TECHNICAL MANUAL
No. 1-260

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *21 May 1965*

ROTARY WING FLIGHT

*This manual supersedes TM 1-260, 24 September 1957, including C 2, 12 September 1961 and C 3, 21 November 1962.

CHAPTER 1

GENERAL

1.1. Purpose

This manual is an expandable guide to be ısed by the helicopter aviator trainee in the ıarly phases of training, by the helicopter avia- ;or in the study and operation of helicopters,)y the flight and ground instructor as a text-)ook or reference in presenting instruction, ınd by the checkpilot in the flight evaluation of :he student's fundamental knowledge of rotary ving flight. Expansion of this manual will be)rovided by additional coverage in future :hanges.

.2. Scope

a. Emphasis is given to basic helicopter ıerodynamics and flight techniques with discus- ions on autorotations, night flying, operations 'rom unimproved areas, precautionary meas- ıres, and formation flying.

b. Information in this manual is general and .pplicable, in part, to all helicopters. The flight echniques discussed are applicable principally o the OH-13 and OH-23 helicopters. Specific light procedures and practices for individual .elicopters are found in the applicable opera- or's manual. Additional references are given n appendix I.

c. The material presented herein is applica- le to nuclear or nonnuclear warfare.

d. Users of this manual are encouraged to submit recommended changes or comments to improve it. Comments should be keyed to the specific page, paragraph, and line of the text in which change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to Commandant, United States Army Aviation School, Fort Rucker, Ala. 36362.

1.3. Typical Single Rotor Helicopter Configuration

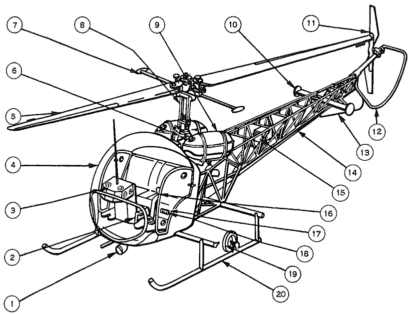
Figure 1.1 shows a typical observation helicopter with a list of terms usually assigned to its principal components and parts.

1.4. Helicopter Configuration and Performance

Information on helicopter configuration and performance under particular conditions of payload and flight is given in appendixes II and III.

1.5. External Load Operations

External load operations are discussed in appendix V.



1. LANDING LIGHT
2. ANTITORQUE PEDALS
3. RADIO CONSOLE
4. PLASTIC BUBBLE
5. MAIN ROTOR BLADE
6. TRANSMISSION
7. STABILIZER BAR
8. MAIN ROTOR MAST
9. FUEL TANKS
10. SYNCHRONIZED STABILIZER
11. TAIL ROTOR BLADE
12. TAIL ROTOR GUARD
13. VENTRAL FIN
14. TAIL BOOM
15. BATTERY
16. CYCLIC CONTROL STICK
17. COLLECTIVE PITCH STICK
18. THROTTLE
19. GROUND HANDLING WHEEL
20. SKID LANDING GEAR

Figure 1.1. Helicopter, single rotor configuration, typical.

CHAPTER 2

BASIC HELICOPTER AERODYNAMICS

Section I. Effect of ATMOSPHERE ON FLIGHT

2.1. Atmosphere.

The great mass of air which completely envelops the earth (the atmosphere) does not end abruptly, but becomes less dense (fewer molecules per unit volume) with increasing distance away from the earth's surface. For details, see TM 1-300.

2.2. Physical Properties of Atmosphere

The atmosphere is a mixture of several gases. Dry, pure air will contain approximately 78 percent nitrogen, 21 percent oxygen, and minute concentrations of other gases such as carbon dioxide, hydrogen, helium, neon, krypton, and argon. Water vapor in the atmosphere will vary from unsubstantial amounts to 4 percent by volume (100 percent humidity).

2.3 Characteristics of Atmospheric Gases

Due to similarities in the physical nature of all gases, the gases of the atmosphere can be treated as a single gas. The kinetic gas theory, which pertains to the qualities of gases, states that—

a. All gases are composed of molecules which are physically alike and behave in a similar manner.

b. Gas molecules are relatively far apart as compared to the molecular structure of solids, and are in a state of random motion, with an average velocity proportional to their kinetic energy or temperature. These gas molecules continually strike each other and the walls of any container in which they are confined.

2.4. Atmospheric Pressure

Atmospheric pressure is the result of the weight of all individual molecules in any given *column* of the atmosphere. If, for example, a cubic foot of dry, pure air in a column of the atmosphere weighs approximately 0.07651 pounds, any relative cubic foot of air resting on this one will weigh less because there is less air above it.

2.5. Atmospheric Density and Density Altitude

a. Atmospheric Density. Any volume of air is less *dense* than the air on which it rests. Assuming a constant temperature, the density of a volume of air will vary directly with the pressure. If the pressure is doubled, the density is doubled; if the pressure is halved, the density is halved. The new density compares to the same fractional part of standard density as the new pressure to a fractional part of the standard pressure.

b. Density Altitude. Density altitude refers to a theoretical density which exists under the standard conditions of a given altitude. The efficiency of an airfoil, either wings or rotor blades, is impaired at high altitudes by the lack of air density. All aircraft, regardless of design, have an eventual ceiling limit where the air is too "thin" to provie enough lift to sustain flight. The effect of air density on helicopter performance is vital due to the critical loading and confined area-type operation usually required of the helicopter.

2.6. Effects of Temperature and Humidity on Density Altitude

Air that occupies 1 cubic foot of space will require more space if the temperature is increased. Another density change is brought about by moisture content (humidity) of air.

With the absorption of moisture, as on a hot humid day, the density of air is reduced. Aircraft performance capabilities are also reduced. Since temperature and humidity change almost constantly, performance predictions are difficult. An average atmosphere, however, has been established as standard, and aircraft performance can be planned and evaluated by use of this standard.

2.7. Computing Density Altitude

A method of computing density altitude is given in appendix IV.

Section II. GENERAL AERODYNAMICS

2.8. Airfoil

a. General. An *airfoil* is any surface, such as a wing or rotor blade, designed to produce lift when air passes over it. The airfoils for an airplane are the wings. Helicopter airfoils are the rotor blades (rotating wings). The same *basic* aerodynamic principles apply to both: one-third of airfoil lift is produced by the impact of air on the undersurface of the airfoil, and two-thirds of the lift is produced by a pressure drop over the upper surface of the airfoil (fig. 2.1).

b. Chord. An imaginary line from the leading edge to the trailing edge of an airfoil is known as the *chord* (fig. 2.1).

c. Relative Wind. Air flowing opposite and parallel to the direction of airfoil motion is known as *relative wind* (fig. 2.1).

2.9. Airfoil Configuration

Airfoil sections vary considerably. An airfoil may be unsymmetrical (A, fig. 2.2) or symmetrical (B, fig. 2.2), depending on the specific requirements to be met.

a. Unsymmetrical Airfoils. On an unsymmetrical airfoil, the center of pressure (an imaginary point on an airfoil chord where all aerodynamic forces are considered to be concentrated) moves forward as the angle of attack is increased. Most airplanes have unsymmetrical airfoils. An unsymmetrical airfoil normally is unsatisfactory for use as a helicopter rotor blade because of the rapid movement of the center of pressure back and forth on the rotor airfoil throughout each blade revolution.

b. Symmetrical Airfoils. A symmetrical airfoil has the characteristic of limiting center-of-pressure travel. Hence, helicopter rotor

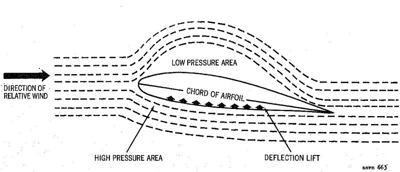


Figure 2.1. Relationship of airfoil to lift.

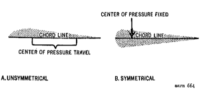


Figure 2.2. Airfoil section configuration.

blades are usually symmetrically designed so that the center of pressure remains relatively stable.

2.10. Weight and Lift

a. Weight. The total weight of a helicopter is the first force that must be overcome before flight is possible. Lift is the beneficial force needed to overcome or balance that total weight (fig. 2.3).

b. Lift. When wind velocity across an object increases, pressure lessens (Bernoulli's principle). As applied to the airfoils of a helicopter (fig. 2.1), the curvature of the top surface of a typical airfoil forces air over a longer path than that over the bottom surface. Since this air has farther to travel, its velocity increases, causing the pressure on top of the airfoil to be less than that on the bottom. This pressure difference tends to lift the airfoil into the area of lower pressure.

2.11. Thrust-Drag Relationship

Thrust and drag, like weight and lift, are closely related. Thrust moves the helicopter in the desired direction; drag tends to hold it back. In the helicopter, both lift and thrust are obtained from the main rotor. In vertical ascent (par. 2.27), thrust acts upward in a vertical direction; drag, the opposing force, acts vertically downward. In forward flight,

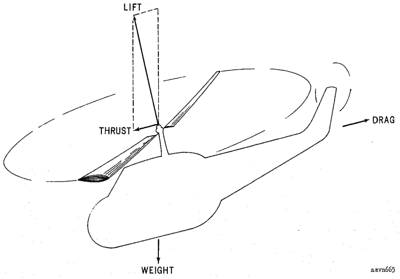


Figure 2.3. Force acting on helicopter in flight.

thrust is forward and drag to the rear. In rearward flight, the two are reversed.

2.12. Angle of Attack

a. General. The *angle of attack* (fig. 2.4) is the angle at which an airfoil passes through the air. This angle is measured between the chord of the airfoil and the relative wind. When the angle of attack is increased, deflection of the airstream causes an upward pressure on the underside of the airfoil and the flow of air over the top side of the airfoil increases in speed, further reducing the pressure on the top side. These forces combine to furnish lift.

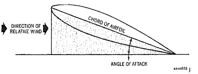


Figure 2.4. Angle of attack.

b. Helicopter. An aviator can increase or decrease the rotor blade angle of attack without changing the attitude of the fuselage. He does this by changing the pitch of the rotor blades with the collective pitch control. Unde most flight conditions, the angle of attack o each rotor blade continually changes as it turn through 360° (fig. 2.5). This continuous chang occurs when the rotor plane-of-rotation (roto disc) is tilted by cyclic pitch control, as it i during forward, rearward, and sideward fligh (par. 2.28).

2.13. Stall

As angle of attack is increased, lift will als increase up to a certain angle. Beyond thi angle, the air loses its streamlined path ove the airfoil and the airfoil will *stall.* More pre cisely, airflow will no longer be able to follov the contour of the upper airfoil surface, bu will break away (fig. 2.6) and form burble (eddies) over the upper surface. The angle o attack at which this separation takes place i called the *separation point,* the *burble point,* o the *stalling point.*

2.14. Velocity

A certain minimum velocity is required fo an airfoil to develop sufficient lift to get a heli copter into the air. A helicopter's rotor blade must move through the air at comparativel high speed to produce sufficient lift to raise th

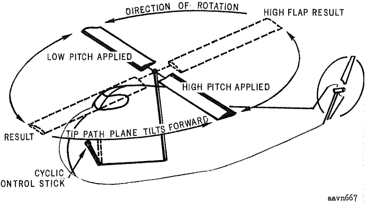


Figure 2.5. Angle of attack variations.

helicopter off the ground or keep it in the air. The rotor can turn at the required takeoff speed while the fuselage speed remains at zeor. Speed of the rotor blades, and resultant velocity of airflow over them, is independent of fuselage speed. The helicopter can rise vertically. It can fly forward, backward, or sideward as the aviator desires. It can even remain stationary (*hover*) in the air, with the rotor blades developing sufficient lift to support the helicopter.

2.15. Velocity—Angle of Attack

Relation between velocity of airflow and angle of attack on an airfoil, and their effect on lift, can be expressed as follows: For a given angle of attack, the greater the velocity, the greater the lift (within design capabilities of the airfoil). For a given velocity, the greater the angle of attack (up to the stalling angle), the greater the lift.

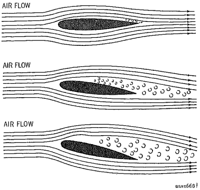


Figure 2.6. Effect of angle of attack on airflow.

Section III. AERODYNAMICS OF HELICOPTER POWERED FLIGHT

2.16. Torque

Newton's third law of motion states, "To every action there is an opposite and equal reaction." As a helicopter rotor turns in one direction, the fuselage tends to rotate in the opposite direction. This effect is called *torque*, and provision must be made to counteract and control this effect during flight. In tandem rotor and coaxial helicopter designs, the rotors turn in opposite directions and thereby neutralize or eliminate torque effect. In tip-jet helicopters, power originates at the blade tip and equal and opposite reaction is against the air; there is no torque between the rotor and the fuselage. The torque problem is, however, especially important in helicopters of single main rotor configuration. Since torque effect on the fuselage is a direct result of engine power supplied to the main rotor, any change in engine power brings about a corresponding change in torque effect. Furthermore, power varies with flight maneuvers and conditions, resulting in a variable torque effect.

2.17. Antitorque Rotor

Compensation for torque in the single main rotor helicopter is accomplished by means of a *variable pitch, antitorque rotor* (tail rotor), located on the end of a tail-boom extension at the rear of the fuselage. Driven by the engine at a constant ratio, the tail rotor produces thrust in a horizontal plane opposite to torque reaction developed by the main rotor (fig. 2.7). Since torque effect varies during flight when power changes are made (par. 2.16), it is necessary to vary the thrust of the tail rotor. Foot pedals (antitorque pedals) enable the aviator to compensate for torque variance in all flight regimes and permit him to increase or decrease tail rotor thrust, as needed, to counteract torque effect.

2.18. Heading Control

The tail rotor and its control linkage n(serve as a means of counteracting (2.17), but also permit control of during taxiing, hovering, and sid(tions on takeoffs and approaches. of more control than is necessary

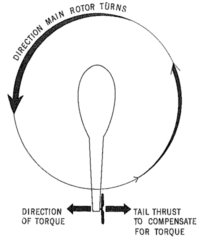


Figure 2.7. Compensating torque reaction.

torque will cause the nose of the helicopter to swing in the direction of pedal movement (left pedal to the left and right pedal to the right). To maintain a constant heading at a hover or during takeoff or approach, an aviator use antitorque pedals to apply just e pitch on the tail rotor to neutralize torq possible weathervane effect in a cros Heading control in forward flight at a normally is accomplished by flying th copter to the desired heading with cycli trol, using a coordinated bank and turn.

2.19. Pendular Action

It is normal for the fuselage of a heli to act like a pendulum (to swing laterall longitudinally). Abrupt changes of flig rection, caused by overcontrolling, exag this pendular action and should be av Overcontrolling of the cyclic results in a changes of the main rotor tip-path plane are not reflected in corresponding chang the fuselage. The cyclic control shou moved at a rate which will cause the main and the fuselage to move as a unit.

2.20. Gyroscopic Precession

a. Gyroscopic precession (a phenon characteristic of all rotating bodies) is tl sult of an applied force against a rotating and occurs approximately 90° in the dir of rotation from the point where the fo applied (fig. 2.8). (See also fig. 2.5.) If

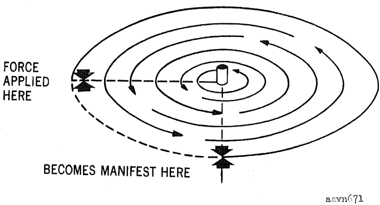


Figure 2.8. Gyroscopic precession.

control linkage were not employed in the helicopter, an aviator would have to move the cyclic stick 90° out of phase, or to the right, when he wanted to tilt the disc area forward.

b. To simplify directional control, helicopters employ a mechanical linkage which actually places cyclic pitch change of the main rotor 90° ahead in the cycle of rotation (fig. 2.9). This causes the main rotor to tilt in phase with the movement of the cyclic control.

2.21. Dissymmetry of Lift

a. The area within an imaginary circle formed by the rotating blade tips of a helicopter is known as the *disc area* or *rotor disc*. When hovering in still air, lift created by the rotor blades at all segments of the disc area is equal. Dissymmetry of lift is the difference in lift that exists between the advancing half of the disc area and the retreating half. It is created by horizontal flight or by wind.

b. At normal takeoff rpm and zero airspeed, the rotating blade-tip speed of most helicopters is approximately 600 feet per second (409 miles per hour or 355 knots). To compare the lift of the advancing half of the disc area to the lift of the retreating half, the following mathematical formula can be used:

$$L = (C^L) \times \left(\frac{D}{2}\right) \times (A) \times (V^2)$$

In this formula, L is equal to the lift; C^L equals the coefficient of lift; D equals density of the air; A equals the blade area in square feet; and V equals velocity, in relation to the relative wind.

c. In forward flight, two factors of the basic lift formula (D and A) are the same for both advancing and retreating blades. Since the airfoil shape is fixed for a given rotor blade, lift changes with the two variables: *angle of attack* and *velocity*. These two variable factors must compensate each other in forward flight to maintain desired flight attitudes. For example—

(1) When the helicopter is hovering in still air, the tip speed of the advancing blade is about 600 feet/second and V^2 is 360,000. The tip speed of the retreating blade is the same. Since dissymmetry of lift is created by the horizontal movement of the helicopter in forward flight (fig. 2.10) the advancing blade has the combined speed of blade velocity plus speed of the helicopter. The retreating blade loses speed in proportion to the forward speed of the helicopter.

(2) If the helicopter is moving forward at a speed of 100 knots, the velocity of the rotor disc will be equal to approximately 170 feet per second. In feet per second, tip speed of the advancing blade equal 600, helicopter speed 170, with their sum 770 and V^2 amounting to 592,900. But the retreating blade is traveling at a tip speed of 600, minus 170, which is 430, and V^2 equals 184,900. As can be seen from the difference between advancing and retreating blade velocities, a pronounced speed and lift variation exists.

d. In the above example, the advancing blade will produce considerably more lift than the retreating blade. This dissymmetry of lift, combined with gyroscopic precession, will cause the helicopter to nose up sharply as soon as any appreciable forward speed is reached. Cyclic pitch control, a design feature that permits continual changes in the angle of attack during each revolution of the rotor, compensates the dissymmetry of lift. As the forward speed of the helicopter is increased, the aviator must apply more and more forward cyclic to hold a given rotor tip-path plane. The mechanical addition of more pitch to the retreating blade and less pitch to the advancing blade is continued, throughout the speed range, to the top speed of the helicopter. At this point, the retreating blade will stall, because of its attempt to develop and equal the lift of the advancing blade.

e. Dissymmetry of lift can occur as a resul of—

(1) Accelerations.

(2) Decelerations.

(3) Prolonged gusts or turbulence.

(4) Rotor rpm increases.

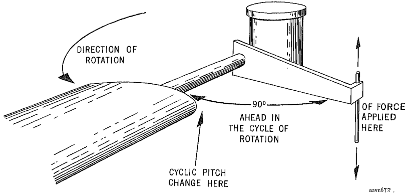


Figure 2.9. Mechanically compensated gyroscopic precession.

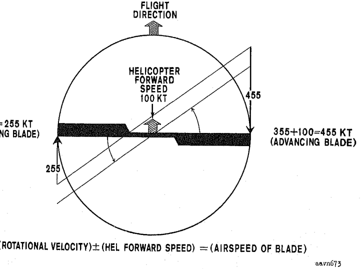


Figure 2.10. Dissymmetry of lift.

(5) Rotor rpm decreases.

(6) Heavy downward application of collective pitch.

(7) Heavy upward application of collective pitch.

f. If uncorrected, dissymmetry of lift will cause an attitude change which can surprise the inexperienced aviator. As his experience increases, the aviator makes the required corrections to prevent attitude changes caused by dissymmetry of lift. For the particular maneuver being performed, he has learned to give primary attention to controlling helicopter attitude to an exact degree in relation to the horizon. If he controls attitude properly, he at the same time corrects for dissymmetry of lift during all phases of flight.

2.22. Hovering

a. *Hovering* is the term applied when a helicopter maintains a constant position at a selected point, usually a few feet above the ground. For a helicopter to hover, the main rotor must supply lift equal to the total weight of the helicopter. By rotation of the blades at high velocity and increase of blade *pitch* (angle of attack), the necessary lift for a hover is induced. The forces of lift and weight reach a state of balance.

b. Hovering is actually an element of vertical flight. Assuming a no-wind condition, the tip-path plane of the blades will remain horizontal. If the angle of attack (pitch) of the blades is increased while their velocity remains constant, additional vertical thrust is obtained. Thus, by upsetting the vertical balance of forces, the helicopter will climb vertically. By the same principle, the reverse is true; decreased pitch will result in helicopter descent.

2.23. Airflow While Hovering

a. At a hover, the rotor system requires a great volume of air upon which to work. This air must be pulled from the surrounding airmass, resulting in a costly process which absorbs a great deal of horsepower. This air which is delivered to the rotating blades is pulled from above at a relatively high velocity, forcing the rotor system to fly upstream in a descending column of air (fig. 2.11).

b. Rotor tip vortex (which is an air swirl at the tip of wings or rotor blades) and the recirculation of turbulent air are also factors to be considered in hovering. Consequently, the hovering rotor is operating in an undesirable air-supply environment which requires high blade angles of attack and high power expenditures, accompanied by high fuel consumption and heavy wear on the helicopter due to sand and debris ingestion.

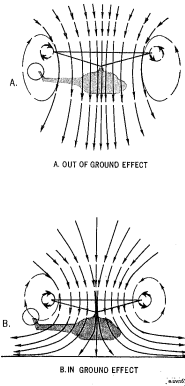


Figure 2.11. Airflow while hovering.

2.24. Ground Effect

The high cost of hovering is somewhat relieved when operating in ground effect (B, fig. 2.11). *Ground effect* is a condition of improved performance encountered when hovering near ground or water surfaces at a height of no more than one-half the rotor diameter. It is more pronounced the nearer the ground is approached. Helicopter operations within ground effect are more efficient than those out of ground effect (see performance charts in operator's handbook and A, fig. 2.11) due to the reduction of rotor tip vortex and the flattening out of the rotor downwash. Ground effect reduces induced drag, permits lower blade angle of attack, and results in a reduction of power required.

2.25. Translational Lift

a. The efficiency of the hovering rotor system is improved by each knot of incoming wind gained by forward motion of the helicopter or by surface headwind. (See rule No. 4, app. III.). As the helicopter moves forward, fresh air enters the system in an amount sufficient to relieve the hovering air-supply problem and improve performance (fig. 2.12). At approximately 18 knots, the rotor system receives a sufficient volume of free, undisturbed air to relieve the air-supply problem. At this time, lift noticeably improves; this distinct change is referred to as *effective translational lift*. As airspeed increases, translational lift continues to improve up to a speed that normally is used for best climb. Thereafter, as speed increases, additional gains of translational lift are canceled by increased total drag.

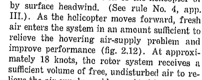


Figure 2.12. Airflow with translational lift in forward flight.

b. At the instant of effective transl
lift and as the hovering air supply patt
broken, there is suddenly at this mome
advancing and retreating blade and di
metry of lift (par. 2.21), which requir
aviator to reposition the cyclic forward
der to maintain the normal takeoff att
Next, usually a need arises for pedal r
tioning to compensate for the stream
effect of forward flight upon the tail boo
the increased efficiency of the tail roto
translational flight).

c. In forward flight, air passing throug
rear portion of the rotor disc has a h
downwash velocity than air passing th
the forward portion. This is known as *t
verse flow effect* (fig. 2.13). This effe
combination with gyroscopic precession
2.20), causes the rotor disc to tilt side
and results in vibration which is most n
able on entry into effective translational

2.26. Translating Tendency

The helicopter has a tendency to move i
direction of tail rotor thrust (to the r
when hovering (par. 2.22). This transl
tendency is overcome by rigging the helic
with the tip-path plane (par. 2.28) of the
rotor tilted slightly to the left. This rig
results in a thrust force action to the left e
to and compensating the tendency to tran
to the right (fig. 2.14). In helicopters ha
a fully articulated rotor system, the av
prevents this translating tendency by appl
left cyclic control which results in a hover
the left side slightly low.

2.27. Vertical Flight

During vertical ascent, thrust acts verti
upward, while drag and weight act vertic
downward (fig. 2.15). Drag, opposing the
ward motion of the helicopter, is increased
the downwash of air from the main ro
Thrust must be sufficient to overcome
weight and drag forces. Since the main r
is responsible for both thrust and lift, the f
representing the total airfoil reaction to the
may be considered as two components—*lift*
thrust. Lift is the force component requi

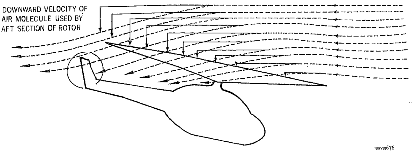


Figure 2.13. Transverse flow effect.

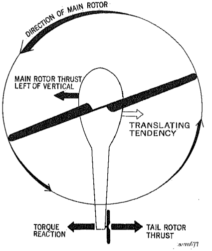


Figure 2.14. Compensating translating tendency (helicopter rigged slightly left).

to support the weight of the helicopter. Thrust is the force component required to overcome the drag.

2.28. Horizontal Flight

In any kind of helicopter flight (vertical, forward, backward, sideward, or hovering), the lift forces of a rotor system are perpendicular to the *tip-path plane* (plane of rotation) (fig. 2.16). The tip-path plane is *the imaginary circular plane the circumference of which is inscribed by the tips of the blades in a cycle of rotation.* During vertical ascent or hovering, the tip-path plane is horizontal and the resultant force acts vertically upward (fig. 2.17). An aviator accomplishes horizontal flight by tilting the tip-path plane. The resultant force tilts with the rotor (fig. 2.18), acting both upward and horizontally. The total force can, there-

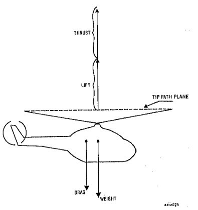


Figure 2.15. Aerodynamic forces in vertical flight.

fore, be resolved into two components—*lift* and *thrust*. The lift component is equal to an opposite weight. The thrust component acts in the direction of flight to move the helicopter.

2.29. Retreating Blade Stall

a. A tendency for the retreating blade to stall in forward flight is inherent in all present-day helicopters, and is a major factor in limiting their forward speed. Just as the stall of an airplane wing limits the low-speed possibilities of the airplane, the stall of a rotor blade limits the high speed potential of a helicopter (fig. 2.19). The airspeed of the retreating blade (the blade moving away from the direction of flight) slows down as forward speed increases. The retreating blade must, however, produce an amount of lift equal to that of the advancing blade (B, fig. 2.19). Therefore, as the airspeed of the retreating blade decreases with forward speed, the blade angle of attack must be increased to equalize lift throughout the rotor disc area. As this angle increase is continued, the blade will stall at some high forward speed (C, fig. 2.19).

b. The angle of attack distribution along the blade in forward flight is not uniform; some point along the blade will stall before the rest. This is principally a result of the amount and direction of the flow of air being encountered by the rotor disc. In normal powered flight, the flow of air is down through the rotor system. As this downward flow increases, the angles of attack increase at the blade tips, in comparison to the angles at blade roots. At high forward speeds, downflow increases as the rotor is tilted into the wind to provide thrust in overcoming drag. The angle of attack increases on the retreating blade as forward speed increases, and the highest blade angles of attack are at the tips. Thus, in the powered helicopter, blade stall occurs at the tip of the retreating blade, spreading inboard as speed increases. The advancing blade, having relatively uniform low angles of attack, is not subject to blade stall.

c. The stall condition described in *b* above is much more common in some helicopter configurations than in others. Retreating blade stall is generally less common to the observa type helicopter used in training than to heavier cargo-type helicopter.

Note. Retreating blade stall does not occur in n autorotations.

2.30. Effects of Retreating Blade Stall

a. Upon entry into blade stall, the first e is generally a noticeable vibration of the copter. This period is followed by a liftin pitch-up of the nose and a rolling tendenc the helicopter. If the cyclic stick is held ward and collective pitch is not reduced (increased, this condition becomes aggrava the vibration greatly increases, and control be lost.

b. By being familiar with the condit which lead to blade stall, the aviator sh realize when he is flying under such circ stances and should take corrective action. major warnings of approaching retrea blade stall conditions are—

(1) Abnormal vibration.

(2) Pitch-up of the nose.

(3) Tendency for the helicopter to rol the direction of the stalled side.

c. When operating at high forward spe the following conditions are most likely to p duce blade stall:

(1) High blade loading (high g weight).

(2) Low rotor rpm.

(3) High density altitude.

(4) Steep or abrupt turns.

(5) Turbulent air.

2.31. Corrective Actions in Retreating Blade Stall

a. When flight conditions are such that bl stall is likely, extreme caution should be ex eised when maneuvering. An abrupt maneu such as a steep turn or pullup may result dangerously severe blade stall. Aviator cont and structural limitations of the helicop would be threatened.

b. At the onset of blade stall, the aviat should take the following corrective actions:

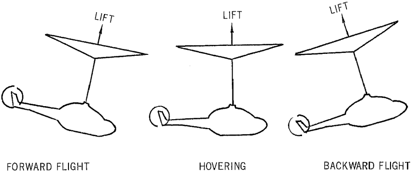


Figure 2.16. Lift perpendicular to tip-path plane.

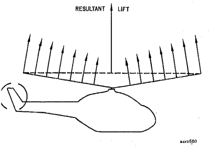


Figure 2.17. Vertical ascent or hover.

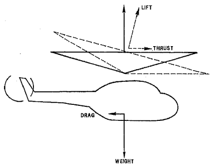


Figure 2.18. Forward flight.

(1) Reduce collective pitch.
(2) Increase rotor rpm.
(3) Reduce forward airspeed.
(4) Descend to lower altitude.
(5) Minimize maneuvering.

2.32. Settling With Power

a. Cause. An aviator may experience settling with power accidentally. Conditions likely to cause "settling" are typified by a helicopter in a vertical or nearly vertical descent (with power) of at least 300 feet per minute and with a relatively low airspeed. Actual critical rate depends on load, rotor rpm, density altitude, and other factors. The rotor system must be using *some* of the available engine power (from 20 to 100 percent) and the horizontal velocity *must not* exceed 10 knots. Under such conditions, the helicopter descends in turbulent air that has just been accelerated downward by the rotor. Reaction of this air on rotor blades at high angles of attack stalls the blades at the hub (center), and the stall progresses outward along the blade as the rate of descent increases.

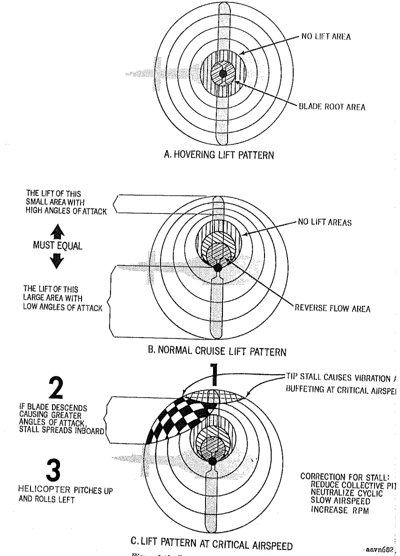


Figure 2.19. Retreating blade stall.

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Note. Rates of descent in "settling" have been recorded in excess of 2,200 feet per minute. The condition can be hazardous if inadvertently performed near the ground.

b. Recovery. Tendency to stop the descent by application of additional collective pitch results in increasing the stall and increasing the rate of descent. Recovery from settling with power can be accomplished by increasing forward speed and/or partially lowering the collective pitch.

2.33. Resonance

A helicopter is subject to *sympathetic* and *ground resonance.*

a. Sympathetic Resonance. Sympathetic resonance is a harmonic beat between the main and tail rotor systems or other components or assemblies which might damage the helicopter. This type of resonance has been engineered out of most helicopters (e.g., by designing the main and tail gear boxes in odd decimal ratios). Thus, the beat of one component (assembly) cannot, under normal conditions, harmonize with the beat of another component (assembly), and sympathetic resonance is not of immediate concern to the aviator. However, when resonance ranges are not designed out, the helicopter tachometer is appropriately marked and the resonance range must be avoided (see the applicable operator's manual).

b. Ground Resonance. Ground resonance may develop when a series of shocks cause the rotor system to become unbalanced. This condition, if allowed to progress, can be extremely dangerous and usually results in structural failure. Ground resonance is most common to three-bladed helicopters using landing wheels. The rotor blades in a three-bladed helicopter are equally spaced (120°) but are constructed to allow some horizontal drag. Ground resonance occurs when the helicopter makes contact with the ground during landing or takeoff. When one wheel of the helicopter strikes the ground ahead of the other (s), a shock is transmitted through the fuselage to the rotor. Another shock is transmitted when the next wheel hits. The first shock from ground contact (A, fig. 2.20) causes the blades straddling the contact point to jolt out of angular balance. If repeated by the next contact (B, fig. 2.20), a resonance is established which sets up a self-energizing oscillation of the fuselage. Unless immediate corrective action is taken, the oscillation severity increases rapidly and the helicopter disintegrates.

c. Corrective Action for Ground Resonance.

(1) If rotor rpm is in the normal range, take off to a hover. A change of rotor rpm may also aid in breaking the oscillation.

(2) If rotor rpm is below the normal range, reduce power. Use of the rotor brake may also aid in breaking the oscillation.

2.34. Weight and Balance

The permissible center of gravity (C.G.) travel is very limited in many helicopters, and the weight of aviator, gasoline, passengers, cargo, etc., must be carefully distributed to prevent the helicopter from flying with a dangerous nose-low, nose-high, or lateral (side-low) attitude. If such attitudes exceed the limits of cyclic control, the rotor will be forced to follow the tilt of the fuselage.

a. The helicopter will fly at a speed and direction proportionate to the tilt of the rotor system. The amount of cyclic control the aviator can apply to level the rotor system could be limited by the manner in which the helicopter is loaded. If a helicopter is loaded "out of C.G. limits" (fig. 2.21), the aviator may find that when he applies corrective cyclic control as far as it will go, the helicopter attitude will remain low on the heavy end or side. He will not be able to level the helicopter, or perhaps raise the nose in order to decelerate and land. Under such circumstances, he is in an extremely dangerous predicament.

b. Efforts have been made, in newer helicopter designs, to place the loading compartment directly under the main rotor drive shaft to minimize C.G. travel; however, the aviator must still balance his load so as to remain within C.G. travel limits. He must know the C.G. travel limits of his particular helicopter and must exercise great care in loading, as prescribed in the operator's manual for the particular helicopter.

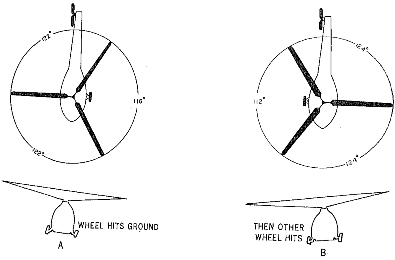

Figure 2.20. Ground shock causing blade unbalance.

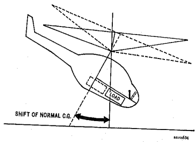

Figure 2.21 Excessive loading forward of the center of gravity.

Section IV. AERODYNAMICS OF AUTOROTATION

2.35. General

Autorotation is a means of safely landing a helicopter after engine failure or certain other emergencies. A helicopter transmission is designed to allow the main rotor to rotate freely in its original direction when the engine stops.

2.36. Autorotation

a. Rotor Blade Driving Region. The portion of a rotor blade between approximately 25 to 70 percent radius (fig. 2.22) is known as the autorotative or driving region. This region operates at a comparatively high angle of attack (fig. 2.22, blade element A), which results in a slight but important forward inclination of aerodynamic force. This inclination supplies thrust slightly ahead of the rotating axis and tends to speed up this portion of the blade.

b. Driven Region. The area of a rotor blade outboard of the 70 percent radius is known as the propeller or driven region. Analysis of blade element B in figure 2.22 shows that the aerodynamic force inclines slightly behind the rotating axis. This results in a small drag force which tends to slow the tip portion of the blade.

c. Stall Region. The blade area inboard of 25 percent radius is known as the stall region, since it operates above its maximum angle of attack (stall angle). This region contributes little lift but considerable drag, which tends to slow the blade.

d. Rotor RPM. Rotor rpm stabilizes or achieves equilibrium when autorotative (thrust) force and antiautorotative (drag) force are equal. If rotor rpm has been increased by entering an updraft, a general lessening in angle of attack will follow along the entire blade. This causes more aerodynamic force vectors to incline slightly backward, which results in an overall decrease in autorotative thrust, with the rotor tending to slow down. If rotor rpm has been decreased by entering a downdraft, autorotative forces will tend to accelerate the rotor back to its equilibrium rpm.

2.37. Forward Flight Autorotations

In forward flight autorotation, the aerodynamic regions (described in par. 2.36) displace across the disc (fig. 2.23), and the aerodynamic force perpendicular to the axis of rotation changes sign (plus or minus) at each

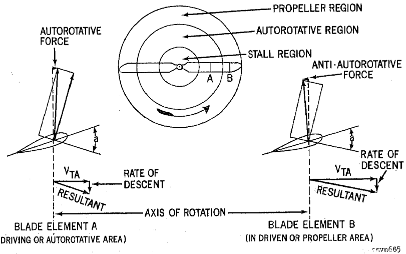

Figure 2.22. Blade forces.

180° of rotation; i.e., the given blade element supplies an autorotative force (thrust) in the retreating position (blade element C, fig. 2.23) and an antiautorotative force (drag) in the advancing position (blade element C1, fig. 2.23). Assuming a constant collective pitch setting, an overall greater angle of attack of the rotor *disc* (as in a flare, par. 2.38) increases rotor rpm; a lessening in overall angle of attack decreases rotor rpm.

2.38. Flares During Autorotation

Forward speed during autorotative descent permits an aviator to incline the rotor disc rearward, thus causing a *flare* (par. 5.16). Tl additional induced lift momentarily checks fo ward speed as well as descent. The great volume of air acting on the rotor disc will no mally increase rpm (somewhat) during th flare. As the forward and descent speed neau zero, the upward flow of air practically cease and rotor rpm again decreases; the helicopte settles at an increased rate and with reduce forward speed. The flare, usually performe at 30 to 50 feet above the ground, enables th aviator to make an emergency landing wit little or no landing roll.

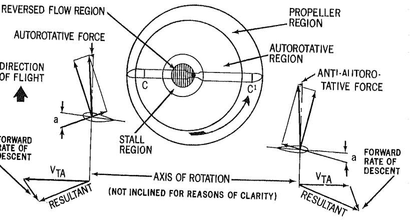

Figure 2.23. Displacement of blade forces.

CHAPTER 3

PRESOLO HELICOPTER FLIGHT TRAINING

3.1. General

The presolo phase of training is the most important portion of the overall training of a helicopter aviator. It has been, and continues to be, an area of constant research in the Army training effort. In this introductory flying phase of demonstration and practice, the student is taking the first step in a long training program aimed toward developing him into an operational aviator. Training programs must not be designed to rush through the low cost, highly formative, presolo portion of training. An early solo is often academically and economically unsound. This becomes apparent in later stages of training when the student must relearn the fundamentals of flight in larger and more costly aircraft.

3.2. Presolo Flight Training Sequence Chart

Figure 3.1 is a complete presolo training chart with suggested exercises listed in an hourly sequence. This sequence of introduction will develop a firm foundation of basic airmanship upon which later stages of training can be built. This chart may also serve as a study guide for those who contemplate helicopter flight training, or for potential helicopter flight instructors.

3.3. Breakdown of Figure 3.1

The chart items in figure 3.1 are grouped into six sections which lead up to the solo: the first two sections require explanation; the last four sections deal with maneuvers which are explained in chapters 4 and 5.

a. The first section includes—

(1) *Preflight inspection.* The instructor pilot explains each part and assembly listed on the inspection guides. He insures, by daily practical exercise and oral examination, that the student becomes familiar with all components, systems, and accessories, and with the proper checks for the airworthiness of each item.

(2) *Cockpit procedure.* The instructor pilot supervises the student in the proper sequence of cockpit procedures, engine starting, and systems checks, increasing responsibilities each day until the student can perform all checks in their proper sequence.

(3) *Introduction to controls.* The instructor pilot fully describes all controls, giving the use and effect of each.

(4) *Antitorque pedals.* The instructor pilot has the student hold the nose of the helicopter on a distant object with pedals, while the instructor pilot moves the helicopter sideward and rearward, and changes torque by momentary throttle and pitch actions.

(5) *Basic flight attitudes for hover, acceleration, and deceleration.* The instructor pilot places grease pencil marks on the bubble or windshield in a manner that will facilitate and clarify a demonstration of these basic attitudes and their effect.

(6) *Collective pitch and throttle.* The student uses collective pitch and pedals; the instructor pilot is on cyclic and is assisting with throttle control.

b. The second section includes—

(1) *Basic flight attitudes.* The instructor pilot assists with the stationary hover. The student rotates, on command, to the normal acceleration attitude. Upon

													Solo Check				Failure Rechecks				
	Hrs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Introduction	Preflight inspection	D	P	C	C	C	C	C	C	C	C	←									→
Introduction	Cockpit procedure	D	P	C	C	C	←														→
Introduction	Introduction to controls	D	P	C	←																→
Introduction	Antitorque pedals single control exercise (student on pedals)	D	P	C	←																→
Introduction	Basic flight attitudes for hover, acceleration, and deceleration	D	P	C	←																→
Introduction	Collective pitch and throttle (I. P. on cyclic, student on pedals and collective)	D	P	C	←																→
Attitude - Power Heading Control	Basic flight attitudes - low level 3 to 5 feet acceleration, coasting hover, deceleration	D	P	P	C	←															→
Attitude - Power Heading Control	Normal takeoff control of attitude and heading to 50 feet or above		D	P	C	C	←														→
Attitude - Power Heading Control	Establishment of slow cruise attitude at 50 feet or above		D	P	C	C	←														→
Attitude - Power Heading Control	Normal approach control of attitude and heading from 50 feet (to open area)		D	P	C	C	←														→
Traffic Pattern	Normal takeoff (using basic attitudes and power settings)			D	P	P	C	C	C	C	C	C	C	C	←						→
Traffic Pattern	Traffic pattern (using basic attitudes and power settings)			D	P	P	C	C	C	C	C	C	C	C	←						→
Traffic Pattern	Normal approach (using basic attitudes)			D	P	P	P	C	C	C	C	C	C	C	←						→
Airwork	Attitude control/airspeed			D	P	P	P	C	C	C	C	C	C	C	←						→
Airwork	Power control/altitude			D	P	P	C	C	C	C	C	C	C	C	←						→
Airwork	Pedal trim control			D	P	P	P	C	C	C	C	C	C	C	←						→
Airwork	Turns - 90°, 180°, 360°			D	P	P	C	C	C	C	C	C	C	C	←						→
Airwork	Rpm control for stabilized cruise, slow cruise, climb, descent				D	P	P	C	←												→
Airwork	Rpm control during full range power change				D	P	P	C	←												→
Airwork	Methods of cross-check				D	P	P	C	C	C	C	C	C	C	←						→
Airwork	Forced landing entry straight ahead, maximum distance (with power recovery after entry)				D	D	P	C	C	←											→
Airwork	Forced landing entry straight ahead, shortened glide (with power recovery after entry)					D	D	P	C	←											→
Hovering	Hovering - stationary						D	P	C	C	C	C	←								→
Hovering	Hovering, moving sideward and rearward, and 90°, 180°, 360° turns						D	P	C	←											→
Hovering	Takeoff to and landing from hover						D	P	C	C	C	C	←								→
Hovering	Hovering autorotation						D	D	P	P	C	C	←								→
Forced Landing and Basic Autorotations	Forced landing entry with bank and turn (with power recovery after bank established)							D	P	C	←										→
Forced Landing and Basic Autorotations	Forced landing (all above) to termination with power							D	P	P	C	C	C	←							→
Forced Landing and Basic Autorotations	Basic autorotation and landing								D	P	C	C	C	←							→
Forced Landing and Basic Autorotations	Recovery from low rotor rpm or bounce									D	←										→
Forced Landing and Basic Autorotations	Basic autorotation 180° and landing									D	P	C	C	←							→
Forced Landing and Basic Autorotations	Antitorque failure										D	D	←								→
Solo	First supervised solo												x						x		
Solo	Second supervised solo													x						x	
Solo	Third supervised solo														x						x

Legend:
D - Introduction/demonstration
P - Practice and student oral summary
C - Check accomplished material
←→ - Completed and on review as required
x - Solo

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Figure 3.1. Presolo flight training sequence chart.

acceleration to 5 to 10 knots, the student rotates to a hovering attitude. (He attempts to hold steady attitude, good track, and good heading control on a distant reference point, with emphasis on attitude, heading, and altitude of 3 to 5 feet.) On command, the student rotates to a normal deceleration attitude (usually level) and holds until the helicopter stops.

Note. This exercise is repeated until the student can perform the entire exercise with reasonable accuracy.

(2) *Normal takeoff control of attitude and heading to 50 feet.* The same exercise as in (1) above is practiced except the helicopter is allowed to reach 18 or 20 knots and effective translational lift for a normal climb.

(3) *Establishment of slow cruise attitude at 50 feet.* The student rotates attitude to a slow cruise attitude on command from the instructor pilot and establishes slow cruise power for a steady-state airspeed at approximately 50 feet.

(4) *Normal approach control of attitude and heading from 50 feet.* The instructor pilot selects an approach point in a nearby open area. When the student reaches a normal approach sight picture, he holds slow cruise attitude and with collective pitch sets up a line of descent toward the selected spot. When the rate of closure or groundspeed appears to be noticeably increasing, the student rotates attitude to the normal deceleration attitude, using collective pitch to maintain descent toward the selected spot. The instructor pilot assists with rpm control and the hover.

Note. This exercise must be repeated until the student holds steady attitudes and good heading (slip control), and has no difficulty with attitude and power control during changes from acceleration to climb, to slow cruise, to descent.

Note. In figure 3.1 the stationary hover, hovering exercises, and takeoff and landing from a hover are introduced and practiced after the first four sections of the chart are accomplished. By this time, the student normally is able to perform the stationary hover without difficulty.

c. Sections 3 through 6 contain maneuvers which are described in chapters 4 and 5.

CHAPTER 4

GENERAL HELICOPTER FLIGHT TECHNIQUES

Section I. INTRODUCTION

4.1. General

a. Mission accomplishment requires so much of the helicopter aviator's attention that the actual flying of the machine must be automatic. An aviator who is totally absorbed by the operation of his helicopter is a machine operator and, at this point in his development, is only a *potential* operational aviator. The operational aviator must use methods and cross-checks that permit him to devote most of his attention to the mission being accomplished, while flying his helicopter with precision.

b. In learning to fly a helicopter, the greatest portion of the student's effort must be devoted to increasing his knowledge and understanding of aviation know-how. The trained aviator looks ahead to the overall mission, the route segment, the maneuver, and the task or "job" unit within the maneuver. He must be mentally and physically coordinated so that he performs all operational job units required to fly the helicopter, without noticeable effort or distraction to the overall mission. The 1 or 2 hours per day that the student spends in the helicopter should be channeled toward testing, proving, investigating, and applying his aviation know-how. Only a small portion of his effort will be devoted to the actual physical moving of controls, switches, and levers. The required physical coordination of control movement should come as a byproduct of the expansion and application of knowledge. Control movements which are difficult for the student to perform should be practiced in an exercise form until the student's response becomes automatic.

4.2. Attitude Flying

a. All aviator training requirements outlined in this chapter follow the principles of *attitude flying* (par. 4.15). In accordance with this concept, all aviator performance is based upon knowledge, planning, projection, and prediction—with control action, feel, touch, and coordination being items of cross-check. Subject matter for the student pilot being trained according to these principles is listed below, in order of importance. It is necessary that emphasis be given to the subject areas in this order:

(1) Knowledge of aerodynamics, physics, and mechanics of flight.

(2) Specific knowledge of the systems, components, controls, and structures of the helicopter being used.

(3) Knowledge of the methods and rules of *attitude flying*, which are similar to the rules of attitude instrument flying in TM 1-215.

(4) Specific knowledge of the breakdown of attitudes and cross-checks for each maneuver; and development in dividing attention and cross-checking outward from a specific center of attention for each segment of a maneuver.

(5) Development of smooth and coordinated physical application of controls: the ability to hold specific attitudes and power settings or to change attitudes and power (in accordance with (3) and (4) above).

b. The physical application of the controls (*a*(5) above) is considered to be less important than the other four subject areas. Professional aviators become so proficient in these subject areas that they appear to fly the helicopter with little movement of the controls. Their skill is the result of thorough application of the principles in *a*(1) through (4) above during the learning and practice phases of training. This application becomes habitual, then automatic.

c. All maneuvers described in this chapter are presented as flight training exercises. Each flight exercise is designed to evoke *thought* processes, to expand knowledge, and to develop the ability to divide attention and cross-check in a manner that promotes correct physical response on the controls.

Section II. GROUND OPERATIONS AND HOVERING

4.3. Preflight Inspection

Once the helicopter aviator has the assigned helicopter number and the mission assignment, he becomes the aviator in command and is ready to begin his preflight inspection. Before he leaves for the flight line, he checks all available sources for possible information on the mission to be flown. Then he checks any available summaries as to organizational or aviator reports on the helicopter's suitability for the intended mission. He next files a flight plan, or assures that one has been filed, and departs for the helicopter.

a. Actual preflight inspections are nothing more than a detailed comparison of the assigned helicopter to the aviator's mental image or idea of a standard helicopter (in type and model), and to the different types of helicopters he has inspected in the past. Aviator proficiency in preflight inspection is gained by a slow accumulation of daily comparison experience. The more experience the aviator has, the more precise is his image of the standard helicopter. Check of the helicopter forms and records provides additional information for this comparison. A published preflight inspection guide for each helicopter provides the sequence of inspection to be followed.

b. Key points for an aviator's preflight inspection proficiency include—

(1) A knowledge of helicopter component design and maintenance practices.

(2) A firm and detailed mental image of the "zero time" appearance of the elicopter to be flown.

ce to the published preflight n guide, which provides a se- .. of inspection to be followed.

(4) Development of genuine interest and curiosity in helicopter design and maintenance problems.

c. A good preflight inspection requires approximately 10 minutes on small helicopters and up to 20 minutes on larger configurations. Preflight inspection time, when totaled on a monthly basis, constitutes a heavy time allotment. For example, 40 preflight inspections per month at 20 minutes each equal 800 minutes or 13½ hours. This time should involve a continuing study of helicopter design and maintenance problems. The professional aviator should keep notes on his findings and make careful and objective written reports. He should follow through with aviator reports and participation in maintenance and design discussions or conferences. Frequent research of maintenance and operator's manuals will also be an asset.

d. School training in preflight inspection provides only the methods of inspections; comparison experience is accumulated by the aviator on the flight line.

e. In addition to the detailed comparison discussed in *a* above, the aviator must—

(1) Check special equipment and supplies required for the mission.

(2) Check the loading of the helicopter, with special emphasis on proper weight, balance, and security.

(3) Perform the progressive sequence of checks and operations in accordance with the published cockpit and starting procedures.

(4) Perform pretakeoff check, tune radios, and obtain necessary clearances.

(5) Check operation of controls and center-of-gravity hang of the fuselage at "gear light" or "skid light" power setting prior to breaking ground. ("Gear light" or "skid light" power setting is that power setting at which some of the weight of the helicopter is being supported by the rotor system.)

Note. If these checks verify that the helicopter favorably compares with the aviator's image of the ideal helicopter, the preflight inspection is completed and the aviator is free to take off to a hover.

4.4. Taxiing

a. General. Helicopters equipped with wheels and brakes have excellent taxi control characteristics. Those equipped with skids can be taxied for a few feet, but generally this type helicopter is hovered from place to place. When taxiing, the aviator must maintain adequate clearance of main rotor(s) in relation to obstructions and other aircraft. He must—

(1) Insure that clearance is sufficient for the area sweep of the tail rotor and pylon during a pivotal turn.

(2) Properly use cyclic and collective pitch, for control of speed to not more than approximately 5 miles per hour (speed of a brisk walk).

(3) Recognize conditions which produce ground resonance, and know the recovery procedures for ground resonance.

(4) Be familiar with the standard marking for taxiways and parking areas.

(5) Be familiar with the light and hand signals used by tower and ground control personnel.

b. Procedure for Taxiing. To taxi a wheel- and brake-equipped helicopter—

(1) Set rotor rpm in normal operating range.

(2) Tilt rotor tip-path plane slightly forward.

(3) Increase collective pitch and manifold pressure to obtain a moving speed of not more than that of a brisk walk.

(4) Use antitorque pedals for directional control. If helicopter has a tail wheel, it should be unlocked for turning a[illegible] locked for long straight-ahead taxiin[illegible] (Also see local regulations for furth[illegible] guidance.)

Note. Brakes should not be used for dir[illegible] tional control. However, it is general pr[illegible] tice to apply "inside" brake for spot parki[illegible] and pivotal turn control.

c. Procedure for Slowing or Stopping. F[illegible] slowing or stopping the helicopter wh[illegible] taxiing—

(1) Level the rotor and lower pitch.

(2) As the helicopter slows, touch bo[illegible] brakes to stop at the desired spot.

(3) For an alternate method to slow [illegible] stop, tilt the rotor slightly rearwa[illegible] The addition of collective pitch a[illegible] power should then cause the helico[illegible] ter to slow and finally stop.

Note. For brake failure and emerge[illegible] stop, perform a takeoff to hover.

4.5. Takeoff To Hover and Landing From Hover

a. General. In all helicopters, the takeoff and landing from a hover is primarily an app[illegible] cation of physics and aerodynamics. Therefo[illegible] development of aviator skill is dependent on [illegible] knowledge of the physics and aerodynamics [illegible] volved. The smooth and apparently continuo[illegible] transition from a parking position up to [illegible] stabilized hover is not a single operation. T[illegible] transition contains many separate elements [illegible] key points, each of which is more of an appli[illegible] thinking process than a physical skill.

b. Takeoff-To-Hover Exercise. The compl[illegible] maneuver must contain all points in this ex[illegible] cise. The finished maneuver will be a smoo[illegible] blend of all items listed below.

(1) Visually clear the area. Check for [illegible] jects, conditions, or people that co[illegible] be affected or disturbed by a hoveri[illegible] helicopter.

(2) Determine wind direction and vel[illegible] ity. Mentally review and predict t[illegible] possible effect of this wind upon t[illegible] helicopter at lift-off.

(3) Tune radios, make advisory calls, a[illegible] just volume. For training, all rad[illegible]

should be on and tuned to local facilities.

(4) Adjust the friction on the collective pitch and throttle. Use enough friction to hold these controls, so that the left hand can be momentarily free to operate carburetor heat, lights, and radios in flight.

(5) Make final pretakeoff check. This check includes pressures, temperatures, electrical systems, final area check, and operating rpm.

Note. From this point until the final establishment of a stabilized hover, *compare* the performance, control action, center of gravity, and sound of *this* helicopter to the standard response of your ideal helicopter of this type. If the response or performance differs greatly at any point, *reduce power.*

(6) Increase manifold pressure slowly to gear light condition or until the rotor is supporting some of the helicopter weight. For reciprocating engines, center attention on rpm instrument, and cross-check to manifold pressure and outward to a fixed point near the horizon. For this exercise, increase manifold pressure ½ inch at a time with collective pitch if rpm is on the mark, or with throttle if rpm is low. Center attention on rpm, with cross-check to manifold pressure. Decide whether the next ½ inch of manifold pressure should be made with pitch or throttle to keep rpm on the exact mark.

Note. With increased proficiency, the above action appears to be a smooth and continuous coordination.

(7) Be alert for the first sign of gear light condition, which usually is a need for antitorque pedal *repositioning.* As main rotor lift increases and weight upon the landing gear becomes less, torque may turn the fuselage.

(8) Shift center of attention to the fixed point near the horizon with cross-check to rpm and manifold pressure. Hold the helicopter heading on the fixed reference point with pedal *repositioning* so that an imaginary line would extend from the fixed point between your feet to your seat. (See A, fig. 4.1.)

(9) Be alert for the second sign of gear light condition, which is often a need for repositioning of the cyclic control. Make a positive repositioning of the cyclic in a direction opposite to and preventing any horizontal movement of the helicopter.

(10) Continue the increase of power to find the center of gravity (C.G.) attitude or the center of gravity hang of the fuselage, which is the fore and aft and lateral attitude of the fuselage just prior to breaking ground contact. (After breaking ground contact, this attitude is referred to as the hovering attitude.)

Note. There will be a tendency for certain portions of the landing gear to leave the ground first, due to the location of the center of gravity for each load condition. Therefore, if power is increased with heading maintained by repositioning of pedals and all horizontal motion prevented by repositioning of the cyclic, a point will be reached where the rotor is almost supporting the full weight of the helicopter, but where some portion of the landing gear still is in contact with the ground.

(11) Identify the C.G. attitude (C.G. hang): check some windshield or canopy part against the horizon. If the attitude appears normal, if the controls are responding normally, and if the helicopter feels and sounds normal, you are cleared to lift to a hover.

(12) Continue the power application and the helicopter will rise vertically to a full stabilized hover, holding its position and heading steadily without requiring noticeable change of attitude.

(13) The exercise is complete. Hover briefly prior to moving out.

c. Landing From Hover Exercise. Landing from a hover is accomplished by reversing the exercise given in *b* above.

(1) Hover briefly and position the helicopter over the intended landing spot.

(2) Select reference point near the horizon.

(3) Use pedal control to hold a line from the reference point between your feet to your seat.

(4) Use cyclic to prevent any horizontal motion. If the helicopter moves horizontally in relation to your reference point, ease back to the original position.

(5) Attempt to reduce power ½ inch at a time, with pitch and/or throttle, so as to maintain rpm on the exact mark. The aim is to develop a slow, constant downward settling.

(6) As the downward settling slows, reduce another ½ inch of manifold pressure.

(7) At initial ground contact, continue the procedure in (5) above until all weight of the helicopter is on the landing gear.

(8) During early training or in transition to other helicopters, it is best to use the distant reference point as the center of attention. Cross-check inward to rpm and manifold pressure. Cross-check downward for positioning over parking panel.

(9) More advanced aviators may center their attention on the wheel, skid, or some point in close to the helicopter.

Caution: **Some helicopters must be landed without pauses once the landing gear touches the ground, due to the possibility of ground resonance.**

4.6. Hovering

The stationary hover and the moving hover appear to be highly skilled, coordinated physical accomplishments when executed by a seasoned aviator, but as is true with all other maneuvers, these maneuvers can be divided into simple key point and cross-check exercises.

4.7. Stationary Hover

a. General. The stationary hover actually begins at that moment of takeoff to a hover when the rotor is supporting most of the weight of the helicopter. Power application will then determine the height of the hover. They key points, thought processes, and cross-checks involved in hovering can be mastered by use of the exercise given in *b* below.

b. Stationary Hover Exercise.

(1) At the moment of "lift-off," take special note of the exact forward horizon picture outlined through the visual frame of hardware parts of the cockpit. Use windshield frames, the top of the radio box, instrument panel, antennas, or a mark (grease pencil) on the windshield glass to determine an exact hovering attitude in reference to a point on the distant horizon. It is important to use the distant horizon, for this reference will be used later to program the moving hover, the normal takeoff, and the climbout.

(2) In peripheral vision, find the lateral hang of the fuselage at "lift-off," using door frames or side window frames. The lateral hang of the fuselage can also be determined on the forward horizon picture. (The aviator will receive an indication of a change in the attitude of the helicopter prior to actual movement of the helicopter. Corrections then must be applied immediately to maintain the level attitude and position of the helicopter.)

(3) Accomplish all forward or rearward horizontal control by slight adjustments to the noseup, nosedown attitude as measured against some distant point on or near the horizon. Use an airframe part or grease pencil mark on the distant horizon for exact attitude control.

(4) Control sideward motion by slightly raising or lowering the lateral attitude (as seen in peripheral vision).

Note. Pedal turns to new headings often require establishing new attitudes and control centers when surface winds are not calm. The main rotor tilt must remain into the wind and the weathervane effect on the fuselage must be counteracted.

4.8. Characteristics of Stationary Hover

a. The stationary hovering exercise is properly accomplished when—

(1) The hover is maintained by slight noseup, nosedown, and lateral attitude changes made *on and around a specific and recognizable base attitude.*

(2) The only cyclic control movement at any moment is that motion necessary to slightly change or hold the specific hovering attitudes (in normal wind conditions).

(3) The changes of attitude are made at a rate and amount so as not to be noticeable by a casual observer/passenger.

(4) Heading control is accomplished by prompt pedal repositioning, which holds and keeps an aviator's feet and the pedals straddling an imaginary line straight ahead to a distant reference point (building, tree, bush, etc.).

(5) Hovering height is held to the specified height published in the operator's manual by use of collective pitch.

b. The stationary hovering exercise is *not* properly accomplished when—

(1) The helicopter attitude is constantly changing, or there is no recognizable and obvious base attitude around which the aviator is working.

(2) The noseup, nosedown, and lateral changes of attitude are made at a rate and in amounts which are noticeable to a casual observer/passenger.

(3) Due to overcontrolling, the hover is accomplished by rapid and constant cyclic jiggling, or thrashing of the cyclic *without a corresponding change of airframe attitudes.*

(4) The fuselage does not hold a constant heading on a distant reference point.

(5) The hovering height is rising and lowering.

(6) The horizontal positioning is unsteady and changing.

4.9. Moving Hover Exercises

The moving hover is generally less difficult than the stationary hover and can be accomplished through use of the following exercises:

a. Using the base attitudes required for the stationary hover, lower the nose approximately 2° or 3°. (In instrument flying, 2½° corresponds to *one bar width* on the attitude indicator.)

b. Hold this attitude steady until the forward hovering rate has reached that of a brisk walk.

c. Return the attitude to the original stationary hovering attitude for a coasting hover. Raise the attitude slightly to reduce speed, or lower the attitude slightly to increase speed. Then, when desired speed has been attained, return to the stationary hovering attitude for a steady coasting rate.

d. Use lateral attitude control for positioning over the desired line of hover.

e. Use pedals to hold the fuselage heading parallel to the desired line of hover.

f. To stop, raise the nose 2° or 3° above the stationary hovering attitude, then return to the stationary hovering attitude as all forward motion is dissipated.

4.10. Precautions When Hovering

When hovering, watch for and avoid—

a. Parked airplanes.

b. Helicopters which have rotors turning after shutdown.

c. Dusty areas or loose snow.

d. Tents or loose debris.

e. Any area where there is a person or object that could be adversely affected by a hovering rotor downwash.

Section III. NORMAL TAKEOFF

4.11. General

The normal takeoff performed from a stationary hover has fixed, programed elements with few variables. Once the aviator knows where to look and what to think, what to program and what to cross-check, this maneuver will be mastered. The normal takeoff exercise given below presents the exact thought/action/cross-check sequence required to perform this maneuver in most helicopters. See the applicable operator's manual for directions to convert this exercise to the final form required for the specific helicopter.

4.12. Pretakeoff Considerations

Before taking off—

a. Select the takeoff outbound track to be used. Note the wind direction in relation to the intended outbound track.

b. Make a hovering turn to clear the airspace for other traffic (unless cleared by tower or ground crew).

c. Select two or three "line-up" objects (panel, bushes, trees) beyond the takeoff point, over which the outbound track is to be flown.

d. Make final pretakeoff cross-check of instruments for systems, pressures, and temperatures.

e. Hold fuselage heading on and/or parallel to the farthest reference point.

4.13. Normal Takeoff Exercise

a. Note the exact hovering attitude, using airframe/windshield parts on the horizon (or projected horizon through foliage ahead).

(1) Rotate the attitude to approximately 1° lower than hovering attitude; this will result in a slow forward motion.

(2) Rotate attitude to approximately 2° lower than hovering attitude; this will result in noticeable acceleration.

(3) Rotate attitude to approximately 3° lower than the hovering attitude. This is the final attitude change which should be held constant throughout the horizontal run to effective translational lift. Hold attitude constant thereafter to gain a progressive increase in airspeed and altitude.

b. Experiment with this exercise and note the different results when the attitude rotation is less or greater than suggested. (Airspeed/altitude relationship at 70 to 100 feet will be changed.) Note effect when the entire rotation is made at one time rather than in two or three increments. (Helicopter will noticeably settle and more power will be required to hold the hovering run to effective translational lift.) Also experiment, solve, and verify that when starting with the observed hovering attitude, an attitude rotation of a specific number of degrees made at a specific rate will result in a smooth progression from a stationary hover (without appreciable settling) to effective translational lift, and on to a progressive gain of altitude and climb airspeed.

c. Throughout this exercise hold in cross-check—

(1) The *attitude* constant with fore and aft cyclic control. The nose will tend to rise at effective translational lift and thereafter as airspeed increases, due to dissymmetry of lift and resulting blade flapping. Reposition cyclic promptly to hold the selected *normal takeoff attitude* throughout the maneuver.

(2) Hovering height with collective pitch and power control until effective translational lift is reached, then allow the additional lift to cause helicopter to climb.

(3) Power adjusted to the published climb value after climb begins.

(4) The *heading* parallel to the line of outbound reference points. Normally, the fuselage heading will tend to yaw to the left due to the streamlining effect on the fuselage and increasing efficiency of the tail rotor. Note that pedals must be repositioned to hold the heading as airspeed increases and as the climb progresses through various wind conditions.

(5) The helicopter positioning over the intended outbound track, controlled with lateral cyclic. Make reference points pass under aviator's seat or between pedals.

(6) Fuselage alignment parallel to intended track with pedal control and helicopter positioning over the line of outbound track with lateral cyclic control. This is referred to as a *slip*, and is used from a hover up to 50 feet. In the event of engine failure during

takeoff, there would be little chance to align the fuselage with the touchdown direction; therefore, the heading must be aligned with direction in a slip at all times below 50 feet. At 50 feet, reposition pedals to the "climb pedal" position (usually this is a neutral pedal setting) for conversion of the slip to a *crab* (par. 4.22*d*). Thereafter, airspeed should increase rapidly toward the published climb airspeed.

d. After conversion from the slip to crab, or when the airspeed increases to within 5 knots of the published climb airspeed—

(1) Slowly raise attitude toward the tentative or known climb attitude to maintain climb airspeed. This must be a tentative attitude based upon the aviator's knowledge of the average climb attitude for this type helicopter. Thereafter correct, verify, and solve for a firm climb attitude. (This will probably be "slow cruise" attitude also.)

(2) To control outbound track when in a crab (above 50 feet), hold climb pedals and fly a normal banked turn with cyclic to a heading that will result in the desired track (toward a geographic fix on the selected outbound track).

4.14. Summary

a. The normal takeoff is completed when there is a climb airspeed and climb attitude, climb power and normal rpm, climb pedals and level lateral trim, and tracking is over desired outbound track.

b. The exercise is properly accomplished when—

(1) Required attitudes which result in a smooth acceleration and climb are programed and held.

(2) Climb power is programed or checked at effective translational lift with rpm in normal range.

(3) In cross-check, there is good heading and track control.

(4) At 50 feet, a conversion from the slip to a crab is programed.

(5) Climb airspeed is reached, and the attitude is rotated to *climb attitude.*

c. Common *errors* include—

(1) Poor hovering height control during the initial acceleration to translational lift.

(2) No firm attitude around which the aviator is working. Constantly changing attitude results in poor airspeed/altitude relationship.)

(3) Fuselage in a crab prior to 50 feet and/or constantly changing.

(4) No positive conversion from slip to crab at 50 feet.

(5) Poor power control (high or low manifold pressure or torque setting) during climb.

(6) Left or right drift away from outbound track.

Section IV. AIRWORK

4.15. Introduction to Airwork

a. The *attitude* of the aircraft to the horizon and the *power* applied are *the only two elements of control in all aircraft.* Proper use of these two elements of control will produce any desired maneuver within the capability of the aircraft. Therefore, all maneuvers, studies, and exercises of all flight requirements must be based solidly upon *attitude* and *power* control references.

b. The modifiers of the two basic control elements are *time* of application (the initial time to apply and the length of time each attitude and power setting is applied) and the *rate* of change (of attitudes and power settings).

c. Keeping the basic control elements and modifiers in mind, add (1) *cross-check* for a running awareness of what the aircraft is doing at the moment, (2) *knowledge* and *projection* as to what the aircraft is going to do, and

(3) *purpose* and *intent* for exactly what the aviator wants to do. The result will be *attitude flying*.

d. Based upon these principles, airwork presented in this section will include discussion and exercises for—

(1) Attitude control and resulting airspeed.

(2) Power control and resulting altitude, climb, or descent.

(3) Rpm control for steady climb, cruise, or descending flight, and during heavy power changes.

(4) Heading control and resulting track or turns, and antitorque control and resulting lateral trim.

4.16. Attitude Control and Resulting Airspeed

a. Airspeed is a *result* of attitude control. To hold any desired airspeed or make properly controlled changes of airspeed, the aviator must—

(1) Prior to flight, have formed a *clear mental image* of basic attitudes normally expected of the helicopter he is to fly. For example, what are the attitudes (of this type helicopter) for hover, normal acceleration, deceleration, climb, cruise, or slow cruise?

(2) Beginning with the first takeoff to a hover, solve for the exact basic attitudes of the helicopter being flown. How do these basic attitudes compare with the basic attitudes of the ideal helicopter (par. 4.3) or with other helicopters of the same type?

b. During the first few minutes of flight the aviator must make the comparisons described in *a* above, using tentative attitudes to solve for the actual basic attitudes *prior* to engaging in further maneuvers or precision flying exercises.

4.17. Attitude Control Exercise

a. With *center of attention* on the *exact attitude* being held for the desired flight condition, cross-check the airspeed indicator.

b. Predict how this *attitude* is going to affect the airspeed in the next few seconds of flight.

(1) Will it hold the airspeed now indicated?

(2) Will it cause a slowing of airspeed?

(3) Will it cause an increase of airspeed?

Note. Do not concentrate on the airspeed indicator. It is an amount gage, showing only the amount of airspeed at the moment. It cannot be used to predict airspeed in future seconds; therefore, use it in cross-check only. *Do* concentrate your center of attention on attitude (to the exact degree on the horizon) to predict airspeed in future seconds.

c. Hold the attitude steady, change it momentarily, or rotate to a new attitude which, in prediction, will result in the airspeed desired. *Cross-check* the airspeed indicator frequently to assure that the attitude now being held is affecting the airspeed as expected.

d. The exercise is being correctly performed when the aviator—

(1) Rotates to an attitude that, in prediction, will accelerate or decelerate to a desired airspeed.

(2) Cross-checks the approaching airspeed indication desired.

(3) Rotates the attitude to a specific attitude that, in prediction, will hold the desired airspeed.

(4) Holds the attitude constant while in cross-check. He observes the *total* flight condition (mission, maneuver, other traffic, altitude, manifold pressure, rpm, lateral trim, pedal setting, and track); he cross-checks the airspeed indicator—is it low? high? or steady?

Note. The aviator makes slight attitude changes to return to the proper airseed reading (when necessary), *but returns to his last proven attitude* when the airspeed is corrected. After two or three corrections in the same direction, he modifies his proven attitude slightly.

e. The exercise is completed when each step is performed smoothly, promptly, with precision, and without noticeable distraction to the *total flight*.

4.18. Power Control and Resulting Altitude, Climb, or Descent

Altitude is a result of power control. To properly change to or hold any desired altitude the aviator must—

a. Prior to flight, have a clear mental image of tentative or basic power settings normally expected for the type helicopter to be flown. For example, what are the power settings (of the average machine of this type) for hover, climb, cruise, slow cruise, and descent? What differences could normally be expected for various gross weights and density altitude combinations?

b. Upon the first takeoff to a hover and thereafter, solve for the exact basic power settings required for precise altitude control for the helicopter being flown. For good altitude control, this study must be completed before engaging in further maneuvers or precision flying exercises on this flight.

4.19. Altitude Control Exercises

a. Altitude Control Exercise (Climb).

(1) With center of attention on attitude for control of a stable climb airspeed, cross-check and maintain climb power. (Climb power will be published or as required to maintain a 500 feet per minute rate of climb.)

(2) Use pedals to align the fuselage with the outbound track. At 50 feet, reposition the pedals to "climb pedals," which usually is a neutral setting.

(3) Conduct a running cross-check on climb power, since it will be necessary to add throttle to prevent a natural decrease of manifold pressure as altitude is gained and the atmosphere becomes less dense.

b. Altitude Control Exercise (Cruise).

(1) When the climb has reached to within 50 feet of the cruise altitude, rotate the attitude to an acceleration attitude.

(2) When the airspeed reaches cruise airspeed, rotate the attitude to a tentative or known cruise attitude.

(3) As the altitude reaches cruise altitude, begin a reduction of manifold pressure to a tentative or known cruise power setting.

(4) Solve for the exact manifold pressure setting required to hold the desired altitude. Use 2 inches above and below this reading for minor altitude corrections (of 40 feet or less). Use the published climb or descent power setting for large altitude corrections.

Note. Do not concentrate on the altimeter; use it in cross-check only. The altimeter is only an amount gage, showing the amount of altitude at the moment. It cannot be used to predict altitude in future seconds. *Do use* exact manifold pressure settings (to the exact mark) for predicting and controlling altitude trends in future seconds, assuming a stable attitude/airspeed.

Note. Use the following cross-check rule for altitude control at cruise: If the altimeter is not on the desired mark, then the manifold pressure should be plus (+) or minus (−) 2 inches from that value required to hold the desired altitude. If a high or low altimeter reading is not seen and correction initiated within 10 seconds, the aviator has a poor cross-check.

c. Altitude Control Exercise (Slow Cruise).

(1) Rotate the attitude to a tentative or known slow cruise attitude.

(2) Lower the manifold pressure to a tentative or known slow cruise power setting (usually 2 to 3 inches below cruise manifold pressure setting).

Note. Coordinate antitorque pedals with the power reduction in the amount required to prevent yaw during the power change. (Check exact pedal setting required for slow cruise by referring to interal trim or a centered ball.)

(3) Solve for the exact manifold pressure setting required to hold the desired altitude. Use 2 inches above or below this reading for minor altitude corrections.

d. Altitude Control Exercise (Descent).

(1) With cruise or slow cruise attitude/ airspeed, reduce power to the manifold pressure needed to establish a 500 feet per minute descent or to the published descent manifold pressure.

(2) Coordinate pedals to prevent yaw during power change.

(3) Center attention on attitude, with cross-check to manifold pressure and/ or 500 feet per minute descent.

e. Deceleration Exercise. Although this exercise is used primarily for coordination practice, deceleration can be used to effect a rapid deceleration in the air. The maneuver requires a high degree of coordination of all controls, and is practiced at an altitude of approximately 0 feet. The purpose of the maneuver is to maintain a constant altitude, heading, and rpm while slowing the helicopter to a desired groundspeed. To accomplish the maneuver—

(1) Decrease collective pitch while coordinating the throttle to hold rpm, and apply aft cyclic control, flaring the helicopter smoothly to maintain a constant altitude.

(2) At the same time, continuously apply antitorque pedals as necessary to hold a constant heading. (The attitude of the helicopter becomes increasingly nose-high (flared) until the desired groundspeed is reached.)

(3) After speed has been reduced the desired amount, return the helicopter to a normal cruise by lowering the nose with cyclic control to accelerate forward while adding collective pitch and throttle to maintain altitude.

(4) Use pedal to hold the desired heading.

f. Completion of Exercises. These altitude control exercises are completed when all items are performed smoothly, promptly, and with precision. The objective is accomplished when each exercise is performed without noticeable distraction to the total flight; i.e., mission, maneuver, systems, fuel management, other traffic, and navigation.

4.20. Rpm Control

a. Helicopter power controls are designed to combine the following three functions into the collective pitch stick:

(1) A twist-grip throttle serves as the handle for the collective pitch stick. Gripping the throttle and bending the wrist outward will add throttle; bending the wrist inward will decrease throttle.

(2) Raising and lowering the collective pitch stick will increase or decrease the pitch or angle of incidence of the main rotor blades.

(3) A throttle correlation unit is added to the collective pitch linkage. Once this device is set by the throttle for the desired engine rpm, it will automatically add more throttle as the collective pitch is raised and reduce throttle as the collective pitch is lowered. Thus, in theory, this unit will maintain constant rpm as the main rotor loads change. However, being of simple cam design, this correlation device usually works properly only in a narrow range. Increasing collective pitch above or below this range usually results in undesirable rpm changes, which must be corrected.

b. To learn rpm control requires study, practice, and experimentation by the aviator. He must develop a visual cross-check of the rpm instrument. He must, at times, use the sound of the engine or the whine of the transmission to recognize rpm variations. Some throttles require a slight bending of the wrist outward or inward as the collective pitch is raised or lowered for rpm to be exactly maintained throughout the full power range from maximum allowable power (pitch up) to collective pitch full down in needles-joined autorotation.

4.21. Rpm Control Exercises

RPM control exercises, when accomplished step by step and unt natic, will give the aviator an apparent effortless control of rpm. nto three distinct flight groups that require study and practice, as fo *a.* Rpm control and correction during steady state climb, cruise, and descent:

(1) *If rpm is high:*

(*a*) Note manifold pressure reading.

(*b*) Squeeze *off* ½ to 1 inch of manifold pressure with the throttle.

(*c*) Increase collective pitch ½ to 1 inch of manifold pressure (returning to original reading in step (1) above).

(*d*) Cross-check other traffic, attitude, altitude, and track. After approximately 3 seconds, cross-check rpm gage for completed correction. If still high, repeat the exercise.

(2) *If rpm is low:*

(*a*) Note manifold pressure reading.

(*b*) Squeeze *on* ½ to 1 inch of manifold pressure with the throttle.

(*c*) Reduce collective pitch ½ to 1 inch of manifold pressure (returning to original reading in step (1) above).

(*d*) Cross-check other traffic, attitude, altitude, and track. After approximately 3 seconds, cross-check rpm for completed correction. If still low, repeat the exercise.

b. Rpm control and correction during heavy manifold pressure changes:

(1) *Rpm control while reducing collective pitch:*

(*a*) Reduce manifold pressure with collective pitch while cross-checking rpm gage.

(*b*) If rpm is slightly high, make the next inch manifold pressure reduction with throttle.

(*c*) Reduce manifold pressure steadily with pitch and/or throttle in 1-inch increments so as to maintain the desired rpm.

Note. Keep the manifold pressure needle moving in peripheral vision and rpm gage in constant cross-check.

(*d*) Upon reaching the desired manifold pressure for steady state descent, make further corrections to rpm as in *a* above.

(2) *Rpm control while increasing collective pitch:*

(*a*) Increase manifold pressure with collective pitch while cross-checking rpm gage.

(*b*) If rpm is slightly low, make the next inch manifold pressure increase with throttle.

(*c*) Increase manifold pressure steadily with pitch and/or throttle in 1-inch increments so as to maintain the desired rpm.

Note. Keep the manifold pressure needle moving in peripheral vision and rpm gage in constant cross-check.

(*d*) Upon reaching the desired manifold pressure for steady state climb, make further corrections to rpm as in *a* above.

c. Rpm control and correction during hovering or approaches on predetermined line of flight (5° to 20°):

(1) *If rpm is high:*

(*a*) Cross-check rpm frequently.

(*b*) Note manifold pressure reading.

(*c*) At a hover, squeeze *off* 1 inch of manifold pressure with throttle and use collective pitch to maintain the desired hovering height.

(*d*) On approach, squeeze *off* ½ inch (or less) of manifold pressure with throttle and use collective pitch to control line of descent.

(*e*) Cross-check rpm. If still high, repeat exercise.

(2) *If rpm is low:*

(*a*) Cross-check rpm frequently.

(*b*) Note manifold pressure reading.

(*c*) At a hover, squeeze *on* 1 inch of manifold pressure with throttle and use collective pitch to maintain the desired hovering height.

(*d*) On approach, squeeze *on* ½ inch (or less) of manifold pressure with throttle and use collective pitch to control line of descent.

(*e*) Cross-check rpm. If still low, repeat exercise.

4.22. Antitorque Pedals

a. General. The primary purpose of the antitorque pedals is to counteract torque (pars. 2.16 and 2.17). However, the antitorque system usually is designed to have surplus thrust, far beyond that required to counteract torque. This additional thrust, designed into the tail rotor system, is used to provide positive and negative thrust for taxi direction control and to counteract the weathervane effect of the fuselage in crosswind operations. In certain helicopter configurations, care must be exercised in using the thrust power of the antitorque system, since damage to the tail pylon area can result from overstress during fast-rate hovering pedal turns and during taxi conditions over rough ground. (Some tail rotor designs may demand up to 20 percent of the total engine output. This power should be used with caution.)

b. Areas of Consideration. Antitorque pedals are the most misused of the helicopter controls. There are three separate modes of control for correct pedal use, and each of these modes must be analyzed and treated separately by the aviator.

(1) The first group includes normal helicopter operations below 50 feet, during which the fuselage is aligned with a distant point. This group includes taking off to and landing from a hover, the stationary hover, the moving hover, the takeoff and climb slip control, and the approach slip control.

(2) The second group includes coordinated flight and all operations above 50 feet which require pedal use to align and hold the fuselage into the relative wind.

(3) The third group includes proper pedal use in turns. Coordinated turns (at altitude) require the proper use of pedals to keep the fuselage into the relative wind as the bank is initiated, established, and maintained.

c. Heading and Track Control for Operations Below 50 Feet.

(1) Taking off to and landing from a hover require that pedals be repositioned to hold and maintain the nose alignment with a distant reference point. The aviator uses an imaginary line to a distant object and applies pedal to position and maintain the line from his seat through the cyclic and the gap between his pedals (A, fig. 4.1). Aviators in either seat use the same distant reference point with no appreciable error. Figure B, 4.1 shows the fuselage alignment to hovering or takeoff direction.

(2) During the moving hover and the initial climb to 50 feet, pedals control heading as in figure 4.1, and cyclic control is used for direction and lateral positioning over the intended track as in figure 4.2. Using peripheral vision (and cross-check), the helicopter should be positioned with lateral cyclic so the imaginary line is seen running through position 1 (fig. 4.2) during taxi or run-on landings, and position 2 for hovering and climb through 20 feet. The line should be seen between pedals as shown at position 3 for all altitudes over 20 feet, with all track reference points lined up and passing between pedals in passage over each point.

Note. Beginning students may use the method shown in A, figure 4.1 to determine track alignment for all maneuvers.

(3) In crosswind operations, the combined use of pedals and cyclic as in (2) above results in a sideslip, commonly referred to as a *slip*. The aviator does not consciously think *slip*, for he is automatically in a true slip if he holds the fuselage aligned on a distant object with pedals (fig. 4.1) and maintains positioning over the line with cyclic (fig. 4.2).

d. Heading and Track Control for Operations above 50 feet.

(1) For coordinated flight above 50 feet, the pedals assume a purely antitorque role and are promptly repositioned to a climb pedal setting upon reaching 50 feet. This pedal action converts the slip to a crab, which aligns the fuse-

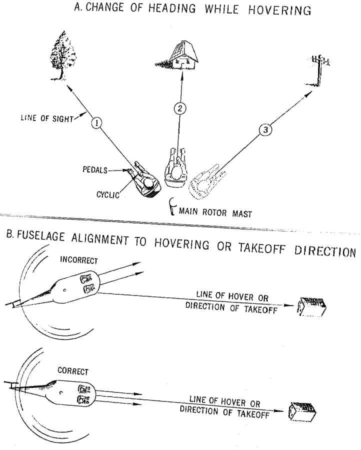


Figure 4.1. Use of references during heading control below 50 feet.

lage with the relative wind, rather than with a distant object.

(a) The helicopter is now in coordinated flight, during which the cyclic controls fuselage heading.

(b) The track is now controlled by a cyclic bank and turn to a heading that will result in the desired track.

(2) Pedals are hereafter coordinated with power changes and should not be used

for heading control. The use of pedals to prevent the momentary yaw of the nose due to gusts should be avoided in early training. Do not move the pedals unless there is a power change.

(3) Power changes require sufficient coordinated pedal to prevent the fuselage from yawing left or right. When the power change is completed, cross-check the new pedal setting and lateral trim of the fuselage (fig. 4.3).

(4) Generally, the average single rotor helicopter will have pedal settings which are normal for various power/speed combinations. Coordinate these settings with power changes and hold in cross-check (for all operations and coordinated flight above 50 feet).

(5) Average pedal settings for a typical single rotor helicopter are shown in figure 4.3. Cross-check these settings for accuracy as described in (6) and (7) below.

(6) Rigging of pedal control linkage will vary in helicopters of the same type. Therefore, in steady climb, cruise, descent, or autorotation, with pedals set as in figure 4.3, cross-check—

(*a*) Turn-and-slip indicator for a centered ball. Pedal into the low ball and note the exact pedal setting required when ball is centered.

(*b*) Door frames or windshield frames for lateral level trim. Pedal into the low side and note the exact pedal setting required.

(*c*) Main rotor tip-path plane. It should be the same distance above the horizon on each side. For level rotor, pedal into the low side.

Note. If the pedal position required is far removed from the normal settings as shown in figure 4.3, write up "pedals out of rig."

(7) In semirigid main rotor configurations, note the lateral hang of the fuselage at a hover (into the wind). If the fuselage is not level, then the one-side low condition must be accepted as level; thereafter, in flight (airwork over 50 feet) adjust pedals for a lateral trim of one-side low as existed at a hover. Proceed as in (6) (*c*) above.

e. Pedal Use in Turns. Use of pedal to enter and maintain a turn requires study and experiment for the particular helicopter being flown.

(1) To determine *if* pedal is required for a coordinated entry to a bank and turn—

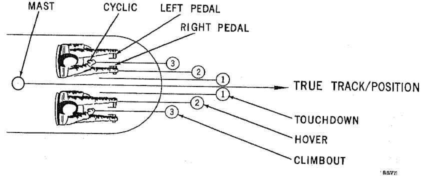


Figure 4.2. Lateral positioning.

Airspeed and manifold pressure	Flight	Pedal setting	Maneuver
	Usual operations below 50 feet	Vary pedals	As required for taxiing
	Usual operations below 50 feet	Usual rigging results in center being 1 inch left pedal	While hovering into the wind
	Usual operations below 50 feet	Vary pedals	As required for crosswind slip control for hovering, takeoffs, and approaches
With 40-knot airspeed and 25 inches manifold pressure	Flight coordinated above 50 feet	Set pedals even for climb	For conversion of slip to coordinated crabbing climb
With 60-knot airspeed and 21 inches manifold pressure	Flight coordinated above 50 feet	Set 1 inch right pedal	For coordinated cruise
With 40-to 60-knot airspeed and 15 inches manifold pressure	Flight coordinated above 50 feet	Set 2 inch right pedal	For coordinated descent
With 40-to 60-knot airspeed and minimum manifold pressure	Flight coordinated above 50 feet	Set 3 inch right pedal	For coordinated autorotation

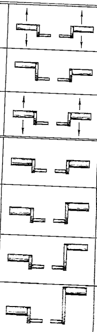


Figure 4-3. Average pedal settings for typical single rotor helicopter.

(*a*) Start at cruise airspeed with the correct pedal setting for lateral trim in straight and level flight.
(*b*) Begin a bank with cyclic only. Use no pedal.
(*c*) Note whether the nose turns in proportion to the bank.

(2) If the nose begins to turn as the bank is initiated, *no pedal* is required for the entry to a turn in this helicopter.
(3) If the nose does not begin to turn as the bank is initiated, use only that pedal required to make the nose turn in proportion to the bank at entry.
(4) After the bank is established, anticipate the normal requirement in all aircraft to require a slight pedal pressure in the direction of the turn for coordinated flight or a centered ball.

23. Traffic Pattern

a. The traffic pattern is used to control the w of traffic around an airport or flight strip. affords a measure of safety, separation, pro- :tion, and administrative control over arriv- ;, departing, and circling aircraft. During ıining, a precise traffic pattern is flown to ɔmote knowledge, planning, prediction, and ;ht discipline. All pattern procedures must strictly followed so that every aviator work- ; in the circuit, and transient aviators arriv- ; and departing, can determine at a glance ː intentions of the other aviators.

ɔ. When approaching a radio-controlled air- ·t in a helicopter, it is possible to expedite ffic by stating, for example—

(1) *Helicopter No. 1234.*
(2) *Position 10 miles east.*
(3) (For landing) *my destination is* (one of the following)—
(*a*) Operations building.
(*b*) Administration building.
(*c*) Fuel service.
(*d*) Weather station.
(*e*) (Other.)

c. The tower will often clear you to a direct approach point on the sod or to a particular runway intersection nearest your destination point. At uncontrolled airports, adhere strictly to standard practices and patterns.

d. Figure 4.4 depicts a typical traffic pattern with general procedures outlined.

Note. If there is no identifiable helicopter traffic pattern, set up one inside the normal airplane pattern (fig. 4.4). Use touchdown and takeoff points to one side of the active runway. If you intend to land on the runway, approach to the near end, then hover clear of the runway immediately.

e. To fly a good traffic pattern, visualize a rectangular ground track and—

(1) Follow good outbound tracking on takeoff and climbout, with steady climb airspeed.
(2) Turn usually less than 90° for drift correction on turn to crosswind leg, so as to track 90° to the takeoff leg.
(3) Select a distant point on the horizon for turn to downwind leg, so as to fly a track parallel to the takeoff and landing direction. Then set up a steady cruise speed and hold a steady altitude.
(4) Turn more than 90° for drift correction on turn to base leg. Change attitude to slow cruise. Change power and pedals to descend at approximately 500 feet per minute or to lose 5 miles per hour for each 100 feet of descent. Watch *far* reference point for turn to final approach leg (fig. 4.5).
(5) Turn short or beyond 90° on turn to final, depending upon the crosswind condition. Before entering approach (or not later than the last 100 feet of the approach), establish a slip with fuselage aligned with the line of approach and the helicopter positioned over the line of approach (see antitorque pedals, par. 4.22).

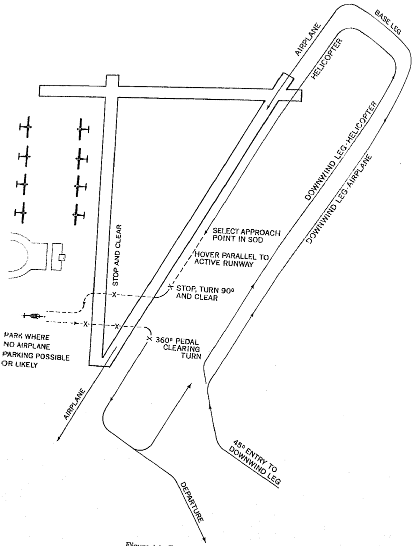


Figure 4.4. Typical traffic pattern.

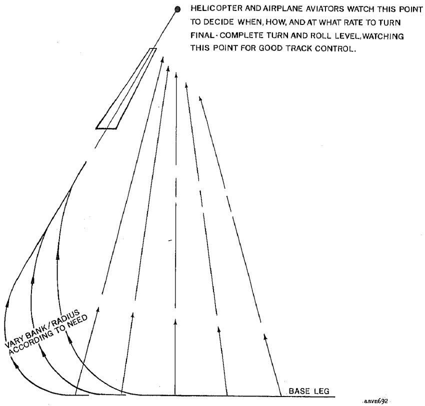


Figure 4.5. Turn to final approach.

Section V. NORMAL APPROACH

4.24. General

Helicopter normal approach techniques follow a line of descending flight which begins upon intercepting a predetermined angle (approximately 12°) at slow cruise airspeed approximately 300 feet above the ground 4.6).

a. The desired line is intercepted, the lowed by use of positive collective pitch so as to establish and maintain a constan

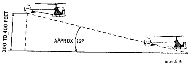


Figure 4.6. Normal approach to hover.

or angle of descent, holding the approach panel in collision or intercept.

b. Slow cruise attitude is held at entry (if the groundspeed is normal) and until there is an apparent increase the rate of closure. Thereafter, the apparent groundspeed (or rate of closure) is maintained at an agreed value, usually an apparent 5 miles per hour. This results in a smooth constant deceleration from the entry down to the hover.

Note. Apparent groundspeed is that phenomenon experienced by the aviator of a helicopter in a descent at a constant airspeed when he observes an apparent increase of speed as altitude is lost. To maintain a constant apparent groundspeed during a descent, the aviator must reduce airspeed as altitude is lost.

c. During the approach, the line of collision or intercept to the panel is slowly changed from the eyes to the wheels or skids. The approach was started with the aviator's eyes on the line; it must be terminated with the wheels or skids on or over the line.

d. At approximately 50 to 25 feet, the aviator begins building in hovering power, arriving just short of the panel and needing only ground effect to establish a stabilized hover or gentle touchdown on the panel.

e. The last 25 feet, eyes should be straight ahead for good yaw control, while approaching with the panel in peripheral vision to the touchdown or hover.

4.25. Normal Approach Exercises

The step by step performance of the normal approach begins with a good turn from base leg to the final approach leg. The track is maintained with a crab, and with *slow cruise attitude* and *slow cruise power*.

a. On Final, Prior to Entry Exercise.

(1) Center attention on *slow cruise attitude*; cross-check *slow cruise manifold pressure*.

(2) Make airspeed corrections with momentary attitude changes.

(3) Make altitude corrections with 2 to 3 inch manifold pressure changes, returning to the exact slow cruise manifold pressure when altitude is corrected.

(4) Analyze apparent groundspeed and decide if it is normal, slow, or fast. If it is fast, entry must have a "lead" (see *b*(1) below).

(5) As the desired approach angle is neared, *hold* slow cruise attitude and slow cruise power (regardless of the existing airspeed or altitude). (It is too late for further corrections to altitude and airspeed. The fuselage must now be used to find the desired approach angle, as seen against some airframe part referred to as a normal approach sight picture (figs. 4.7 and 4.8)).

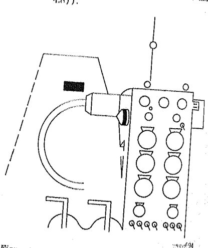


Figure 4.7. Average sight picture for entering normal approach (OH-13).

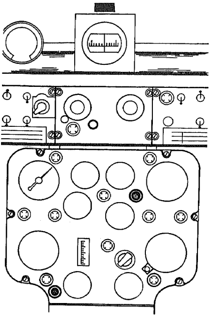


Figure 4.8. Average sight picture for entering normal approach (OH–23).

(6) Prior to reaching the sight picture, it is optional to change from a crab to a slip.

Note. Each phase of the above exercise must be strictly followed to insure desirable conditions for entry. Most common errors in the normal approach procedure can be traced back to poor performance and planning on the final leg prior to entry.

b. Normal Approach Entry Exercise.

(1) If the apparent groundspeed was normal or slow on final, fly up to a point just short of the normal approach sight picture. If the groundspeed was fast, use a point or lead *well* short of the normal approach sight picture.

(2) Cross-check and hold slow cruise attitude to get a true sight picture reading.

(3) Use a positive collective pitch reduction, in the amount necessary to change the line of flight downward toward the panel. Use prompt collective pitch action to make the panel appear to be stationary to the eye.

c. Normal Approach (Intermediate Portion) Exercise.

(1) From this moment on, *do not* use any airframe part or sight picture to control the line of descent. To maintain an angle of descent to a fixed point (for helicopters and airplanes), use the rule of collision or intercept.

Collision Rule: **When two relatively moving objects (aircraft and approach point) have no apparent motion to the eye when viewed from one or the other object, those objects are on a collision or intercept course.**

(2) The sole control of the line of descent (collision course to the panel) is the collective pitch. Use *positive* collective pitch action instantly when needed to prevent apparent motion of the panel.

(3) The *rate of closure* toward the panel is a function of attitude control (cyclic) and is usually maintained by controlling the apparent groundspeed to that of a brisk walk.

(4) If the rate of closure or apparent groundspeed is fast, raise the nose slightly above the slow cruise attitude.

(5) If the groundspeed or rate of closure appears to be slowing too much, lower the nose momentarily to the slow cruise attitude and *wait* until the descent causes an apparent increase back to the desired rate of closure or apparent groundspeed. (Never attempt to accelerate or use an attitude below slow cruise, unless for a go-around.)

d. Normal Approach Termination Exercise.

(1) At 100 feet maintain speed control, as outlined in *c*(3) through (5) below, down to the hover or to touchdown.

(2) Begin to place the wheels or skids on the line of descent (4.24*c* above).

(3) Begin building in hovering power—decelerate so that the helicopter sinks (if necessary) so more power can be added—to arrive just short of the panel, needing only ground effect to establish the hover.

(4) Keep eyes outward for good heading control—use peripheral vision to see panel. Use whatever collective pitch is required to maintain the line to the panel (over and above that described in (3) above).

4.26. Summary

Common errors committed by students performing normal approach techniques indicate a complete lack of knowledge of many items listed in the above exercises. These errors can be eliminated if the student understands and is able to execute these exercises. There are many alternate exercises for introduction and early practice of the normal approach. The example used here is well suited for separate or single control studies (i.e., collective pitch to control line of descent; cyclic control and attitude changes for apparent groundspeed or rate of closure control).

Section VI. MAXIMUM PERFORMANCE TAKEOFF AND STEEP APPROACH

4.27. Maximum Performance Takeoff

a. The maximum performance takeoff is, in reality, a smooth, slowly developed *maximum angle takeoff*. The maneuver is correctly performed when there is a slow, highly efficient steep-angle climb established by using maximum allowable power. The maneuver is completed when the barriers are cleared and a normal climb is established.

b. The exact performance sequence is presented in exercise form. To convert the exercises to an operational maneuver, blend the exercises for a smooth transition throughout.

4.28. Maximum Performance Takeoff Exercises

a. Maximum Performance Takeoff Entry Exercise.

(1) Select a takeoff path as nearly into the wind as barriers will permit.

(2) Select one particular tree for a slip-and-track-control reference point.

(3) Slowly add power to find the C.G. attitude for this particular helicopter, load, and rigging. Hold this attitude during training, with some portion of the landing gear still in contact with the ground. This is the key point in executing maximum performance takeoff.

(4) Add *only enough* collective pitch to cause the helicopter to leave the ground (usually 1 inch or less manifold pressure).

(5) As the helicopter breaks ground, rotate the attitude to a position just short of the normal takeoff attitude.

Note. Abort here and repeat (1) through (5) above until this exercise is performed exactly as stated. All procedures have been included for a good maximum performance takeoff except the addition of maximum allowable power.

b. Maximum Performance Takeoff Intermediate Exercise.

(1) After performing *a*(5) above, add maximum allowable power with throttle while controlling rpm with collective pitch.

Note. For weak engines or poor performance due to load or density altitude, eliminate *a*(4) above and insert (1) above.

(2) Hold the *exact attitude* assumed in *a*(5) above.

(3) Maintain track and heading on the reference tree with good slip control.

(4) Control rpm by ear and frequent cross-check to the rpm instrument.

c. Maximum Performance Takeoff Completion Exercise.

(1) At a point where the barriers are cleared, convert the slip to a crab by repositioning pedals to the "climb pedals" setting.

(2) Lower attitude to the normal takeoff attitude (normal acceleration attitude) to gain normal climb speed.

(3) As climb speed approaches, rotate attitude to normal climb attitude and reduce manifold pressure to the normal climb value.

d. Maximum Performance Takeoff Emergency Climb Exercise (for Nonsupercharged Engines).

(1) For doubtful performance or to clear high barriers, use a 200 rpm overrev at *a*(1) and hold the overrev during the initial 25 feet of climbout.

(2) Gently pull off the 200 rpm overrev down to normal rpm. This will convert the overrev inertia of the main rotor system to lift at a point where ground effect is lost and will assist in gaining translational lift.

4.29. Steep Approach

a. The steep approach (fig. 4.9) is the maximum angle of descent recommended for any given helicopter. It is often referred to as the companion maneuver to the maximum performance takeoff.

b. The steep approach is used when the presence of barriers or the size of the landing area requires a slow steep angle of descent. It is also used at times to avoid turbulence or to shorten the overall approach profile when approaching over rough terrain or congested areas.

c. Generally, aviators will use a normal approach when possible and steepen the angle only by the amount required to have a clear downward approach angle to the touchdown point. Aviators generally avoid approach angles steeper than that recommended for a specific helicopter so as to stay clear of the *Caution* areas depicted on the height velocity diagram in the operator's manual.

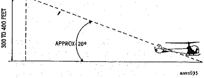


Figure 4.9. Steep approach.

4.30. Steep Approach Exercises

a. Steep Approach—on Final Prior to Entry Exercise.

(1) Establish a good track on final approach leg (using a crab) with 300 feet altitude over the terrain.

(2) Hold slow cruise attitude, with corrections to airspeed accomplished by momentary attitude changes.

(3) Use an exact slow cruise power setting, with altitude corrections accomplished by prompt manifold pressure changes.

(4) Analyze the apparent groundspeed on final. Unless groundspeed is noticeably slow, all entries to the steep approach must have a *lead.* See *b* (1) below.

(5) Well short of the steep approach sight picture (figs. 4.10 and 4.11), discontinue all attempts for altitude and airspeed corrections. *Now* use a slow cruise attitude and a slow cruise manifold pressure setting. (It is too late for further corrections to altitude and airspeed, since the fuselage must now be used as a transit to find the steep approach angle.)

(6) Optional: change from a crab to a slip for track control.

Note. Each step of the above exercise must be performed with precision and without noticeable effort or distraction to the aviator. If the work on final, prior to entry, is erratic, then no two approaches will be alike and efforts throughout the approach would be devoted to recoveries from errors caused by the bad entry.

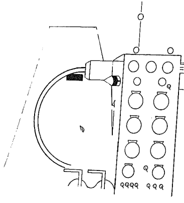


Figure 4.10. Average sight picture for entering steep approach (OH–13).

b. Steep Approach Entry Exercise.

(1) On final, unless the groundspeed is noticeably slow (due to headwind), all steep approaches must have a *lead;* i.e., reducing collective pitch just prior to reaching the steep approach sight picture.

(2) At a point short of the sight picture (depending upon the apparent groundspeed on final), use a positive collective pitch reduction in the amount and at a rate which will change the line of flight downward toward the approach point.

(3) Raise the attitude 3° or 4° in anticipation of an increasing rate of closure.

(4) Use positive collective pitch action to hold the approach panel motionless (the collision course rule).

(5) Cross-check the manifold pressure. If it is somewhere near a "needles joined autorotation" value—

(*a*) Raise the attitude further and hold this deceleration until the helicopter noticeably settles.

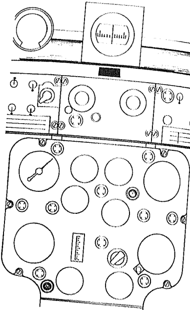


Figure 4.11. Average sight picture for entering steep approach (OH–13).

(*b*) Return the attitude to the original setting while using collective pitch to hold the line of descent. (The manifold pressure will now be higher.)

(6) If the rate of closure appears too slow, lower the attitude to the slow cruise position and *WAIT* until the descent causes an apparent increase back to the normal, comfortable rate of closure.

c. Steep Approach Termination Exercise.

(1) Control the line of descent toward the panel all the way down to the hover (or ground contact) with collective pitch. However, during the final 30 or 40 feet, power should be increasing.

(a) Cross-check manifold pressure.
(b) If low, raise the nose slightly so the helicopter will decelerate and settle. More power will then be required to hold the line of descent.

(2) Use attitude control to regulate the rate of closure, which should be comfortable (too slow or too fast is not comfortable even to the inexperienced aviator).

(3) A good termination is accomplished when the helicopter arrives over the approach point, needing only ground effect to establish a hover or a gentle landing to the ground.

Section VII. RUNNING TAKEOFF AND LANDING

31. Running Takeoff

a. The running takeoff is used when the helicopter will not sustain a hover or perform a normal takeoff from a hover or from the ground. This condition is encountered when the helicopter is heavily loaded and/or during high density altitude operations.

b. The running takeoff is more efficient than the normal takeoff because of the—

(1) Partial elimination of the costly hovering circulation of the air supply.
(2) Ground run toward efficient translational lift, where clean undisturbed air (in volume) is delivered to the rotor system.

c. A general description of the running takeoff maneuver for a loaded helicopter is as follows:

(1) Assure that the terrain ahead will permit a short ground run.
(2) Plan the outbound route for a shallow climb.
(3) Make a pretakeoff check.
(4) Place rotor tip-path plane at the normal takeoff attitude (this is the most efficient attitude) or place cyclic slightly ahead of hovering neutral.
(5) Apply enough power (manifold pressure) to cause a forward movement.
(6) After approximately 6 feet of forward motion, smoothly add maximum available (allowable) power.
(7) Hold the tip-path plane or the attitude constant. With some portion of the landing gear still in contact with the ground, the helicopter will accelerate. The helicopter will leave the ground when sufficient speed is attained for effective translational lift.
(8) Hold the same normal takeoff attitude until climb speed is reached.
(9) Rotate attitude to the normal climb attitude.
(10) Set climb power and climb pedals. Convert slip to crab.

d. An alternate technique for the performance of this maneuver is as follows:

(1) Perform c(1), c(2), and c(3) above.
(2) Apply enough power to find the center of gravity attitude of the loaded helicopter.
(3) Apply enough cyclic to cause a slow forward motion.
(4) After approximately 6 feet of forward motion, apply maximum available (allowable) power.
(5) Hold the steady attitude ((3) above).
(6) Hold good heading on a distant reference point.
(7) When sufficient translational speed is attained, the helicopter will take off.
(8) When normal climb speed is reached, rotate the nose to the normal climb attitude.
(9) Set normal climb power and climb pedals (convert slip to crab).

e. Difficulty arises when demonstrating a running takeoff in a helicopter that can hover—one that is not heavily loaded. Even so, the practice is beneficial for student aviators. The practice exercise is usually set up by limiting the power to 2 inches less than hovering power.

f. The practice maneuver is correctly performed when there is—

(1) A smooth acceleration to translational lift.

(2) Steady and accurate heading and attitude control.

(3) No pitching or lateral lurch of the fuselage as the helicopter breaks ground.

(4) Good track control and acceleration to normal climb speed.

(5) Smooth transition to normal climb attitude and power at 50 feet of altitude.

(6) Good conversion from slip to crab.

4.32. Running Landings

a. All helicopter landings to the ground which have some degree of forward motion at touchdown are referred to as running landings. The amount of forward motion at touchdown may vary from 1 mile per hour up to a relatively high speed of 40 miles per hour.

Note. Running landings having a ground roll of less than 10 feet are often called "run-on" landings.

b. Running landings are used for many reasons:

(1) To avoid unnecessary wear and tear on the helicopter and engine by eliminating the high power, hovering termination.

(2) To minimize blowing of dust, snow, or debris and to avoid rotor downwash damage to surrounding equipment.

(3) To avoid hovering when there is low visibility or no horizon.

(4) To avoid the high noise level of the hover.

(5) To permit landings when there is insufficient power to hover due to load/density altitude problems and where power limitations would be exceeded.

(6) When the approach and landing must be made downwind.

(7) When an emergency exists due to loss of heading control or tail rotor failure.

(8) When the center of gravity is out of limits due to structural failure, cargo shift, or poor weight and balance management.

c. Usually, the running landing is of the run-on type, having a very short ground run. It is performed by—

(1) Making the approach at an angle required to clear barriers or turbulence, but usually at not less than 5° (fig. 4.12).

(2) Planning the approach as if to arrive at a hover, but continuing without pause to the ground, for a touchdown with some forward motion—usually less than 10 feet of ground roll.

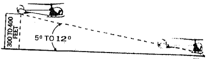


Figure 4.12. Shallow approach

d. To perform running landings under the conditions in *b* (5) above—

(1) Hold slow cruise during the approach, down to approximately 50 feet of altitude.

(2) Use positive collective pitch action to control the line of descent toward the touchdown point.

(3) At 50 feet, rotate to a normal decelerating attitude (often this is a level landing attitude).

(4) Use smooth collective pitch action to touch down on the desired spot.

(5) Have sufficient translational lift to supplement the available power for a smooth touchdown.

CHAPTER 5

AUTOROTATIONS

Section I. BASIC CONSIDERATIONS

5.1. Introduction

An autorotation is considered an emergency procedure and should be treated as such. When a helicopter engine fails during flight, the aviator must rely on autorotation to effect a safe descent and landing. Safe execution of this maneuver depends largely upon the aviator's judgment and his preplanning prior to the emergency.

5.2. General

a. In considering autorotations or forced landings, there are several basic rules or assumptions that the aviator must accept. These are—

(1) That the helicopter is being operated within the safe parameter as prescribed in the height velocity diagram of the appropriate operator's manual.

(2) That the helicopter is being flown over the best routes so that clear and level forced landing areas are available, and that flight over impossible forced landing areas such as water, forests, or precipitous slopes is held to a minimum.

(3) That some missions will be upon orders which prescribe route and altitude to be flown.

b. Except when flying missions which prescribe the route and altitude, a good helicopter aviator will fly at a *safe* altitude (*c* below) and select a *safe* route (*e* below) for his return flights. In the event of engine failure, if the aviator is not following the rules listed in *a* above, he is compelled to make an autorotation with limited choice of landing area, wind direction, airspeed, groundspeed, and landing direction. The resultant forced landing could cause personal injury, and/or damage to or total loss of the helicopter.

c. Safe altitude for a helicopter over open, level terrain is that altitude from which it can make its largest radius 180° turn, using a normal bank while holding a constant cruise airspeed in autorotation. (The OH-13 requires 700 feet for this turn; the OH-19, 900 feet; and the UH-1, 900 feet.) Safe altitude over undesirable areas is that altitude from which a safe landing area can be reached in the event of a forced landing.

d. Safe airspeed is the airspeed which will give the best ground coverage in autorotation. This same airspeed will give turning power when decelerating or lifting around a normal bank autorotation turn.

e. Safe routing normally is selected before the flight by use of charts and maps. A direct line from the departure point to the destination will often take the flight over undesirable terrain. Therefore, the aviator should plot a course which will be over the most favorable terrain without undue deviation from the direct course. During flight, the aviator should scan ahead and make necessary heading changes which will route the flight over the best terrain. These deviations will not add appreciably to flight distance or time.

5.3. Glide and Rate of Descent

a. Each type helicopter has a specific airspeed (given in the autorotation chart of the operator's manual) at which a poweroff glide is most efficient. The best airspeed is the one which combines the most desirable (greatest) glide range with the most desirable (slowest) rate of descent. The specific airspeed is somewhat different for each type helicopter, yet certain factors affect all configurations in the same manner.

b. Specific airspeed is established on the basis of average weather and wind conditions, and normal loading. When the helicopter is operated with excessive loads in high density altitude or strong gusty wind conditions, best performance is achieved from a slightly increased airspeed in the descent. For autorotations in light winds, low density altitude, or light blade loading, best performance is achieved from a slight decrease in normal airspeed. Following this general procedure of fitting airspeed to existing conditions, an aviator can achieve approximately the same glide angle in any set of circumstances and estimate his touchdown point. For example, the best glide ratio (glide to rate of descent) for the OH-13 or OH-23 without litters, in a no-wind condition, is about 4 feet of forward glide to 1 foot of descent. Ideal airspeed for minimum descent is about 40 knots, or about 1,200-feet-per-minute rate of descent. Above and below 40 knots (the specific airspeed for the OH-13 and OH-23), the rate of descent rapidly increases.

5.4. Flght Control

a. A helicopter transmission is designed to allow the main rotor to rotate freely in its original direction if the engine stops. At the *instant* of engine failure, by immediately lowering collective pitch, the helicopter will begin to descend. Air will produce a "ram" effect on the rotor system and impact of the air on the blades will provide sufficient thrust to maintain rotor rpm throughout the descent. Since the tail rotor is driven by the main rotor during autorotation, heading control can be maintained as in normal flight. Higher or lower airspeed is obtained with cyclic control. An aviator has a choice in angle of descent varying from vertical descent to maximum angle of glide and, consequently, a choice in selecting the actual point of touchdown. When making autorotative turns, generally only the cyclic control is used. Use of antitorque pedals to assist or speed the turn causes loss of airspeed and downward pitching of the nose—especially when left pedal is used.

b. Immediately before ground contact, an increase in pitch (angle of attack) will permit the blades to induce sufficient additional lift to slow the descent and allow the helicopter to make a safe, smooth landing. Abrupt rearward movements of the cyclic stick should be avoided. If the cyclic control is moved abruptly rearward, the main rotor blades may flex downward with sufficient force to strike the tail boom.

5.5. Hovering Above 10 Feet

Hovering above 10 feet may be considered a calculated risk and normally should be avoided. (See height velocity chart in operator's manual.) When hovering above this altitude, the collective pitch angle of the blade is very high. If the engine should fail, rotor rpm will fall off rapidly. Although collective pitch may be reduced immediately, altitude may be inadequate to regain sufficient rpm for an uneventful autorotative landing. The rate of descent is very high and collective pitch must be applied rapidly and close to the ground to cushion the landing. Application of collective pitch too soon or too late invariably results in a hard landing.

5.6. Crosswind Autorotative Landing

Crosswind autorotative landings can be made by slipping the helicopter into the wind. Because of the loss of torque, necessary right pedal is applied the moment autorotation begins. This reduces the amount of remaining right pedal travel. However, prior to making a crosswind landing, the fuselage must be aligned with ground track. If directional control is difficult to maintain during descent, the helicopter will probably tend to weathervane when airspeed is dissipated. Maneuver for a landing more into the wind. If loss of directional control is not discovered before actual touchdown, coordinate cyclic control toward the direction of turn and make a turning landing.

5.7. Vertical or Backward Descent Autorotation

Vertical or backward descent autorotation may succeed when an engine fails under high wind conditions directly over, or just upwind of, the only available landing area. A 360° turn may be unwise under such conditions because of the danger of drifting away from the landing area. An altitude of at least 1,000 feet should exist before descending vertically or backwards. The maneuver should last only long enough to establish the desired angle of descent into the area. Forward airspeed must be regained before landing; however, this always results in a great loss of altitude and a high rate of descent. Therefore, desired forward airspeed should be completely regained at a reasonable altitude above the ground.

5.8. Autorotation From High Speed Flight

If the engine fails at above normal cruising speed, execute a flare at a moderate rate to reduce forward speed. The collective pitch stick should be in its lowest position as the flare is completed. An attempt to maintain the same flight attitude with cyclic causes the helicopter to pitch up several seconds after collective pitch stick has been lowered. Since more forward cyclic is required in autorotation, sufficient cyclic travel might not be available to stop this pitching movement if speed has not been reduced.

5.9. Autorotation at Low Altitude

In the event of engine failure at low altitude after takeoff, or while making an approach, lower the collective pitch control as much as possible without building up an excessive rate of descent. Apply pitch to cushion the landing. At 10 feet altitude, there is seldom enough time to reduce collective pitch; at 25 feet, it may be reduced slightly; and at higher altitudes, collective pitch can usually be lowered completely.

5.10. Low Altitude Autorotation From High Speed

If the engine should fail at low altitude and high airspeed, execute a flare to momentarily maintain altitude and to slow forward speed. Simultaneously decrease collective pitch. (Some rpm will be lost during the initial part of the flare, but the loss will be regained as the flare progresses.) Complete a modified flare autorotation with slow forward speed.

5.11. Antitorque System Failure in Forward Flight

If the antitorque system fails in flight, the nose of the helicopter will usually pitch slightly downward and yaw to the right. Violence of pitch and yaw is greater when a failure occurs in the tail rotor blades, and usually is accompanied by severe vibration. Pitching and yawing can be overcome by holding the cyclic control near neutral and entering autorotation immediately. Cyclic control movements should be kept to a minimum until all pitching subsides. Cautiously add power as required to continue flight to a suitable landing area, unless dangerous flight attitudes are incurred. Reduction of rotor rpm to the allowable minimum will aid in overcoming an excessive forward C. G. (nose-low) condition. With effective translational speed, the fuselage remains fairly well streamlined; however, if descent is attempted at near zero airspeed, expect a continuous turning movement to the left. Maintain directional control primarily with cyclic, and secondarily, by gently applying throttle with needles joined, to swing the nose to the right. Landing may be made with forward speed or by flaring. The helicopter will turn during the flare and during subsequent vertical descent; however, damage is unlikely if the helicopter is level at ground contact. The best and safest landing technique, terrain permitting, is to land directly into the wind with at least 20 knots airspeed.

5.12. Antitorque System Failure While Hovering

If the antitorque system fails in hovering flight, the aviator must act quickly because the turning motion of the helicopter builds up rapidly. Immediately close the throttle (without varying collective pitch), to eliminate the turning effect of engine torque on the helicopter. Simultaneously, adjust the cyclic stick to stop all sideward or rearward movements landing. After ground contact, smoothly lower collective pitch.

5.18. Antitorque Failure at Hover

Antitorque failure may be experienced while hovering. To simulate antitorque failure, proceed as follows:

a. Hover the helicopter crosswind (wind from the aviator's right) at normal hovering altitude. To simulate the loss of antitorque control, apply right pedal to start the helicopter turning to the right (or the opposite direction from which the main rotor is turning), and hold this pedal position throughout the rest of the maneuver. Allow the turn to progress at least 90°, then rotate the throttle into the closed position. This will eliminate engine torque effect and cause the rate of turn to decrease.

b. Complete the maneuver in the same manner as in autorotation from a hover.

Note. Antitorque failure normally will be practiced only in reconnaissance helicopters.

Section III. PRESOLO PHASE PRACTICE EXERCISES

5.19. Introduction

Practice exercises in this section are presented in the training sequence designed to promote high proficiency in the shortest possible time.

5.20. Forced Landing Entry (Straight Ahead for Maximum Glide Distance)

a. This exercise can be introduced after the first hour of presolo training. The exercise begins with the instructor splitting the needles sharply (throttle reduction) at cruise airspeed and cruise altitude, with an open field ahead requiring maximum glide distance.

b. The exercise is correctly performed when—

(1) The collective pitch is reduced at a rate that maintains rotor rpm in the green arc.

(2) Antitorque pedals are repositioned to prevent yaw.

(3) Cruise attitude is maintained by cyclic control repositioning.

(4) The student notes the line of descent toward the distant open field and makes an oral "call off" of airspeed (mph or knots) and rotor rpm (amount or "in the green").

[illegible]e the exercise at this point [illegible]in the needles for a power re[illegible]ge to climb power, climb at[illegible]edals.

Note. This exercise should be accomplished expertly before other autorotation exercises are introduced.

5.21. Forced Landing Entry (Straight Ahead for Shortened Glide Distance)

a. This exercise can be introduced immediately after completion of the maximum glide exercise (par. 5.20). The exercise begins with the instructor splitting the needles (throttle reduction) at cruise airspeed and cruise altitude, having an open field closein ahead which requires a steep angle of glide.

b. The exercise is correctly performed when—

(1) Collective pitch is reduced at a rate that will maintain rotor rpm in the green arc.

(2) Antitorque pedals are repositioned in the amount required to prevent yaw.

(3) Attitude is raised promptly to a point above the normal deceleration attitude and held until the airspeed approaches a value approximately 25 percent below slow cruise airspeed. (This will result in a steep angle of descent.)

(4) As the airspeed reaches the value in (3) above, the attitude is rotated to (or near) the slow cruise attitude which will hold this airspeed constant.

(5) The student notes the line of descent toward the close-in open field and makes an oral "call off" of airspeed (mph or knots) and rotor rpm (amount or "in the green").

c. Discontinue the exercise at this point (b(5) above), and execute a power recovery. Assume an acceleration attitude, add climb power, and reposition the pedals for climb. As airspeed approaches the normal climb speed, rotate to the normal climb speed attitude.

d. During subsequent dual periods, forced landing entries requiring maximum glide distance should be alternated with those requiring shortened glide distance. New autorotation exercises should not be attempted until these two basic drills are perfected.

5.22. Forced Landing Entry (From Downwind Heading With Turn)

a. This exercise can be introduced immediately after completion of the straight ahead autorotation entry exercises. The exercise begins with the instructor splitting the needles (throttle reduction) at cruise airspeed and cruise altitude, while flying downwind and having an open field to the left or right.

b. The exercise is properly accomplished when—

(1) Collective pitch is reduced at a rate that will maintain rotor rpm.

(2) Antitorque pedals are repositioned in the amount required to prevent yaw.

(3) Cruise attitude is held during operations (1) and (2) above.

(4) A normal bank is entered (left or right) with lateral cyclic control holding cruise attitude.

(5) As the bank is established, the attitude is changed to slow cruise, providing deceleration lift for turning power.

c. The exercise is completed upon the rotation of attitude at b(5) above without regard to the degree of turn accomplished. Discontinue the exercise by removing bank and making a power recovery.

d. In subsequent dual periods, *all three* entry exercises should be given at least once during each period, so as to develop *split second* accuracy in performing each of these autorotation entry maneuvers.

5.23. Power Recovery

a. Power recovery is a performance sequence used to discontinue autorotation and reestablish normal flight. In practice, it usually is used to establish a climb, although the same procedure may be used to establish a cruise or normal descent.

b. The power recovery is correctly performed when—

(1) The engine tachometer needle is nearly joined to the rotor tachometer needle by use of throttle (i.e., needles joined loosely).

(2) Airspeed is cross-checked. If airspeed is below normal climb airspeed, rotate attitude to an accelerating attitude (usually to a normal takeoff attitude). If airspeed is at or above normal climb airspeed, rotate attitude to a normal climb attitude (usually the same as slow cruise attitude).

(3) Manifold pressure is increased to the published climb power setting by increasing collective pitch and adding throttle (bending wrist outward) to maintain normal rpm.

(4) A steady state climb is established with cross-checks to climb attitude, climb airspeed, climb pedal setting, and normal rpm; the climb is routed over the best terrain and clear of other traffic.

Caution: **Do not join the needles at an excessively high rpm, which causes an engine overrev. Do not increase pitch so rapidly as to reduce rotor rpm below normal operating limits. A smooth control touch and coordination of all control action is essential.**

5.24. Termination With Power

a. Termination with power is an exercise sequence used to terminate an autorotation at a hover (over open terrain, where prior approval is granted).

b. The terminate-with-power exercise is correctly performed when—

(1) At 100 feet, the needles are joined loosely (engine and rotor tachometer needles are nearly joined).

(2) The attitude is smoothly rotated to a normal decelerating attitude or level landing attitude.

(3) At approximately 15 to 25 feet, manifold pressure is increased to arrive at the accepted hovering height by increasing collective pitch and adding throttle so as to hold normal rpm.

(4) The decelerating or landing attitude and heading are held until all forward motion is stopped.

(5) A stationary hover is established.

5.25. Basic Autorotation

a. The basic autorotation is a by-the-numbers (1-2-3) drill. It is a basic exercise which is preplanned and programed throughout. Any deviation from the programed basic autorotation sequence published for a particular helicopter will result in something other than a *basic autorotation.*

b. This maneuver has great training value and should be performed (unassisted) by all students prior to solo. Since the basic autorotation is programed throughout and includes a landing on a large smooth area which permits a touchdown with a variable ground run, it is unsuitable for introduction work in forced landings and autorotations. Therefore, the basic autorotation is usually introduced *after* the student is proficient in the *forced landing entry* series, the *power recovery,* and the *termination with power.*

c. The basic autorotation is correctly accomplished when—

(1) At flight altitude, usually 700 feet, a turn to final approach leg is accomplished, resulting in a good track, steady altitude, and cruise airspeed.

(2) Just prior to entry, a slip is established if necessary for crosswind correction, with final check on airspeed and altitude.

(3) Power is reduced to the minimum while holding *cruise attitude,* with pedals repositioned to prevent yaw. (The wrist is bent inward during the collective pitch reduction so as to maintain normal rpm; then the throttle is eased off to cause the needles to split.)

(4) An oral cross-check is made, including the actual airspeed and rotor rpm in the green (or yellow, as the case may be).

(5) Attitude is rotated to the slow cruise attitude.

Note. Procedures (3), (4), and (5) are accomplished slowly and smoothly in some helicopters; in others, the order is changed to combine (3) and (5), with (4) accomplished last.

(6) With collective pitch positioned to maintain rotor rpm in the green (usually on the down stop), slow cruise attitude is cross-checked and held with the helicopter aligned parallel to the touchdown lane. The nose will tend to lower as airspeed approaches the *slow cruise* value, requiring cyclic repositioning rearward to hold the slow cruise attitude steady.

Note. The center of attention must be on attitude control throughout the maneuver; cross-check everything else outward from this reference center.

(7) With airspeed just reaching slow cruise at approximately 100 feet, an oral cross-check is made, calling off: "Airspeed (_____), rotor in the green, throttle to override."

(8) At 100 feet (if the groundspeed is not too slow and provided airspeed is at slow cruise or higher), the attitude is rotated toward the normal deceleration or level landing attitude.

(9) At the agreed height (usually 10 to 20 feet), an *initial collective pitch* application is made in the amount and at a rate that will be felt as added lift.

Note. For helicopters requiring a nose-high decelerating attitude, the nose is rotated to the level landing attitude at this point.

(10) A firm, positive collective pitch is applied when ground contact is imminent. This will reduce the rate of descent and cause the helicopter to almost parallel the ground for a touchdown two helicopter lengths ahead.

(11) Collective pitch is used in a manner to cause light ground contact of the wheels or skid gear, and then to gradually add the full helicopter weight on the landing gear.

(12) The fuselage is parallel to and over the center line of the lane throughout (9) and (10) above, yielding a ground run of from one to five helicopter lengths, depending upon the prevailing atmospheric conditions.

5.26. Precision Autorotation

a. The precision autorotation to a predetermined spot landing is a highly skilled maneuver, usually performed by advanced students or perfected in postgraduate training. Procedures vary in each type helicopter. Information herein is applicable to the observation-type helicopter; however, portions of this information may be applied to all helicopters.

b. A study of the autorotation chart in figure 5.2, which shows rates of descent for the various airspeeds for steady state autorotation, will give the basic information for introduction to precision autorotation. The acceptable autorotation airspeed range for the various models of observation helicopters ranges from 30 to 70 miles per hour. Note that in this speed range the minimum change of airspeed with maximum change in rate of descent occurs between 30 to 40 miles per hour airspeeds; therefore, this is the best precision range. An aviator in a steady state autorotation at 35 miles per hour may advance or retreat the point of ground contact by increasing or decreasing the airspeed by 5 miles per hour. Airspeeds of less than 30 miles per hour yield high rates of descent. Therefore, during practice exercises, speeds of less than 30 miles per hour are restricted to altitudes over 200 feet.

c. A diagram similar to the one shown in figure 5.2 is available in the operator's manual for each type and model helicopter. A study of this diagram will disclose the precision autorotation parameters for the particular helicopter.

d. Figure 5.3 shows eight example entry points for the precision autorotation. These entry points show positions on the front side, back side, and inside of the precision glideslope. Before considering each of these entry points in detail, some important general considerations to be remembered are these:

(1) The best precision airspeed range as shown in figure 5.2 is 30 to 40 miles per hour. When plotted in profile, this airspeed range becomes the *precision glideslope* or the *cone of precision.*

(2) The main effort in performing the precision autorotation is to *intercept and stay inside* the precision glideslope. At positions 1, 2, 4, 5, and 6, the precision glideslope must be intercepted as soon as possible; then a steady state 30 to 40 miles per hour airspeed is established and tested, holding a slow cruise attitude.

(3) Point CA (fig. 5.3) is the circle of action or the point of collision (which is two or three helicopter lengths short of the touchdown), where (to the eye) the helicopter would hit the ground if collective pitch were not applied.

(4) For recognition purposes, the entry area between positions 4 and 5 can be considered as the entry position of the familiar basic autorotation.

(5) The precision autorotation flight envelope ends at 100 feet. A basic type termination can be made thereafter to a touchdown at point TD (fig. 5.3), *provided* the airspeed is at or above *30 miles per hour* and the *rate of descent is normal.* During practice, it is advisable to make power recoveries at 100 feet for a go-around to the next position exercise. This will permit two complete series to be covered in 1 hour.

(6) Exact attitudes must be used throughout the exercises. The center of attention is split between attitude and the circle of action point. All other references such as airspeed, rotor rpm, etc., are read in cross-check.

(7) The airspeed values and restrictions of the height velocity diagram must be

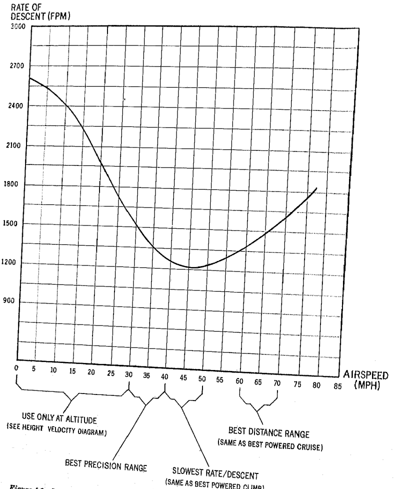


Figure 5.2. Steady state autorotation rate of descent (fpm) for typical observation-type helicopter.

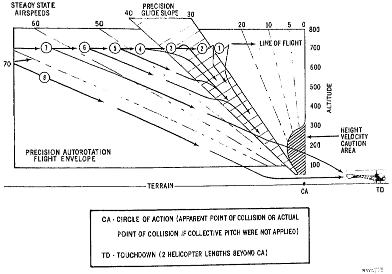


Figure 5.3. Airspeed/line of descent profile for typical observation-type helicopter.

scaled up to comply with the performance charts of larger helicopters. Height velocity diagrams are based on a standard day, and the envelopes must be expanded in proportion to increasing density altitude.

e. Exercises for performing the precision autorotation from positions 1 through 8 in figure 5.3 are as follows:

(1) *Position no. 1.*

(*a*) In the area of position no. 1, the touchdown (TD) point appears to be almost vertical to the student.

(*b*) At cruise airspeed and at 700 feet, into the wind, when the throttle is cut, lower collective pitch, hold heading, and *flare promptly*—stopping all forward motion (gaining altitude if possible).

(*c*) Hold the flare until the airspeed goes through 15 miles per hour, *then* slowly lower the attitude at a rate so as to meet 0 miles per hour reading with a slow cruise or hovering attitude.

(*d*) Settle vertically; a headwind will cause a slight rearward movement.

(*e*) When it appears that the helicopter is about to intercept the precision glideslope, lower attitude smoothly to a point below the normal acceleration attitude.

(*f*) When the airspeed reaches 30 to 40 miles per hour, rotate to a slow cruise attitude.

(*g*) Watch the circle of action (CA) point for evidence of overshooting or undershooting.

(*h*) If undershooting, lower attitude to gain *5 miles per hour;* then return attitude to slow cruise (for further reading of the CA point).

(*i*) If overshooting, raise attitude to lose *5 miles per hour;* then return attitude to slow cruise (for further reading of the CA point).

(*j*) At 100 feet, if airspeed is 40 miles per hour greater, terminate as in a basic autorotation for a landing at the TD point.

(*k*) At 100 feet, if airspeed is 30 miles per hour, hold slow cruise attitude to approximately 50 feet; *then* rotate to the normal deceleration or level landing attitude.

(*l*) Touchdown on TD point as in basic autorotation touchdown.

Note. In reading the precision line of descent in (*f*) through (*i*) above, observation of the CA point is reliable only when the attitude is at slow cruise and when a steady state autorotation is in progress (no deceleration, no acceleration).

(2) *Position no. 2.*

(*a*) In the area of position no. 2, the student estimates that he is almost beyond the precision glideslope.

(*b*) At cruise airspeed and at 700 feet, when the throttle is cut, lower collective pitch, hold heading, and *flare promptly,* stopping all *apparent groundspeed.*

(*c*) As the apparent groundspeed reaches 0 miles per hour, lower attitude to the *slow cruise* attitude. (The airspeed will now be equal to the wind velocity.)

(*d*) Settle vertically and continue as in (*e*) through (*l*) of position no. 1 exercise, above.

(3) *Position no. 3.*

(*a*) In the area of position no. 3, the student estimates that he is in the precision glideslope.

(*b*) At cruise airspeed and at 700 feet, when the throttle is cut, lower collective pitch, hold heading, and *decelerate promptly.*

(*c*) As the airspeed approaches 30 to 40 miles per hour (depending upon the headwind effect on groundspeed), lower attitude to the slow cruise attitude for steady state autorotation and proceed as in (*g*) through (*l*) of position no. 1 exercise, above.

(4) *Position no. 4.*

(*a*) In the area of position no. 4, the student estimates that he is just short of the precision glideslope.

(*b*) At cruise airspeed and at 700 feet, when the throttle is cut, lower collective pitch, hold heading, and *decelerate smoothly.* This will cause a lifting up to the precision glideslope.

(*c*) As the airspeed approaches 30 to 40 miles per hour (depending upon the headwind effect on groundspeed) lower attitude to the slow cruise attitude, for a steady state autorotation, and proceed as in (*g*) through (*l*) of position no. 1 exercise, above.

Note. Exercise no. 4 is the example to use when demonstrating an ideal precision autorotation.

(5) *Position no. 5.*

(*a*) In the area of position no. 5, the student estimates that he is well short of the precision glideslope (at the approximate position where a basic autorotation might be entered).

(*b*) At cruise airspeed and at 700 feet, when the trottle is cut, lower collective pitch, and hold heading and cruise attitude for best distance. (Hold crab, rather than slip, for best distance.)

(*c*) When it appears that the precision glideslope is just ahead, *decelerate smoothly.* This will cause a lifting up to the precision glideslope.

(*d*) As airspeed approaches 30 to 40 miles per hour, rotate attitude to slow cruise for a steady state autorotation and proceed as in (*g*) through (*l*) of position no. 1 exercise, above.

(6) *Position no. 6.*

(*a*) In the area of position no. 6, the student estimates that he is almost too far back for interception of the precision glideslope.

(*b*) He proceeds as in position no. 5 exercise with possible interception of the precision glideslope further down the line of descent.

(7) *Position no. 7.*

(*a*) In the area of position no. 7, the student estimates that he cannot incept the precision glideslope.

(*b*) At cruise airspeed and at 700 feet, when the throttle is cut, lower collective pitch, and hold heading and cruise attitude for best distance.

(*c*) The line of descent appears to be a spot well short of the CA point.

(*d*) At approximately 100 feet, begin a smooth lifting deceleration, converting speed to lift. This will change the line of descent toward the TD point.

(*e*) By regulating the rate and amount of deceleration from 100 feet on, a basic type termination can be made at the TD point.

(8) *Position no. 8.*

(*a*) This exercise is identical to position no. 7 exercise except that the entry is set up farther away from the precision glideslope than it was at no. 7.

(*b*) The line of descent appears to be to a point 100 feet (or more) short of the normal CA point.

(*c*) Holding best distance attitude and trim down to 25 to 30 feet, execute a full flare which is regulated in rate and amount of attitude rotation, so as to arrive at the TD point at the end of the flare.

(*d*) Allow the helicopter to settle to 15 to 20 feet, apply initial collective pitch, rotate attitude to level landing attitude, and apply a firm positive collective pitch in the amount and at a rate necessary to cushion the landing.

CHAPTER 6

HELICOPTER OPERATIONS IN CONFINED AREAS, REMOTE AREAS, AND UNIMPROVED AREAS

6.1. Basic Considerations

For the purpose of this discussion, a *confined area* is any area where the flight of the helicopter is limited in some direction by terrain or the presence of obstructions, natural or manmade. For example, a clearing in the woods, the top of a mountain, the slope of a hill, or the deck of a ship can each be regarded as a confined area.

a. Takeoffs and Landings. Takeoffs and landings should generally be made into the wind to obtain maximum airspeed with minimum groundspeed. Situations may arise which modify this general rule.

b. Turbulence. Turbulence is defined as smaller masses of air moving in any direction contrary to that of the larger airmass. Barriers on the ground and the ground itself may interfere with the smooth flow of air. This interference is transmitted to upper air levels as larger but less intense disturbances. Therefore, the greatest turbulence usually is found at low altitudes. *Gusts* are sudden variation in wind velocity. Normally, gusts are dangerous only in slow flight at very low altitudes. The aviator may be unaware of the gust, and its cessation may reduce airspeed below that required to sustain flight. Gusts cannot be planned for or anticipated. Turbulence, however, can generally be predicted. Turbulence will be found in the following places when wind velocity exceeds 9 knots:

(1) Near the ground on the downwind side of trees, buildings, or hills. The turbulent area is always relative in size to that of the obstacle, and relative in intensity to the velocity of the wind (fig. 6.1).

(2) On the ground on the immediate upwind side of any solid barrier such as leafy trees, buildings, etc. This condition is not generally dangerous unless the wind velocity is approximately 17 knots or higher.

(3) In the air, over and slightly downwind of any sizable barrier, such as a hill. the size of the barrier and the wind velocity determine the height to which the turbulence extends.

(4) At low altitudes on bright sunny days near the border of two dissimilar types of ground, such as the edge of a ramp or runway bordered by sod (fig. 6.2). This type of turbulence is caused by the upward and downward passage of heated or cooled air.

6.2. Reconnaissance

A high and low reconnaissance should be conducted prior to landing in an unfamiliar area.

a. High Reconnaissance. The purpose of a high reconnaissance is to determine suitability of the landing area, locate barriers and estimate their wind effect, select a point for touchdown, and plan the flightpath for approach and takeoff. Altitude and flight pattern for the high reconnaissance is governed by wind and terrain features, including availability of forced-landing areas. The reconnaissance should be low enough to permit study of the general area, yet not so low that attention must be divided between studying the area and avoiding obstructions to flight. It should be high enough to afford a reasonable chance of making a successful forced landing in an emergency, yet not so high that the proposed area cannot be studied adequately.

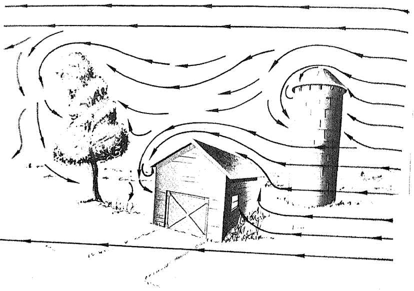


Figure 6.1. Air turbulence (building and trees).

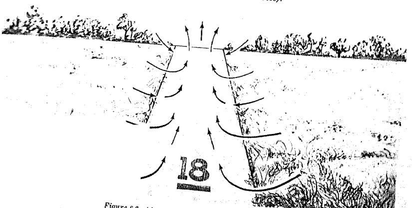


Figure 6.2. Air turbulence (dissimilar ground).

b. Low Reconnaissance.

(1) Except when a running landing is necessary, the low reconnaissance and approach can often be conducted together. To accomplish this, the aviator studies his approach path and the immediate vicinity of his selected touchdown point as he approaches; however, before loss of effective translational lift, he must decide whether the landing can be completed successfully. Never land in an area from which a successful takeoff cannot be made.

(2) When a running landing is contemplated because of load or high density altitude conditions, a "fly-by" type of low reconnaissance is made. Airspeed is adequate to maintain effective translational lift at an altitude sufficient to clear all obstacles and allow the aviator to concentrate on terrain features. The intended landing area should be checked for obstacles and/or obstructions in the approach path or on the landing site; and the point of intended touchdown must be selected.

(3) Upon completion of the low reconnaissance, altitude is regained and the approach and landing executed according to plan.

6.3. Pinnacle and Ridgeline Operations

A *pinnacle* is an area from which the ground drops away steeply on all sides. A *ridgeline* is a long area from which the ground drops away steeply on one or two sides, such as a bluff or precipice. The absence of pinnacle barriers does not necessarily lessen the difficulty of pinnacle operations (fig. 6.3). Updrafts, downdrafts, and turbulence may still present extreme hazards, together with the lack of suitable area in which to make a forced landing.

a. The climb to a pinnacle or ridgeline is executed on the windward side of the area, when practicable, to take advantage of any updrafts (A, fig. 6.3).

b. Load, altitude, wind conditions, and terrain features determine the angle to use in the final part of an aproach to a pinnacle or ridgeline.

c. Approach flightpath is usually parallel to a ridgeline and as nearly into the wind as possible.

Caution: **Remain clear of downdrafts on the leeward or downwind side (B, fig. 6.3). If wind velocity makes crosswind landing hazardous, make a low coordinated turn into the wind just prior to landing.**

d. In approaching a pinnacle, avoid leeward turbulence and keep the helicopter within reach of a forced landing area as long as practicable.

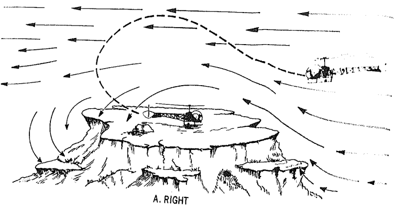
e. Since a pinnacle is higher than immediate surrounding terrain, gaining airspeed on takeoff is more important than gaining altitude. The airspeed gained will cause a more rapid departure from the slopes of the pinnacle. In addition to covering unsafe ground quickly, a higher airspeed affords a more favorable glide angle and thus contributes to the chances of reaching a safe area in the event of forced landing. If no suitable area is available, a higher airspeed will permit the aviator to execute a flare and decrease forward speed prior to autorotative landing.

6.4. Operation Over Barriers

a. In entering an area where obstructions interrupt smooth windflow, turbulence and adjacent regions of calm air near the ground must be considered. In determining the suitability of the area, allowance must be made for abrupt variations of lift often encountered under these conditions.

b. Proper planning of the approach over a barrier should include evaluation of existing wind conditions, availability of forced landing areas near the approach route, and relative height of the obstacle to be cleared. It may often be advantageous to make a crosswind approach and/or landing.

c. Point-of-touchdown should be as far beyond the barrier as practicable to insure against the approach becoming too steep. The final stages of the approach, however, should be conducted short of downdrafts and turbulence which may be encountered at the far end of the area.



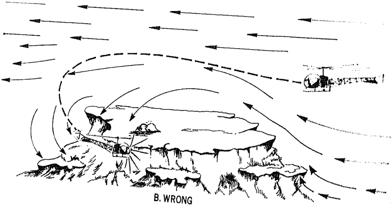


Figure 6.3. Pinnacle approach.

d. For takeoff over a barrier, the helicopter usually must be moved to the downwind end of the area. If obstructions prevent a hovering turn, this movement will have to be made by rearward hovering flight. In this case, a thorough ground reconnaissance should be conducted and markers placed to be used as a guide while in rearward flight. These markers should allow for the proper stopping point to avoid backing into an obstruction, and should include at least two properly aligned points directly in front of the helicopter to assure rearward flight in a straight path.

e. Selection of a takeoff path must consider wind conditions, barrier heights, and availability of forced-landing areas. The angle of climb

st be kept as shallow as barrier clearance
l permit. Clearing a barrier by a narrow
rgin with reserve power is better than clear-
; it by a wide margin using maximum power.

;. Slope Operations

ι. When a helicopter is resting on a slope, ə rotor mast is perpendicular to the inclined rface. However, assuming zero wind condi- ns, the *plane* of the main rotor parallels the ıe horizontal for vertical takeoff or landing, d thus is tilted with respect to the mast. clic control available for this tilt is limited the OH–13, for example, by the swash plate justment. Maximum travel of the swash ate (OH–13) is approximately 8° forward, 7° t, and 6½° laterally. The rotor hits its static ops at about a 7° flap, but dynamic stop cables ɪrmally prevent static-stop engagement by de- easing effective cyclic control at approximate- 5° of flap. A slope of 5° (about 8 feet of rise 100 feet of run) is considered maximum for ɔrmal operation of most helicopters.

b. The approach to a slope is not materially ifferent from the approach to any other land- ɪg area. Allowance must be made for wind, arriers, and forced-landing sites. Since the ope may constitute an obstruction to wind assage, turbulence and downdrafts must be nticipated.

c. If a helicopter is equipped with wheel-type anding gear, brakes must be set prior to mak- ng a landing. The landing is then usually made eading *upslope* (par. 6.6*g*). With skid-type ear, slope landings should be made *cross-slope*. This type landing requires a delicate and posi- ive control touch. The helicopter must be low- red from the true vertical by placing the uphill kid on the ground first. The downhill skid is hen lowered gently to the ground. Corrective yclic control is applied simultaneously to keep he helicopter on the landing point. Normal operating rpm is maintained until the landing is completed. If the aviator runs out of cyclic control before the downhill skid is firmly on the ground, the slope is too steep and the landing attempt should be discontinued.

d. Landing downhill (fig. 6.4) is not recommended with single main rotor type helicopters because of the possibility of striking the tail rotor on the ground.

e. If an uphill landing (fig. 6.4) is necessary, landing too near the bottom of the slope may cause the tail rotor to strike the ground.

f. To takeoff from a slope, move cyclic control toward the slope and slowly add collective pitch. The downhill skid must first be raised to place the helicopter in a level attitude before lifting it vertically to a hover.

6.6. General Precautions

Certain general rules apply to operations in any type of confined area (inclosed, slope, or pinnacle). Some of the more important of these rules are—

a. Know wind direction and approximate velocity at all times. Plan landings and takeoffs with this knowledge in mind.

b. Plan the flightpath, both for approach and takeoff, so as to take maximum advantage of forced-landing areas.

c. Operate the helicopter as near to its normal capabilities as the situation allows. The angle of descent should be no steeper than that necessary to clear existing barriers and to land on a preselected spot. Angle of climb in takeoff should be no steeper than that necessary to clear all barriers in the takeoff path.

d. If low hovering is not made hazardous by the terrain, to minimize the effect of turbulence and to conserve power, the helicopter should be hovered at a lower altitude than normal when in a confined area. High grass or weeds will decrease efficiency of the ground effect; but hovering low or taking off from the ground will partially compensate for this loss of ground effect.

e. Make every landing to a specific point, not merely into a general area. The more confined the area, the more essential that the helicopter be landed precisely upon a definite point. The landing point must be kept in sight during the final approach, particularly during the more critical final phase.

f. Consideration should be given to increases in terrain elevation between the point of original takeoff and subsequent areas of operation,

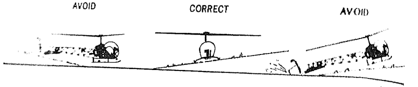


Figure 6.4. Slope operations.

...tial increase in elevation reduces ...engine power. Allowance must al... for wind velocity variations caused ... obstructions at the area of sub...

... (on wheeled helicopters) should be ... the approach for a con... except for a running landing ... landing area is known to be level. ... precludes unexpected roll after ... A slope landing almost invariably results in a wheel roll unless the brakes are preset.

h. In entering any restricted area, judge the diameter clearance of main rotor blades but remain especially alert to prevent possible damage to the tail rotor. Not only must the angle of descent over a barrier clear the tail rotor of all obstructions, but caution must be exercised on the ground to avoid swinging the tail rotor into trees, boulders, or other objects. The aviator is responsible to see that personnel remain clear of the tail rotor at all times.

CHAPTER 7

NIGHT FLYING

7.1. Preflight Inspection

Since defects easily detected in daylight will often escape attention at night, a night preflight inspection must be especially precise and complete. A flashlight is used for the inspection if no better illumination is available. Night inspection is identical to daylight inspection except that special emphasis is given to the inspection of position lights, landing lights, cockpit lights, and instrument lights. When available, an auxiliary power unit (APU) is used to start the engine. The preflight is carried out as follows:

a. Turn on position lights before starting engine. Keep these lights on while the engine is operating, until the rotor has stopped and been secured at the end of the flight. If the helicopter must be parked in the landing area, leave the position lights ON as a warning to other aircraft operating in the area. Check position lights frequently during helicopter night operations.

b. Adjust the landing light to obtain the best results for the maneuver to be performed. The landing light is used for most helicopter operations at altitudes below approximately 200 feet. A temporary reduction in night vision will be noticeable when the landing light is turned off. Use the light with discrimination in haze or fog; its effect is considerably reduced by reflection.

Warning: **Use care when operating the landing light in areas where other helicopters are operating. The light may temporarily blind another aviator if pointed directly at him.**

7.2. Hovering Technique

The landing light beam provides an adequately lighted area in front of the helicopter for drift reference and for observing obstructions during hovering. During the initial portion of night checkout, a tendency for the helicopter to drift, and difficulty in maintaining directional control and hovering altitude, will be noticed. These circumstances require additional attention, as follows:

a. Normally conduct hovering with the landing light ON. However, a more experienced helicopter aviator can hover the OH-13 in the illumination provided by the position lights. The lighting, though not bright, is sufficient if the hover is kept below 5 feet. Determination of groundspeed and drift is difficult in the dimmer light, but experience and practice will add to visual skill. Avoid staring at any fixed point to prevent vertigo. (See chapter 3, TM 1-215, for a detailed discussion of vertigo.)

b. Cross-check frequently with two or more outside reference points. Night landings from a hover are like their companion daylight landings, except that greater caution is required to prevent the helicopter from drifting.

7.3. Takeoff Technique

Before executing a night takeoff, select dis tant reference points to aid in maintaining th proposed flightpath during the climb. Use no mal takeoff procedures whenever possible. U the landing light except for "light failure" de onstrations. Anticipate temporary loss of nigh vision when the light is turned off. Pay special attention to airspeed and altimeter readings during all night operations.

7.4. Approach Technique

a. Use the normal approach at night, conducting the last 100 feet of the approach at a slightly reduced airspeed and rate of descent to obtain a time safety margin in which actual altitude above the ground can be determined if landing light is inoperative. Other than normal approaches may be required for unlighted terrain or in other special circumstances.

Warning: **Do not rely completely on the altimeter when close to the ground.**

c. The following points should be remembered when making a night approach:

(1) When the tactical situation permits, the landing light is used during all approaches.

(2) Position lights of the OH-13 afford enough illumination to see the ground from an altitude of from 3 to 5 feet.

(3) A ground crewman may use a flashlight to indicate the point of touchdown for the aviator. He should point the flashlight at the ground at a 45° angle in the direction toward the approaching helicopter. The aviator should avoid staring at the light. During the early stage of the approach, only the flashlight beam will be visible; but approximately 150 feet from the point of touchdown both the flashlight beam and the lighted ground area will be visible, furnishing some perspective. Landing should be made to the lighted ground area, not to the flashlight.

(4) Approaches to smudge pots can be made; however, the smudge pots must be shielded with perforated tin cans to prevent putting them out with rotor downwash.

(5) The approach light, when available, is mounted on a universal joint which permits adjustments from zero to 15° above the horizontal, making it adaptable for all types of approaches. It casts three separate, colored beams of light. The top beam is amber, the center green, and the bottom red (fig. 7.1). When approaching in the center of any one of the three beams, a brilliant shade of the light is seen. The green beam guides the approach and assures the aviator obstacle clearance if he stays in it (or in the amber beam above it). The red beam indicates that the aviator is too low and may be in danger.

(6) If the helicopter is allowed to drift to the extreme edge of the approach beams, the light may be reduced so much that all beams appear light amber. The aviator, thinking he is high (in the amber beam), may reduce collective pitch to lose altitude; and if the error is not corrected in time, premature ground contact will occur.

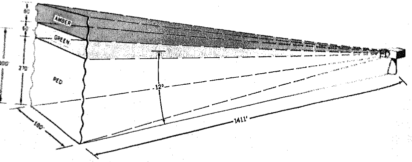


Figure 7.1. Approach light colors and effective distances.

c. An aviator may experience difficulty in properly executing the approach, for the following reasons:

(1) Overshooting the landing point because of failure to reduce the rate of descent and forward airspeed.

(2) Undershooting the landing point because of reduction in airspeed too quickly and failure to compensate with collective pitch to check the rate of descent. As a result, the helicopter settles almost vertically.

(3) Staring at the approach light too long, causing loss of perspective, and consequently, becoming disoriented.

7.5. Autorotations

Night autorotations are performed in exactly the same manner as those in daylight (ch. 5), but greater concentration is required of the aviator. The landing light should be turned on about 200 feet above the ground. Eyes must be kept in motion. Drift corrections must not be neglected by concentrating too intently on applying pitch. Proper perspective must be retained at *all* times.

7.6. Poor Visibility

Discretion must be used in deciding whether or not to make flights under poor visibility conditions. If during a flight the horizon becomes invisible, flight will probably be hazardous but may be continued if necessary and if sufficient ground lights are available as reference points. If the horizon is not visible before takeoff, the flight should not be attempted. Helicopters that lack instrument flying equipment require constant outside visual reference to maintain proper fuselage attitude. Low altitude and contour flights may be flown with the landing light ON and adjusted to the best possible angle.

7.7. Forced Landings

Every attempt should be made to become familiar with the terrain over which night flights are made. If an emergency autorotative landing is necessary, normal daylight procedure is followed, using the landing light during the latter phase of the descent to observe obstructions and select a landing area. In night autorotation, prescribed airspeed is maintained until terrain detail becomes discernible, to afford some choice of landing point. Excessive nose-high attitude, as in a flare, with the landing light set at or near 5° will result in temporary loss of ground reference.

7.8. Crosswind Considerations

When possible, takeoffs and approaches are made generally into the wind; however, they must occasionally be made crosswind. Procedures for crosswind takeoffs and approaches are as follows:

a. During the initial portion of the takeoff, keep the fuselage aligned with the ground track. Once the climb has been established, crab the helicopter into the wind.

b. Use crab and/or slip during early stages of the crosswind approach. During the final stage of approach, use slip only to align the fuselage with the ground track. This places the helicopter in a more advantageous position in the event of a forced landing, and affords better view of the landing area. Crabbing at low altitude and airspeed may render a successful forced landing difficult or even impossible.

CHAPTER 8

PRECAUTIONARY MEASURES AND CRITICAL CONDITIONS

8.1. General Precautionary Rules

Because of its unique flight characteristics, a helicopter is capable of many missions no other aircraft can perform. A helicopter aviator must, however, realize the hazards involved in helicopter flight and know how to apply precautions which might save the helicopter or even his life. He should—

a. Always check ballast prior to flying.

b. Assure that any object placed in the cockpit of a helicopter is well secured to prevent fouling of the controls.

c. Caution approaching or departing passengers of main rotor/tail rotor dangers at all times during ground operations, especially on slopes or uneven terrain. Personnel carrying long objects such as pipe, wood, tripods, etc., should not be allowed to approach a helicopter whose rotor blades are turning, because of the danger of these objects striking the rotor blades.

d. Always taxi slowly.

e. Maintain proper rpm when taxiing.

f. Always hover for a moment before beginning a new flight.

g. Avoid hovering above 10 feet (see height velocity diagram in operator's handbook).

h. Be especially careful to maintain proper rpm when practicing hovering turns, sideward flight, and similar low airspeed maneuvers.

i. Use caution when hovering on the lee side of buildings or obstructions.

j. Never check magnetos in flight.

k. Use caution when adjusting mixture in flight.

l. Develop and use a constant cross-check for carburetor heat, pressures, temperatures, and fuel quantity.

m. Never perform acrobatic maneuvers.

n. When flying in rough, gusty air, use special care to maintain proper rpm.

o. Always clear the area overhead, ahead, to each side, and below before entering practice autorotations.

p. Avoid engine overspeeding beyond the manufacturer's recommendations. This limit is usually several hundred rpm over the red line. If exceeded, an engine inspection is required to determine damage and, in some cases, the engine must be replaced.

q. Avoid low level flight and contour flying, except to meet mission requirements.

8.2. Rotor Rpm Operating Limits

Limits of rotor rpm vary with each type of helicopter. In general, the lower limit is determined primarily by the control characteristics of the helicopter during autorotation. Since the tail rotor is driven by the main rotor, a minimum rotor rpm exists at which tail rotor thrust is insufficient for proper control. For example, flight tests in the OH-13 disclose this minimum to be at 260 rpm, so that a safety factor of 110 percent of 260 (286 rpm) is set as minimum rpm. The upper limit of 360 rpm (OH-13) is based upon both autorotative characteristics and strength of the rotor system, and is the result of structural failure tests plus an adequate margin required by FAA safety standards.

8.3. Engine Rpm Operating Limits

a. Engine rpm limits are based on the power-on operation of the helicopter. Maximum engine rpm is established by the engine manufacturer and substantiated by FAA-type tests which reveal the rpm at which engine performance is considered most efficient while driving a rotor system at its design rpm. Minimum engine rpm is established to insure satisfactory control, high speed characteristics, and engine operation. A range of several hundred rpm is usually provided. The minimum rpm limit is important in its effect on stability and top speed. At a constant level flight airspeed, a decrease in engine rpm will require increased forward cyclic movement. At high speed with an aft center-of-gravity location, the aviator is more likely to run out of forward cyclic control when operating at low rpm. Minimum rpm establishes aft center-of-gravity limit, horizontal stabilizer size, and top speed.

Minimum rpm limit is a compromise of center-of-gravity limit and top speed, and practical operating rpm. Exceeding the maximum or minimum limits increases the possibility of losing fore and aft cyclic control. An objectionable vibration in the main rotor and possible loss of control may occur at high speeds if rpm is allowed to fall below the minimum.

8.4. Stabilizer Bar Resonance (OH–13 Helicopter

When running up the OH–13 the engine should not be operated continuously between ... rotor rpm. Undesirable oscillations of the stabilizer bar occur in this rpm range. ... oscillations are hardly noticeable ... uncomfortable to the aviator, ... operation in this range may damage the stabilizer bar assembly.

8.5. Carburetor Ice

Carburetor ice results from cooling due to ... of venturi airflow through the carburetor and rapid evaporation of gasoline. ... begins in the induction system to ... and progresses into the carburetor ... or the ice may build up throughout the induction system.

Prevention of Ice. While employing cruising power ... just before takeoff, sufficient carburetor heat must be applied to maintain the air temperature within the proper operating range. During the preflight inspection, the air filter screen must be checked when the helicopter has been exposed to freezing rain or snow. A partially clogged air filter can reduce manifold pressure to the point where sufficient power for flight is not available. For maximum engine efficiency, the filter should be frequently checked and cleaned.

b. Indications of Carburetor Ice. Indications of carburetor ice include—

(1) Unexplained loss of rpm or manifold pressure.

(2) The carburetor air temperature gage indicating in the "caution" range.

(3) Engine roughness.

c. Removal of Carburetor Ice. If carburetor ice is suspected, the manifold pressure gage is checked and full carburetor heat applied for 2 to 3 minutes. A constant throttle and collective pitch setting is maintained when performing this check. At the end of 2 or 3 minutes, carburetor heat is turned off. If the manifold pressure gage indicates higher than when the check was initiated, carburetor ice was present. Carburetor heat is then readjusted to safe operating range.

d. Carburetor Air Temperature Gage. The carburetor air temperature gage is range-marked for *desired*, *caution*, and *maximum* operating temperatures. For example, in the OH–13, range markings are—

Green arc: 32° C. to 40° C. (*desired* operating temperatures).

Yellow arc: −10° C. to 32° C. (*caution* operating temperatures).

Red Mark: 40° C. (*maximum* operating limit).

***Caution:* When operating at very low carburetor air temperatures (−15° C. or below), carburetor heat should not be added to bring the temperature up into the icing (caution) range; icing will not occur with carburetor air temperature −15° C. or below.**

8.6. Extreme Attitudes and Overcontrolling

a. Design characteristics of a helicopter preclude the possibility of safe inverted flight; therefore, maneuvers which would place a helicopter in danger of such an extreme attitude should be avoided.

b. A helicopter should not be loaded so as to cause an extreme tail-low attitude when taking off to a hover. Aft center of gravity is dangerous while hovering and even more dangerous while in flight because of limited forward travel of the cyclic stick.

c. Heavy loading forward of the center of gravity should be avoided. Limited aft travel of the cyclic stick results, endangering controllability.

d. Extreme nose-low attitude should be avoided when executing a normal takeoff. Such an attitude may require more power than the engine can deliver and will allow the helicopter to settle to the ground in an unsafe landing attitude. In the event of a forced landing, only a comparatively level attitude can assure a safe touchdown.

e. Rearward cyclic control should never be abruptly applied. The violent backward-pitching action of the rotor disc may cause the main rotor blades to flex downward into the tail boom.

f. Large or unnecessary movements of the cyclic control should be avoided while at a hover. Such movements of the cyclic control can cause sufficient loss of lift, under certain conditions, to make the helicopter inadvertently settle to the ground.

g. When executing 360° hovering turns in winds of 13 knots or more, the tail of the helicopter will rise when the downwind portion of the turn is reached. When this happens, if the rear cyclic control limit is exceeded, the helicopter will accelerate forward, and a landing must be made immediately.

8.7. High Speed Autorotations

When entering autorotations at high airspeeds, the nose pitches upward after collective pitch is lowered. With an aft center of gravity, this condition can become critical by having insufficient forward cyclic control to effect a recovery. (A large amount of forward cyclic control is used even in recovery of a well-balanced helicopter.) To avoid losing forward cyclic control, a moderate flare must be executed with a simultaneous reduction of collective pitch. The pitch should be in the FULL DOWN position as the flare is completed at best glide airspeed.

8.8. Operations With Reduced Visibilty and Low Ceiling Conditions

By reducing speed to the limits of visibility, and remaining in effective translational lift so that a rapid deceleration may be executed if an obstacle appears in the flightpath, flight can be continued until ceiling and visibility approach zero. The aviator must, however, be aware of the hazards of downwind flight at low altitudes under these conditions. Whenever further flight appears hazardous, an aviator can execute a landing (vertical if necessary) and remain on the ground until further flight is possible.

Note. An instrument qualified aviator in a properly equipped helicopter may receive a clearance and continue the flight under actual instrument conditions.

8.9. Operations in Precipitation

a. Rain and Snow. Light rain and snow have comparatively little effect on the helicopter and flight can usually be continued. However, heavy rain and snow have an abrasive effect on the rotor blades and flight should be discontinued during heavy rain or snow.

b. Hail. Hail, the most serious type of precipitation from an abrasive standpoint, should be avoided by skirting weather areas where hail is likely. If hail *is* encountered during flight, a landing should be made as soon as possible and the helicopter inspected for damage.

c. Freezing Rain.

(1) Freezing rain is the most dangerous type of precipitation encountered. Ice quickly forms on the bubble, and complete loss of vision through the bubble can be expected as the ice thickens. By looking to the side or jettisoning the door, the aviator may retain enough visibility to effect a safe landing.

Warning: **An aviator should never stare through a bubble on which ice is forming; a loss of sence of direction and movement may result.**

(3) Formation of ice on the rotor blades causes an unbalanced condition and a disruption of streamlined airflow. The resultant loss of airfoil symmetry may cause the center of pressure to migrate as the angle of attack changes, resulting in reduced control effect and abnormal feedback of undesirable control pressures. Uneven ice formation causes unbalanced rotor blades which produce excessive vibration of the entire helicopter.

Caution: **The aviator must not attempt to throw ice off the blades by sudden rotor acceleration, or by rapid control movements. At best, only a small portion of the blade ice could be thrown off, probably incurring additional rotor unbalance.**

(3) Under weather conditions in which temperature and dewpoint are close together and near freezing, ice may build up rapidly on a rotor system operating at low rpm (as in a parked helicopter with idling engine). When these conditions are suspected, the aviator should stop the engine and inspect the rotor blades before attempting a takeoff.

(4) Additional indications of icing include—

(a) Rubble ice. (Ice is slow to build up on a heated cockpit.)

(b) Loss of rpm. As the ice builds up, drag increases, causing a loss in rpm. The aviator must repeatedly add power and/or reduce pitch to maintain rpm.

(c) Mushy cyclic control.

(d) Excessive vibration.

8.10. Air Density and Pressure Altitude

Low air density at high pressure altitude reduces helicopter efficiency during hot weather operation (app. IV). When air is subjected to heat, it expands and becomes thinner (fewer air particles per cubic foot). Since lift is obtained from air particles and since, under thinner air conditions, there are fewer air particles per cubic foot, it is necessary to operate rotor blades at a higher angle of attack (pitch). The unsupercharged engine also suffers from the thinner air condition and less power is available. Vertical ascent, hovering, and vertical descent may become impossible; running takeoffs and landings may become necessary as operation becomes more critical.

8.11. Flight Technique in Hot Weather

When flying in hot weather, the aviator should—

a. Make full use of wind and translational lift.

b. Hover as low as possible and no longer than necessary.

c. Maintain maximum allowable engine rpm.

d. Accelerate very slowly into forward flight.

e. Employ running takeoffs and landings when necessary.

f. Use caution in maximum performance takeoffs and steep approaches.

g. Avoid high rates of descent in all approaches.

8.12. Other Operations

a. High-Altitude Operation. Although civil and military tests have proved that the helicopter is capable of performing successfully at high altitudes, they have also proved that high-altitude operation usually is marginal and demands a high degree of aviator proficiency. Aviators assigned high-altitude missions must be thoroughly familiar with the factors affecting helicopter performance and the flight techniques involved. To operate successfully at high altitudes, the aviator must first determine that the factors affecting helicopter performance do not exceed the operating limits of the machine. Factors having the greatest effect are wind, density altitude, and load.

(1) *Wind.* With sufficient wind velocity to afford effective translational lift while hovering, helicopter performance is considerably improved. Translational lift is present at any forward speed or wind condition but is considered insignificant at speeds less than 15 knots.

(2) *Density altitude.* Density altitude is pressure altitude corrected for temperature (app. IV). Increased density altitude indicates less dense air and results in reduced lift. Density altitude increases with increased temperature; and temperature changes may vary density altitude at a particular geographic elevation by several thousand feet during a day. For example, high altitude tests at an airfield with an elevation of 6,320 feet showed that density altitude varied during the day from 3,500 to 7,000 feet.

(3) *Load.* When operating under high density altitude conditions, the helicopter performs less efficiently and loads must be reduced.

b. Effect of Altitude on Instrument Readings. The thinner air of higher altitudes causes the airspeed indicator to read low. True airspeed may be roughly computed by adding 2 percent to the indicated airspeed for each 1,000 feet of altitude above sea level. For example, an indicated airspeed of 100 miles per hour at 10,000 feet will be a true airspeed of 120 miles per hour. A more accurate computation may be made by using the E6B computer. Manifold pressure is reduced approximately 1 inch for each 1,000 feet of increase in altitude. If an engine can maintain 29 inches of manifold pressure at sea level, only 19 inches would be available at 10,000 feet.

c. High Altitude Flight Technique. Of the three major factors limiting helicopter performance at high altitude (*a* above), only load may be controlled by the aviator. At the expense of range, smaller amounts of fuel may be carried to improve performance or increase useful load. The weight and balance aircraft records should be consulted to insure efficient loading. Where practical, running landings and takeoffs could be used. Favorable wind conditions are helpful, with landings and takeoffs directly into the wind if possible. In mountainous terrain, flight should be on the upwind side of slopes to take advantage of updrafts. When landing on ridges, the safest approach is usually made lengthwise of the ridge, flying near the upwind edge to avoid possible downdrafts and to be in position to autorotate down the upwind side of the slope in case of forced landing. Using the updraft in this manner results in lower rate of descent, improved glide ratio, and greater choice of a landing area.

d. Operations Over Tall Grass. Tall grass disrupts airflow and disturbs normal downwash angle with two results: the induced rotor drag is increased and the rotor airflow pattern is changed. More power will be required to hover, and takeoff may be very difficult. Before attempting to hover over tall grass, make sure that at least 2 or 3 inches more manifold pressure are available than are required to hover over normal terrain.

e. Operations Over Water. Altitude is difficult to determine when operating over water with a smooth or glassy surface. Thus, caution must be exercised to prevent the helicopter from inadvertently striking the water or from "landing" several feet above the surface. This problem does not exist over rough water but a *very* rough water surface may disperse the "ground" effect and thereby require more power to hover. Movements of the water surface, wind ripples, waves, current flow, or even agitation by the helicopter's own rotor wash tend to give the aviator a false feeling of helicopter movement. The aviator should avoid staring at the water; he can remain oriented by frequent reference to objects in the water such as ships, buoys, floating debris, or objects on a distant shoreline.

CHAPTER 9

FORMATION FLYING

Section I. GENERAL

9.1. Introduction

a. Formation flying is the grouping of aircraft in a flight pattern arranged for a specific purpose. The aircraft involved must be able to take off and rendezvous quickly, and must follow prescribed procedures to enter the landing pattern, execute the breakup, and land quickly.

b. Aviators undergoing training in formation flying must be fully aware of the responsibility and vigilance required. Though formation flying generally is not dangerous, any aspect of this training *can* be dangerous if principles are violated.

c. Normal terminology derived from airplane formation flying is applied to helicopter formation flying to the extent practicable.

9.2. Formation Factors

Two or more helicopters, holding positions relative to each other and under the command of a designated aviator, constitute a formation. Important factors in determining the best formation are—

a. Objectives of the mission.

b. Simplicity to permit easy control, facilitate flight discipline, and afford reconnaissance efficiency.

c. Flexibility to meet different situations, and ability to quickly close up to fill vacancies.

d. Mutual support and maximum protection.

e. Maneuverability for evasive tactics.

f. Provisions for rapid development of combined offensive and defensive power.

9.3. Free Cruise (Day)

a. When aviators are required to fly a fixed position in a formation that cannot be freely varied in turns, excessive power changes are required to maintain position. Such power changes result in greatly increased fuel consumption, pilot fatigue, etc. In a 3-plane section V-formation and a 6-plane column of Vees formation, the established position of the wingmen and second section leader remains fixed, even in step right or left turns. The only way the wingmen can maintain their rigidly defined positions is to increase power if they are on the outside of a turn, and to decrease power if they are on the inside of a turn.

b. In a 2-plane section the position of the wingman is not as rigidly established as in a 3-plane section. The wingman has the prerogative in a steep turn to freely move from a position 45° astern on one side of the section leader to a position 45° astern on the other side. Such a prerogative is called "free cruise." It allows the wingman to maintain "position" with an established power setting by matching his relative speed with that of the leader. The wingman's relative speed is less than that of the section leader when the wingman in on the outside of a turn, and greater than that of the section leader when the wingman in on the inside of a turn. To equalize the relative speed differential without power change, the wingman slides to the outside of a turn when his relative speed is greater than that of the section leader, and to the inside of a turn when his relative speed is less than that of the section leader.

c. In a 4-plane flight formation, when the second section is in a heavy right or heavy left position, the same procedures apply. The second section may slide to the outside of the turn when its relative speed is greater than that of the flight leader, and to the inside of the turn when relative speed is less than that of the flight leader.

Section II. TYPE FORMATIONS

9.4. General

a. Sections.

(1) *Two-plane section.* The basic tactical unit consists of two helicopters of the same type. The section leader normally is designated the number one helicopter; the wingman, the number two helicopter. The wingman may fly on the right or left side of the section leader, depending upon instructions. The wingman is considered to be in right echelon position when flying on the right, and in left echelon position when flying on the left. In either case, the position of the wingman is 45° astern of the leader, with a distance between helicopters of about 1½ times the rotor disc diameter and with a vertical "stepped-up" separation of 1 to 3 feet above the leader (fig. 9.1). The position of the wingman should never exceed a 45° bearing to the lead helicopter. The angle of 45° and the vertical separation of 1 to 3 feet are measured from like parts of the two helicopters; e.g., rotor hub to rotor hub, or cockpit to cockpit. The position of the wingman permits full view of the lead helicopter from either the aviator's or copilot's seat and thus permits detection of any change in the flight attitude of the section leader.

(2) *Three-plane section.* The 3-plane section is rarely used for tactical employment, or for carrier operations where control and maneuverability factors ...itical. However, it may be used ...rade formation and for admin-...ve resupply when ... ding po-sition designations of helicopters in a 3-plane section V-formation, see figure 9.2.

b. Flights.

(1) *Tactical 4-plane flight.* The 4-plane flight, composed of two 2-plane sections, is the best tactical formation.

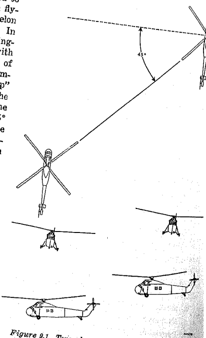


Figure 9.1. Two-plane section tactical formation.

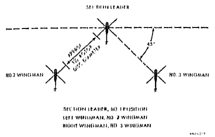


Figure 9.2. Three-plane section V-formation.

It is a compact, fluid, maneuverable formation able to deploy as the situation demands. In this formation, the leader of the second section flies 45° astern of the flight leader, 1 to 3 feet above the flight leader, and opposite the side of the wingman of the flight leader. Spacing between sections should be sufficient to permit the wingman of the flight leader to move from or to either echelon position without danger. Figure A, 9.3 shows the flight with the second section on the right (heavy right). Figure B, 9.3 shows the second section on the left (heavy left).

(2) *Six-plane flight.* This flight is composed of two 3-plane sections. The basic formation of the 6-plane flight is a column of Vees (fig. 9.4). The second 3-plane section is behind and above the first section. The distance between sections should be sufficient to allow a wingman of the first section to move from V-formation to echelon formation without danger. The 6-plane flight is seldom used for tactical employment but may be used for administrative resupply. It should not be used when operating from helicopter carriers except under ideal conditions, such as when the carrier is at anchor and flight operations have become a routine affair.

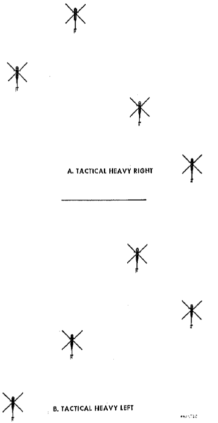


Figure 9.3. Four-plane flight formation.

c. *Responsibilities of Section and Flight Leaders.* Section and/or flight leaders are responsible for—

(1) Maintaining smooth flight.

(2) Maintaining correct formation positions. Either the section or the flight leader must be prepared to assume the "lead" position when required.

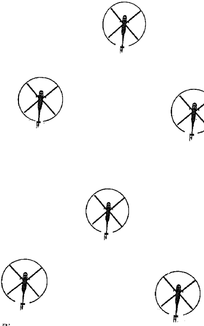


Figure 9.4. Six-plane column of Vees formation.

(3) Special instructions concerning tactics, communications, and plans applicable to each mission. Preflight briefing will be presented by unit briefing officers and flight leaders. These briefings will be detailed and complete, covering each aviator's specific duties, responsibilities, and course of action. Briefing will include, but need not be limited to, the following:

(a) Mission number, helicopter assignments, call signs, and flight positions.

(b) Type of mission, destination, and fuel reserves to be maintained.

(c) Flight chain of command (alternate flight leader).

(d) Time to start engine, takeoff, join-up, and time on target.

(e) Routes, terrain, geographic landmarkers, and power settings (inbound and outbound).

(f) Anticipated weather and instructions for weather penetrations.

(g) Target or landing site assignments, initial point (IP), departure point (DP), method and sequence of approach landing, departure, and rendezvous.

(h) Emergency procedures, including downed aviator procedure, escape and evasion, and alternate fields en route.

(i) Navigational aids, rescue facilities, and radio procedures.

(j) Briefing of troops being transported concerning emergency procedures, life vests, life rafts, smoking regulations, operation of survival equipment, etc.

9.5. Two-Plane (Section) Tactics

Section tactics should be practiced until the section leader and wingman are proficient in the following maneuvers:

a. Right and Left Echelon. The section leader directs the wingman to move from right echelon position to left echelon position by holding up his left arm and hand (fig. 9.5). He then gives the command of execution by slightly rocking his helicopter from side to side. On the command of execution, the number two wingman executes a "cross over" to his position in section left echelon formation. The move from left echelon to right echelon is performed in a similar manner, except that the section leader's copilot gives the hand signal.

b. Turns, Climbs, and Glides. In practicing various climbs, glides, and left and right turns, the section leader should fly as smoothly as possible so that the wingman's required power changes are held to a minimum.

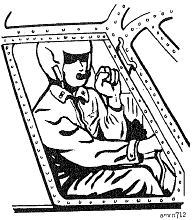


Figure 9.5. Signal for section echelon formation.

c. Column Formation. In a column formation (fig. 9.6) the wingman, directly behind the section leader, is separated by two to four helicopter lengths and stepped up 1 to 3 feet above the lead helicopter. To signal a column formation, the section leader swishes the tail of his helicopter from side to side. The wingman remains at the same altitude and heading, but reduces airspeed slightly to increase the distance between helicopters. When this distance is from two to four helicopter lengths, the wingman moves to a column position directly behind the section leader. When the section leader desires his wingman to join up, he rocks his helicopter up and down (nose-up, nose-down positions). This rocking action appears as small climbs and descents to the wingman, who reverses the process used in forming the column position, and thus returns to his previous echelon position.

d. Formation Breakup.

(1) When the section leader desires to execute a formation breakup, he places his wingman in echelon formation on the side opposite from which he will break. After rocking his helicopter from side to side to indicate he intends to break away, he executes a 90° to 180° turn away from the wingman. When flying a light helicopter, the wingman waits 5 to 10 seconds and turns to follow the section leader. The time interval of 5 to 10 seconds separates the helicopters by 300 to 500 feet and provides proper spacing for carrier landings or for practice of the rendezvous and joinup (*e* below).

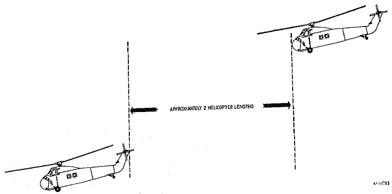


Figure 9.6. Two-plane section column formation.

(2) For large helicopters, a 10 to 15 second interval is required between each helicopter.

(3) Helicopters should never be banked in excess of 60° when executing a formation breakup. This amount of bank is sufficient and, if exceeded, could possibly overstress the helicopter. At night and when loaded, bank should not exceed 45°. All turns should be level.

e. Rendezvous and Joinup of Helicopters.

(1) When the section leader desires to rendezvous and join up his section (fig. 9.7), he rocks his helicopter up and down (nose-up, nose-down positions) to signal the wingman of the impending maneuver. He then starts a 180° standard rate turn in the desired direction (either left or right). Thus, to execute a left rendezvous and joinup, the section leader turns to the left. The wingman continues on his original course until the section leader, in his turn, is passing through a 45° outbound bearing to the left. The wingman then starts a left turn (greater than standard rate) toward the section leader, and continues the turn until the nose of his helicopter is approximately 45° ahead of the section leader. This now places the section leader to the right. The wingman maintains this relative bearing until the result of the relative motion of his helicopter places him within 200 feet laterally to the left of his intended position in the formation. The wingman then stops his rate of closure for a moment and moves into his position in the formation. To execute a right turn rendezvous and joinup, the above procedures are reversed.

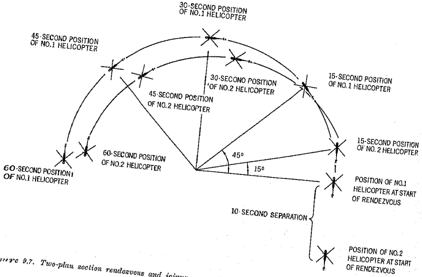


Figure 9.7. Two-plan section rendezvous and joinup procedure with separation of 10 seconds between helicopters.

(2) Normally, longitudinal separation between the section leader and the wingman, after they have executed a formation breakup, is not more than 5 to 15 seconds. The procedure for rendezvous and joinup of helicopters described above uses a 10-second longitudinal separation between helicopters. (fig. 9.7). The same procedures can be used when the longitudinal separations between helicopters are 1 minute or more (fig. 9.8). The wingman, upon receiving instructions to execute a left rendezvous and joinup, continues on his original course until the section leader, in the process of his standard rate left turn, bears 45° to the left. (Since the separation between helicopters is 1 minute or more, the section leader will nearly complete or will complete a 180° left turn before he reaches a position that bears 45° from the wingman.) At this position, the wingman executes the procedure to rendezvous the joinup.

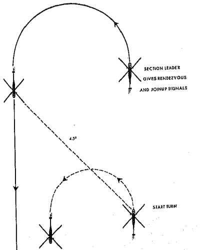


Figure 9.8. Two-plane section rendezvous and joinup procedure with separation of 1 minute or more between helicopters.

f. Change of Leader. When the section leader desires to pass the leadership responsibilities of the section to the wingman, he places the wingman in either left or right echelon formation, pats his head, and points to the wingman. This signifies that he is passing the "lead" to the wingman. The section leader then moves several helicopter lengths away from his wingman. At this point, keeping his eyes on the wingman, he reduces speed slightly, moves to the echelon position, and becomes the wingman.

g. Radio and Hand Signal Communication. Either radio or hand signal communications may be used during section tactics. However, hand signals cannot be used effectively in CH-37 type helicopters due to the location and size of the engine nacelles. Other visual signals such as swishing the tail assembly of the helicopter are sometimes difficult to interpret while using the CH-37. Well-planned operations and detailed briefings by the flight leaders tend to minimize radio transmissions.

9.6. Three-Plane (Section) Tactics

Section tactics should be practiced until the section leader and the two wingmen are proficient in the following maneuvers:

a. Right and Left Echelon. To form a right echelon formation from a V-formation, the section leader signals the number two wingman as described in paragraph 9.5*a*. On the command of execution, the number two wingman reduces speed slightly until the section leader and number three wingman have moved ahead by at least one helicopter length. Then the number two wingman crosses over to his position in section right echelon formation (fig. 9.9). To return to a V-formation from a right echelon formation, the section leader signals the number three wingman, who passes the signal on to [illegible] number two wingman. (The hand signal [illegible] the same signal used to form a left [illegible] formation from a V-formation—to hold [illegible] left arm and hand. However, in this [illegible] signal is for the number two wingman [illegible] from right echelon formation to V-[illegible].) On the signal of execution (the [illegible] leader rocks his helicopter from side to [illegible] the number two wingman reverses the [illegible] to form a right echelon formation [illegible] to his original position in the V-[illegible]. Left echelon is formed under sim-[illegible] procedures.

[illegible] *Formation.* The signal to form a [illegible] formation from a V-formation is the [illegible] forth in paragraph 9.5*c*. When the [illegible] received, the number two and the num-[illegible] wingmen reduce speed slightly until the section leader has moved ahead of the number two wingman by 100 feet and ahead of the number three wingman by 200 feet. The number two wingman then moves laterally to a position 1 to 3 feet above and 75 to 100 feet behind the section leader. The number three wingman then moves laterally to a position that is 1 to 3 feet above and 75 to 100 feet behind the number two wingman, which completes the column formation. The column formation is returned to the V-formation by reversing the procedure.

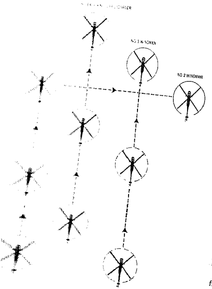


Figure 9.8. Three-plane section right echelon formation formed from a 3-plane V-formation

c. Formation Breakup. The section is placed in right echelon during this formation. The section leader then breaks up the formation as discussed in paragraph 9.5*d*.

d. Rendezvous and Joinup of Helicopters. This maneuver is executed in the same manner as described in paragraph 9.5*e* and in figure 9.7. The only difference is that three helicopters execute the maneuver instead of two.

e. Turns, Climbs, and Glides. The requirements for turns, climbs, and glides for the 3-plane section are covered in paragraph 9.5*h*.

f. Change of Leader. The change of leader is accomplished from a right or left echelon formation. The section leader gives the hand signal indicated in paragraph 9.5*f* and then slides away from the formation for a distance of several helicopter lengths. At this point he reduces speed slightly until the formation moves ahead of him and he is opposite his new position in the formation. He then moves into position and becomes either the number two or three wingman as the case may be.

g. Radio and Hand Signal Communication. Either radio or hand signals may be used during the practice of 3-phase section tactics. For additional information, see paragraph 9.5*g*.

9.7. Four-Plane (Flight) Tactics

Flight tactics should be practiced until the aviators are proficient in the maneuvers listed below.

Note. To gain experience and competence in leading a flight, aviators should frequently exchange positions within the formation during practice flights.

a. Right and Left Echelon Formation.

(1) *Tactical heavy left formation to right echelon.* To place the flight into right

echelon formation from tactical heavy left formation, the flight leader gives the proper hand signal (fig. 9.10) to the second section leader. The flight leader then gives the command of execution (rocks his helicopter from side to side). The leader of the second section then moves his section into flight right echelon formation (fig. 9.11).

LIGHT LEADER HOLDS UP ARM AND HAND AND
)VES ARM UP AND DOWN TO INDICATE HE IS
3NALING TO SECOND SECTION LEADER. RPVN:717

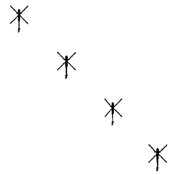
Figure 9.10. Signal for flight echelon.

(2) *Tactical heavy right formation to left echelon.* To execute this formation, reverse the procedure in (1) above.

(3) *Tactical heavy right formation to right echelon.* To place the flight into right echelon formation, the flight leader moves his wingman to the right echelon position. The second section then moves into position and completes the formation.

(4) *Tactical heavy left formation to left echelon.* To execute this formation, reverse the procedure in (3) above.

b. Turns, Climbs, and Glides. The flight ader should execute all turns, climbs, and lides as smoothly as possible. During turns of 0° or more, the second section is not restricted



EACH HELICOPTER IN THE FOUR-PLANE FLIGHT RIGHT ECHELON FORMATION IS ON
AN ANGLE APPROXIMATELY 45° FROM THE LEADER. THE DISTANCE BETWEEN
EACH HELICOPTER IS 1½ ROTOR DIAMETERS.

Figure 9.11. Four-plane flight right echelon formation.

to flying a fixed position of heavy right or heavy left position on the flight leader. If the second section is in a heavy right position at the start of a 90° or more right turn, the relative speed of this section to the flight leader will be the same. However, as the turn progresses, the relative speed of the second section will increase because the second section is on the inside of the turn. Therefore, the second section will, as the increase in relative speed becomes apparent, move from the heavy right position to a position with adequate spacing (fig. 9.12) behind the flight leader. This is known as "free cruise." In this position, the relative speed of the second section leader will be the same as that of the flight leader. Conversely, if the second section were flying in the heavy left position at the start of a 90° or more right turn, it would also move to a position behind the flight leader. At the completion of the turn, the second section can return to its original position. In steep turns, the second section leader may, in consideration for his wingman, move from heavy right to heavy left position every 90°.

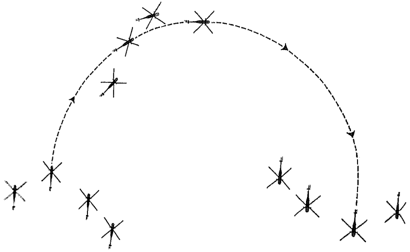


Figure 9.12. Four-plane flight formation turns of 90° to 180°.

c. *Change of Leader.* The change of leader of either section within a 4-plane flight may be accomplished as set forth in paragraph 9.5*f*. When the flight leader is changed in the first section, his wingman becomes the flight leader.

d. *Column Formation.* To signal for a column formation, the flight leader fishtails his helicopter slightly. The number two, three, and four helicopters reduce speed and move into their respective positions.

e. *Formation Breakup.* The breakup for a flight can be executed from the right or left echelon formation and is performed in the same manner as a section breakup (par. 9.5*d*). The only difference is that there are four helicopters instead of two.

f. *Rendezvous and Joinup of Helicopters.*

(1) When the flight leader desires to rendezvous and join up his flight (fig. 9.13), he rocks his helicopter up and down (nose-up, nose-down positions) to signal the aviators in the other helicopters of the impending maneuver. (This signal may be relayed by the number two wingman to the number three wingman, and by the number three wingman to the number four wingman.) The flight leader then starts a 180° standard rate turn in the desired direction (to the left or to the right). Thus, to execute a left rendezvous and joinup, the flight leader will turn to the left. The number two helicopter continues on its original course until the flight leader (number one helicopter), in his turn, is passing through a 45° outbound bearing to the left. The number two wingman then starts a left turn (greater than standard rate) toward the flight leader and continues the turn until the nose

of his helicopter is approximately 45° ahead of the flight leader. This places the flight leader to the right. The number two wingman maintains this relative bearing until the result of the relative motion of his helicopter places him within 200 feet laterally to the left of his intended position in the formation. The wingman then stops his rate of closure for a moment and "crosses over" to his position in the formation (number three position or right echelon of the flight leader).

(2) When the second section leader (number three helicopter) receives instructions from the flight leader to execute a left rendezvous and joinup, he continues on his original course until the flight leader has reached a position 45° to the left of him. (If the rendezvous and joinup procedure is properly executed, the number two wingman will also be approximately on a 45° bearing from the number three helicopter.) The second section leader then starts a turn toward the flight leader and continues the turn until the nose of his helicopter is approximately 45° ahead of the flight leader. This places the flight leader to the right.

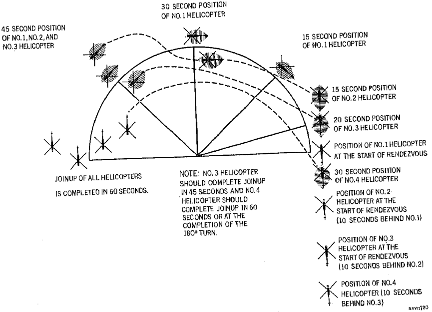


Figure 9.13. Four-plane flight formation rendezvous and joinup procedure with separation of 10 seconds between helicopters.

The second section leader maintains the relative bearing until the relative position of his helicopter places him [illegible] feet laterally to the left of his intended position in the formation. The second section leader then stops his rate of closure for a moment and moves into his position in the formation.

[illegible] When the second section leader's wingman (the number four helicopter) receives instructions that the flight will execute a rendezvous and joinup, he continues in his original course until the flight leader has reached a position that bears 45° to the left. (If the rendezvous and joinup procedure is properly executed, the number two and number three helicopters will also be in the close vicinity of the flight leader and thus can be considered to bear 45° from the number four helicopter.) The number four wingman then starts a turn toward the flight leader and continues the turn until the nose of his helicopter is approximately 45° ahead of the flight leader. This places the flight leader to the right. The number four wingman maintains this position until the relative position of his helicopter places him [illegible] feet laterally to the left of his intended position in the formation. The number four wingman then stops his rate of closure for a moment and moves into position. To execute a right turn rendezvous and joinup, the procedures for the left turn are reversed.

[illegible] Normally after a formation breakup, longitudinal separation between helicopters is not more than 5 to 15 seconds. The procedure for rendezvous and joinup of helicopters described in (1) through (3) above uses a 10-second longitudinal separation between helicopters (fig. 9.13). The same procedures can be used when the longitudinal separations between helicopters are 1 minute or more. The only difference is that the flight leader, in a 1-minute separation, will complete a 180° turn before he consecutively bears 45° from the other helicopters (fig. 9.14).

g. Radio and Hand Signal Communication. Either radio or hand signals may be used during the practice of 4-plane flight tactics. For additional information, see paragraph 9.5g.

h. Inadvertent Instrument Flight While in Formation. If helicopters inadvertently enter instrument flight conditions while in formation,

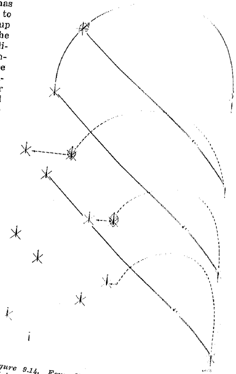


Figure 9.14. Four flight formation rendezvous and joinup procedure with separation of 1 minute or more between helicopters.

the flight elements remain in visual contact with each other if possible. The flight leader makes no radical turns or speed changes and performs a 180° formation turn out of the IFR condition. However, if the helicopters in formation (fig. 9.15) cannot maintain visual contact with one another, the procedure given below is followed:

Note. Flight operations should not be conducted when ceiling is below 800 feet and visibility is below 2 miles.

(1) The flight leader continues straight ahead and reports his magnetic heading and altitude.

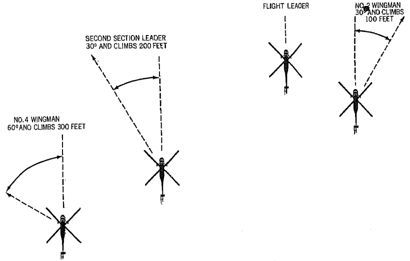
(2) The number two wingman executes a 30° turn away from the flight leader, and climbs 100 feet.

(3) The second section leader (the number three man) executes a 30° turn away from the first section or flight leader, and climbs 200 feet. This turn is always in opposite direction to the turn of the number two wingman.

(4) The number four wingman of the second section executes a 60° turn away from his section leader, and climbs 300 feet.

(5) After all helicopters have completed the initial breakaway turn and climbed to the assigned altitude, they fly a straight course for 30 seconds. The flight leader then announces over the radio, "Number two and four helicopters, complete the 180° turn." The number two and four helicopters acknowledge the communication, and continue their turn until they have completed a 180° turn from the original heading of the formation.

(6) After ordering the aviators of the number two and number four helicopters to "complete the 180° turn," the



PROCEDURES TO FOLLOW WHEN A FLIGHT OF HELICOPTERS ENTERS IFR AND CANNOT MAINTAIN VISUAL CONTACT WITH ONE ANOTHER.

Figure 9.15. Four-plane flight formation under instrument conditions.

[illegible] leader waits 10 seconds and in- [illegible] the number three helicopter to [illegible] his 180° turn. Simultane- [illegible] the flight leader starts his own [illegible] 180° turn.

[illegible] the aviator of the helicopter at [illegible] altitude reports that he has [illegible] VFR conditions, the aircraft [illegible] next higher altitude can start a [illegible] to VFR conditions. This se- [illegible] is continued until all aviators [illegible] to the flight leader that they [illegible] VFR, giving their location if [illegible]

[illegible] procedure for formation breakup [illegible] encountering instrument weath- [illegible] only result in lateral separa- [illegible] if all aviators could not, for ex- [illegible] maintain altitude within plus [illegible] 100 feet. However, the lat- [illegible] separations as provided are suffi- [illegible] prevent midair collisions.

[illegible] (Flight) Tactics

[illegible] should be practiced until [illegible] the second section leader, and [illegible] proficient in the maneuvers [illegible] gain experience and compe- [illegible] flight at any time, aviators [illegible] exchange positions within the [illegible] practice flights.

[illegible] *Echelon Formation.* To [illegible] right echelon formation [illegible] Vees formation, the flight [illegible] hand signal for section [illegible] (fig. 9.5), and the sig- [illegible] echelon formation (fig. 9.10) [illegible] wingman. The number two [illegible] the signal for right echelon [illegible] second section leader. On com- [illegible] (the flight leader rocks his [illegible] to side), the number two [illegible] to the right echelon position in [illegible] As a safety precaution, the [illegible] increases the interval between [illegible] or two helicopter lengths as he [illegible] The flight leader's command of execu- [illegible] the number two wingman is in right [illegible] the second section moves to a [illegible] to the right and rear of the number two wingman in the first section. The second section leader then places the number five wingman in right echelon formation, and the section closes up to the proper position to complete the flight echelon formation (fig. 9.16). A similar sequence of events is utilized to form the flight into left echelon formation.

b. Turns, Climbs, and Glides. Turns are never made to the right when the flight is in right echelon formation, or to the left when the flight is in left echelon formation.

c. Column Formation. To place the flight into column formation from the column of Vees formation, the flight leader swishes the tail of his helicopter from side to side. When the signal is received, the number two and three wingmen and the second section reduce speed slightly. The number two wingman allows the flight leader to move ahead of him 75 to 100 feet, then moves laterally to the right, to a position 1 to 3 feet above and 75 to 100 feet behind the flight leader. The number three wingman allows the number two wingman to move ahead of him by 75 to 100 feet. The number three wingman then moves laterally to the left to a position 1 to 3 feet above and 75 to 100 feet behind the number two wingman. The second section leader allows the number three wingman to move ahead of the second section by 75 to 100 feet where he can observe the number two and number three wingmen as they move into column formation. The second section leader then places himself 1 to 3 feet above and 75 to 100 feet behind the number three wingman. The number five and six wingmen then move respectively into column formation behind the second section leader in the manner described above for the number two and three wingmen of the first section.

d. Formation Breakup. To execute a formation breakup, the flight leader places the flight in echelon formation on the side opposite that from which he will break. He then rocks his helicopter from side to side to indicate his intent to break away from the formation and executes a 90° to 180° turn away from the flight. Each wingman in succession waits 5 to 10 seconds, then turns and follows the helicopter ahead. The time interval of 5 to 10 seconds separates the helicopters by 300 to 500 feet and

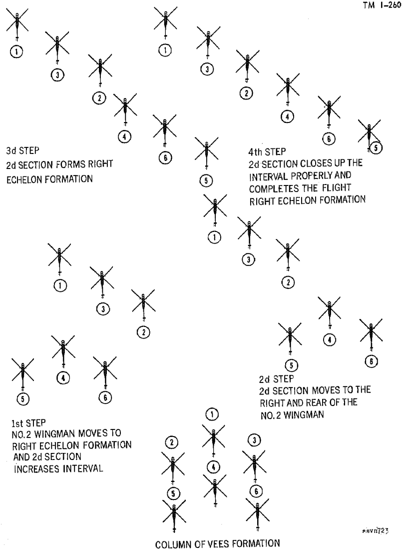


Figure 9.16. Six-plane flight right echelon formation.

[illegible] spacing for carrier landings or [illegible] the rendezvous and joinup, below.

[illegible] and Joinup of Helicopters. [illegible] flight leader desires to rendezvous [illegible] his flight (fig. 9.17), he rocks his [illegible] up and down (nose-up, nose-down [illegible] signal the aviators in the other [illegible] of the impending maneuver. (This [illegible] relayed by the other helicopters.) [illegible] leader then starts a 180° standard [illegible] in the desired direction (to the left or [illegible]). Thus, to execute a left rendezvous [illegible] joinup, the flight leader will turn to [illegible]. The other helicopters in the formation [illegible] the original course until the flight [illegible] consecutive order bears 45° from each [illegible] helicopter. As the flight leader reaches [illegible] position relative to each helicopter, [illegible] aviator concerned starts a left turn [illegible] flight leader and continues the turn [illegible] of his helicopter is approximately 45° ahead of the flight leader. This now places the flight leader to the right. Each aviator maintains this relative bearing until the relative motion of his helicopter places him within 200 feet laterally to the left of his intended position in the formation. At this point the rate of closure is stopped for a moment, and the aviator moves his helicopter into position within the formation. To execute a right turn rendezvous and joinup, the procedures for a left turn are reversed. A 6-plane flight uses a column of Vees formation during joinup.

f. Change of Leader. To change the leader within either section, the flight leader or the second section leader may use the method set forth in paragraph 9.5*f*.

g. Radio and Hand Signal Communication. Either radio or hand signals may be used during the practice of 6-plane flight tactics. For additional information, see paragraph 9.5*g*.

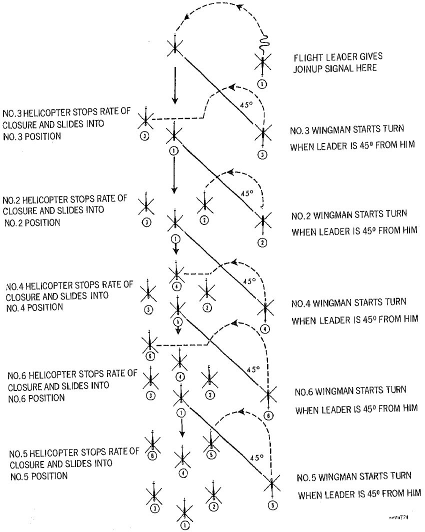


Figure 9.17. Six-plane flight rendezvous and joinup procedure.

Section III. NIGHT FORMATION FLYING

9.9. General

a. Aviators who perform night formation flying should have intensive training and the necessary proficiency in day formation flying. To reduce the hazards of night flying and effect better teamwork, this training should be conducted as a unit.

b. Night formation flying procedures for the 4-plane flight are given below. These procedures are generally applicable to night formation flying in the 2-plane section.

9.10. Rendezvous and Joinup of Aircraft

a. To rendezvous and join up his flight (fig. 9.19), the flight leader signals his intention, either by radio communication or by a prearranged light signal code. He then starts a level standard-rate turn in the desired direction of rendezvous and joinup. Thus, to execute a left rendezvous and joinup, the flight leader turns to the left. The number two wingman continues on his original course until the flight leader, in his turn, is passing through a 20° to 30° outbound bearing to the left. The number two wingman then starts a left turn toward the flight leader and continues the turn until the nose of his helicopter is approximately 20° to 30° ahead of the flight leader. This places the flight leader to the right. The number two wingman maintains this relative bearing until his helicopter places him within 100 feet of a position that bears 60° left-astern of the flight leader, separated by a distance of two rotor diameters. He then stops his rate of closure for a moment and crosses over to his position of right echelon on the flight leader. This position (fig. 9.19) is 60° right-astern of the flight leader, separated by a distance of two rotor diameters.

b. When the second section leader (number three helicopter) receives instructions from the flight leader to execute a left rendezvous and joinup, he continues on his original course until the number two wingman, in his turn, reaches a position 20° to 30° from him to the left. The second section leader then starts a turn toward the number two helicopter, and continues the turn until the nose of his helicopter is approximately 20° to 30° ahead of the number two helicopter. This now places the number two helicopter to the right. The second section leader maintains this relative bearing until his helicopter places him within 100 feet adjacent to his intended position in the formation. He then stops his rate of closure and moves into position. The second section leader's wingman (number four helicopter) executes a rendezvous and joinup in a similar manner.

c. To execute a right rendezvous and joinup, the procedures in *a* and *b* above are reversed.

d. The differences between night and day rendezvous and joinup are—

(1) At night, a 20° to 30° relative motion angle is used instead of the 45° angle used during the day. Accordingly, more time is required to effect a rendezvous and joinup. The 20° to 30° angle permits, as a safety precaution, the joining helicopters to approach the formation at a slight angle somewhat from the rear.

(2) At night, each helicopter waits until the helicopter immediately ahead turns 20° to 30° before initiating its own procedures to rendezvous and join up. The aviators in each successive helicopter always keep the helicopter immediately ahead in view.

(3) Aviators executing a rendezvous and joinup on a dark, moonless night must take care that their rate of closure is slow enough to be stopped instantly, and that they do not overrun the helicopters immediately ahead. The silhouette of a helicopter cannot be seen except at a dangerously close distance; the only point of reference is the running lights.

(4) A rendezvous will take longer to effect at night. The flight leader must make all his turns standard rate or less, and should never make any abrupt movements. Unless the flight is exceptionally well trained, all heading changes

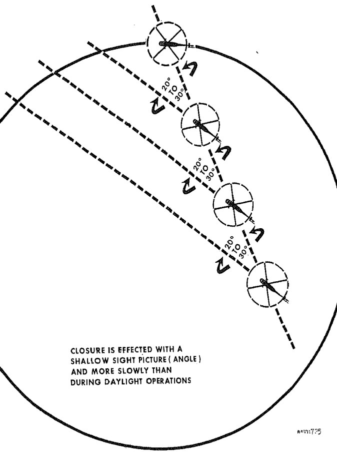


Figure 9.18. Night rendezvous and joinup of helicopters.

of 30° or more should be announced by the leader prior to effecting the turn.

9.11. Breakup

When approaching the field for a night formation breakup preparatory to landing, the flight leader places the flight in a column. This is the easiest and safest formation for executing a breakup at night. A breakup executed from an echelon formation involving more than two helicopters should not be attempted unless the flight is exceptionally well trained. Prior to executing a formation breakup, the flight leader should indicate his intentions either by radio communication or by a prearranged signal code. Sufficient interval between helicopters must be maintained in order to land the flight expeditiously and prevent the possibility of a waveoff or go-around. Night formation landings require special training and should be attempted only by those aviators who have received such training.

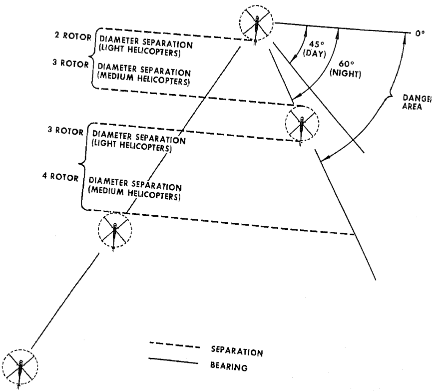


Figure 9.19. Separation and bearing of helicopters in night formation flying.

APPENDIX I

REFERENCES

AR 95-series	(Army Aviation.)
AR 320-5	Dictionary of United States Army Terms.
AR 320-50	Authorized Abbreviations and Brevity Codes.
AR 715-232	Emergency Purchase of Army Aviation Fuels, Oils, Parts, Supplies, Equipment, and Necessary Services from Commercial Sources.
DA Pam 108-1	Index of Army Motion Pictures, Filmstrips, Slides, Tapes, and Phono-Recordings.
DA Pam 310-series	Military Publications Indexes (as applicable).
FM 1-100	Army Aviation.
FM 21-5	Military Training.
FM 21-6	Techniques of Military Instruction.
FM 21-30	Military Symbols.
FM 57-35	Airmobile Operations.
TM 1-215	Attitude Instrument Flying.
TM 1-225	Navigation for Army Aviation.
TM 1-250	Principles of Fixed Wing Flight.
TM 1-300	Meterology for Army Aviation.
TM 55-series-10	(Appropriate Aircraft Operator's Manuals.)
TM 57-210	Air Movement of Troops and Equipment.
FAA Advisory Circular	Helicopter Rating Guide.
FAA Advisory Circular	Helicopter Instructor Guide.

APPENDIX II

CURRENT ARMY HELICOPTERS

1. General

This appendix discusses Army helicopters which are presently used in accomplishing the role of Army aviation. Helicopters now in the experimental or developmental stage are not included.

2. OH-13H (Observation)

The OH-13H (fig. II.1), manufactured by Bell Helicopter Company, is a standard observation helicopter. Designed for operations in confined areas of the combat zone, it can carry one passenger, two litter patients, or 400 pounds of cargo. It has a speed from 0 to 87 nautical miles per hour. The OH-13H is a multipurpose helicopter designed for training, command and control, wire laying, aeromedical evacuation, observation, radiological survey, armed reconnaissance and security, topographic survey, and light resupply missions. It is powered by a 250 shp Lycoming engine which is derated to 200 hp. The OH-13S currently being purchased is very similar to the OH-13H. The major difference is the addition of a turbo-supercharger to the engine. The derated horsepower of the OH-13S engine is 220. It can be transported by rail, water, military aircraft, or truck. For additional characteristics of this helicopter, see table I.

3. OH-23D (Observation)

The OH-23D (fig. II.2), manufactured by Hiller Aircraft Corporation, is a three-place helicopter with a single main rotor and anti-torque tail rotor. Designed for operations in confined areas of the combat zone, it can carry two passengers, two litter patients, or 400 pounds of cargo. The OH-23D is a multipurpose helicopter designed for training, command and control, wire laying, aeromedical evacuation, observation, radiological survey, armed reconnaissance and security, topographic survey, and light resupply missions. It is powered by a 250-horsepower engine and can be transported by rail, water, military aircraft, or truck. For additional characteristics of this helicopter, see table I.

4. UH-1 (Utility)

The UH-1A, B, or D, manufactured by Bell Helicopter Corporation, is a utility-type, compact design helicopter which features a low silhouette. This helicopter is powered by a single gas turbine Lycoming engine. The UH-1A can carry one crewman and six passengers; one crewman, two litters, and a medical attendant; or one crewman and a payload of 2,000 pounds. The UH-1B can carry one crewman and eight passengers; one crewman, three litters, and a medical attendant; or one crewman and a payload of 2,578 pounds. The UH-1D (fig. II.3) can carry 1 crewman and 12 passengers; 1 crewman, 6 litters, and a medical attendant; or 1 crewman and a payload of 2,289 pounds. These helicopters are capable of operating from unprepared landing areas and under all-weather conditions. Cargo and equipment not feasible to load inside can be transported externally. The UH-1 can be equipped with various armament systems to perform the mission of aerial suppressive fire. For additional characteristics of these helicopters, see table I.

5. UH-19 (Utility)

The UH-19 (fig. II.4), manufactured by Sikorsky Aircraft, Division of United Aircraf Corporation, is a limited standard utility hel copter capable of carrying six troops, six litte patients, or a normal cargo load of up to 1,5(pounds. With a cruising speed of approximat ly 70 knots, the UH-19D is powered by a sing

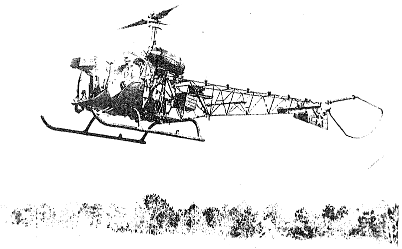


Figure II.1. OH-13H (observation).

700-horsepower Pratt and Whitney engine and has a service ceiling of 15,400 feet. This helicopter usually is used in the movement of troops and supplies. Other capabilities include resupply, troop transport, air-sea rescue, observation, and aeromedical evacuation. For additional characteristics of this helicopter, see table I.

6. CH-21C (Light Cargo)

The CH-21C (fig. II.5), manufactured by Vertol Division of Boeing Aircraft Company, is a single-engine, tandem-rotor helicopter capable of carrying 2 pilots and 12 troops, or 2 pilots and 12 litter patients. This helicopter has a normal cargo load of 3,000 pounds and a cruising speed of approximately 80 knots. It is equipped with a single 1,425-horsepower Wright engine. Some mission capabilities of this helicopter include airlift of troops and equipment, aerial command post, salvage operations, fire support, and wire laying. For additional characteristics of this helicopter, see table I.

7. CH-34C (Light Cargo)

The CH-34C (fig. II.6), manufactured by Sikorsky Aircraft, Division of United Aircraft Corporation, is powered by a single Wright engine, with a four-bladed main rotor and a four-bladed antitorque tail rotor. With space for 18 troops or 8 litters, this helicopter can carry a

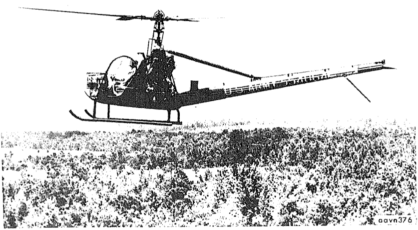


Figure II.2. OH-23D (observation).

normal cargo load of 4,000 pounds. Designed for a pilot and copilot, it has a cruising speed of approximately 85 knots. Some mission capabilities include airlift of troops and equipment, aerial command post, salvage operations, fire support, and wire laying. For additional characteristics of this helicopter, see table I.

8. CH-37B (Medium Cargo)

The CH-37B (fig. II.7), manufactured by Sikorsky Aircraft, Division of United Aircraft Corporation, is a twin-engine helicopter designed for the transport of cargo and troops and for the evacuation of casualties. It is powered by Pratt and Whitney twin engines mounted in pods on each side of the fuselage, and is capable of carrying a load of 5,000 pounds. The CH-37B has clamshell doors in a loading ramp in the nose, and can lift approximately 23 troops or 24 litter patients. Some additional mission capabilities of this helicopter include salvage operations and ship-to-shore operations. For additional characteristics of this helicopter, see table I.

9. CH-47A (Medium Cargo)

The CH-47A (fig. II.8), manufactured by Vertol Division of Boeing Aircraft Company, is a tandem-rotor, medium transport helicopter, powered by two Lycoming T-55-L-5 free-turbine engines. A rear ramp permits rapid straight-in loading and unloading of troops, vehicles, and cargo. Items which are too bulky to fit within the payload compartment can be transported on the 8-ton capacity external cargo hook. Load release normally is accomplished hydraulically. In the event of utility hydraulic system failure, release may be effected electrically or mechanically. For additional characteristics of this helicopter, see table I.

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Figure II.3. UH-1D (utility).

Figure 11.4. UH-19 (utility).

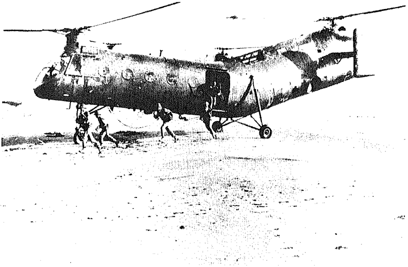


Figure II.5. CH-21C (light cargo).

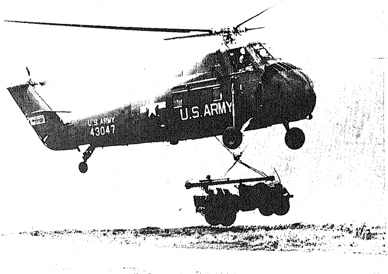


Figure II.6. CH-34C (light cargo).

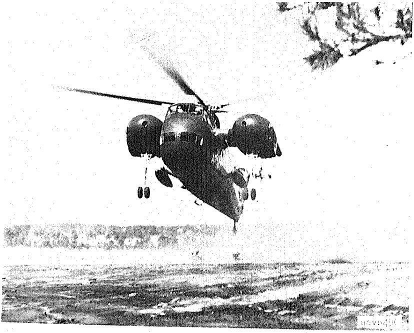


Figure II.7. CH-37B (medium cargo).

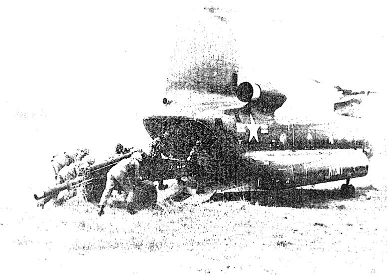


Figure II.8. CH-47A (medium cargo).

Table I. Helicopter Characteristics

Table I. Helicopter Characteristics.

1	2	3	4	5	6	7	8	9	10	11	12	13
A. AIRCRAFT	UNIT	OH-13H OBSERVATION	OH-23D OBSERVATION	UH-1A UTILITY	UH-1B[6] UTILITY	UH-1D[6] UTILITY	UH-19D UTILITY	CH-21C CARGO	CH-34C CARGO	CH-37B CARGO	CH-47A[3] CARGO	CH-54[3] CARGO
B. CREW (200 lbs Ea)	Ea	1	1	1	1	1	1	2	2	3	3	2
C. DIMENSIONS:												
(1) Length - Fuselage	Ft & In	30'3"	28'6"	39'6"	39'6"	40'1/2"	42'3"	52'7"	46'9"	64'11"	51'0"	70'3"
(2) Length - Blades Unfolded	Ft & In	41'5"	40'8"	57'10"	52'11"	53'1"	62'3"	86'4"	65'10"	88'0"	98'3.25"	88'
(3) Length - Blades Folded	Ft & In	NA	NA	NA	NA	NA	42'3"	52'7"	37'0"	55'8"	51'0"	70'3"
(4) Width - Blades Folded	Ft & In	NA	NA	NA	NA	NA	11'7"	14'0"	13'0"	22'4"	12'5"	21'10"
(5) Width - Tread	Ft & In	8'10"	7'6"	8'6"	8'4"	8'6"	11'0"	13'4"	12'0"	19'9"	11'11"	19'9"
(6) Height Extreme	Ft & In	9'6"	10'2"	11'5"	14'6"	13'1"	15'3"	15'9"	15'11"	22'0"	19'	24'10"
(7) Diameter Main Rotor	Ft & In	35'2"	35'5"	43'9"	44'0"	48'3"	53'0"	44'0"	56'0"	72'0"	59'1.25"	72'
(8) Diameter Tail Rotor	Ft & In	5'8"	5'6"	8'5"	8'6"	8'6"	8'9"	NA	9'6"	15'0"	NA	15'8"
D. CARGO DOOR												
(1) Dimensions - Width/Height	In	NA	NA	48" x 48"	48" x 48"	92" x 49"	68" x 48"	49" x 59"	53" x 48"	Nose 87X72 Bottom 72" x 48"	90" Wide 78" High	NA
(2) Location - Side of Fuselage	In	NA	NA	Left & Right	Left & Right	Left & Right	Right	Cargo-Left Rescue-Right	Right	72" x 72"	Rear	NA
E. CARGO COMPARTMENT												
(1) Height of Floor Above Ground	In	NA	NA	26"	22"	32"	30"	38"	34"	36"	30"	NA
(2) Length Usable	In	NA	NA	48"	60"	92"	130"	240"	163.5"	30'4"	366"	NA
(3) Width Floor	In	NA	NA	80.5"	80.5"	98"	66"	46"	59"	87"	90"	NA
(4) Height (Clear of Obstructions)	In	NA	NA	56"	56"	52"	60"	60"	70"	69"	78"	9'4"
(5) Cargo Space Optimum	Cu Ft	NA	NA	140'	140'	220'	300'	422'	363'	1,252'	1,482'	NA
F. EXTERNAL CARGO[2]												
(1) Maximum Recommended External Load	Lbs	NA	NA	3,000	3,500	4,000	2,000	5,000	5,000	10,000	16,000	20,760
(2) Rescue Hoist Capacity	Lbs	NA	NA	NA	NA	NA	400 or 600[5]	400	600	600	600	NA
(3) Cargo Loading Winch Capacity	Lbs	NA	NA	NA	NA	NA	NA	NA	NA	2,000	3,000	NA
G. PASSENGER CAPACITY												
(1) Troop Seats (240 lbs Per Man)	Ea	1	2	6	8	12	6	12	12 or 18	23	33	NA
(2) Litters and Ambulatory	Ea	2 + 0	2 + 1	2 + 1	3 + 1	6 + 1	6 + 0	12 + 0	8 + 0	24 + 0	24 + 3	NA
H. OPERATIONAL CHARACTERISTICS[1,2]												
(1) Maximum Allowable Gross Wt	Lbs	2,500	2,700	7,200[4]	8,500[4]	8,600[4]	7,900	13,500	13,500	31,000	33,000	38,000
(2) Basic Weight	Lbs	1,718	1,821	4,020	4,487	4,655	5,650	8,899	7,738	21,500	17,200	17,740
(3) Useful Load	Lbs	782	879	3,180	4,012	3,945	2,250	5,601	5,867	9,500	15,800	20,760
(4) Internal Fuel Capacity	Lbs/Gal	258/43	276/46	812/125	1,008/155	1,430/220	1,050/175	1,800/300	1,572/262	2,388/398	4,095/630	5,720/880
(5) Normal Cruising Speed[6]	Kts	70	70	80	90	100	70	80	85	90	130	95
(6) Endurance at Cruising Speed	Hrs + Min	2 + 00	2 + 05	1 + 40	2 + 50	2 + 00	3 + 30	2 + 40	2 + 50	1 + 05	2 + 40	1 + 45
(7) Grade of Fuel	Oct	115/145	115/145	JP-4	JP-4	JP-4	115/145	115/145	115/145	115/145	JP-4	JP-4
(8) Fuel Consumption Per Hour[7]	Lbs/Gal	102/17	102/17	422/65	457/75	487/75	160/60	480/80	456/76	1,200/200	1,300/200	3,460/532

DEFINITIONS: (FM 57-210, dated Oct 60, page 100)

MAXIMUM ALLOWABLE GROSS WEIGHT: The maximum allowed total weight of the helicopter prior to takeoff; the "BASIC WEIGHT" of the helicopter plus the crew, personnel equipment, special devices, passengers/cargo, and usable fuel and oil. This is limited by structure, power available, or landing load.

BASIC WEIGHT: The empty weight of the helicopter in its basic configuration, to include all appointments, integral equipment, instrumentation, and trapped fuel and oil, but excludes passengers, cargo, crew, and fuel and oil.

USEFUL LOAD: The load-carrying capability of a helicopter. It includes the payload, crew, and usable fuel and oil required for the mission. Here it is the difference between "MAXIMUM ALLOWABLE GROSS WEIGHT" and the "BASIC WEIGHT" as defined above. Thus, it is evident that a reduction of the fuel load will reduce the ENDURANCE and increase the PAYLOAD. Full oil is required for all missions.

PAYLOAD: The useful load less the crew, full oil, and the required fuel for the mission.

NORMAL CRUISING SPEED: The true airspeed which a helicopter can normally be expected to maintain at some standard power setting below rated military power. This speed will vary with altitude.

ENDURANCE AT CRUISING SPEED. The time that a helicopter can remain airborne at normal cruising speed with fuel aboard without using the required fuel reserve. The data listed under "OPERATIONAL CHARACTERISTICS" is computed utilizing full fuel minus a 30-minute reserve.

FOOTNOTES:

[1] All data computed at standard conditions at sea level.

[2] Detail weight computations and characteristics taken from current technical manuals on each helicopter.

[3] Data subject to change, resulting from developmental testing.

[4] Basic weight for standard helicopter. (Weapons systems and components not established.)

[5] UH-19D: Helicopters prior to serial no. 56-1519 are equipped with provisions for a 400 pound capacity rescue hoist; subsequent helicopters are equipped with provisions for a 600 pound capacity rescue hoist.

[6] Airspeeds of helicopters will vary with gross weight and altitude. See appropriate operator's manual for correct airspeed.

[7] Computed at maximum gross weight and at sea

APPENDIX III

PRACTICAL METHODS FOR PREDICTING HELICOPTER PERFORMANCE

1. General

The practical methods for predicting helicopter performance under particular conditions of payload and flight given in this appendix apply to the OH-13 type helicopter or to similar helicopter configurations using the 200-horsepower air-cooled engine. (The techniques described result from engineering tests on the OH-13 as published by Jack Fairchild and Hans Weichsel, Jr., of Bell Aircraft Corporation.) These practical methods allow better utilization of the helicopter, a clearer understanding of factors influencing helicopter performance, and sound principles on which to base flight decisions; however, they are not intended as substitutes for experience and good judgment.

2. Manifold Pressure and Payload

a. Power-curve tests on the 200-horsepower air-cooled engine show that 1 inch of manifold pressure is equivalent to 6 horsepower. Speed-power polar of the helicopter demonstrates that 1 horsepower will lift 13.5 pounds of weight while hovering. Combined, these two facts give—

RULE NO. 1. One inch of manifold pressure will lift 80 pounds of payload.

b. With this knowledge, the aviator can obtain a rough estimate of the additional weight he can safely carry to be able to hover, then enter flight. This rule should be applied before landing at destination, in this manner:

(1) Momentarily apply full throttle at 100 feet altitude or less and determine the maximum manifold pressure. This manifold pressure is approximately equal to the maximum manifold pressure available for takeoff.

(2) While hovering, check manifold pressure required for the hover.

(3) Find the difference between maximum available manifold pressure and manifold pressure required to hover.

(4) Change the difference in manifold pressure into weight (1 inch of manifold pressure equals 80 pounds) to get the approximate additional payload which can be carried to lift to a hover for safe takeoff.

Note. Temperature, winds, altitude, fuel load, flight weight, empty weight, etc., are included in the above method and need not be considered separately.

3. Manifold Pressure and Hovering Ceiling

a. By using available manifold pressure to determine hovering ceiling, an aviator can predict whether or not he can hover at a destination.

RULE NO. 2. If wind velocity at point of intended landing is approximately the same as at point of takeoff, and the flight is made within the same airmass (no radical temperature change), 1,000 feet is added to the point-of-takeoff altitude for each inch of manifold pressure in excess of that required to hover.

b. This method should be applied as follows:

(1) Check manifold pressure at a normal hover prior to takeoff.

(2) While hovering, momentarily apply full throttle and note maximum manifold pressure available.

(3) The difference in these two manifold pressure readings is equivalent to 1,000 feet altitude per 1 inch of excess manifold pressure. Apply this additional altitude to the point-of-takeoff altitude to get the maximum altitude (above sea level) at which the heli-

copter may be hovered with ground effect.

4. Payload and Wind

In winds from 0 to about 15 knots, the hovering ceiling of the helicopter will increase from 100 feet for each knot of wind. In winds from about 15 knots to 26 knots, the hovering ceiling will increase about 350 feet for each knot of wind.

RULE NO. 3. The payload may be increased 8 pounds for each knot of wind from 0 to 15 knots, or may be increased 28 pounds for each knot of wind from 15 knots to 26 knots.

Note. These load changes apply to a *decrease* in wind velocity (and load reduction) as well as to an increase.

5. Hovering and Skid Height

Hovering altitude over level terrain is ideal with skid clearance of approximately 4 feet. Variable hovering altitudes, due to obstacles or rough terrain, have a decided effect on helicopter performance in determining hovering ceiling and payload. These effects are best estimated as follows:

RULE NO. 4.

(1) To hover under 4 feet, 300 feet is added to the hovering ceiling or 24 pounds to the payload for each 6 inches of decrease in skid height from the 4-foot hover.

(2) To hover between 4 feet and 10 feet, 300 feet is subtracted from the hovering ceiling or 24 pounds from the payload for each foot of increase in skid height.

Note. Ground effect decreases rapidly above 10 feet, and hovering should not be attempted.

6. Hovering Ceiling and Gross Weight

The hovering ceiling will vary in proportion to the gross weight of the helicopter. To determine hovering ceiling for a known gross weight, the following rule should be applied:

RULE NO. 5.

(1) A 100-pound *reduction* in gross weight increases hovering ceiling in or out of ground effect about 1,300 feet.

(2) A 100-pound *increase* in gross weight decreases hovering ceiling about 1,300 feet.

Note. These factors are true up to the maximum gross weight of the helicopter (2,500 pounds for the OH–13).

7. Service Ceiling and Gross Weight

The service ceiling of the helicopter varies with gross weight. To determine the effects of gross weight on service ceiling, the following rule should be applied:

RULE NO. 6. A 100-pound *decrease* in gross weight adds 800 feet to the service ceiling, and, conversely, a 100-pound *increase* in gross weight reduces the service ceiling 800 feet.

8. Rate of Climb and Gross Weight

To determine the effects of gross weight on rate of climb, the following rule should be applied:

RULE NO. 7.

(1) Using *maximum* rate of climb, a change in gross weight of 100 pounds alters the rate of climb about 80 feet per minute in forward flight (45 mph).

(2) On *vertical* rate of climb, a change in gross weight of 100 pounds alters the rate of climb about 180 feet per minute.

APPENDIX IV

AIR DENSITY AND COMPUTATION OF DENSITY ALTITUDE

1. Air Density

a. Air, like liquids and other gases, is a fluid. Because it is a fluid, it flows and changes shape under pressure. Air is said to be "thin" at high altitudes; that is, there are fewer molecules per cubic foot of air at 10,000 feet than at sea level. The air at sea level is thin when compared to air compressed in a truck tire. A cubic inch of air compressed in a truck tire is denser than a cubic inch of "free" air at sea level. For example, in a stack of blankets, the bottom blanket is under pressure of all blankets above it. As a result of this pressure, the bottom blanket may be squeezed down until it is only one-tenth as bulky as the fluffy blanket on top. There is still just as much wool in the bottom blanket as there is in the one on top, but the wool in the bottom blanket is ten times more dense. If the second blanket from the bottom of the stack were removed, a force of 15 pounds might be required to pull it out. The second blanket from the top may require only 1 pound of force. In the same way, air layers near the surface have much greater density than air layers at higher altitudes.

b. The above principle may be applied in flying aircraft. At lower levels, the propeller or rotor blade is cutting through more and denser air, which also offers more support (lift) and increases air resistance. The same amount of power, applied at higher altitudes where the air is thinner and less dense, propels the aircraft faster.

2. Factors Influence Air Density

a. Temperature. Even when pressure remains constant, great changes in air density will be caused by temperature changes. The same amount of air that occupies 1 cubic inch at a low temperature will expand and occupy 2, 3, or 4 cubic inches as the temperature goes higher and higher. It is easier for an airplane or helicopter to take off in cold weather when the air is dense than in hot weather when the air is thin, because the wings or blades must displace a certain amount of air in taking off. In taking off from a high altitude field on a hot day, an airplane will require a longer than ordinary run and a helicopter may require a ground run rather than rising vertically. The air at the higher altitude would be thin not only because of the decrease in density caused by higher temperature, but also because of the lower pressure found at the higher elevation.

b. Moisture. When temperature and pressure are constant, changes in the moisture content of the air will change air density. Air always contains some moisture in the form of water vapor, but the amount varies from almost none to 100 percent humidity. The density of the air decreases as the moisture content increases. Therefore, aircraft taking off from a high altitude field on a hot, humid day will require additional ground roll to get off the ground, due to the further reduced density resulting from high humidity.

3. Standard Atmosphere

Due to the fluctuations of atmospheric conditions, a criteria of standard atmospheric conditions has been established. These standard conditions assume a certain pressure (29.92" Hg or 1013.2 mb.) and temperature (59° F. or 15° C.) at sea level, with a given temperature lapse rate of 3.56° F. per 1,000 feet of elevation. Aircraft performance is evaluated using these standard atmospheric conditions.

4. Helicopter Performance

Helicopter operation in hot weather is generally less efficient than in cold weather. Vertical ascent, hovering, and vertical descent may be impossible when the temperature is high. Necessity for running takeoffs and landings arises with decrease in air density. Engine rpm loss is likely, and will require extra concentration by the aviator to keep rpm above minimum limit. An overrev is permissible during takeoff and landing, provided it does not exceed the maximum allowable (red line). Although civil and military tests have proven the helicopter capable of performing successfully at high altitudes, they have also proven that high altitude operations are usually marginal and demand a high degree of aviator proficiency.

5. Density Altitude

Army helicopter aviators must be familiar with the high-altitude factors affecting helicopter performance and the flying techniques of such operations. The three major factors to understand are—

a. Air Density.

(1) An increase in altitude causes a decrease in air density.

(2) An increase in temperature causes a decrease in air density.

(3) An increase in humidity causes a decrease in air density.

b. *Wind.*

(1) If there is sufficient wind velocity to afford translational lift while hovering, helicopter performance is improved considerably.

(2) Translational lift, present with any forward speed or headwind, has an insignificant effect until speeds of approximately 15 to 20 knots are obtained.

c. Load.

(1) Load is a variable factor and must be considered carefully by the aviator. Smaller amounts of fuel may be carried to improve performance or increase useful load; however, this necessitates a sacrifice in range.

(2) Under conditions of high density altitude, additional engine power is required to compensate for the thin air. If the maximum gross weight of the helicopter exceeds the limits of available engine power, a reduction in load may be necessary.

(3) Due to changes to density altitude and wind velocity during the day, the weight-carrying capability of a particular helicopter may vary many times during a single day.

(4) Established service ceilings for each helicopter must be considered in computing maximum load for safe operations.

6. Measuring Density Altitude

No instrument is available for measuring density altitude directly. It must be computed from the temperature and pressure at the particular altitude under consideration. The chart shown in figure IV.1 may be used as a field expedient in computing density altitude; however, the answers derived are based on variables and must be considered as close approximations.

7. Steps in Computing Density Altitude

Using the chart shown in figure IV.1 as a guide, density altitude is computed as follows:

Step	*Example*
a. Determine barometric pressure for point of takeoff/landing.	28.60" Hg
b. Determine field elevation at point of takeoff/landing.	2,000′
c. Apply altitude addition/subtraction to field elevation obtained in *b* above. Use amount corresponding to appropriate barometric reading found in *a* above. (Readings shown in two columns on right of chart.)	1,245
d. Find resulting pressure altitude.	3,245′
e. Obtain outside air temperature at field elevation of point of intended takeoff/landing.	95° F. (35° C.)
f. Move a pointer horizontally along temperature scale at the bot-	3,245′

Step	*Example*
tom of chart to degree reading obtained (*e* above), then vertically along temperature line until pointer intersects the diagonal pressure altitude line (*d* above). (Interpolate as necessary.)	
g. Move pointer horizontally to the left and read resultant density altitude in feet.	6,400′

8. Simplified Computation of Density Altitude (Approximate)

a. Density altitude should be determined before computing aircraft weight and balance data. The length of runway necessary for airplanes and the power requirements for helicopters are contained in the operator's manual for the appropriate aircraft.

b. The following formula may be used as a field expedient to determine approximate density altitude:

$DA = PA + (120 \times V_t)$, where—

DA is density altitude,

PA is pressure altitude,

120 is a temperature correction constant,

V_t is the variation of the actual air temperature from standard temperature at the pressure altitude.

c. The steps in computing density altitude by this formula are—

(1) Set *29.92* in the Kollsman window of the aircraft altimeter and read the pressure altitude directly from the altimeter face.

(2) Determine the standard temperature for the pressure altitude. Standard temperature of the air at sea level is 15° C., and the standard decrease of temperature with altitude above sea level is 2° C. per 1,000 feet. Therefore, for each 1,000 feet of pressure altitude above sea level, 2° C. is subtracted from 15° C. For each 1,000 feet of pressure altitude below sea level, 2° C. is added to 15° C.

(3) Subtract the standard temperature from the actual temperature to find the variation in the two temperatures.

(4) Substitute the determined values into the formula.

d. The following sample problems illustrate the use of the formula method of density altitude computation for—

(1) *Air temperatures above standard:*

Pressure altitude	2,010 feet.
Actual temperature (of the free air)	30° C.
Standard temperature	11° C.
Temperature variation	+19° C.

$DA = PA + (120 \times V_t)$
$= 2{,}010 + (120 \times 19)$
$= 2{,}010 + 2{,}280$
$= 4{,}290$ feet.

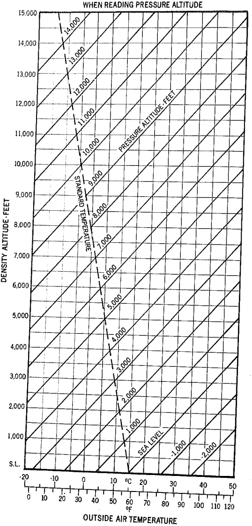
(2) *Air temperatures below standard:*

Pressure altitude	1,070 feet.
Actual temperature (of the free air)	6° C.
Standard temperature	13° C.
Temperature variation	−7° C.

$DA = PA + (120 \times V_t)$
$= 1{,}070 + (120 \times -7)$
$= 1{,}070 - 840$
$= 230$ feet.

(3) *A proposed landing site at altitude higher than point of departure:*

Pressure altitude at departure site	1,200 feet.
Actual altitude of departure site	1,020 feet.
Air temperature at departure site	15° C.
Actual altitude of proposed landing site	4,100 feet.
Standard temperature at proposed landing site	7° C.
Pressure altitude at proposed landing site (this is the pressure altitude at the departure site plus the difference between the actual altitudes of the two sites)	4,280 feet.
Computed free-air temperature at the proposed landing site (this is the temperature at the departure site minus 2° C.	

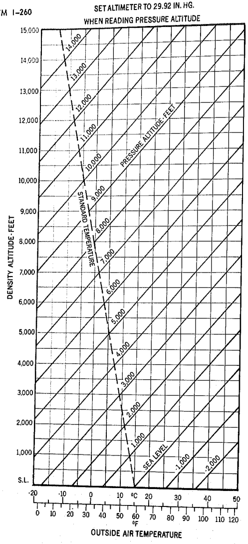


ALTIMETER SETTING IN.HG.	ALTITUDE ADDITION FOR OBTAINING PRESSURE ALTITUDE
28.0	1,825
28.1	1,725
28.2	1,630
28.3	1,535
28.4	1,435
28.5	1,340
28.6	1,245
28.7	1,150
28.8	1,050
28.9	955
29.0	865
29.1	770
29.2	675
29.3	580
29.4	485
29.5	390
29.6	300
29.7	205
29.8	110
29.9	20
29.92	0
30.0	- 75
30.1	-165
30.2	-255
30.3	-350
30.4	-440
30.5	-530
30.6	-620
30.7	-710
30.8	-805
30.9	-895
31.0	-965

Figure IV.1. Pressure altitude density chart.

for each 1,000 feet of difference between the actual altitudes of the two sites) ----------- 9° C.
Temperature variation --- 2° C.

$DA = PA + (120 \times V_t)$
$= 4{,}280 + (120 \times 2)$
$= 4{,}280 + 240$
$= 4{,}520$ feet at the proposed landing site.



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29.1	770
29.2	675
29.3	580
29.4	485
29.5	390
29.6	300
29.7	205
29.8	110
29.9	20
29.92	0
30.0	- 75
30.1	-165
30.2	-255
30.3	-350
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Figure IV.1. Pressure altitude density chart.

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APPENDIX V

EXTERNAL LOAD OPERATIONS

1. Preflight Procedures

An aviator planning an external load operation must be familiar with the operator's manual for the helicopter to be flown. The operator's manual contains information on sling capability, gross load limitation, airspeed limitation, performance data, systems operation, and hand signals for the ground crew.

a. Sling Capability. To plan his flight, the aviator must know the type and capability of the sling with which the helicopter is equipped. Some slings are of the nonrotating type and require a swivel hook; some helicopters use a nylon strap between the hook and the load as a vibration damper. In any helicopter, the weight capability of the sling must not be exceeded.

b. Gross Weight Limitation. Sling loads do not require the computation of weight and balance; however, for planning purposes the aviator must use the gross weight chart found in the operator's manual. This chart provides the flight crew with a rapid means of determining the load-carrying capabilities of the helicopter within safe operating limits. In extremely cold climates, structural limits can be exceeded without exceeding the performance limitations. Any flight exceeding gross weight limits should be written up on DA Form 2408-13 (Aircraft Inspection and Maintenance Record).

c. Airspeed Limitation. When computing the desired airspeed for the proposed mission, the aviator must refer to the operator's manual where there are airspeed correction tables for instrument error; charts for hovering, takeoff, climb, best range, maximum endurance, and landing distance; and operating limits charts which indicate maximum airspeed for a given load and density altitude. These charts give the best performance airspeed for various loads and pressure altitudes.

d. Performance Data. The operator's manual also contains charts which compute various loads and pressure altitudes for hovering, takeoff, climbs, range, maximum endurance, and landing distances, and show the expected performance of the helicopter equipped with a specific engine of a given rated horsepower. Engine operating limitation charts are available for each type and model engine, giving power limitations based on operating rpm, type and grade fuel used, and temperature.

e. Systems Operation. The operator's manual gives a complete operational explanation of the sling and its release systems. On the preflight, the aviator must check the condition of the sling and make an operational test of each mode of cargo release.

f. Hand Signals for Ground Crewmen. Hand signals to be used by the ground crew for day or night operation are published in the operator's manual. The preflight is not complete until the aviator has briefed his ground crew on their duties and the mission to be performed.

2. Pickup Procedures

a. To pick up an external cargo, the aviator positions the helicopter approximately 100 yards short of the pickup point into the windline at an altitude of approximately 100 to 125 feet. Speed should be commensurate with the type helicopter, terrain, and wind. He then establishes a rate of descent and reduces speed to arrive at a point 6 to 8 feet short of the pickup point at an altitude of 6 to 8 feet. At this point, the rate of descent has stopped and the helicopter is in a level attitude with forward movement limited to that indicated by the signalman.

b. The signalman directs the aviator to a position over the load, and the load is attached to the hook by the hookup crew. As soon as the load is securely attached, the hookup crew clears the area directly beneath the helicopter and signals the signalman that the load is ready to lift.

c. On direction from the signalman, the aviator takes up the slack in the sling until he "feels" the load. He then increases power slowly until the helicopter is centered directly over the load. The aviator then hovers the helicopter momentarily to determine if sufficient power is available for transition to forward flight.

d. The signalman indicates to the aviator by giving the takeoff signal that the load is clear of the ground and properly suspended. The takeoff should be accomplished with as little nosedown attitude as possible, so that most of the available power can be transmitted into lift rather than forward thrust in the initial takeoff phase. This procedure decreases the possibility of the helicopter sinking and the load striking the ground before gaining sufficient translational lift to begin a climb. When the helicopter has attained a safe altitude, power is reduced to that necessary for a climb to the desired cruising altitude.

3. In-Flight Procedure

a. *Power Check*. Before attempting forward flight with external cargo, the helicopter should be hovered momentarily to determine how much power is required to maintain hovering flight. If this requirement is very near the maximum allowable power, forward flight should not be attempted because of the possibility of the load striking the ground. This is due to a sinking tendency as the helicopter moves into forward flight and the nonavailability of additional power to counteract this tendency.

b. *Aircraft Performance*. High-stacked, light loads generally tend to shift farther aft as airspeed is increased. When the load is heavier, more compact, and balanced, the ride is steadier and the airspeed may be safely increased. With any type of external cargo load, airspeeds of over 90 knots are not recommended in the CH-34. Any unbalanced load may jump, oscillate, or rotate, resulting in loss of control and undue stress on the helicopter. This requires reducing forward airspeed immediately, regaining control, and "steadying up" the cargo load. The weight and balance of the load determine air worthiness (steadiness in flight) and the maximum airspeed at which the helicopter may be safely flown. At the first indication of buildup in oscillation, it is mandatory to slow airspeed immediately because the oscillation may endanger the helicopter and personnel, and may necessitate jettisoning the load. For a complete explanation of the release systems for the helicopter to be flown, see the operator's manual.

c. *Operation of Release*. Generally, the three positions (or mode selections) for external cargo release are *on*, *safe*, and *auto*. The desired position should be decided upon prior to reaching a hover over the intended release point. When the helicopter is in a hover over the desired release point and the relative motion of the helicopter over the ground is zero, the pilot instructs the copilot to place the master cargo switch in the desired release-mode position. Upon signal from the signalman, the crew chief, or at the aviator's own discretion (as the situation may dictate), the release button is actuated. If the *auto* mode has been selected, the cargo load should release automatically when the load tension is reduced (as the load touches the ground).

4. Release Procedure

a. The transporting helicopter approaches the cargo release area and is guided into position for cargo release by the signalman who has positioned himself in the same manner as for hookup (par. 6*b*). The cargo release men stand by, but are not actively employed unless the helicopter crew cannot release the cargo, either electrically or mechanically, from within the helicopter.

b. The signalman directs the lowering of the load onto the ground, then directs the helicopter crew to release the load.

c. After the signalman insures that the cargo sling is completely released from the cargo hook, he gives the aviator the signal to take off and then moves quickly aside out of the takeoff path.

5. Emergency Procedure

When the cargo cannot be released by either the helicopter crew or ground personnel and no applicable instructions are contained in the unit SOP or other directives, the cargo release crew may—

a. Cut the cargo free with any sharp object, such as a pocket knife, bayonet, or sheath knife.

b. If the cargo net is metallic, use a cable cutter; i.e., diagonal cutters, pliers, or a similar cutting device.

c. Release cargo snap fasteners and cut draw cable.

6. Duties of Ground Crew

a. *General.* The ground crew normally consists of three men—the signalman and two hookup men. However, if the situation demands, one man may serve as the hookup crew. The transported unit is responsible for providing the ground crew personnel for helicopter external load operations. These crews should be properly trained and kept abreast of developments on new equipment and operational techniques and procedures. Ground crews should be briefed by the aviator or an aviation representative who is familiar with the mission to be performed. The ground crew must—

(1) Be familiar with the type of cargo to be transported.

(2) Direct the planning of the cargo load for hookup.

(3) Inspect the load to insure that the slings are not fouled and the load is secured and ready for hookup.

(4) Insure that the area to be used is clear of obstructions that could snag the

(5) Insure that cargo weight does not exceed the capability of the helicopter. load, sling, or cargo net.

(6) Be familiar with helicopter hand signals for both day and night operations.

b. *Duties of Signalman.*

(1) As the helicopter approaches the hookup area, the signalman takes a position about 50 feet beyond and upwind from the load, facing the load with his arms raised above his head. His position must be such that the aviator can plan his approach on him; the signalman must remain in view of the aviator during the entire hookup and departure process.

(2) As the helicopter approaches the load, the signalman positions himself approximately 45° off the aviator's side of the helicopter, remaining approximately 50 feet away from the load.

(3) After the helicopter has come to a hover, the signalman guides the aviator directly over the load for hookup. (All signals must be precise, with no unnecessary movements.)

(4) After the hookup is completed, the signalman signals the aviator that the load is securely attached. He then gives the hookup men sufficient time to clear from beneath the helicopter before giving the aviator the signal to move upward.

(5) As the helicopter moves upward, the signalman insures that the load is properly secured and that the cargo is properly suspended.

(6) The signalman then gives the aviator the takeoff signal and moves quickly aside to be clear of the takeoff path.

c. *Duties of Hookup Men.*

(1) As the helicopter hovers over the sling load, the hookup men will position themselves next to the cargo to prepare for hookup. Their position should be one from which the hookup can be accomplished quickly and easily and in plain view of the signalman at all times.

(2) After the hookup, the hookup men must insure that the cargo hook is properly secured and then move quickly from beneath the helicopter and out of the takeoff path.

Caution: **In case of an emergency, the hookup men will exit from beneath the helicopter to the right; the aviator will move the helicopter to the left.**

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By Order of the Secretary of the Army:

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