helicopter tends to pitch up as collective pitch is increased. Apply pedal trim, as required, to keep the ball centered.

To recover to straight-and-level flight, apply cyclic in the direction opposite the turn. The rate of roll-out should be the same as the rate used when rolling into the turn. As the turn recovery is initiated, the attitude indicator becomes primary for bank. When the helicopter is approximately level, the heading indicator becomes primary for bank as in straight-and-level flight. Cross-check the airspeed indicator and ball closely to maintain the desired airspeed and pedal trim.

Turn to a Predetermined Heading

A helicopter turns as long as its lateral axis is tilted; therefore, the recovery must start before the desired heading is reached. The amount of lead varies with the rate of turn and piloting technique.

As a guide, when making a 3° per second rate of turn, use a lead of one-half the bank angle. For example, if using a 12° bank angle, use half of that, or 6° , as the lead point prior to the desired heading. Use this lead until the exact amount required by a particular technique can be determined. The bank angle should never exceed the number of degrees to be turned. As in any standard rate turn, the rate of recovery should be the same as the rate of entry. During turns to predetermined headings, cross-check the primary and supporting pitch, bank, and power instruments closely.

Timed Turns

A timed turn is a turn in which the clock and turn-and-slip indicator are used to change heading a definite number of degrees in a given time. For example, using a standard rate turn, a helicopter turns 45° in 15 seconds. Using a half-



Figure 6-14. Flight Instrument Indications in a Standard-Rate Turn to the Left.

standard rate turn, the helicopter turns 45° in 30 seconds. Timed turns can be used if the heading indicator becomes inoperative.

Prior to performing timed turns, the turn coordinator should be calibrated to determine the accuracy of its indications. To do this, establish a standard rate turn by referring to the turn-and-slip indicator. Then, as the sweep second hand of the clock passes a cardinal point (12, 3, 6, or 9), check the heading on the heading indicator. While holding the indicated rate of turn constant, note the heading changes at 10-second intervals. If the helicopter turns more or less than 30° in that interval, a smaller or larger deflection of the needle is necessary to produce a standard rate turn. After the turn-and-slip indicator has been calibrated during turns in each direction, note the corrected deflections, if any, and apply them during all timed turns.

Use the same cross-check and control technique in making timed turns that is used to make turns to a predetermined heading, but substitute the clock for the heading indicator. The needle of the turn-and-slip indicator is primary for bank control, the altimeter is primary for pitch control, and the airspeed indicator is primary for power control. Begin the roll-in when the clock's second hand passes a cardinal point; hold the turn at the calibrated standard rate indication, or half-standard rate for small changes in heading; then begin the roll-out when the computed number of seconds has elapsed. If the roll-in and roll-out rates are the same, the time

taken during entry and recovery need not be considered in the time computation.

If practicing timed turns with a full instrument panel, check the heading indicator for the accuracy of the turns. If executing turns without the heading indicator, use the magnetic compass at the completion of the turn to check turn accuracy, taking compass deviation errors into consideration.

Change of Airspeed in Turns

Changing airspeed in turns is an effective maneuver for increasing proficiency in all three basic instrument skills. Since the maneuver involves simultaneous changes in all components of control, proper execution requires a rapid cross-check and interpretation, as well as smooth control. Proficiency in the maneuver also contributes to confidence in the instruments during attitude and power changes involved in more complex maneuvers.

Pitch and power control techniques are the same as those used during airspeed changes in straight-and-level flight. As discussed previously, the angle of bank necessary for a given rate of turn is proportional to the true airspeed. Since the turns are executed at standard rate, the angle of bank must be varied in direct proportion to the airspeed change in order to maintain a constant rate of turn. During a reduction of airspeed, decrease the angle of bank and increase the pitch attitude to maintain altitude and a standard rate turn.

Altimeter and turn indicator readings should remain constant throughout the turn. The altimeter is primary for pitch control, and the turn needle is primary for bank control. Manifold pressure is primary for power control while the airspeed is changing. As the airspeed approaches the new indication, the airspeed indicator becomes primary for power control.

Two methods of changing airspeed in turns may be used. In the first method, airspeed is changed after the turn is established. In the second method, the airspeed change is initiated simultaneously with the turn entry. The first method is easier, but regardless of the method used, the rate of cross-check must be increased as power is reduced. As the helicopter decelerates, check the altimeter and VSI for needed pitch changes, and the bank instruments for needed bank changes. If the needle of the turn-and-slip indicator shows a deviation from the desired deflection, change the bank. Adjust pitch attitude to maintain altitude. When the airspeed approaches that desired, the airspeed indicator becomes primary for power control. Adjust the power to maintain the desired airspeed. Use pedal trim to ensure the maneuver is coordinated.

Until control technique is very smooth, frequently cross-check the attitude indicator to keep from overcontrolling and to provide approximate bank angles appropriate for the changing airspeeds.

Compass Turns

The use of gyroscopic heading indicators makes heading control very easy. However, if the heading indicator fails or the helicopter is not equipped with one, use the magnetic compass for heading reference. When making compass-only turns, a pilot needs to adjust for the lead or lag created by acceleration and deceleration errors so that the helicopter rolls out on the desired heading. When turning to a heading of north, the lead for the roll-out must include the number of degrees of latitude plus the lead normally used in recovery from turns. During a turn to a south heading, maintain the turn until the compass passes south the number of degrees of latitude, minus the normal roll-out lead. For example, when turning from an easterly direction to north, where the latitude is 30°, start the roll-out when the compass reads 37° (30° plus one-half the 15° angle of bank, or whatever amount is appropriate for the rate of roll-out). When turning from an easterly direction to south, start the roll-out when the magnetic compass reads 203° (180° plus 30° minus one-half the angle of bank). When making similar turns from a westerly direction, the appropriate points at which to begin the roll-out would be 323° for a turn to north, and 157° for a turn to south.

30° Bank Turn

A turn using 30° of bank is seldom necessary or advisable in instrument meteorological conditions (IMC), and is considered an unusual attitude in a helicopter. However, it is an excellent maneuver to practice to increase the ability to react quickly and smoothly to rapid changes of attitude. Even though the entry and recovery techniques are the same as for any other turn, it is more difficult to control pitch because of the decrease in vertical lift as the bank increases. Also, because of the decrease in vertical lift, there is a tendency to lose altitude and/or airspeed. Therefore, to maintain a constant altitude and airspeed, additional power is required. Do not initiate a correction, however, until the instruments indicate the need for one. During the maneuver, note the need for a correction on the altimeter and VSI, check the attitude indicator, and then make the necessary adjustments. After making a change, check the altimeter and VSI again to determine whether or not the correction was adequate.

Climbing and Descending Turns

For climbing and descending turns, the techniques described previously for straight climbs, descents, and standard rate turns are combined. For practice, simultaneously turn and start the climb or descent. The primary and supporting instruments for a stabilized constant airspeed left climbing turn are illustrated in *Figure 6-15*. The level off from a climbing or descending turn is the same as the level off from a straight climb or descent. To return to straight-and-level flight, stop the turn and then level off, or level off and then stop the turn, or simultaneously level off and stop the turn. During climbing and descending turns, keep the ball of the turn indicator centered with pedal trim.

Common Errors During Turns

1. Failure to maintain desired turn rate
2. Failure to maintain altitude in level turns
3. Failure to maintain desired airspeed
4. Variation in the rate of entry and recovery
5. Failure to use proper lead in turns to a heading
6. Failure to properly compute time during timed turns
7. Failure to use proper leads and lags during the compass turns
8. Improper use of power
9. Failure to use proper pedal trim

Unusual Attitudes

Any maneuver not required for normal helicopter instrument flight is an unusual attitude and may be caused by any one or combination of factors such as turbulence, disorientation, instrument failure, confusion, preoccupation with flight deck duties, carelessness in cross-checking, errors in instrument interpretation, or lack of proficiency in aircraft control. Due to the instability characteristics of the helicopter, unusual attitudes can be extremely critical. As soon as an unusual attitude is detected, make a recovery to straight-and-level flight as soon as possible with a minimum loss of altitude.

To recover from an unusual attitude, a pilot should correct bank-and-pitch attitude and adjust power as necessary. All components are changed almost simultaneously, with little lead of one over the other. A pilot must be able to perform this task with and without the attitude indicator. If the helicopter is in a climbing or descending turn, adjust bank, pitch, and power. The bank attitude should be corrected by referring to the turn-and-slip indicator and attitude indicator. Pitch attitude should be corrected by reference to the altimeter, airspeed indicator, VSI, and attitude indicator. Adjust power by referring to the airspeed indicator and manifold pressure.

Since the displacement of the controls used in recovery from unusual attitudes may be greater than those used for normal flight, make careful adjustments as straight-and-level flight

is approached. Cross-check the other instruments closely to avoid overcontrolling.

Common Errors During Unusual Attitude Recoveries

1. Failure to make proper pitch correction
2. Failure to make proper bank correction
3. Failure to make proper power correction
4. Overcontrolling pitch and/or bank attitude
5. Overcontrolling power
6. Excessive loss of altitude

Emergencies

Emergencies during instrument flight are handled similarly to those occurring during VFR flight. A thorough knowledge of the helicopter and its systems, as well as good aeronautical knowledge and judgment, is the best preparation for emergency situations. Safe operations begin with preflight planning and a thorough preflight inspection. Plan a route of flight to include adequate landing sites in the event of an emergency landing. Make sure all resources, such as maps, publications, flashlights, and fire extinguishers are readily available for use in an emergency.

During any emergency, first fly the aircraft. This means ensure the helicopter is under control, and determine emergency



Figure 6-15. Flight Instrument Indications for a Stabilized Left Climbing Turn at a Constant Airspeed.

landing sites. Then perform the emergency checklist memory items, followed by items written in the rotorcraft flight manual (RFM). When all these items are under control, notify air traffic control (ATC). Declare any emergency on the last assigned ATC frequency. If one was not issued, transmit on the emergency frequency 121.5. Set the transponder to the emergency squawk code 7700. This code triggers an alarm or special indicator in radar facilities.

When experiencing most in-flight emergencies, such as low fuel or complete electrical failure, land as soon as possible. In the event of an electrical fire, turn off all nonessential equipment and land immediately. Some essential electrical instruments, such as the attitude indicator, may be required for a safe landing. A navigation radio failure may not require an immediate landing if the flight can continue safely. In this case, land as soon as practical. ATC may be able to provide vectors to a safe landing area. For specific details on what to do during an emergency, refer to the RFM for the helicopter.

Autorotations

Both straight-ahead and turning autorotations should be practiced by reference to instruments. This training ensures prompt corrective action to maintain positive aircraft control in the event of an engine failure.

To enter autorotation, reduce collective pitch smoothly to maintain a safe rotor RPM and apply pedal trim to keep the ball of the turn-and-slip indicator centered. The pitch attitude of the helicopter should be approximately level as shown by the attitude indicator. The airspeed indicator is the primary pitch instrument and should be adjusted to the recommended autorotation speed. The heading indicator is primary for bank in a straight-ahead autorotation. In a turning autorotation, a standard rate turn should be maintained by reference to the needle of the turn-and-slip indicator.

Common Errors During Autorotations

1. Uncoordinated entry due to improper pedal trim
2. Poor airspeed control due to improper pitch attitude
3. Poor heading control in straight-ahead autorotations
4. Failure to maintain proper rotor RPM
5. Failure to maintain a standard rate turn during turning autorotations

Servo Failure

Most helicopters certified for single-pilot IFR flight are required to have autopilots, which greatly reduces pilot workload. If an autopilot servo fails, however, resume manual control of the helicopter. The amount of workload increase depends on which

servo fails. If a cyclic servo fails, a pilot may want to land immediately because the workload increases tremendously. If an antitorque or collective servo fails, continuing to the next suitable landing site might be possible.

Instrument Takeoff

The procedures and techniques described here should be modified as necessary to conform to those set forth in the operating instructions for the particular helicopter being flown. During training, instrument takeoffs should not be attempted except when receiving instruction from an appropriately certificated, proficient flight instructor pilot.

Adjust the miniature aircraft in the attitude indicator, as appropriate, for the aircraft being flown. After the helicopter is aligned with the runway or takeoff pad, to prevent forward movement of a helicopter equipped with a wheel-type landing gear, set the parking brakes or apply the toe brakes. If the parking brake is used, it must be unlocked after the takeoff has been completed. Apply sufficient friction to the collective pitch control to minimize overcontrolling and to prevent creeping. Excessive friction should be avoided since it limits collective pitch movement.

After checking all instruments for proper indications, start the takeoff by applying collective pitch and a predetermined power setting. Add power smoothly and steadily to gain airspeed and altitude simultaneously and to prevent settling to the ground. As power is applied and the helicopter becomes airborne, use the antitorque pedals initially to maintain the desired heading. At the same time, apply forward cyclic to begin accelerating to climbing airspeed. During the initial acceleration, the pitch attitude of the helicopter, as read on the attitude indicator, should be one- to two-bar widths low. The primary and supporting instruments after becoming airborne are illustrated in *Figure 6-16*. As the airspeed increases to the appropriate climb airspeed, adjust pitch gradually to climb attitude. As climb airspeed is reached, reduce power to the climb power setting and transition to a fully coordinated straight climb.

During the initial climb out, minor heading corrections should be made with pedals only until sufficient airspeed is attained to transition to fully coordinated flight. Throughout the instrument takeoff, instrument cross-check and interpretations must be rapid and accurate, and aircraft control positive and smooth.



Figure 6-16. Flight Instrument Indications During an Instrument Takeoff.

Common Errors During Instrument Takeoffs

1. Failure to maintain heading
2. Overcontrolling pedals
3. Failure to use required power
4. Failure to adjust pitch attitude as climbing airspeed is reached

Illustrations of technological advancements in instrumentation are described as follows. In *Figure 6-17*, a typical PFD depicts an aircraft flying straight-and-level at 3,000 feet and 100 knots. *Figure 6-18* illustrates a nose-low pitch attitude in a right turn. MFDs can be configured to provide navigation information such as the moving map in *Figure 6-19* or information pertaining to aircraft systems as in *Figure 6-20*.

Changing Technology

Advances in technology have brought about changes in the instrumentation found in all types of aircraft, including helicopters. Electronic displays commonly referred to as “glass cockpits” are becoming more common. Primary flight displays (PFDs) and multi-function displays (MFDs) are changing not only what information is available to a pilot but also how that information is displayed.



Figure 6-17. PFD Indications During Straight-and-Level Flight.

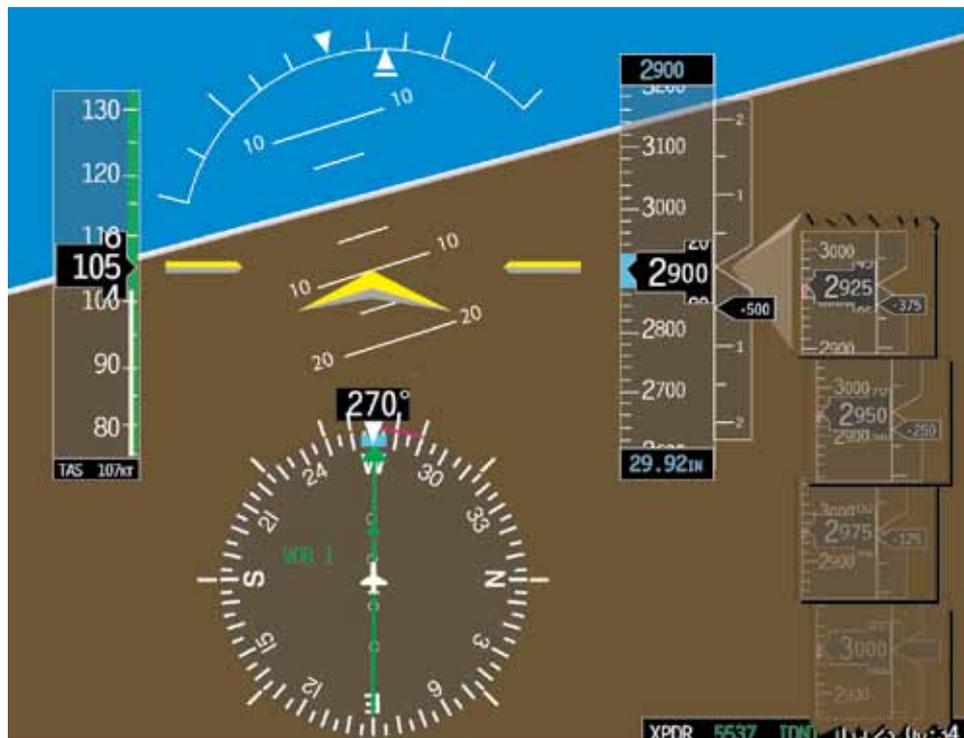


Figure 6-18. PFD Indications During a Nose-Low Pitch Attitude in a Right Turn.



Figure 6-19. MFD Display of a Moving Map.



Figure 6-20. MFD Display of Aircraft Systems.