SECTION VI
FLIGHT CHARACTERISTICS

TABLE OF CONTENTS

INTRODUCTION.

The helicopter is capable of flight over a speed range extending from approximately 30 knots rearward to approximately 142 knots forward and sideward flight up to 35 knots.

The helicopter has an automatic flight control system, (AFCS) which improves its basic flying qualities. The rotor of this helicopter can be safely engaged and stopped in winds up to 60 knots. Cyclic and tail rotor pitch control provide taxi capability in winds from any direction. The tricycle landing gear gives good ground handling characteristics and minimum radius turns are easily accomplished. Water maneuvers in any direction while floating in a level attitude are accomplished with minimum power expenditure. The helicopter lifts into a hover in a generally level attitude; however, this is a function of of center of gravity location; aft CG giving a slightly nose high attitude, and forward CG a slight nose down attitude. Two control system characteristics are incorporated which simplify coordination of controls, when lifting off to a hover. As increasing collective pitch results in an increase in main rotor torque, an increase in tail rotor thrust will be required to offset the yawing moment induced. This is accomplished automatically by an integral mechanical coupling within the control system which alters tail rotor pitch as a function of collective pitch. Therefore, pedal applications required by the pilot to hold his heading as power is applied to hover will be very small. The second mode of mechanical coupling, also provided during a collective change, imparts a proportional lateral tilt to the rotor cone to counteract the rolling unbalance and lateral drift induced by the change in tail rotor thrust. Rpm control during all ranges of flight is simplified with the turbine engine installation. Once a rotor speed is selected the engine fuel control will automatically maintain the selected rpm. Only small adjustments to engine trim speeds will be required to compensate for a slight droop which occurs after power changes.

LEVEL FLIGHT CHARACTERISTICS.

Control displacement while moving away from a hover is positive in all directions; however, initial response to a cyclic input will be slightly greater with the AFCS operating. Any oscillation induced by an aerodynamic disturbance, while hovering, will be dampened within one cycle with the AFCS operating. With the AFCS off, the oscillations are mildly divergent but are easily controlled by the pilot. While transitioning from hovering into forward flight, without AFCS at high weights, momentary application of aft cyclic to maintain desired pitch attitude after the basic applications of forward cyclic may be noted, but control is easily maintained. During climb, control is positive about all axes and no difficulty is encountered in maintaining best rate-of-climb speed. The heading will be maintained at all flight conditions with yaw channel of the AFCS operating, and the helicopter will return to original heading without oscillation if disturbed by a gust. Without the yaw channel operating, any disturbance in yaw will be dampened in a few cycles. When entering sideslips, control positions will always be in the proper direction, (right lateral cyclic with left pedal) and no control reversals will be encountered throughout the range of sideslip angles. There is adequate tail rotor power available to accomplish any desired directional maneuvering. In the speed range from 50 knots to Vmax, a forward cyclic increment will be required to increase airspeeds. The helicopter will always exhibit a tendency to return to trim following a disturbance in pitch or roll, with AFCS engaged. With the AFCS off, any oscillations in pitch and roll will be dampened in a few cycles. At high rotor speeds, disturbances in pitch and roll will be dampened best. At higher rotor speeds, control margins are greater. No violent helicopter motions are encountered when entering autorotation in forward flight; however, some trim change will be noticed. The amount of cyclic trim change required is a function of airspeed at the time of autorotational entry. At high forward speeds, some right lateral and aft longitudinal trim changes are required. The amount of trim change on autorotational entry will decrease with airspeed. Rpm decay rate after a sudden reduction of power is high if collective pitch is not lowered rapidly; however, rotor rpm builds up again on reduction of collective pitch. Adequate tail rotor power is available during autorotation to accomplish all maneuvering and directional control is positive in sideslip. Flare is effective in reducing airspeed and rate-of-descent, if recommended rotor speed is maintained in autorotation and there is adequate rotor inertia for an effective flare. Power off touchdown is made in a slightly nose high attitude, but the helicopter is capable of low autorotation touchdown speeds when desired. Power on approach and vertical landing is accomplished using normal technique. Run-on landings are easily accomplished on properly prepared surfaces with final approaches and touchdowns made in a near level attitude. The tricycle landing gear affords good control after touchdown.

LEVEL FLIGHT CHARACTERISTICS UNDER VARIOUS SPEED CONDITIONS.

For hovering or low speed flight, high rotor rpm is required because of the high power and control necessary. When hovering or flying at low speed and increased forward speed is desired, the cyclic stick is moved forward. A momentary settling may occur with rapid acceleration, and then the helicopter will begin to climb because the main rotor blades encounter an increased flow of air due to the forward movement of the helicopter. As the helicopter accelerates to approximately 50 knots IAS, collective pitch should be steadily decreased to maintain a constant altitude. To maintain the same altitude above approximately 60 knots IAS, an increase in collective pitch is necessary until maximum speed is reached. At maximum speed, a higher collective pitch setting is required than for hovering and power turbine speed should be between 100 and 103%, depending where it is smoothest. As forward speed is increased, the helicopter will assume an increasing nosedown attitude. This is caused by the rotor blade flapping hinges that are located at a distance from the center of the rotor hub. When the main rotor blade tip-path plane is tilted forward to increase forward speed, the centrigugal force of the blades will tend to align the plane of the rotor hub, and consequently the fuselage, with the forward tilted tip-path plane. The automatic stabilization equipment introduces fore-and-aft cyclic control corrections to maintain a given fuselage pitch attitude thus providing automatic cruising speed control. As the helicopter is decelerated from cruise condition, power required decreases until 50 - 80 knots is attained. Below this airspeed, power required increases as airspeed decreases. (Figure 6-1 portrays only unaccelerated level flight condition.) During conditions of light gross weights, low altitudes and temperatures, power required will normally be less than power available allowing a margin for maneuver. At heavy gross weights, high altitudes and temperatures, the power required may exceed the power available; thereby, preventing level flight at slower speeds. Figure 6-1 illustrates conditions where power required exceeds power available resulting in descending flight until increased forward airspeed is attained. When the helicopter is decelerating, descending or rotor RPM has decayed and the condition is to be reversed, power required will be even greater. Even if there is sufficient power available to reverse the rate of descent or deceleration, the engines may not fully accelerate before the speed or RPM has decayed below the point where level flight is possible. When operating in conditions where OGE hover is not possible, level flight below 50 KIAS and less than 103% N_r should be avoided.

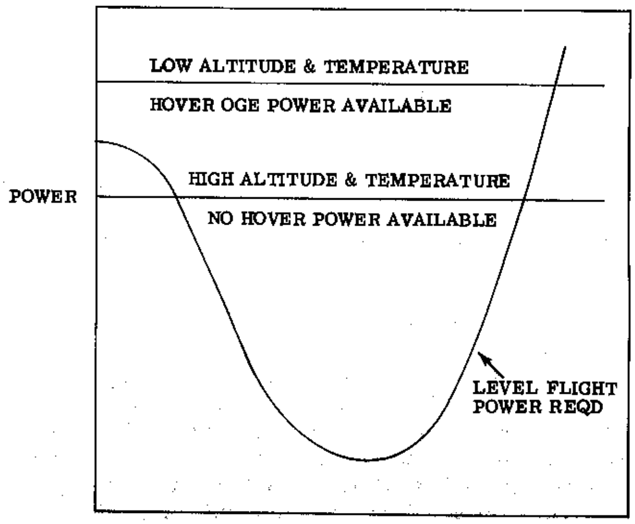

Figure 6-1. Forward Airspeed Unaccelerated Level Flight

STALLS.

Stalls, as applied to a fixed-wing aircraft, will not occur in a helicopter. However, the helicopter may encounter a stall condition referred to as blade stall described in this section.

BLADE STALL.

Blade stall, the tendency of the retreating blade to stall in forward flight, limits the high speed potential of the helicopter, increases stresses, and decreases component life. The retreating blade (the blade moving away from the direction of flight) has a tendency to stall because the blade tip is traveling at the rotational velocity minus the forward speed of the helicopter. As the velocity of the retreating blade decreases, the blade angle of attack must be increased to equalize lift to provide stabilized flight. As the angle of attack increases, with the highest blade angles being at the tip, the blade will stall (loose lift and increase drag). The increased drag will cause loss of rotor speed unless power is increased. The advancing blade (the blade moving into the direction of flight) on the other hand is traveling at a substantially higher speed and has relatively uniform low angles of attack and is not subjected to blade stall. Blade stall will first occur at the blade tip and is most likely to occur when operating at high values of airspeed, gross weight, density altitude, and power and especially with low rotor RPM. Maneuvers, acceleration, or turbulent air, all of which increase "g" load factors, will induce blade stall by reducing the airspeed at which blade stall will occur. The blade stall chart as presented in figure A-35 portrays the airspeeds at various pressure altitudes, temperatures, gross weights, rotor speeds, and load factors (angle of bank) as limited by blade stall. This blade stall chart establishes maximum recommended airspeeds to allow for turbulence, mild maneuvers, and necessary control inputs to maintain the desired flight attitude. At these speeds roughness, encountered by reasonable maneuvers or mild turbulence, can be tolerated. Severe turbulence or abrupt control maneuvers at this point will increase the severity of the stall and the helicopter will become more difficult to control. In the blade stall condition, each main rotor blade will stall as it passes through the stall region and create vibrations per revolution equal to the number of blades. If stall is allowed to fully develop (speeds in excess of those shown in figure A-35), loss of control will be experienced and the helicopter will pitch upward and to the left. The use of forward cyclic stick to control this pitch up is ineffective and may aggravate the stall as it increases the blade angle of attack of the retreating blade.

METHODS OF ELIMINATING ROUGHNESS CAUSED BY BLADE STALL.

If blade stall is causing roughness in the helicopter during high speed flight, or when maneuvering at lower speeds, the roughness may be eliminated by accomplishing one or any combination of the following:

1. Decrease collective pitch.

2. Decrease the severity of the maneuver.

3. Gradually decrease airspeed.

SETTLING WITH POWER.

At high altitudes, at high gross weights, or when operating with reduced power, it may not be possible to maintain level flight due to a lack of power that will cause settling to occur. The settling is of minor consequences, except at certain rates of descent and low forward speed, where it is extremely critical. During an approach, as the glide slope steepens at constant speed, the power required initially decreases; however, this trend does not continue indefinitely. After a certain glide slope is reached, further steepening of the glide slope requires more, rather than less power. At any altitude or gross weight, when the airspeed is below translational lift and the rate of descent is high, settling with power may occur. The possibility of entering settling with power is further increased, during conditions of low airspeed and high rates of descent, if a tailwind exists or a large or rapid application of aft cyclic is applied. When a critical power settling condition occurs, roughness and a partial loss of control may occur, indicated by ineffectiveness of the controls. The vertical velocity of the downward airflow through the main rotor is high while at near hovering attitude. Under certain power and rate of descent combinations, the downwash from the rotor begins to recirculate, up, around, and back down through the effective outer rim of the rotor disc. The helicopter sinks into the air mass it has just displaced in trying to obtain lift and the main rotor blades work continually in their own turbulent airstream. The velocity of the recirculating air mass may become so high that full up collective pitch lever may not produce sufficient lift to control rate of descent. Increasing collective pitch and/or adding more power normally has little effect towards recovery since it only antagonizes the turbulent airflow. To recover from the condition, increase forward airspeed, decrease collective pitch, or enter autorotation if altitude permits. A considerable loss of altitude may occur before the condition is recognized and recovery is completed. During approach for landing, the conditions causing power settling should be avoided. During descent or takeoff above congested areas or mountanious terrain, anticipate changes in wind velocity and direction and cross-check airspeed with ground speed.

CAUTION

When operating below translational lift, avoid rates of descent in excess of 500 feet per minute for normal operations, and 300 feet per minute when operating in conditions of high density altitude / high gross weights.

FLIGHT CONTROLS.

FLIGHT CONTROL SERVOS.

The primary servos at the rotor assembly and the auxiliary servos at the mixing unit are both in operation at all times. Because of the servo units, the control forces are virtually eliminated and are constant throughout their full range. This may cause a tendency to over-control at first, because there is very little feel in operating the cyclic stick unless the cyclic stick trim system is in operation. If either servo system should fail or malfunction, it may be turned off, provided there is hydraulic pressure in the other system. Both servo systems may be turned off by the pilot; however, the switching prevents both servos being turned off at the same time. If the primary boost, which physically controls the lower swashplate is turned off, movement of the lower controls and swashplate is accomplished through the auxiliary boost which is located near the cockpit controls. In this instance, feel of the pilot's control remains almost unchanged except for small differences due to friction and lost motion in the control system. If the auxiliary boost is turned off, the pilot physically moves the push-pull rods and bellcranks up to the primary boost. In this instance, a friction force of several pounds is noticeable and stability augmentation through the AFCS is lost. In addition, if the auxiliary servos are inoperative, the tail rotor control forces will be transmitted to the tail rotor pedals since the tail rotor does not have a separate servo.

NOTE

Prior to turning auxiliary servo off, AFCS should be turned off to avoid cyclic jump if the auxiliary servo is to be turned on again.

COORDINATION OF FLIGHT CONTROLS.

The climb and descent of the helicopter is controlled primarily by raising or lowering the collective pitch lever; however, coordinated movements of the tail rotor pedals and cyclic stick are necessary to maintain a constant heading. When collective pitch is increased to ascend, additional torque is developed by the main rotor. This torque can be compensated for by use of the tail rotor pedals. However, minor changes are accomplished by the yaw compensator, which is a mechanical coupling within the flight control system that changes tail rotor pitch proportionately with a change in the main rotor collective pitch. The torque-compensating tail rotor pitch changes are accomplished automatically when the automatic flight control system is engaged. Sideward flight from hovering is accomplished primarily by lateral displacement of the cyclic stick; however, it is necessary to use tail rotor control to prevent the nose from swinging toward the direction of flight. When flying sidewards to the right, the cyclic stick is displaced to the right and the left tail rotor pedal is used to keep the nose of the helicopter in the original direction. For sideward flight to the left, the cyclic stick is displaced to the left and the right tail rotor pedal is used. In hovering with no wind no appreciable movement of the cyclic stick is necessary; however, with a wind condition the cyclic stick should be held into the wind to maintain the same relative position above the ground. Turns while hovering are accomplished primarily by depressing the right pedal for a right turn and the left pedal for a left turn. During forward flight at low speeds, coordinated movements of the cyclic stick and tail rotor pedals are necessary to accomplish turns. In high speed flights, less pedal displacement is necessary to accomplish turns.

HELICOPTER VIBRATION.

The inherent vibrations in any helicopter are those created by the mechanical functions of the engines and transmission systems, dynamic action of the main and tail rotors, and aerodynamic effects on the fuselage. The overall vibration level is influenced by the many individual frequencies of vibration and combinations thereof. Many multiples of a basic frequency are felt, and often two or more different superimposed frequencies create beats. The overall magnitude is the resultant of the amplitudes of all the frequencies. It would be difficult for the pilot to completely separate all the types of vibrations encountered. Generally, these are divided into three categories; namely, (1) low (2) medium, and (3) high frequencies. Varying magnitudes of all three types of vibrations are often present in an individual helicopter. Only through experience will the pilot be able to judge what is normal to the model and what is abnormal and correctable.

LOW FREQUENCY VIBRATIONS

One Times Main Rotor Speed (One Per Revolution).

This vibration emanates from the main rotor system and is generally caused by main rotor head or blade unbalances. This vibration produces a rotary excitation of the fuselage which feels like a lateral oscillatory roll or wallow to the pilot. If this vibration is present in all regimes of flight, it should be noted in Form 781. The most probable causes are:

1. Main rotor blades out of track. A blade track adjustment is not warranted even though the blades appear to be slightly out of track, if a one per revolution vibration is not present. Out of track condition could be caused by:

   a. Damaged main rotor blade trailing edges.

   b. Main rotor blade static balance beyond tolerances.

2. Worn or loose control rod end bearings.

If the vibration is present in a hover only, the cause could be the same as item 1. as well as:

   a. Main rotor blade dynamic balance beyond tolerances.

Ground Roll.

Ground roll is a one per revolution lateral roll of the helicopter which often occurs during rotor engagement, and is due to the in-plane misalignment of the main rotor blades, causing an out-of-balance condition in the main rotor system. When the rotor attains flying speed, centrifugal force normally aligns the blades and the vibration disappears. If the vibration continues with the rotor up to speed at flat pitch, but disappears when the helicopter is lifted into a hover, then the cause could be as follows:

1. Static balance of main rotor blades.

2. The landing gear struts need servicing.

2/3 Times Main Rotor Speed (2/3 Per Revolution).

In flight conditions that result in high main rotor blade flapping angles, a condition of negative pitch lag coupling can occur in which the capability of rotor system damping is exceeded. This condition, called pitch lag instability, is felt as a heavy lateral rotary oscillation which can become increasingly violent if airspeed is allowed to build up or N_r is further decreased. It is not desirable to remain in this condition. Immediate corrective action is to lower the collective, increase rotor speed, and reduce airspeed and/or the severity of the maneuver.

Flight conditions under which pitch lag instability may be encountered are as follows:

1. At forward CG loadings.

   a. High forward speeds.

   b. Right sideward flight or hovering in a right crosswind.

2. At any CG loading.

   a. Exceeding allowable forward speed.

   b. High gross weight.

   c. Low rotor speed.

   d. Steep turns, level or climbing.

   e. Gusty wind conditions.

   f. Abrupt pull up from a dive.

If 2/3 per revolution vibrations should be experienced during the above conditions, it should be noted in Form 781.

Tail Shake.

Tail shake, sometimes erroneously referred to as two per revolution vibration, is an aerodynamic effect of the tail rotor passing through the disturbed air of the main rotor system in certain flight regimes. This vibration will be felt as a random impulse around the yaw axis. The trailing position of the tail rotor relative to the main rotor head, resulting from flying the helicopter in a right slip, can induce this vibration in the speed range of 50-80 knots, especially with an aft center of gravity loading.

TAIL ROTOR BUZZ

Under certain flight conditions, a medium frequency tail rotor vibration may occur. The pilot can identify this condition, commonly referred to as "tail rotor buzz", by a loud buzzing sound and simultaneous airframe vibration originating in the tail rotor area. Buzz has not been encountered in forward flight. Buzz can occur in hovering flight regimes in which the relative wind is from the right. Susceptibility to buzz increases with increases in tail rotor blade pitch, relative wind velocity, helicopter gross weight, main rotor rpm, and relative wind direction (increasing from 020 to 060, diminishing after 100 degrees).

Critical relative wind directions result from several flight regimes. Some examples are listed:

a. Crosswind hover, wind from right, front quarter.

b. Right sideward flight while headed into the wind, the combined velocities producing a resultant wind from the right, front quarter.

Recovery from buzz may be achieved by reducing the tail rotor blade pitch or changing the relative wind direction. Applying right tail rotor pedal produces the most rapid recovery, as it simultaneously reduces tail rotor pitch and brings the relative wind direction toward the nose of the helicopter. Lowering the collective pitch decreases the buzz vibration and might be employed when external clearance precludes turning right and when altitude permits a descent and/or landing.

MEDIUM FREQUENCY VIBRATIONS.

Five Times Main Rotor Speed (Five Per Revolution).

The five per revolution vibration is caused by the dynamic response of the main rotor blades to unsymmetrical aerodynamic blade loading. Its intensity is greatest at high forward speeds, at low gross weights, and during transition to a hover at high gross weights. It is felt in transition to a hover as a steady vertical shake caused by the main rotor blades traversing the downwash of preceding blades. This is normal to the helicopter when felt at the point where the collective pitch is increased to sustain the hover, or when hover taxiing the helicopter into and out of translational lift. The effect can be reduced in transition to a hover by leveling the helicopter just prior to applying collective pitch, and by planning the approach so that final pitch application at a slow rate will be sufficient to attain the hover. At high speeds, the difference in the lift distribution between the advancing and retreating main rotor blades results in heavy vibratory loads on the rotor head as the spanwise center of lift of each blade moves in and out. It is felt as a combination of vertical and lateral shake at the same frequency. The bifilar absorber assembly is designed to counteract the four per revolution inplane force (in the plane of rotation of the rotor head). The five per revolution vibration levels in the cockpit and cabin have been substantially reduced in the vertical as well as lateral levels by the reduction of the airframe torsional response obtained by reducing the four per revolution in plane force. Once properly tuned the bifilar absorber assembly will remain in a tuned condition over a wide range of rotational speeds. The lateral portion of the vibration is often reflected in the left tail rotor pedal or the copilot's collective pitch stick. Lateral vibration will usually decrease as N_r is increased. If five per revolution vibration is excessive at high forward speeds, an attempt should be made to distinguish between vertical and lateral vibration. Fly the helicopter to maximum speed to see if the visual cues of lateral vibration are noticed. A possible cause could be improper torque of the main gear box tiedown bolts. The type of vibration felt should be noted in Form 781. If visual cues of lateral vibration are noticed, beginning at some airspeed above 100 knots IAS, and worsen as airspeed increases, the ramp may be at fault. Reduce airspeed below 100 knots IAS, lower the aft ramp to the extent of the safety cables, and then fly the helicopter to maximum speed. If the vibration is noticeably reduced, then the cause is the ramp interfering with normal fuselage motion. Note the type and cause of vibrations in Form 781. If lowering the aft ramp in flight does not reduce the vibration sufficiently, and the vibration is encountered randomly in various flight regimes, the tail rotor may be the cause.

One Times Tail Rotor Speed.

Vibration (caused at 1243 cycles per minute at 100% N_r) is usually due to tail rotor blade pattern dissymmetries and is not easily identifiable by the pilot because of its proximity to five times main rotor frequency. It is evidenced by an increase in overall helicopter vibration. Since this frequency is close to five per revolution (1015 cycles per minute) the two frequencies sometimes modulate (beat) at a frequency of 228 cycles per minute, which is felt as a shudder throughout the helicopter and is hard to distinguish from one per revolution (203 cycles per minute). When excessive vibration is suspected in all regimes of flight, it should be noted in Form 781.

HIGH FREQUENCY VIBRATIONS.

High frequency vibrations may be felt as a tingling sensation in the soles of the feet or a tickling in the nose. In extreme cases, the instrument pointers will appear to be fuzzy. High frequency vibrations will normally emanate from the engine, main gear box input section, or tail rotor drive system, and are often equally apparent in a ground run as in flight. The most important cue, by far, to high frequency vibration will be the associated sounds. If a crewmember is available in the cabin area, he can assist in locating and defining vibrations as well as visually monitoring the tail rotor tip path plane.

Tail Rotor Drive Shaft Vibrations.

Generally, these vibrations are caused by an unbalanced drive shaft or bad bearings. These vibrations can be identified during ground run by feeling the tail cone.

Main Gear Box Vibrations.

The main gear box contains many possible sources of high frequency vibrations such as the various gear box mounted accessories, the accessory gear train, the APU and APU clutch, oil cooler blower, and the input bevel gear and freewheeling units. These vibrations are generally heard rather than felt in the airframe. Combinations of these high frequency vibrations in extreme cases could result in the pilot sensing low or medium frequency vibrations. These would be detected as vibrations which are affected only by variation in main rotor speed, and may be just as apparent in a ground run as in flight. There are also numerous gear clash sounds that occur under various conditions, the acceptability of which can only be determined by experience or measurements by instrumentation.

Engine Vibrations.

The engine gas generator and power turbine will normally beat together at various N_g and N_f combinations, or with N_f split off from N_r. To the pilot, the only obvious evidence of excess vibrations will be greatly increased high pitch noise levels. If the magnitude appears abnormal, it is well to check alignment of the power turbine or high speed main gear box input shaft and conditions of engine mounts. It is often possible to reduce this vibration by rotating the engine main drive shaft in relation to the main gear box input shaft in 90^o increments until in a ground run the vibration is diminished. If the noise level of one engine seems excessive compared to the other engine at the same power condition, and if the excessive noise varies, with N_g or N_f changes and is perhaps accompanied by a tingling vibration in the engine control levers, then a bad engine bearing or rubbing compressor blades may be indicated. Listen carefully to the engine during normal shutdown. Any unusual noises during coastdown after the speed control has been shut off might require an engine change. Note any engine vibrations in Form 781.

MANEUVERING FLIGHT.

The high degree of maneuverability makes it possible to execute many maneuvers such as hovering, vertical take-offs, and vertical landings which permit operations from extremely small areas.

DIVING.

Blade stall limitations are especially critical during recovery when G load factors are increased. The recovery from a dive should be made very shallow to prevent the occurrence of blade stall.

FLIGHT WITH EXTERNAL LOADS.

The helicopter has no unusual characteristics when carrying an external load, except in strong or gusty winds when the cargo may tend to swing.

WARNING

External loads which have aerodynamic characteristics may cause oscillations to the extent that the load may oscillate into the rotor blades and/or fuselage. Oscillations can usually be controlled by slowing the forward speed of the helicopter or entering a coordinated turn so that centrifugal force will aid in recentering the external sling load.

TAIL ROTOR EFFECTIVENESS.

Exceptional circumstances may sometimes lead to power-on operation between 98 and 100% N_r. Below 98% N_r, a number of factors may work in combination to cause a reduction in yaw control authority available to the pilot. Yaw control authority (Tail Rotor Thrust Available) is directly influenced by main rotor RPM, cyclic, collective and rudder pedal inputs, power settings, flight path, wind, and density altitude. Generally, the most important factor affecting yaw control authority will be main rotor RPM. Consequently, when at or near maximum engine power settings, at high density altitudes, yaw control authority will be lost at some point as main rotor RPM is progressively decreased below 98% and the aircraft will yaw to the right (The point at which yaw control authority is lost is variable and dependent upon the factors listed previously. Loss of yaw control authority is insidious in nature because of rudder pedal inputs made by the AFCS.)

When the engine is operating at or near topping, the application of any control requiring an increase in torque will cause the main rotor RPM to decrease. Control applications that cause this effect are increasing collective, left tail rotor pedal and rapid aft cyclic.

SECTION VII

SYSTEMS OPERATION

TABLE OF CONTENTS

ENGINE.

ENGINE CONTROL SYSTEM.

The power available from the engine is proportional to the gas generator speed (N_g) and power turbine inlet temperature (T_5) relationship. The engine must be operated within the N_g and T_5 limits. The engine fuel control accomplished this by maintaining certain scheduled acceleration, deceleration, and steady state limits. Acceleration, due to increased power requirements or speed selector movement, is controlled by a maximum fuel flow schedule limit, or by the topping governor. Deceleration, due to decreased power requirements or speed selector movement, is controlled by a minimum fuel flow schedule. Selected steady state conditions are maintained at optimum efficiency by a leadlag servo system which dampens the effect of power transients, and the control governor which maintains power turbine speed within the specified 8.5% droop limit at maximum speed selector position.

FUEL CONTROL SCHEDULING.

The fuel control does not monitor power turbine inlet temperature (T_5) directly. It monitors compressor discharge pressure and adjusts fuel flow to maintain engine temperatures within safe and predetermined scheduled limits. The amount or ratio of fuel to be burned, in proportion to the amount of compressor air available for both combustion and cooling, directly determines the temperature of the combustion gases at any point in a turboshaft engine. This ratio is known as W_f (weight flow of fuel) to compressor discharge pressure (P_3), and is used within the control to determine the required fuel flow schedules. Maintenance of a continuous flame within the gas generator combustion system depends on a proper mixture of fuel and air. As performance factors change, the values of both will change. The proportion between the two must be maintained or scheduled within limits or the flame will be lost (blowout or flameout). During deceleration, if fuel flow (which is decreasing) drops below a given amount, a lean blowout due to an insufficient amount of fuel for the air being used may occur. During acceleration, if fuel flow (which is increasing) rises above a given amount, a rich blowout and/or overtemperature due to an excessive amount of fuel for the air being used may be encountered.

TOPPING GOVERNOR.

The fuel control incorporates a topping governor which operates as a safety device, preventing overtemperature and overspeed of the gas generator. There exists a relationship between the operating temperature (T_5) and the gas generator speed (N_g). This temperature/speed relationship is a function of ambient temperature (T_2). The topping governor limits the maximum attainable gas generator speed for various ambient temperatures, and in doing so limits the maximum operating temperature (T_5). The topping governor is therefore a speed control exclusively, indirectly controlling T_5. For operation at maximum power, the gas generator operator operates near or at the highest possible T_5, except when low ambient temperatures (T_2) are encountered, then the maximum gas generator speed limit is reached first.

BOTTOMING.

The engine is considered at bottoming during deceleration whenever a minimum fuel flow (W_f) to compressor discharge pressure (P_3) ratio is attained. The bottoming schedule determines gas generator idle speed and the minmum W_f/P_3 ratio to sustain normal combustion.

DROOP.

Actual power turbine speed may vary from 5.5 to 8.5 percent from minimum to maximum load at a given speed selector position in the N_f governing range. This droop characteristic is a design feature incorporated to ensure N_f stability and to provide better multi-engine load sharing. The engine control parameters (N_g, W_f/P_3, and T_2) which maintain power turbine speed (N_f) within the desired operational tolerance for any given condition, are commonly referred to as droop lines or droop schedules.

GOVERNING RANGE.

In the governing range the engine drives the helicopter rotor at the speed and power selected by the pilot. The fuel control governing range is 89% N_f or above. However, the beeper trim system range is approximatley 91% to 108%. The engine control system maintains this selected speed by varying gas generator speed to meet the different power requirements produced by a change in the helicopter blade pitch angles, forward speeds, and atmospheric conditions. As blade pitch angle is increased, the engine fuel control increases gas generator speed until the maximum gas generator speed is reached. If the blade pitch angle is increased after the maximum gas generator speed is reached, a reduction in main rotor speed will occur.

TEMPERATURE LIMITS.

The amount of heat which engine components (particularly turbine buckets and turbine nozzles) can withstand without structural damage limits the amount of heat energy which should be released by burning fuel. Temperature is controlled by limiting the maximum fuel flow for the prevailing gas generator speed and inlet conditions.

COMPRESSOR STALLS.

Stall designates reversals of flow within the compressor. The severity of stall depends upon the number of reversals which take place per second. Low speed compressor stall is indicated by a moderate to fast rise in exhaust gas temperature. Severe compressor stall is marked by violent mechanical vibrations and increased engine noise level. Each compressor has a maximum pressure ratio for every speed at which it operates. The maximum pressure ratio sets a limit on the compressor discharge which can result from rotating the compressor at a particular speed. As long as the pressure at the compressor discharge equals, or is below this limit, the compressor will deliver air smoothly. However, if this limit is exceeded, flow will be reduced and there will be some reverse flow through the compressor. If it were not for the engine fuel control system, stall could occur during an attempt to accelerate the engine. A sudden and excessive increase in fuel flow might generate a volume of gas which would create an excessive backpressure at the compressor discharge, and compressor stall would result. Because each compressor speed has its own maximum compressor ratio, each must have its own stall point. Stall is avoided automatically by the fuel control which limits fuel flow during engine acceleration.

COLD HANGUP.

During a normal start on the automatic system of the fuel control, certain fuel flow scheduling malfunctions, although not affecting engine lite-off capabilities, may cause the engine gas generator speed (N_g) to fail to accelerate to normal idle speed. N_g will remain at approximately 35% with T_5 low. In this case, the emergency fuel control lever can be utilized after lite-off, to bypass the automatic features of the control and provide manual scheduling of fuel by the pilot to assist the engine acceleration to the normal idle speed range.

MAXIMUM POWER AVAILABLE AND TOPPING.

Maximum power available checks may be accomplished while in a hover, while in forward flight, or while on the ground; however, checks made while in a hover are more accurate. The foreign object deflector, when installed, reduces power available during forward flight; and, when not installed, ram air increases power available. Checks made with the helicopter on the ground are least desirable but are sometimes necessary because of dust, loose snow, helicopter too heavy to hover, etc. When the power available checks and topping adjustments are made with the helicopter on the ground or in low hover below 10 feet, T_5 limits may be reached early because of recirculation of exhaust gases into engine intake. Therefore, it is recommended that engine topping be rechecked after takeoff. Before making this check, compute the maximum power available for existing temperature and altitude. Compare the torque computed with that torque attained. If engine deterioration is suspected, proceed with N_g/T_5 relationship check in this section. During all the following procedures, be constantly aware of the engine and transmission limitations; namely, 721°C T_5 and 102.7% N_g, and 103% torque (123% single engine).

CAUTION

While making this check, it is permissible to operate the engine above 102.7% N_g and above 721°C T_5 for up to 28 seconds. However, under no circumstances should the engine be operated above 106% N_g or 735°C T_5 for any time period.

NOTE

Maximum power available checks performed in forward flight are not as accurate as those performed in a hover. However, when required to perform a maximum power available check during forward flight, the following approximate corrections should be applied to the power computed value obtained from chart (Figure A-3).

	CORRECTION WITH FOD SHIELD ON	CORRECTION WITH FOD SHIELD OFF
60 KIAS	-1	+1
80 KIAS	-2	+1
100 KIAS	-3	+2
120 KIAS	-3	+3
140 KIAS	-4	+4

Example given: OAT = +20°C, pressure altitude = 6,000 feet. Nr-103, 80 KIAS. FOD shield on. Find: maximum power available.

Enter chart A-3 at plus 20° C on the "with wind or forward flight" line. Go horizontally to 6,000 feet PA and then down vertically to 103 Nr. The answer (uncorrected for FOD Shield) is 88% Q. Subtract 2% Q to get 86% Q. This is what the engine should be producing at 80 KIAS forward flight. If it does not proceed with the maximum power, check in the next paragraph if necessary to complete the mission.

Maximum Power Available Check.

The following procedure describes a maximum power available check on the No. 1 engine with the helicopter either in a hover or forward flight. Checks made with the helicopter on the ground should be made on one engine, using collective to obtain desired engine readings. Maximum power available on No. 2 engine should be checked in the same manner. If the engine is not properly topped during the maximum power available check, proceed with topping adjustment.

1. Record OAT.
2. Push both speed selectors to maximum.
3. Using the engine beeper trim button, advance No. 1 speed Selector to maximum N_f.
4. If limits have not yet been reached using the engine beeper trim button, slowly retard the speed selector on No. 2 engine, observing the corresponding rise in N_g, T_5, and torque of No. 1 engine.
5. Continue retarding No. 2 speed selector until N_g and T_5 of the No. 1 engine no longer increase and N_f droops at least two percent. Note the N_g and T_5 readings on No. 1 engine. This is the topping reading.

NOTE

When OAT is below 10°C (50°F), the anti-icing system should be turned on when the topping check is made. At these low temperatures, with anti-ice operating, an increase in T_5 will result at any given N_g speed since additional air flow is being extracted from the compressor. If an engine is at topping, or is using maximum power with anti-icing off, and it is subsequently turned on, an overtemperature condition can result if the engine is already at or near the T_5 limits. If the engine is topped with the anti-icing on, subsequent deactivation of the anti-icing system will not result in T_5 overtemperature or N_g overspeed unless the OAT has increased sufficiently to affect the temperature limits. When engines are topped with the anti-icing system on, maximum power (torque) available will be some four percent less than topping with the anti-icing system off.

5. No adjustment to topping is required if either of the following conditions is met:
   a. For recorded OAT, N_g is within +0.0% to -0.5% of limit shown in figure A-38 and T_5 is less than 721°C.
   b. T_5 is 716°C to 721°C and N_g does not exceed the maximum operational limit shown in figure A-38 for recorded OAT.

CAUTION

A sudden increase in torque of the adjusting screw may indicate that the topping adjustment screw has bottomed. If this happens, do not attempt further adjustment. Continued rotation could cause failure of internal components of the fuel control.

Topping Adjustments.

1. If T_5 is less than 716°C and N_g is more than -0.5% below maximum speed limit specified in figure A-38 for recorded OAT, proceed as follows:
   a. Reduce power on engine being adjusted until N_g is at least 2% below topping.
   b. Direct crewman to rotate topping adjustment clockwise, being careful not to exceed T_5 limit. One full turn (36 clicks) increases topping approximately 2-1/4% N_g (16 clicks, approximately 1% N_g; 1 click equals approximately 1°T_5).
   c. Repeat steps 1 through 5 of Maximum Power Available Check until one of the conditions in step 5 is met.

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d. When ambient temperatures are below 25°C (77°F) and no increase in N_g is noted after topping adjustment has been increased, reset adjustment to original position. Engine is operating on its maximum fuel flow limit. In this case, it is necessary to fly at higher altitudes, as indicated in the following chart, where high gas generator speeds are obtained at lower fuel flows.

Ground Ambient Temperature	Altitude Required
Above 25°C	Sea level
-24°C to 25°C	2500 feet
-41°C to -24°C	5000 feet
Below -41°C	7500 feet

2. If T_5 exceeds 721° or N_g exceeds the speed limit specified in figure A-38 for recorded OAT, proceed as follows:

   a. Reduce power on engine being adjusted until N_g is at least 2% below topping.

   b. Rotate topping adjustment counterclockwise. One full turn (36 clicks) decreases topping approximately 2-1/4% N_g (16 clicks, approximately 1% N_g; 1 click equals 1° T_5).

   c. Repeat steps 1 through 5 of Maximum Power Available Check until one of the conditions in step 5 is met.

NOTE

Since T_5 and/or N_g may vary at each topping check, it will not be necessary to readjust topping unless T_5 exceeds 721°C and/or N_g exceeds 102.7%.

ENGINE FUEL CONTROL SYSTEM OPERATION.

The engine fuel control system must schedule fuel flow and variable vane positioning during three general operating conditions. These general operating conditions are: starting, idle, and governing range. The regimes of these conditions are related to the various engine speed control lever settings.

ENGINE STARTING.

During start, as the speed selector is advanced to the GRD IDLE position, the stopcock opens and allows fuel to pass through the flow divider and to enter the number one (low pressure) manifold to the nozzles where it is mixed with compressor-discharge air. As the fuel-air mixture leaves the nozzles, it is ignited by the two igniter plugs in the combustion chamber and enters a sustained combustion process. The fuel temperature sensing portion of the flow divider operates in conjunction with an auxiliary metering valve in the fuel control. The auxiliary metering valve is arranged in tandem with the main metering valve in a manner that allows its orifice area to decrease as the orifice area of the main metering valve increases. The lower portion of the flow divider housing contains a bellows that senses fuel temperature to vary the area opening of an attached needle valve. The temperature compensated needle valve and the fuel control auxiliary metering valve are arranged in series with each other and in parallel with the main metering valve. Fuel flow past the auxiliary metering valve is routed to the flow divider needle valve where it is biased by fuel temperature and then ported back to the fuel control to be added to the main flow. As the engine accelerates and fuel flow increases, the auxiliary metering valve will move toward the closed position and will be fully closed at 250 lb/hr flow. At this point, the temperature compensating system is eliminated and total fuel will be metered by the main system.

Normal Start.

A normal start is one in which the engine accelerates from starter initiation, through lite-off, to idle speed in a 40 second time period (standard day conditions). This time period includes: 20 seconds from time starter is engaged to lite-off, (10 seconds maximum for starter to accelerate engine from 0 to 19% N_g and 7 to 10 seconds to lite-off), and 20 seconds as the engine accelerates to idle speed. Engine acceleration from lite-off to ground idle is a function of ambient air temperature and can vary from a 20 second minimum at 15°C to a maximum of 30 seconds at 55°C, or 45 seconds at -55°C. The normal engine starting procedure requires starting the APU first so that the accessory section of the main gear box is activated.

Starting and Rotor Engagement Procedures With APU Inoperative.

This procedure is limited to ambient temperatures above -6.7°C (20°F). The main transmission chip detector should be monitored, during flight, following an engine start and rotor engagement with APU inoperative.

NOTE

This procedure is allowed to permit use of the helicopter, with the APU inoperative, when overriding operational requirements dictate. However, accelerated wear to the main transmission input sleeve bearings can be expected when using this procedure.

Engine Starting With External Power.

Should be APU be inoperative, the engines may be started with either ac or dc external power. Accomplish ENGINE STARTING AND ROTOR ENGAGEMENT procedures outlined in section II for one of the engines, with rotor brake off, and refer to Rotor Engagement with APU Inoperative in this section.

Starting With Battery.

Should the APU be inoperative, and neither ac nor dc external power is available, it may be possible to start the engines with battery power only. All dc operated equipment not essential for engine start must be rendered inoperative, either by turning off switches or pulling circuit breakers, to permit maximum utilization of available battery power to attempt to obtain 19% N_g for the engine start. One engine should be started from the battery, and the start should be made with the rotor brake off. Refer to EMERGENCY BATTERY START in section III, and Rotor Engagement With APU Inoperative in this section.

CAUTION

When starting with less than 19% N_g is attempted, a successful start is unlikely and engine overtemperatures should be expected. If it is evident that 19% N_g cannot be obtained, refer to EMERGENCY BATTERY START in Section III.

NOTE

If initial attempt is aborted, make second attempt on other engine.

Paralleling Batteries.

In the event that the battery voltage is so low that a battery start cannot be accomplished, an additional source of battery power may be connected in parallel with the installed battery, either at the battery or through the dc external power receptacle.

NOTE

When paralleling batteries through the dc external power receptacle, both the battery and external power switches must be on and the battery compartment door must be opened.

Rotor Engagement With APU Inoperative.

Should the APU be inoperative, and one engine can be started by utilizing external power, or battery power, it is imperative that extreme caution be exercised when engaging the rotor head. The rotor brake should be off as the one engine is started. After engine lite-off, and as N_g increases, the rotor head will begin to rotate. At approximately 8% N_r, the transmission oil pressure should be above minimums required, servo pressures should be sufficient to operate the flight controls, and a successful rotor engagement can be completed. As the rotor acceleration continues, utilize minimum torque necessary for a smooth rotor engagement. The speed selector should not be advanced forward of the ground idle position until the transmission oil pressure and servo pressures are normal. As the rotor builds up speed, the transmission oil pump supplies the required lubrication. The cyclic stick and collective pitch lever must be held firmly, since a slight kick-back may feed back into the controls as servo pressure builds up. After the rotor is engaged, disconnect the external power (if connected) and start the other engine. After the rotors are engaged, complete items under BEFORE STARTING ENGINES except APU start, flight control servo check, cyclic stick trim check.

CAUTION

The speed selector should not be advanced forward of the ground idle position until the transmission oil pressure and one of the servo system pressures are normal. This procedure is necessary to preclude damage to the main transmission input sleeve bearing as a result of initial lack of lubrication and to assure positive control of the rotor head system during rotor engagement.

CAUTION

When ambient temperatures are -6.7°C (20°F) or colder, refer to Engine Start and Rotor Engagement Procedures With APU Inoperative in section IX.

NOTE

When an external power start has been accomplished, the flight control servo check cannot be performed as during normal procedures. If dc external power or battery was utilized, ac equipment will not be available until after rotor engagement.

Engine Starter Drop Out.

Starter operation and drop out may be determined by noting the magnetic compass heading during engine start, or by noting the loadmeters, which drop to zero when the starter is engaged and resume their normal readings when the starter drops out. When the starter is energized, the compass will swing violently to an new heading. At approximately 45 to 53% N_g, the compass should swing back to its original heading signifying the starter has dropped out. The starter bleed valve will drop out when the starter drops out.

IDLING ENGINES.

Idle to Transition Range. A small advance of the speed selector will cause the engine to accelerate to the transition range. As the speed selector is advanced, T_5 will advance fairly rapidly as the fuel flow/compressor-discharge pressure (W_f/P_3) ratio increases until it is limited by the fuel control. At this point, the feedback function of the fuel control will decrease the fuel flow/compressor-discharge pressure (W_f/P_3) ratio, lowering T_5, until a new steady state operation is attained. During this time, N_g should show a steady increase.

NOTE

Prolonged operation of the engine in the transition range (between idling and minimum governing range) is not recommended.

Idle to Operating (Nf Governing) Range.

As the speed selector is advanced from the GRD IDLE position into the normal operating range, T_5 and N_g will advance rapidly as the fuel flow/compressor-discharge pressure ratio increases until it reaches the maximum acceleration schedule. Fuel flow will continue to increase in proportion to N_g, according to the rate of speed lever advancement. At this point, the fuel flow/compressor-discharge pressure ratio and T_5 will decrease along the topping schedule as N_g increases to the new steady-state condition.

Increasing Engine Load.

Increasing engine load causes the gas generator to accelerate. During acceleration, maximum fuel flow is delivered to the engine, with the rate of increase limited by the 3D cam contours to avoid compressor stall, rich or lean blowout, or turbine overtemperature. When the gas generator speed required to match output power to the new load is reached, fuel flow decreases to the level necessary to maintain the new steady-state speed.

Decreasing Engine Load.

Decreasing engine load causes the gas generator to decelerate. During deceleration, the engine fuel control supplies the minimum fuel flow which will maintain combustion until the gas generator approaches the speed which will match output power to the new load. The engine fuel control then supplies the fuel flow necessary to maintain this speed.

Retarding Speed Selector.

Retarding the speed selector slightly, under normal or military load conditions, so that Ng does not drop below 91% Ng, will yield a deceleration not affected by feedback. The fuel flow/compressor-discharge (W_f/P_3) ratio decreases to the limit set by the new speed selector position and remains constant as the engine decelerates to the new steady-state condition.

Deceleration To Idle.

Retarding the speed selector from the normal operating range to GRD IDLE decreases fuel flow until the minimum fuel flow/compressor-discharge pressure ratio stop is reached. The gas generator slows down on a minimum fuel flow/compressor-discharge pressure ratio schedule and the negative feedback function of the engine fuel controls starts increasing the fuel flow/compressor-discharge pressure ratio until the bottoming schedule is reached. The gas generator then decelerates with an increasing fuel flow/compressor-discharge pressure ratio determined by the bottoming schedule until idle speed is attained.

SHUTDOWN.

The engine can be immediately shutdown from any operating condition in an emergency. When the speed selector is moved to the SHUT-OFF position, the stopcock shuts off all fuel to engine. However, it is advisable to operate the engine for a minimum of one minute at low power to allow the engine parts in the turbine (hot) section to cool down.

CAUTION

Indiscriminate use of emergency shutdown procedure from high performance conditions will increase the possibility of engine seizure and decrease the useful life of the engine.

ENGINE COMPRESSOR DETERIORATION.

In addition to salt water spray ingestion (refer to Section II, SALT WATER OPERATION), operational experience has shown that when helicopters operate in severe environments engines will experience a reduction in compressor efficiency and subsequent decrease in stall margin due to one or more of the following:

1. Compressor contamination and/or fouling due to inlet ingestion and buildup of carbon, dirt and oil based deposits on compressor blades/vanes, and exhaust gas reingestion.

2. Compressor blade/vane roughness and leading edge curl (erosion) due to sand/dust ingestion.

3. Compressor foreign object damage (FOD).

ENGINE COMPRESSOR STALL MARGIN CHECK.

The purpose of this check is to monitor stall margin to assure transient, stall free operation. Monitoring the available stall margin provides a means of problem detection before inflight discrepancies occur. It is necessary to periodically accomplish stall margin check and perform required corrective maintenance when stall margin has decreased below acceptable limits. The stall margin is measured by requiring the compressor to operate with the variable vanes blocked in the open position as N_g is reduced (instructions for accomplishing stall margin check are in T.O. 1H-3(C)E-2-2).

Ng/T5 RELATIONSHIP CHECK.

The N_g/T_5 relationship check, for comparison to the N_g/T_5 BASELINE, will identify engine compressor deterioration and thermocouple/aircraft instrument errors.

The N_g/T_5 BASELINE will be established on (1) initial engine installation or (2) following an acceptable Stall Margin Check on those engines that have accumulated time and the N_g/T_5 BASELINE was not established at initial installation. Procedures for establishing the N_g/T_5 BASELINE are contained in T.O. 1H-3(C)C-6CF-1. Also, the N_g/T_5 BASELINE will be maintained on the aircraft and filed with the AFTO 781 until the engine is replaced. When the engine is replaced, the N_g/T_5 BASELINE on the replaced engine will be destroyed and the N_g/T_5 BASELINE on the replacement engine retained with the aircraft (refer to EXAMPLE Figure 7-7 for information/guidance.

The N_g/T_5 relationship check (for comparison to the BASELINE) will be accomplished as follows:

NOTE

> There will be instances when the N_g/T_5 check will not be correct on T58-GE-5 engines at OAT above 40°C (104°F). Therefore, this check should be made at a lower OAT.

a. Perform the N_g/T_5 relationship check in any flight condition. Shut off anti-icing/compressor bleed. Also, if check is made in a hover, perform check at 40 feet (or higher) wheel height and head aircraft into the wind. This will prevent reingestation of exhaust gases.

b. Observe aircraft OAT. Select an OAT on the N_g/T_5 BASELINE chart closest to the aircraft OAT observed and establish the required Ng.

c. Stabilize N_g and record indicated T_5. Move horizontally to the right from the selected OAT to the "X" T_5 column (BASELINE).

d. If the indicated T_5 is more than 10°C below or 35°C above the "X" column value, make a Form 781 entry for appropriate maintenance action. Also, when indicated T_5 is more than 35°C above the "X" column value, operation below 40 feet over salt water should not be attempted until corrective maintenance has been accomplished.

ALTERNATE FUELS.

Flow divider density settings significantly affect engine starting characteristics if an improper density setting is utilized. However, once a successful start has been achieved, engine operation on any of the approved alternate fuels will be normal regardless of fuel control/flow divider density setting. To preclude starting problems, alternate fuels (see figure 7-2) should be chosen, if possible, which have the same density setting as the fuel remaining in the tank. When fuels requiring different density settings are mixed, or when the fuel density is unknown, (see figure 7-3) the flow divider/fuel control should be set at JP-4. In this situation, the engine may experience a cold hang-up, which can be corrected by USE OF EMERGENCY FUEL CONTROL LEVER TO ASSIST STARTING procedures in section III. The density setting should be changed to JP-5 once it is assured that the fuel control/flow divider contains an alternate fuel requiring a JP-5 density setting and the change entered in the Form 781. The following order of preference should be utilized when selecting an alternate fuel for cold weather operation (-10°F OAT and below).

General Grade	Starting Temperature Limit (Approximate)
JP-4	-65°F
Commercial Jet-B	-65°F
JP-5	-55°F
Commercial Jet A-1	-25°F
Commercial Jet A	-20°F
JP-8	-20°F

FUEL SYSTEM.

(Refer to figure 7-4.)

FUEL SYSTEM MANAGEMENT.

Forward and Aft Main Tanks.

Only that fuel contained in the forward and aft main tanks can be supplied directly to the engines. Fuel contained in the internal or external auxiliary tanks must be transferred into the forward or aft main tanks before it can be supplied to the engines. During normal operations, the forward tank supplies the No. 1 engine and the aft tank supplies the No. 2 engine. Each main tank contains two boost pumps which improve the engine operating envelope by providing fuel under pressure. Continuous use of one boost pump per tank is recommended to prevent inadvertent operation without boost pumps when their use is required (Refer to EQUIPMENT LIMITATIONS, Section V).

CAUTION

> If one fuel low-level caution light comes on, turn on all available boost pumps and open the crossfeed. If both fuel low-level caution lights come on, turn on all available boost pumps, open the crossfeed, and avoid nose-up attitudes greater than six degrees.

CAUTION

> The boost pumps in an empty tank should be shut off to conserve the life of the boost pumps and to prevent the possibility of fire. If the boost pumps are inadvertently left on, thermal limit switches in the pumps will automatically shut the pumps off if the temperature of the pump rises to 204°C (400°F), due to the lack of lubrication. This temperature, however, is considerably lower than the spontaneous flash point of the fuel and/or vapors.

	MILITARY SPECIFICATION	FUEL GRADE	NATO SYMBOL	FREEZE POINT °C (°F)	COMMERCIAL DESIGNATION
RECOMMENDED FUELS					
	MIL-T-5624	JP-4	△2 F-40	–58 (–72)	
ALTERNATE FUELS					
HIGH FLASH POINT KEROSENE	MIL-T-5624	JP-5	△2 F-44	–46 (–51)	
	MIL-T-83133	JP-8	△2 F-34	–50 (–58)	JET A-1
KEROSENE			F-34	–40 (–40)	JET A
			F-35	–47 (–53)	JET A-1
EMERGENCY FUELS					
LEADED AVIATION GASOLINE (NOT CONTAINING TCP)	MIL-G-5572	80/87	F-12	–60 (–76)	AvGas 80/87
	MIL-G-5572	100/130	F-18	–50 (–76)	AvGas 100/130
	MIL-G-5572	115/145	F-22	–60 (–76)	AvGas 115/145

WARNING

WHEN USING FUELS WITHOUT ICING INHIBITOR, AVOID FLYING AT ALTITUDES WHERE INDICATED OAT IS BELOW 0°C (32°F) TO PRECLUDE FUEL SYSTEM ICING.

NOTE

1. FUELS LISTED FROM TOP TO BOTTOM IN ORDER OF PREFERENCE.

△2 CONTAINS FUEL SYSTEM ICING INHIBITOR (FS11).

3. REFER TO T.O. 42B1-1-14 FOR ADDITIONAL FUEL USAGE DATA.

4. REFER TO NATO INTERCHANGEABILITY TABLES T.O. 42B1-1-15 FOR NATO NATIONAL SPECIFICATIONS.

Figure 7-2. Fuel Availability Chart

FUEL, FUEL CONTROL AND DIVIDER SETTINGS VS TYPE START TO EXPECT (INITIAL STARTS ONLY)

FUEL	FUEL CONTROL SETTING	FLOW DIVIDER SETTING	TYPE OF START TO EXPECT
JP-4	4	4	NORMAL
JP-4	4	5	MOST PROBABLE HOT
JP-4	5	4	COLD HANGUP TENDENCIES
JP-4	5	5	MOST PROBABLE HOT
JP-5	5	5	NORMAL
JP-5	4	5	HOT TENDENCIES
JP-5	5	4	MOST PROBABLE HANGUP
JP-5	4	4	MOST PROBABLE HANGUP
JP-8	5	5	NORMAL

Figure 7-3. Fuel, Fuel Control and Divider Settings vs Type Start

OPERATION OF FUEL SYSTEM

CONDITION	CROSSFEED SWITCH	FUEL SHUT-OFF VALVES	BOOST PUMP SWITCHES
		BOTH ENGINES OPERATING	
Normal Operation - Fwd tank to left engine and aft tank to right engine	CLOSED	Both - OPEN	4 pumps - ON or 1 pump - ON for each tank
Both tanks to both engines	OPEN	Both - OPEN	*4 pumps - ON or 1 pump - ON for each tank
Either tank to both engines	OPEN	Both - OPEN	*Tank in use - BOTH - ON Tank not in use - 1 pump - ON
		ONE ENGINE OPERATING	
Fwd tank to left engine or aft tank to right engine	CLOSED	Good engine - OPEN Failed engine - CLOSED	Tank in use - BOTH - ON Tank not in use - BOTH - OFF
Both tanks to either engine	OPEN	Good engine - OPEN Failed engine - CLOSED	*4 pumps - ON or 1 pump - ON for each tank
Either tank to opposite engine	OPEN	Good engine— OPEN Failed engine - CLOSED	*Tank in use - BOTH - ON Tank not in use - 1 pump - ON

*When using fuel from both tanks, it is possible that fuel will actually be supplied from one tank only. This can occur if the difference in the normal operating pressure of the boost pumps is sufficient to close the check valve downstream of the weaker pumps. When using fuel from both tanks, check the fuel quantity gages periodically. If the fuel is being consumed at an unequal rate from the tanks, it may be more satisfactory to operate from one tank at a time in order to equalize the fuel quantity in each tank. This is accomplished by turning on two boost pumps in the tank containing the greater quantity of fuel and operating only one boost pump in the other tank. If one boost pump is inoperative in the tank containing the greater amount of fuel, equalization is accomplished by shutting off the boost pumps in the tank that is not to be used.

Figure 7-4. Operation of Fuel System Table

Internal Auxiliary Fuel Tanks.

The internal auxiliary fuel tank system, either single or dual tanks, may be installed to increase the range and endurance of all CH-3E helicopters prior to 16 . The single tank installation allows gravity transfer into either or both of the main tanks. The dual tank installation (two single tank systems) allows gravity transfer from the forward or aft auxiliary tank to its respective main tanks, and provides double the fuel capacity. Manual fuel shut-off valves are provided to control fuel transfer into the main tanks. The fuel transfer lines are equipped with a float valve which prevents overfilling of the main tanks. Each tank is also equipped with a fuel jettison line and dump valve.

External Auxiliary Fuel Tanks.

On CH-3E 16 ▶ and all HH-3E helicopters, external auxiliary fuel tanks may be installed to increase the range and endurance. Fuel may be simultaneously transferred from both external tanks to both main tanks by pressurizing the external tanks with engine compressor bleed air. Placing the pressurization switch in the PRESS position will open the auxiliary tank fuel valve and the bleed air shut-off valve for the respective external tank. Float valves in the main tanks operate at approximately 1900 to 2200 pounds, allowing fuel transfer at a rate greater than dual engine consumption. Fuel may be transferred into the main tanks as and when desired during flight. To preclude possible fuel discharge during fuel transfer from external tanks, leave the main tank selector (FWD and AFT) switches in the SELECT position at all times unless it is not desired to service a particular tank during a fuel transfer or air refueling operation. To control fuel transfer, place either or both of the auxiliary fuel tank pressure switches, LTK and RTK, in the PRESS or OFF position.

CAUTION

Improper fuel transfer procedures may cause fuel to discharge from the main tank filler cap (relief) valves.

NOTE

Flow light may flicker during probe retraction and fuel transfer.

When the auxiliary fuel tanks are empty, or fuel transfer is completed, turn the pressurization switches to OFF and resume normal fuel management. Empty auxiliary tanks will be noted when the fuel indicating system shows a steady decrease in the main tank fuel levels below approximately 1700 pounds.

During ground pressure or air refueling operations, all main and auxiliary fuel tanks can be simultaneously refueled. Individual selector switch selection will also permit any one or a combination of tanks to be refueled.

Fuel Crossfeed Procedures.

The fuel crossfeed valve provides a flexible operating system. When operating on crossfeed and one tank runs dry, both engines will continue to operate providing a boost pump is ON in the tank containing fuel.

WARNING

Both engines will flameout when operating on crossfeed if one tank runs dry and the boost pumps are off in the tank containing fuel.

During single engine operation, fuel may be transferred to either engine from either or both tanks at the same time.

6. Fuel quantity gages - MONITOR.

To Stop Fuel Dump.

1. Manual fuel dump line valve - CLOSED.
2. Manual fuel close line valve - OPEN.
3. Crossfeed valve - AS REQUIRED.
4. Boost pump - AS REQUIRED.

See IS-147

~~AFCS SYSTEM GROUND CHECKS.~~

AFCS Hardover Check (Pitch, Roll, Collective, and Yaw).

These checks may be performed before the first flight after maintenance work has been performed on the flight control system, the primary or the auxiliary servo system linkage, or on the AFCS servo valves. They may also be performed whenever a check of system authority is desired.

NOTE

If it is planned to activate the hardover switches in flight, the complete AFCS hardover check must be performed (with APU running) prior to engaging the rotors.

1. PITCH, ROLL, COLL, and YAW monitor switches on channel monitor panel - ON.

2. AFCS indicator mode selector knob - POSITION A.

WARNING

Actuation of the hardover switches with the AFCS engaged or disengaged can result in a full AFCS command hardover condition for the channel actuated.

3. All hardover switches in the forward position.

   a. Pitch hardover switch - FWD.

   b. Roll hardover switch - LEFT.

   c. Collective hardover switch - UP.

   d. Yaw hardover switch - LEFT.

4. With all hardover switches in the forward position, monitor the AFCS indicator for the following:

   a. The horizontal bar should rise (pitch channel).

   b. The vertical bar should move to the left (roll channel).

   c. The vertical arrow should rise (collective channel).

   d. The horizontal arrow should swing to the left (yaw channel).

5. Cyclic trim release button (cyclic stick) - DEPRESS. Move the cyclic stick from stop-to-stop. Control movement aft and right should be slower than movement forward and left; however, the rate of stick travel should not exceed one second from stop-to-stop. Push the collective pitch lever down. A force of 3 to 6 pounds will be required to move the collective pitch lever down. Push the right pedal to its extreme forward position. A force of 11 to 25 pounds will be required on the right pedal to prevent movement. Additional force will be required to move the right pedal. There is no force in the cyclic stick.

CAUTION

Any resistance or seizing of controls, or excessive pedal force during these checks, indicates improper adjustment of control linkages, and the helicopter should not be flown until the discrepancy is corrected.

6. All hardover switches in the aft position.

   a. Pitch hardover switch - AFT.

   b. Roll hardover switch - RIGHT.

   c. ~~Collective hardover switch - DOWN.~~

   d. Yaw hardover switch - RIGHT.

 See 15-147

7. With all hardover switches in the aft position, monitor the hover indicator for the following:

a. The horizontal bar should drop (pitch channel).

b. The vertical bar should move to the right (roll channel).

c. The vertical arrow should drop (collective channel).

d. The horizontal arrow should swing to the right (yaw channel).

8. Cyclic trim release button (cyclic stick) - DEPRESS. Move the cyclic stick from stop-to-stop. Control movement forward and left should be slower than movement aft and right; however, the rate of stick travel should not exceed one second from stop-to-stop. Raise the collective pitch. A force of 3 to 6 pounds will be required to move the collective pitch lever up. Push left pedal to its extreme forward position. A force of 11 to 25 pounds will be required on the left pedal to prevent movement. Additional force will be required to move the left pedal.

CAUTION

Any resistance or seizing of controls, or excessive pedal force during these checks, indicates improper adjustment of control linkages, and the helicopter should not be flown until the discrepancy is corrected.

9. All hardover switches - CENTERED and switch guards closed.

CAUTION LIGHT PANEL INDICATION CHART.

The caution light panel indication chart (figure 7-5) explains the affected caution light system, the circuit, the controlling component, and the indicated condition. The caution light panel (figure 1-20) will illuminate if any of the listed caution lights system or components are affected.

ADVISORY LIGHT PANEL INDICATION CHART.

The advisory light panel indication chart (figure 7-6) explains the affected advisory light system, the circuit, the controlling component, and the indicated condition. The advisory light panel (figure 1-20) will illuminate whenever any of the listed advisory lights systems or components are affected.

Figures 7-5 and 7-6 Deleted

T58GE5 Ng/T5 RELATIONSHIP CHECK

Engine S/N ____________________ A/C S/N ____________________

Date: ____________________

OAT (°C)	NG %	POWER TURBINE INLET TEMPERATURE ($C^{O}T_{5}$)											
								X					
-40	86.5	422	426	430	434	438	443	447	451	455	459	463	467
-35	87.5	438	442	446	451	455	459	463	467	471	475	479	484
-30	88.5	454	458	462	467	471	475	479	484	488	492	496	500
-25	89.0	465	469	474	478	482	487	491	495	499	504	508	512
-20	90.0	481	485	490	494	498	503	507	512	516	520	524	529
-15	91.0	497	501	506	510	514	519	523	528	532	537	542	546
-10	92.0	514	518	523	527	531	536	541	546	550	555	560	564
-5	92.5	524	529	534	538	543	548	552	557	561	566	571	576
0	93.5	540	545	550	555	559	564	569	574	578	583	588	593
5	94.5	557	562	567	572	576	581	586	591	596	601	605	610
10	95.5	573	578	583	588	593	598	603	608	613	617	622	627
15	96.0	585	590	595	600	605	610	615	620	625	630	635	640
20	97.0	601	605	611	616	621	626	631	636	641	645	651	657
25	97.5	614	619	624	630	635	640	645	650	655	661	666	670
30	98.5	630	635	640	645	650	656	661	666	671	677	682	687
35	99.5	646	651	657	662	667	673	678	684	689	694	699	705
40	100.0	659	664	670	675	680	686	691	697	702	708	713	718

Figure 7-7. EXAMPLE: Ng/T5 Relationship Check Chart (T58-GE-5)

EXAMPLE (T58-GE-5 Engine, Figure 7-7):

1. During FCF the "X" column value (BASELINE) was established, i.e. OAT 15°C, Ng stabilized at 96%, indicated T_5 was 615°C.

2. During this check the following were observed:

   OAT = 29°C
   Ng = Stabilized at 98.5%
   T5 = 670°C Indicated

3. Move horizontally to the right from 30°C OAT (closest to observed aircraft OAT of 29°C) until the "X" T_5 column is encountered (661°C). Allowable T_5 for this engine at this OAT is 651° C to 696° C (661° - 10° C to +35° C).

4. Engine is acceptable since observed T_5 (670°C) is within the limits of 10°C below to 35°C above the "X" column value (661°C).

SECTION VIII
CREW DUTIES

TABLE OF CONTENTS

CREW DUTIES AND RESPONSIBILITIES.

Each flight crewmember is delegated duties and responsibilities other than the primary duties outlined in NORMAL PROCEDURES, section II. These additional duties and responsibilities are prescribed in this section.

PILOT.

It will be the responsibility of the pilot to ensure that the helicopter and equipment is thoroughly inspected in sufficient time prior to departure to permit correction of discrepancies without delaying the scheduled take-off. The manner and proficiency with which each crewmember performs his related duty is the responsibility of the pilot. Therefore, the pilot must possess and maintain a thorough knowledge of each crewmember's duty and the problems related thereto. He must determine that the weight and center of gravity are within prescribed limits and thoroughly brief the crew on all particulars pertinent to the mission, ensuring that all passengers have been briefed on the operational use of emergency equipment and are familiar with warning signals and emergency procedures. The pilot must coordinate the activities of other crewmembers and the relationship of one crewmember's duty to another. The pilot is also responsible to ensure that any required debriefing is accomplished, and that required flight logs, records, and maintenance forms are prepared.

Crew and Passenger Briefing Guide.

The following briefing guides are provided to assist the pilot in conducting briefings, as applicable to the type mission assigned.

Crew Briefing.

1. Mission requirements.
2. Flight plan.
3. Fuel load.
4. Emergency - survival equipment.
5. Weather.
6. Special equipment.
7. Weight and balance.
8. Crew duties and responsibilities.

Passenger Briefing.

When the helicopter is used to transport personnel, passengers will be briefed before and during flight, as necessary. The pilot will normally perform this duty unless delegated to the copilot or flight mechanic. The briefing will cover predeparture briefing, over water briefing (when applicable). The following checklists include the items to be discussed during the briefing:

Predeparture Briefing.

1. Introduction of crew.
2. Destination.
3. Flight altitude.
4. Departure time and estimated time enroute.
5. Enroute weather.
6. Seats and safety belts. (Cover rules and demonstrate operation.)
7. Movement in the helicopter.
8. Smoking.
9. Emergency exits (location and operation).
10. Emergency landings or autorotations, (signals and exits).
11. Bailout (signals and exits).
12. Emergency equipment (fire extinguishers, crash axe, first aid kits, parachutes, and emergency exit lights).

13. Use of portable electronic device.

14. Helicopter characteristics. Passenger information card in helicopters.

WARNING

On those helicopters that lack soundproofing on on the cargo compartment walls and ceiling, all passengers should wear ear protection devices to avoid ear damage.

Over Water Briefing.

If flight plan includes the crossing of any extensive bodies of water, the following items will be included in addition to the emergency procedures contained in Predeparture Briefing.

1. Use of survival equipment (life vest, rafts, etc.).
2. Escape from parachute after entering water.
3. Emergency landing (signals, positions, exits, location of first aid kits, and emergency radio).

COPILOT.

The copilot assists the pilot in mission planning by obtaining pertinent weather forecasts, intelligence reports, maps, and other related documents; assists the flight mechanic in determining the cargo and passenger distribution and computing the center of gravity of the helicopter; assists the pilot in performing the exterior and interior inspections of the helicopter, and performs any additional inspection requirements deemed necessary by the pilot; assists the pilot in the operation of controls and equipment on the ground and in the air, and operate the helicopter in flight upon instructions from the pilot. The copilot should be familiar with the duties of the pilot and other crewmembers so that he may perform their duties in the absence of a complete crew complement. The copilot also prepares the flight log, required records and maintenance forms, and operates the communications and navigation equipment. In the absence of crewmembers, the copilot may be called upon to perform the following duties:

1. Rescue hoist operator.
2. Litter attendant.
3. Loadmaster.
4. Lower or raise cargo sling.
5. Handle sea anchor and mooring equipment in water operation.

FLIGHT MECHANIC.

The flight mechanic, at the discretion of the aircraft commander, will compute the weight and balance and complete the TOLD card. He will perform preflight duties, insuring that the aircraft is properly serviced and that all required maintenance inspections and discrepancies have been properly cleared prior to flight. He will also determine that all mission essential and emergency equipment is aboard and properly stowed. Before taxiing he will insure that the cargo compartment is secured for flight. During flight he will assist the pilot and copilot by observing engine instruments, circuit breakers, fuel management, warning and caution lights, fire detector indicators, electrical voltage and loads, evidence of fuel, oil and hydraulic leaks, landing gear operations and scanner duties. He will also perform the following duties:

1. Hoist Operator
2. Raise and lower cargo sling and provide verbal instructions during cargo sling operations an necessary.
3. Cargo and/or passenger loadmaster
4. Litter Attendant
5. Gunner

He will report abnormal conditions to the pilot and recommend corrective action, and ascertain that aircraft limitations are not exceeded. He will insure that the AFTO Form 781 is completed and assist in debriefing the ground crew personnel on all discrepancies noted. Away from home station, he may be required to analyze system malfunctions, perform minor maintenance repairs and maintain the AFTO Form 781. He is responsible for servicing and securing the helicopter any time when away from home station and ground crew personnel are not available. He also monitors ground movement of the helicopter and assists in mooring, etc., affiliated with water operations.

Rescue Hoist Operator.

The primary hoist operator during rescue operations is the flight mechanic, however, these duties may be delegated to other crew members as the mission dictates.

SMOKE/FLARE DROP CHECKLIST

1. Safety harness - ON.
2. Interphone Control — Set.
3. Gloves — On.
4. Door — Open.
5. Smoke/Flare device — Prepared.
6. Smoke/Flare drop checklist — "Completed" (FM).

HOIST OPERATOR'S BEFORE PICKUP CHECKLIST.

1. Safety harness - ON.
2. Cabin interphone control - Set.
3. Gloves - ON.
4. Door - Open.
5. Hoist master switch - "CREW" (P)

6. Hoist - Checked

7. Rescue device - Attached

8. Hot mike switch - ON.

9. Hoist operator's before pickup checklist - "Completed and ready for pickup, acknowledge." (FM)

NOTE

The pilot and copilot will acknowledge Hot Mike operation.

HOIST OPERATOR'S AFTER PICKUP CHECKLIST.

1. Survivor - "In and secure, ready for take-off." (FM)

2. Hot mike - OFF.

3. Hoist and cabin - Secure

4. Hoist master switch - "OFF, after pickup checklist completed." (FM)

GUNNERS OPERATING PROCEDURES.

The following instructions are provided for the performance of all normal and emergency aircrew procedures, from the time the aircrew reports to the loaded aircraft until after landing.

OPERATING PROCEDURES.

Preflight.

1. Applicable Exits - OPEN

2. Gun Mounts - Firing Position
   Remove pins position mounts and guns into firing position. Lock in place with pins.

CAUTION

Ensure that no portions of the aircraft are in the guns field of fire.

3. Guns - Checked

   a. Check guns for security in proper firing positions, freedom of movement throughout full travel, and extension installation on right hand gun.

   b. Check operating controls and safety lever for proper operation, barrel and bolt assembly for cleanliness.

   c. Safety Lever - S (Safety)

4. Gun - Stowed
   Remove pins and position mounts and guns in stowed position. Lock in place with pins. To stow guns and mount, reverse procedures in Steps 1 and 2.

5. Ammunition - Checked and Secured.
   Check type, quantity and proper loading in ammo can.

Arming

1. Personnel Harness - Checked and on. Properly adjusted and safety pin installed.

2. Helmet Visor/Goggles - Down/On

3. Guns - Firing Position
Place guns and mounts in firing position in accordance with preflight procedures.

4. Gunners — Left, Right, Aft Gunner — Request permission to arm gun. (For arming guns, see figure 8-1).

a. Safety Lever - F (Firing)

b. Cocking Lever - Pull cocking lever full aft and push full forward.

c. Safety Lever - S (Safety)

d. Latch Lever - Turn aft and raise cover.

CAUTION

Do not turn latch lever more than required to unlock the cover, as damage to the latch spring will result.

e. Ammunition - Position on feed tray.

f. Latching Cover - Close

5. Shell Casing Chute - Installed

WARNING

Weapons fired without the shell casing chute installed will cause damage to the aircraft's rotor blade system.

6. Gunners — Report by position; i.e., left gun, right gun, aft gun — "GUN ARMED AND READY TO FIRE."

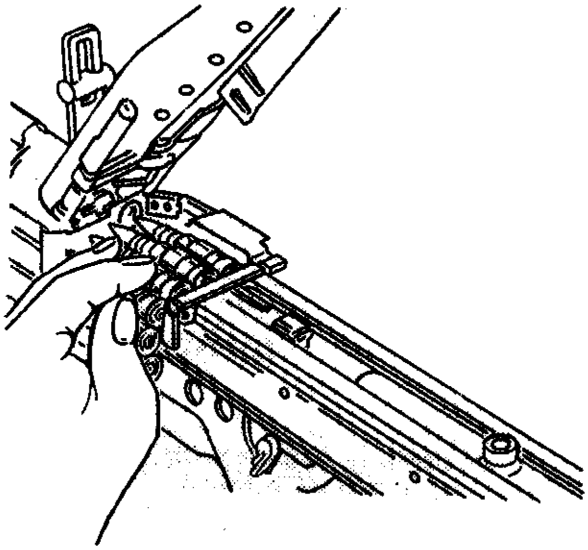


Figure 8-1. Arming Gun

Firing.

1. Gunner - REQUEST PERMISSION FROM PILOT TO FIRE.

2. Safety lever - F (Firing).

3. Guns - FIRE AS NECESSARY.

NOTE

Trigger must be completely released to fire single rounds or to interrupt firing at any time.

De-Arming.

1. Guns - DE-ARMED.

a. Latch on feed cover - RELEASE.

b. Feed cover - RAISE.

c. Feed chute/ammo - REMOVE.

d. Gun - CLEAR, ON S (Safety).

CAUTION

Before stowing, wait 5 minutes to allow the barrel/chamber to cool.

2. Guns and mounts - STOW.

EMERGENCY AIRCREW PROCEDURES.

The following descriptive and procedural material is provided for the performance of emergency aircrew procedures from the time the aircrew reports to the loaded aircraft until after landing.

Misfire.

A misfire is the complete failure of the weapon to fire. This is not dangerous but must be treated as a malfunction in the firing mechanism or a faulty round. A misfire should not be confused with a hang fire.

Hangfire.

A hangfire is a delay in the function of the propelling charge. The amount of delay is unpredictable, but in most cases will fall within the range of a split second to several seconds. Hangfire cannot be distinguished immediately from a misfire and therein lies the principal danger of assuming a failure of the weapon to fire immediately upon actuation of the firing mechanism as a misfire, whereas, it may prove to be a hangfire.

Cookoff.

A cookoff is the firing of the explosive components of a round due to the overheated chamber of the weapon and not to the actuating of the firing mechanism. When a cookoff occurs, the projectile may be propelled from the weapon with its normal velocity. If a cookoff is suspected, and round has not been extracted within 10 seconds, wait five minutes before the bolt is retracted.

Time Interval.

The definite time intervals for waiting after failure of weapon to fire are prescribed as follows:

1. Keep round locked in chamber for five seconds from the time a misfire occurs to insure against an explosion outside of the gun if a hangfire develops.

2. If the barrel is hot and a misfire stops automatic operation of the gun, wait five seconds with the round locked in the chamber to insure against hangfire dangers. If the round cannot be extracted within an additional ten seconds, it must remain locked in the chamber for at least five minutes due to the possibility of a cookoff.

Procedures in Case of Failure to Fire.

After a failure to fire, the following precautions, as applicable, will be observed:

1. Guns - ON TARGET.
   Keep gun trained on target for a minimum of five seconds.

2. Cocking handle - AFT.
   Pull cocking handle aft to attempt to eject round.

WARNING

If the round does not eject, do not attempt to fire the gun.

3. If round is ejected - RESUME FIRING.

4. If round is not ejected - RAISE COVER AND REMOVE BELT.

5. Close cover - ATTEMPT TO FIRE.
   If round fails to fire, inform pilot and wait five minutes for possible cookoff before bolt is retracted.

FLARE EJECTOR SET OPERATING PROCEDURES.

Any or all crewmembers (up to six) can operate the flare ejector set at one time. The six flare firing points are:

1. Pilot's cyclic stick
2. Copilot's cyclic stick
3. Flare programming control panel
4. Left side flare release panel
5. Flight mechanic's panel
6. Ramp observer flare release panel

All presets are made at the control panel. The number of flares per burst, the number of bursts for each firing initiated, and the time interval between bursts must be set on the control panel for mission requirements as instructed by the pilot.

Set the control panel BURSTS REMAINING indicator for total number of flares loaded divided by the control panel FLARES PER BURST switch setting. Settings are as follows:

FLARES LOADED	FLARES PER BURST SETTING	BURSTS REMAINING SETTING
32	1	32
32	2	16
32	3	11

Normal FLARES PER BURST switch setting is two flares per burst.

OPERATING INSTRUCTIONS.

Preflight

1. All flare ejector set circuit breakers - CLOSED.

2. Control panel - SET.

   a. FLARES PER BURST switch - AS REQUIRED.

   b. BURST SELECTOR - AS REQUIRED.

   c. INTERVAL SELECTOR - AS REQUIRED.

   d. BURSTS REMAINING - TO NUMBER OF BURSTS LOADED.

   e. TRANSFER/OFF switch - OFF.

   f. POWER/OFF switch - OFF.

   g. AUTO/OFF switch - AUTO.

Arming.

1. Pilot's AN/ALE-20 ARMING SWITCH - ON.

2. Control panel POWER/OFF switch - POWER.

Firing.

Upon missile sighting, press the release button at any release position; all release buttons are wired in parallel so that any crewmember observing an enemy missile launch can release a flare. Pressing the FAST TRAIN button on the control panel fires a flare every 65 milliseconds until all flares are released.

NOTE

No programming controls shall be adjusted during the execution of a flare program.

De-Arming.

1. Pilot's AN/ALE-20 ARMING SWITCH - OFF.

2. Control panel POWER/OFF switch - OFF.

CARGO SLING PROCEDURES.

1. Power available check - "COMPLETED" (P)

2. Crew/ground personnel - "BRIEFED AS REQUIRED" (P,)

3. Cargo Sling - LOWERED (FM)

4. Safety harness - ON (FM)

5. Cargo door - OPEN (FM)

6. Sling master switch - "SLING" (P)

7. Cargo Sling Checklist - "COMPLETED" (FM)

AFTER RELEASE CHECKLIST.

1. Cargo sling - STOWED (FM)

2. Cargo hook switch — "SAFE" (CP)

3. After Release Checklist - "COMPLETED" (FM)

SECTION IX

ALL WEATHER OPERATION

TABLE OF CONTENTS

INTRODUCTION.

This section contains those procedures that differ from or are in addition to the normal operating procedures outlined in section II, except where repetition is necessary for emphasis, clarity, or continuity of thought.

INSTRUMENT FLIGHT PROCEDURES.

Flight in this helicopter, during instrument conditions, is comparable to fixed wing instrument flight. The AFCS provides stable flight characteristics which are desirable for instrument flight. An instrument qualified helicopter pilot can safely perform instrument flight and approaches.

PREPARATION FOR INSTRUMENT FLIGHT.

Complete the normal inspection outlined in section II of this manual. Particular attention should be given to anti-icing system, pitot heat, windshield wipers, lighting, instrument systems, and navigational aids for proper operation.

WARNING

In cold weather, make sure all instruments have warmed up sufficiently to ensure normal operation. Check for sluggish instruments during taxiing.

INSTRUMENT TAKEOFFS.

In addition to these conditions which normally require an instrument takeoff, (e.g. precipitation, low ceilings, and night takeoffs) helicopter induced restrictions to visibility, such as dust or snow blown by the rotor downwash, may require an instrument takeoff. There are two recommended instrument takeoff techniques; the normal and the running takeoff. The running takeoff is recommended when there is insufficient power to perform the normal instrument takeoff. The attitude indicator should be adjusted by setting the pitch and roll adjustment knobs at the zero trim dots to assure that when the helicopter is flown, the correct attitude indications will be given. Attitude indicator may be readjusted during climb and cruise.

Normal Instrument Takeoff.

The normal instrument takeoff may be made either from the ground or from a hover. Align the helicopter with the desired takeoff heading and crosscheck the heading indicator. Advance the speed selectors to maximum N_r. Smoothly increase collective pitch to obtain a positive climb rate. Then change pitch attitude to a 8 degree nose low indication and maintain a level bank attitude. Maintain this attitude and cross-check the vertical velocity indicator and altimeter for positive climb indications while accelerating to 70 knots IAS. Then raise the nose slowly to a nose up indication of approximately 3 degrees, reduce collective pitch to obtain desired climb power, and adjust attitude to maintain desired climb airspeed.

WARNING

Do not attempt to hover the helicopter under actual instrument conditions. Instrumentation is not adequate to safely accomplish this maneuver.

Running Instrument Takeoff.

This takeoff is similar to a visual running takeoff. Align the helicopter with the takeoff direction and cross-check the heading indicator. Advance speed selectors to maximum N_r. Begin takeoff roll, ac- ■

celerating to 35 - 40 knots IAS. Move the cyclic stick aft, as necessary, while increasing collective pitch to obtain power for takeoff. As the helicopter leaves the ground, establish a 3 degree nose low pitch attitude, and proceed as in a normal instrument takeoff.

CAUTION

The helicopter may have a tendency to leave the ground in a slightly nose-down attitude. Care should be exercised to avoid striking the nose wheel on the ground.

INSTRUMENT CLIMB.

Climb under instrument conditions is similar to the climb technique and procedures outlined in section II for normal conditions. Recommended climb speed is 70 - 80 knots IAS with maximum continous power, or military power, if required. Standard rate turns are recommended below approximately 6000 feet MSL. At higher altitudes, half standard rate turns are recommended. Turns should be limited to a maximum bank angle of 30 degrees. For short duration climbs during cruise, increase collective pitch to obtain desired climb rate while maintaining cruise airspeed.

INSTRUMENT CRUISE.

Conduct instrument cruise flight as in normal flight procedures outlined in section II. Instrument cruise airspeed should be established in a speed range where vibrations are at a minimum. Refer to the Appendix, as necessary, to determine best cruise airspeeds. A minimum speed of approximately 70 knots IAS should be observed to maintain normal flight characteristics associated with forward flight. Crusing flight turns should be limited to bank angle of 30 degrees. Standard rate turns are recommended below approximately 6000 feet MSL. At higher altitudes, half standard rate turns are recommended.

RADIO AND NAVIGATION EQUIPMENT.

Radio and navigation equipment is operated in the normal manner.

WARNING

Operate the gyro select switch during level flight only; switching gyros during a bank could result in a severe roll.

HOLDING.

If delays are anticipated, fuel may be conserved by reducing power, as desired, or by establishing maximum endurance cruise.

DESCENT.

Normal enroute descents or radar descents to traffic altitudes are made at cruise airspeeds. Adjust power, as required, to obtain the desired rate of descent.

NOTE

If an emergency or other occasion requires expeditious descent, the following procedure may be used:

1. Reduce collective as much as possible, but not to exceed N_r limits, and lower the landing gear if desired.

2. Maintain cruise airspeed (if desired). Airspeed may be increased but not to exceed the maximum airspeed limitation in section V.

3. Initiate recovery approximately 500 feet above the assigned or desired altitude.

INSTRUMENT APPROACHES.

Use standard instrument approach procedures. Utilizing cruise airspeeds throughout the approach will reduce the effects of wind.

WARNING

For single engine approach maintain cruise speed if possible. Do not let airspeed fall below 70 knots. Operation at lower speeds can result in loss of altitude at higher gross weights and MISSED APPROACHES may not be possible.

NOTE

Instrument approaches with one engine inoperative will normally be the same as a two engine approach except for a possible reduction in airspeed. With auxiliary servo off, use maximum of 100 knots and 1/2 standard rate turns.

VOR/ADF/Range Approach.

Accomplish these approaches in accordance with figure 9-1.

Radar Approach.

Accomplish a radar approach in accordance with figure 9-2. Single engine radar approach procedures are included in figure 9-2. This emergency approach should use a 5 mile final approach to landing. Maintain an airspeed of 70 knots IAS to ensure single engine capability.

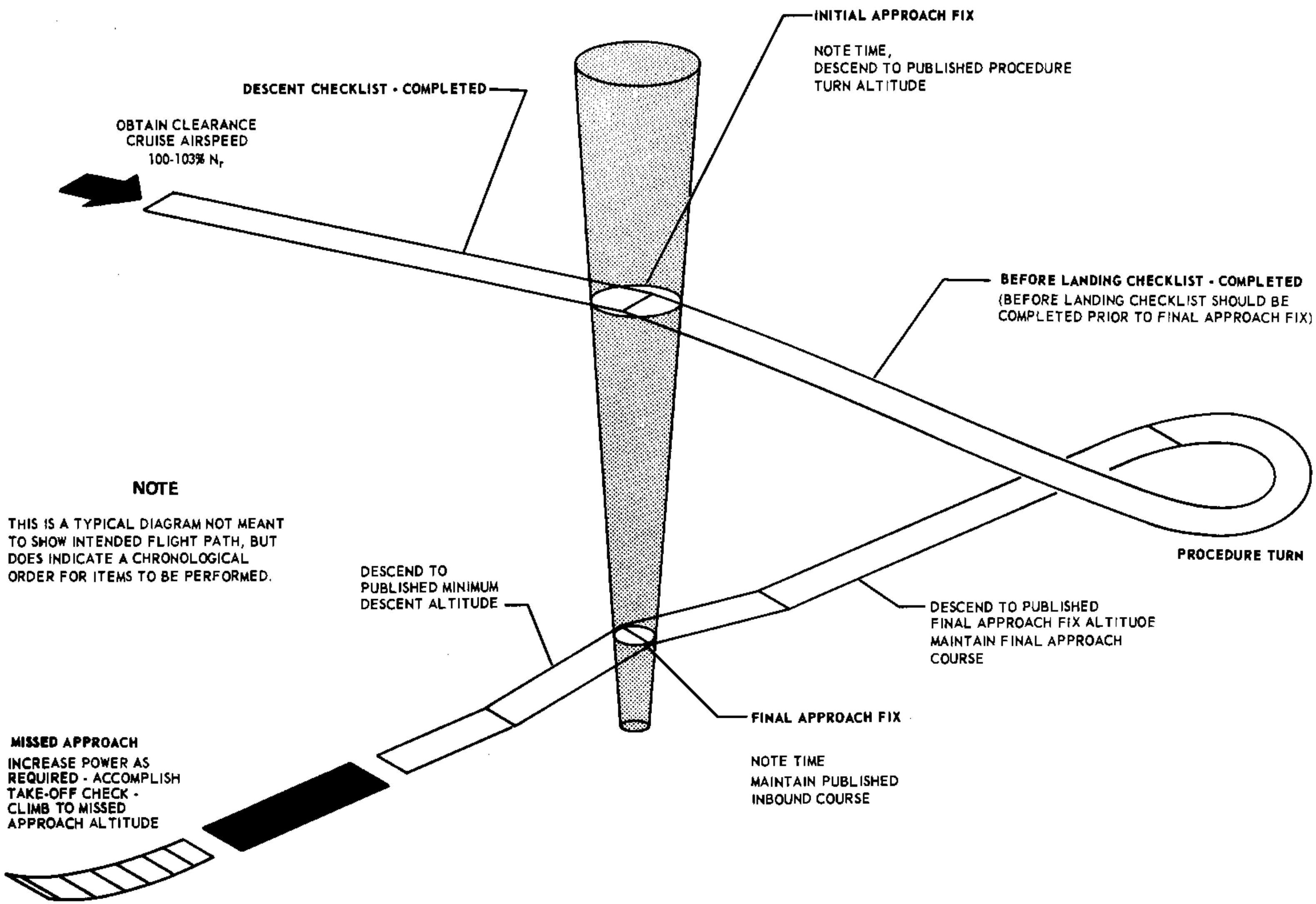
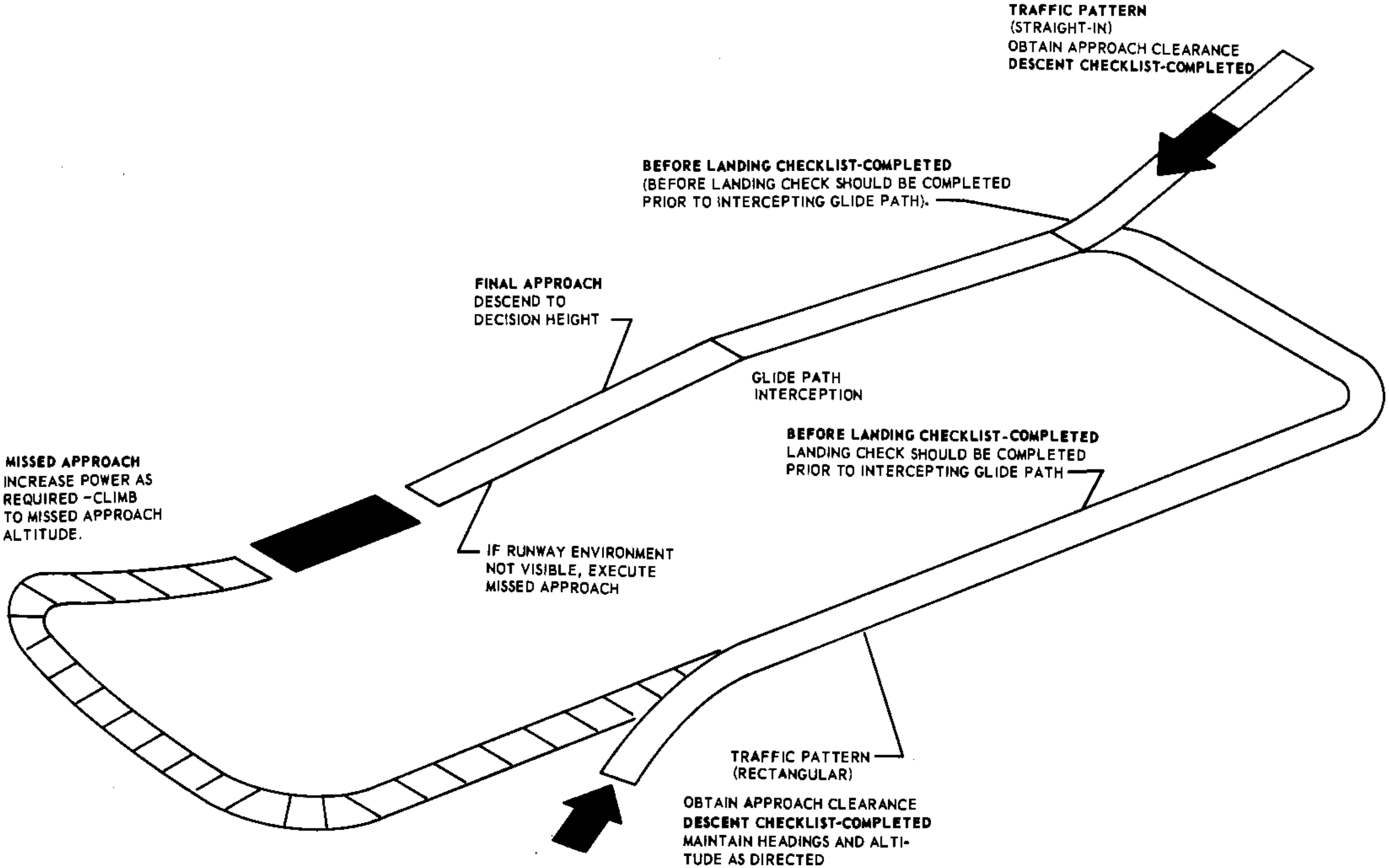


Figure 9-1. Range, ADF, VOR Approach (Typical) (Normal and Single Engine)



NOTE

THIS IS A TYPICAL DIAGRAM, NOT MEANT TO SHOW INTENDED FLIGHT PATH, BUT DOES INDICATE A CHRONOLOGICAL ORDER FOR ITEMS TO BE PERFORMED

Figure 9-2. Radar Approach (Typical) (Normal and Single Engine)

TACAN and ILS Approaches.

(See figures 9-3 and 9-4.)

Missed Approach Procedure.

If a missed approach is necessary, increase power as required to obtain the desired rate of climb while establishing desired airspeed. Continue climb to missed approach altitude as published or as instructed by approach control and accomplish AFTER TAKEOFF check.

ICE AND RAIN.

WARNING

To preclude the possibility of engine failure due to ice ingestion, the foreign object deflector shield must be installed prior to flight in known or forecast icing conditions, or visible moisture at or below 5°C (41°F). Without the foreign object deflector installed, minimize flight in icing conditions inadvertently encountered.

ICE.

Encountering icing in flight may result in loss of forward visibility, serious loss of lift and loss of rotor effeciency. Ingested ice can cause engine damage. Asymmetrical shedding of ice from rotor blades can cause large amplitude vibrations.

WARNING

- Do not attempt flight in freezing rain. Flight in icing conditions exceeding trace icing is not recommended unless contrahesive polyethelene anti-icing tape is installed on the main rotor blades. Flight in known light icing conditions is permitted if the tape is installed.
- Ice may form on rotor system without other visible signs of icing.

CAUTION

Minimize flight in icing conditions without anti-icing tape installed to avoid rotor blade damage.

The greatest dangers caused by ice accumulation are lowered rotor blade efficiency and loss of engine power. Ice accumulation accelerates blade stall, reduces rate-of-climb capability, and increases power requirements, thus increasing fuel consumption and decreasing range and endurance, and may impair control response and reduce engine power by obstructing the engine air inlet area. Icing of the engine inlet area is an ever present possibility when operating in weather with temperatures near the freezing point. Engine inlet icing is more prevalent when ambient temperatures are below 10°C (50°F). The engine inlet anti-icing system should be operated continuously during all conditions when ice may be encountered. A loss of gas generator speed and a rise in power turbine inlet temperature is indicative of engine icing. Engine inlet icing does not necessarily occur with blade icing.

Exterior Inspection.

Check the lower section of the engine air inlet for evidence of ice. Moisture, collected on the previous flight, can accumulate in the lower section and freeze. An attempted engine start could cause damage. If ice is suspected, check the engine to insure it is free to rotate. If the engine is not free to rotate, external heat must be applied to the forward engine section to permit thawing. Start the engine as soon as possible after thawing to remove all moisture before refreezing can recur. Check that the helicopter surfaces, controls, pitot tubes, static ports, ducts, blades, and oleo shock struts are free from ice.

WARNING

Remove all ice accumulations prior to flight. Snow, frost or light ice (up to 1/16") can be removed from the aircraft and rotor blades by normal run-up. A brush may be used as an alternate method. Moderate and severe ice accumulations will be removed in accordance with appropriate maintenance technical data instructions.

Rotor Engagement.

CAUTION

The helicopter may yaw on ice due to the lack of tail rotor control at low rpm when rotors are first engaged. Under these conditions the helicopter should be properly secured or moved to a dry area.

Taxiing.

When it is necessary to taxi on ice covered surfaces, use slow ground speeds so that cyclic stick displacement may be used as the primary braking force.

Takeoff.

The pilot must ascertain that the helicopter wheels are not frozen to the surface. A slight yawing motion, induced by light tail rotor pedal motion, should break the wheels free when they are frozen to the surface. Takeoffs into fog or low clouds, when the temperature is at or near freezing, could result in engine inlet icing. Rate of climb speeds should be higher than normal under such conditions.

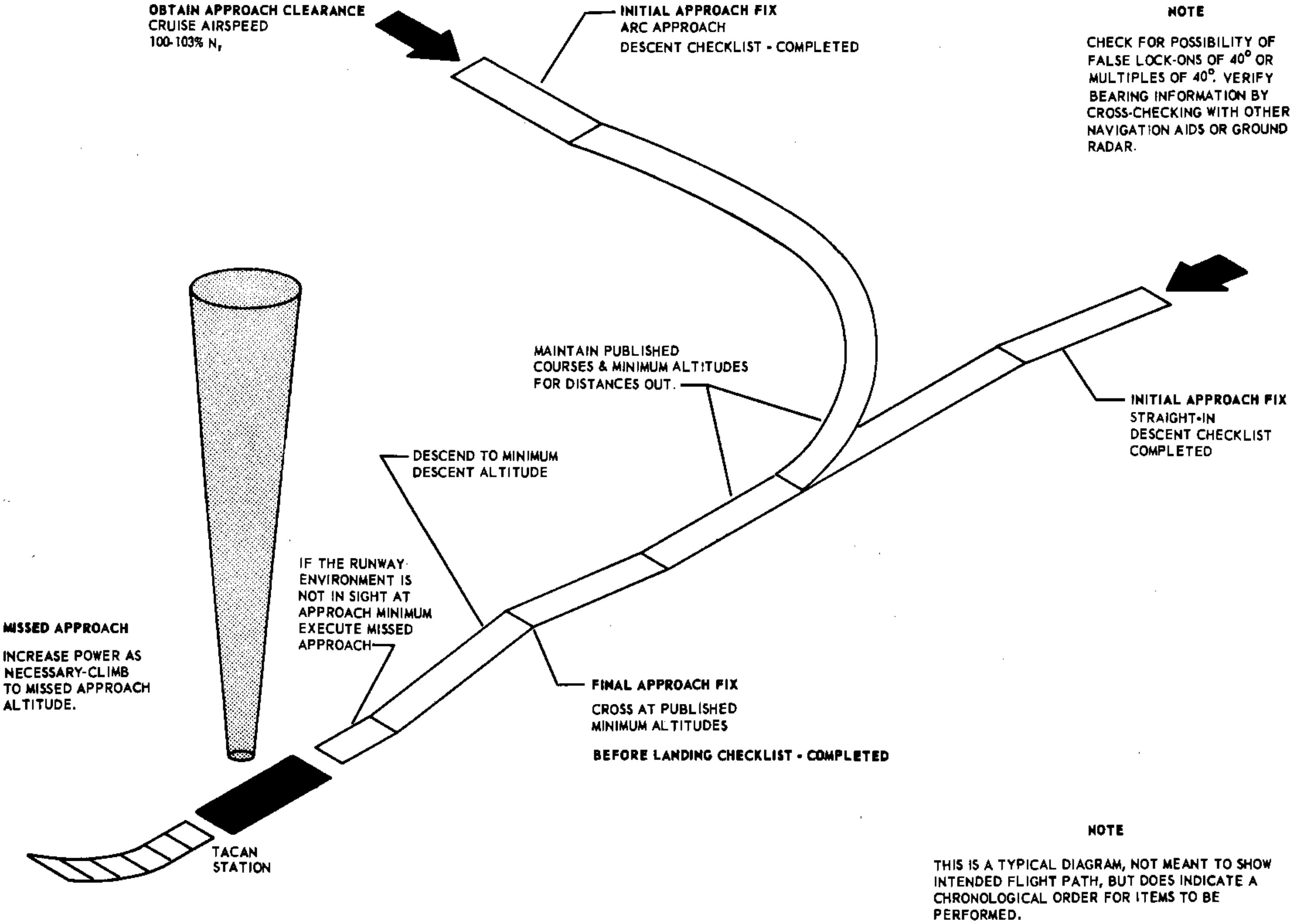


Figure 9-3. Tacan Approach (Typical) (Normal and Single Engine)

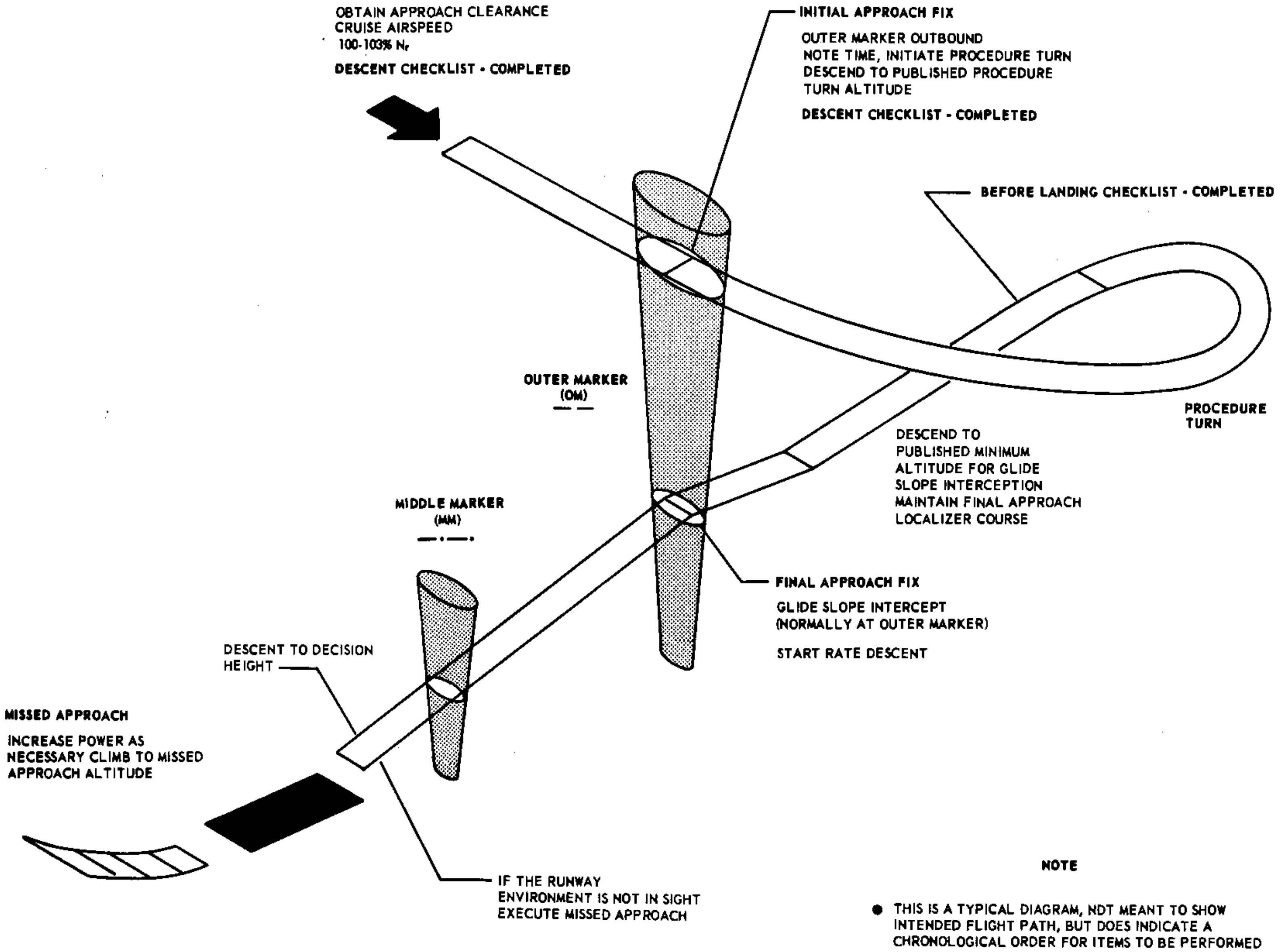


Figure 9-4. ILS Approach (Typical) (Normal and Single Engine)

DURING FLIGHT.

During icing conditions, the main rotor assembly and rotor blades will collect ice. After a sufficient amount has collected, vibration may be noted in the controls and the airframe. Occasional rotor vibration may be experienced due to shedding of ice that has accumulated on the blades. Shedding may be detected in cruise by light rotor vibrations accompanied by a decrease in torque and an increase in airspeed. Engine inlet icing may also be encountered, but not necessarily concurrent with rotor blade icing. When icing is present during low altitude flights or approach, additional power will be necessary to maintain safe flight. Also, do not lower the landing gear until in the landing pattern to avoid excessive ice accumulation on the landing gear and exposed components. Use the heater, as required.

WARNING

When engine inlet icing is detected, change altitude immediately to leave the icing layer. Reduce power as necessary to maintain normal power turbine inlet temperatures.

LANDING.

Accomplish a normal landing, but if icing is present, increased power may be necessary to insure a safe landing. If power requirements become critical, and terrain permits, a running landing should be accomplished. When shutting down the rotors on ice, extreme caution should be used when applying the rotor brake to preclude inducing a yaw. If possible, select a dry area to shut down. If not possible, have the nose wheel secured and apply only small amounts of rotor brake until the rotor is stopped.

RAIN.

Heavy water ingestion into the engines will cause the steady-state fuel requirements to increase appreciably. Gas generator speed will decrease, accompanied by a reduction in power output, when abnormally heavy water ingestion causes the engine steady-state fuel requirements to exceed the fuel controls ability to maintain gas generator speed. Gas generator speed may or may not stabilize at some lower level, depending upon the amount of water being ingested. The emergency fuel control lever can be used to stabilize gas generator speed and restore power within the limits of the maximum fuel flow of the fuel control.

NOTE

Rain on the windshield will reduce visibility whether the windshield wipers are operating or not.

TURBULENCE AND THUNDERSTORMS.

The helicopter handles very well in light to moderate turbulence. As turbulence levels increase, cruise airspeeds should be reduced for comfort, ease of control, and reduced blade stall effects. If thunderstorms or turbulence cannot be avoided, the following procedures should be followed:

1. BAR ALT - OFF.

2. Attitude: The key to proper flight technique through turbulence is attitude. Both pitch and bank should be controlled by reference to the attitude indicator (ADI). Do not change trim after the proper attitude has been established. Extreme gusts will cause large attitude changes. Use smooth and moderate cyclic inputs to re-establish the desired attitude. To avoid overstressing the helicopter, do not make large or abrupt attitude changes.

3. Airspeed: Adjust power to establish a speed of approximately 80 KIAS. Trim the helicopter for level flight at this speed and apply enough friction to hold collective in place. Severe turbulence will cause large and rapid variations in indicated airspeed. Do not chase the airspeed.

4. Altitude: Severe vertical gusts may cause appreciable altitude deviations. Allow altitude to vary. Sacrifice altitude to maintain the desired attitude. Do not chase the altimeter.

CAUTION

Flights through thunderstorms or other areas of extreme turbulence must be avoided whenever possible. Maximum use of weather forecast facilities, and air or ground radar, to aid in avoiding thunderstorms and turbulence are essential. If a storm cannot be avoided, and a landing is practical, land and wait for the storm to pass.

NOTE

The AFCS barometric altitude channel should be disengaged to prevent possible damage to the barometric altitude controller, if strong updrafts or downdrafts cause the helicopter to be displaced more than 200 feet from the engaged altitude.

NOTE

When lightening is encountered at night, the dome light, spotlight, and instrumentlights should be turned to full intensity to preclude temporary blindness.

LIGHTNING STRIKES.

Although the possibility of a lightning strike is remote, with increasing use of all-weather capabilities the helicopter could inadvertently be exposed to lightning damage. Therefore, static tests were conducted to determine lightning strike effects on rotors. Simulated lightning tests indicated that lightning strikes may damage helicopter rotors. The degree of damage will depend on the magnitude of the charge and the point of contact. Catastrophic structural failure is not anticipated. However, damage to hub bearings, blade pockets, and blade tips was demonstrated. Also adhesive bond separations occurred between the blade spar and pockets and between the spar and leading edge abrasion strip. Some blade pockets deformed to the extent that partial or complete separation of the damaged sections could be expected. Such damage can aerodynamically produce severe structural vibration and serious control problems which, if prolonged, could endanger the helicopter and crew. If lightning damage occurs, as indicated by control problems or vibration changes, especially abnormal noise, the pilot's assessment of the extent of damage, the mission requirements, and the demands of the current flight situation will determine the required action.

WARNING

Avoid flight in or near thunderstorms especially in areas of observed or anticipated lightning discharge.

NOTE

Abnormal operating noises almost always accompany rotor damage, but loudness or pitch is not valid indication of damage sustained.

1. If a lightning strike occurs but there are no indications of damage to the helicopter, the following precautions are recommended to minimize risk:

a. Reduce airspeed as much as practical to maintain safe flight but keep power on and maintain normal N_r.

b. Proceed to the nearest suitable landing site and descend with partial power, avoiding abrupt control inputs.

c. Do not autorotate but accomplish precautionary landing, shutdown, and visually inspect rotors for damage before proceeding.

d. Record suspected lightning strike in maintenance forms.

2. If minor lightning damage is suspected but vibration indication is slight and no control problems appear, flight may be continued to a suitable landing site, but avoid unnecessary delay in landing to assess damage.

3. If lightning damage is moderately serious, an immediate emergency landing is recommended.

4. In the event severe lightning damage makes the helicopter difficult or impossible to control, make an emergency landing or bailout.

NIGHT FLYING.

Night flying does not present any additional instrument flight problems, but does add the physical problems of illumination of cockpit instruments and interior and exterior reflections. Exterior lights may reflect on surrounding clouds to hamper night adaptation and make instrument reading difficult.

WARNING

The forward rotating anti-collision light may be turned off when flight conditions cause the pilot to experience spatial disorientation as a result of the reflections of the rotating light against the clouds, dust, water spray, etc.

TAKEOFF PROCEDURE.

There is basically little difference in the technique used on night take-offs from that used in day operations. Care should be exercised to make a clean decisive break from the ground to a safe hovering altitude. The landing lights should be used to illuminate the ground. The effectiveness of the landing light improves as the helicopter is brought to a hover. The use of search or flood lights is discretionary with the pilot as he can best judge conditions. The landing light should be positioned for immediate use in the event of an emergency. The searchlight provides good illumination and gives less reflections from a runway for take-offs and landings.

LANDING PROCEDURE.

In poorly lighted or unlighted areas, the searchlight can be used to clear the landing area prior to landing. Use care to correct for side drift before contacting the ground.

WARNING

Rotation of the searchlight while the helicopter is in a hover, may cause the pilot to become spatially disorientated, because the light does not rotate in a level plane.

WARNING

Night approaches into unlighted areas over smooth, featureless terrain such as water, snow, dry lake beds and salt flats can result in complete loss of depth perception and inadvertent ground contact.

COLD WEATHER PROCEDURES.

The major problems in cold weather operations are the preparation for flight, restricted visibility from blowing snow, and the adverse effects on helicopter materials. Moisture, usually from condensation or melted ice, may freeze in critical areas. Tire, landing gear strut, fire extinguisher bottle, and accumulator air pressures will decrease as the temperatures decrease. Extreme diligence on the part of both ground and flight crews is required to insure successful cold weather operation. Icing conditions are not considered in this discussion, as they are covered under ICE AND RAIN, in this section.

The problems encountered when operating from snow covered surfaces are compounded when operating from other than an operational air base. The restricted visibility caused by blowing snow can be partially overcome by utilizing smoke grenades or some other object distinguishable in color (such as pine boughs, painted jerry can, or emergency kit), placed in the landing area for reference. The smoke grenade will reveal the wind direction and allow an estimate of its speed. The danger of breaking through snow crust is minimized by maintaining maximum rpm when resting on an unknown snow surface. Pilots should be aware that the horizon may be lost when flying over large unbroken expanses of snow. If such a situation exists, the helicopter should be flown entirely by instruments at a safe instrument altitude. Colored glasses should be worn in snow areas to prevent snow blindness.

WARNING

Static electricity generated by the helicopter should be dissipated before attempting a sling or hoist pickup, particularly in colder dry climatic conditions when static electricity buildups are large. To dissipate this static charge, allow the sling or hoist to touch the ground, or use a conductor to make contact between the helicopter and the ground.

NOTE

Hoist and sling operations are possible under loose or powdery snow conditions, provided normal precautions for maintaining ground references under low visibility are followed.

NOTE

Human efficiency is reduced sharply as temperature drops below -18°C (0°F). In arctic and sub-arctic operations, rotor wash is known to have a super-cooling effect which may reduce the efficiency of exposed personnel as much as may be expected by a 11°C (20°F) drop in temperature. Consequently, the time that survivors and/or ground personnel are exposed to rotor wash should be held to a minimum.

PREPARATION FOR FLIGHT.

In addition to accomplishing a normal exterior inspection, the rotor head, main rotor blades, tail rotor, and flight controls should be thoroughly inspected and be free of all ice and snow. Failure to remove snow and ice accumulations while on the ground can result in serious aerodynamic and structural effects when flight is attempted. It is recommended that ice chocks be used on the landing gear wheels due to the minimum traction afforded on snow and ice surfaces. Check that fuel tank vents, static ports, and pitot tubes are free of snow and ice; that landing gear struts, tires and hydraulic accumulators are properly inflated; and that a warm well-charged battery has been installed. Manually check compressor rotors for freedom of rotation. If ice or snow is found, the engine should be thawed out with hot air prior to attempting to start.

CAUTION

If the ambient temperature is below -29°C (-20°F), do not rotate the rotor head by hand, as damage to the main transmission may result.

CAUTION

Do not attempt to chip or scrape snow and ice from any surfaces or controls. Portable ground heaters or de-icing fluid may be used to remove any accumulation that cannot be swept off.

STARTING APU ENGINE.

When operating at extreme low temperatures, it will be necessary to have the dual APU accumulators installed to facilitate APU turbine engine starts. The amount of pressure required for a start increases as the temperature decreases. At -54°C (-65°F) a pressure of approximately 4000 psi is required to start the turbine engine.

WARM-UP AND GROUND TESTS.

Immediately after APU start, turn on the cabin heater, engine inlet anti-icing, pitot heat, and windshield anti-ice systems. Check the transmission oil pressure and temperature. The flight controls will be checked prior to rotor engagement. During cold weather conditions, condensed moisture which accumulates in the primary servos may freeze, resulting in a flight control restriction and/or servo hardover. If a frozen control condition is suspected, operation will be terminated and discrepancy annotated in the AFTO Form 781 for maintenance inspection/action.

WARNING

Aircraft damage and personnel injury can result if rotor is engaged with a flight control restriction or servo hardover condition.

CAUTION

Allow a longer warm-up period during cold weather due to the time required to bring engine and transmission oil temperatures up to desired operating range. Operate the APU until the main transmission oil temperature gage indicates -15°C (+5°F) before rotor engagement is accomplished. As an example, at a transmission temperature of -37°C (-35°F), an APU run of approximately 4 minutes is required. At extremely low temperatures, heating by circulating oil with the APU may not be adequate. In this case, apply external heat as directed under Engine Start and Rotor Engagement Procedures with APU Inoperative (Below -6.7°C (20°F)) in this section. In the event of a rotor brake failure, do not start engines until this warm-up period is completed to prevent damage to the main transmission.

CAUTION

When starting the APU with ambient temperatures below -29°C (-20°F), the APU should be shut down if the clutch hangs up more than 6 seconds and if the total starting time is more than 18 seconds. Refer to BEFORE STARTING ENGINES in section II.

ENGINE STARTING.

At extremely low temperatures, it is possible that the the engine oil pressure will go to a maximum value or actually peg-out on the gage during an engine start. If oil pressure does not return to within operating limits within 30 seconds after reaching ground idle, shut down the engines and investigate. Insure that ground heater ducts have been removed; then accomplish normal engine start as outlined in section II. If there is no indication of oil pressure after 30 seconds of engine operation at ground idle, or if oil pressure drops to zero after a few minutes of ground operation, stop engines and investigate.

Engine Start and Rotor Engagement Procedure With APU Inoperative (Below -6.7°C (20°F).

When the ambient temperature is -6.7°C (20°F) or less, and the APU is inoperative, proceed as follows:

1. Install a heavy canvas cloth or equivalent over the main transmission area to form a heat barrier (optional).

2. Lower the right and left transmission service platforms, keeping all other service platforms and access panels closed.

3. Utilizing two H1 400,000 BTU heaters (or equivalent) with 12 inch ducts, direct one heater outlet to each side of the lower center portion of the main transmission housing until the main transmission oil temperature indicates -6.7°C (20°F), or warmer, and heat has been applied for the following listed time periods.

Ambient temperature	Time duration
-37°C (-35°F) or warmer	5 min
-43°C (-45°F)	10 min
-48°C (-55°F)	15 min
-54°C (-65°F)	20 min

NOTE

These times are based on heater duct outlet temperatures of 93 ± 14°C (200 ± 25°F). If outlet temperature is different than this, or if only one heater is available, additional heating may be required.

4. After the above preheat is accomplished, start either engine with rotor brake off. (Refer to Engine Start and Rotor Engagement With APU Inoperative in section VII.) When oil pressure stabilizes and the transmission oil temperature gage maintains an indication of -6.7°C (20°F) or warmer, rotor speed may be slowly increased to 100% N_r.

TAXIING INSTRUCTIONS.

The helicopter can be taxied in soft snow. The deeper the snow, the more difficult taxiing and steering may become, and increased collective pitch may be necessary. Helicopters should not be taxied on a snow-covered surface that is suspected or known to contain hidden obstructions or hazards. Normally, the rotor wash at taxiing power will create a restriction to visibility from blowing snow. If this should occur, taxi the helicopter at a low pitch and higher ground speed, if possible, to get ahead of the blowing snow, or have the helicopter towed to a take-off position. Ground handling characteristics of the helicopter on loose or packed snow at temperatures below -18°C (0°F) are good, and wheel braking action is fair to good. However, as temperatures rise toward freezing, snow-covered surfaces become more slippery and increased caution must be exercised.

TAKEOFF.

Select an area devoid of loose or powdery snow to minimize the restriction to visibility from blowing snow, and ascertain that the wheels are not frozen to the snow or ice.

DURING FLIGHT.

During flight, use the cabin heater, engine inlet anti-icing, and windshield anti-ice protective systems, as required. After take-off from water, wet snow, or slush covered field, operate the landing gear through several complete cycles to preclude their freezing in the retracted position. Slower operation of the landing gear can be expected in cold weather due to stiffening of all lubricants.

WARNING

In the event inadvertent icing is encountered without a foreign object deflector installed, a change of altitude should be made to avoid icing conditions. Without a deflector, the accumulated ice forward of the engine can be dislodged and ingested causing a single or dual engine failure. The ice particles can cause sufficient amount of damage to the engines that a restart would be impossible.

DESCENT.

Accomplish normal descent as outlined in section II.

LANDING.

If possible, select an area clear of loose or powdery snow so that visibility will not be restricted by blowing snow. Loose powdery snow and crusts (surface and hidden) should be anticipated on all landings on snow. Snow depth is less in clear areas where there is little or no drift effect. The snow coverage in clear areas normally forms gentle swells similar to the swells present in a large body of water. The crest of these swells are usually crusted and are suitable for landings. Generally, the heaviest crust will be present on the up wind side of the crest.

Deep snow is prevalent in valleys and to the lee (due to the prevailing winds) of wooded areas and ridges. These are suitable for landings. The best procedures to minimize blowing snow is a running landing. If terrain does not permit a running landing, an approach to a touchdown should be made. Limited visibility will result if hovering is attempted before touchdown. If possible, landings should always be made where visual ground reference can be maintained. After contacting the surface, maintain maximum rpm, while slowly reducing collective pitch to a minimum until the wheels come to rest on a level plane or the bottom of the fuselage comes to rest on the surface. This will prevent any serious consequences if one wheel should hang up or break through a crust of snow (in which case another landing site will have to be selected). Providing there are no obstructions, the tail rotor will be clear when the fuselage rests on a surface or a nose low attitude is maintained. Except in an emergency, never reduce rpm until it is positively determined that the helicopter will not settle. Competent personnel should physically check the snow depth and hardness and, if possible, evaluate the surface before reducing rpm. Make smooth power changes when the fuselage is resting on the surface.

WARNING

Main rotor and tail rotor blade ground clearances are reduced with the helicopter resting on the fuselage. Therefore, personnel entering or leaving the helicopter should exercise extreme caution to preclude being struck by the blades.

CAUTION

If the smoke grenade, or any other object that may be used as a reference should become completely obscured during the approach and/or landing, accomplish a go-around.

STOPPING OF ENGINES.

Make a normal engine shutdown as outlined in section II. As soon as the helicopter is parked, check the wheels and release the brakes. If parking brakes are left on in slush and snow, the brakes may freeze. At extreme low temperatures, the collective pitch lever friction lock should be left in the OFF position during shutdown. After shutdown, when the helicopter becomes cold soaked, the friction lock nut will contract on the collective pitch lever causing it to bind if left in the ON position. If the friction lock was left ON during extreme low temperatures, the pilot's compartment will have to be heated sufficiently to allow the friction lock nut to expand and again be moveable.

BEFORE LEAVING THE HELICOPTER.

When possible, leave helicopter parked with full fuel tanks. Every effort should be made during servicing to prevent moisture from entering the fuel system. Condensation should be drained from the fuel and oil sumps and drains, and all ice removed from vents, drains, and breathers. Close the door, hatch, and maintenance platform. Clean landing gear oleo struts of dirt, snow, and ice, with a clean cloth soaked in hydraulic fluid. Check that protective covers have been installed. (Engine exhaust and air-inlet protective covers should not be installed until after engine cools down).

HOT WEATHER PROCEDURES.

Hot weather operation, as distinguished from desert operation, generally means operation in a hot and humid atmosphere. High humidity usually results in the condensation of moisture throughout the helicopter, which causes malfunctioning of electrical equipment, fogging of instruments, rusting of steel parts, and the growth of fungi in vital areas of the helicopter. Further results may be the pollution of lubricants and fluids and deterioration of nonmetallic materials. Normal procedures, outlined in section II, will be followed for all phases of operation with emphasis placed on the data contained herein. More power will be required to hover during hot weather than on a standard day. Hovering ceilings will be lower for the same gross weight and power settings on a hot day. The flight should be thoroughly planned to compensate for existing conditions by using the charts in the Appendixes. Check for the presence of corrosion or fungus at joints, hinge points, and similar locations. Any fungus or corrosion found must be removed. If instruments, equipment, and controls are moisture coated, wipe them dry with a clean, soft cloth.

NOTE

As fuel density decreases with a rise in ambient temperature, total useable fuel quantities will be reduced, thus resulting in a decrease in normal operating range.

BEFORE LEAVING THE HELICOPTER.

When the helicopter is parked, doors, windows, and ramp should be left open if weather permits. The pilot's window should remain closed to prevent unexpected rain showers from pooling water on the AFCS channel monitor panel which could possibly create short circuits in the AFCS. The copilot's window should remain closed to protect the HF radio from rain.

DESERT PROCEDURES.

Desert operation generally means operation in a very hot, dry, dusty, often-windy atmosphere. Under such conditions, sand and dust will often be found in vital areas of the helicopter. Severe damage to the affected parts may be caused by sand and dust. The helicopter should be towed into takeoff position, which if at all possible, should be on a hard clear surface, free from sand and dust.

PREPARATION FOR FLIGHT.

Plan the flight thoroughly to compensate for existing conditions by using the charts in the Appendix. Check for the presence of sand and dust in control hinges and actuating linkages, and inspect the tires for proper inflation. High temperatures may cause over inflation. The oleo struts should be checked for sand and dust, especially in the area next to the cylinder seal, and any accumulation removed with a clean dry cloth. Inspect for, and have removed any sand or dust deposits on instrument panel and switches, and on and around flight and engine controls.

ENGINE STARTING, WARM-UP, AND GROUND TESTS.

If possible, engine starting and ground operation should be accomplished from a hard clean surface. Accomplish the normal engine start, warm-up, and ground tests as outlined in section II, but limit ground operation to a minimum as the down-wash from the main rotor may stir up clouds of sand. Every effort should be made to minimize the sand from being blown up around the main rotor and engines.

TAXIING INSTRUCTIONS.

When it is absolutely necessary to taxi in sand and dust, get the helicopter airborne as quickly as possible in order to minimize sand and dust intake by the engines.

TAKEOFF.

Execute normal takeoff and climb as outlined in section II. If the rotor should stir up sand and dust, takeoff, but do not hover, and climb out as rapidly as possible.

DURING FLIGHT AND DESCENT.

Avoid flying through sand or dust storms, when possible. Excessive dust and grit in the air will cause considerable damage to internal engine parts.

LANDING.

The best procedures to minimize blowing sand and dust is a running landing. If the terrain does not permit running landing, an approach to touchdown should be made.

CAUTION

If operation in sand cannot be avoided, landings should be made using an approach angle that is greater than the angle used for normal approaches. The approach angle should be compatible with available power. Touchdown roll should be kept to a minimum to preclude the possibility of overloading the landing gear. Maximum performance takeoffs should be used. All doors and windows should be kept closed during landings and takeoffs to help prevent sand from entering the cockpit and cargo area. These procedures will lessen sand clouds and insure greater visibility. Hovering and prolonged operation in sand is not recommended because unpredictable foreign object damage can result.

STOPPING ENGINES.

The engine should be shut down as soon as practical, after landing, to minimize the ingestion of sand and dust.

BEFORE LEAVING HELICOPTER.

Accomplish the normal procedures as outlined in section II. Install all protective covers and shields and leave windows and doors open to ventilate the helicopter, except when sand and dust are blowing.