# SECTION V

# OPERATING LIMITATIONS

This section contains all the limitations which must be observed during normal operation. Limitations characteristic to specialized phases of operation need not be repeated in this section. Examples of these specialized phases include-turbulent air flight, one-engine flight limitations, arctic operations, etc.

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## INTRODUCTION

The operating limitations contained in this section are derived from experience gained during the design, production, and flight test of the helicopter. These limitations, which must be observed if safe and efficient operation are to be attained, should be studied carefully to familiarize the pilot with proper operation of the helicopter and associated equipment. The instruments in the helicopter are marked as shown in figure 5-1 to indicate to the pilot that flight operation is in a safe, desirable, or unsafe region. Appropriate explanations are provided where the markings are not self-explanatory. In addition, other limitations on operational procedures, maneuvers, and loading are covered.

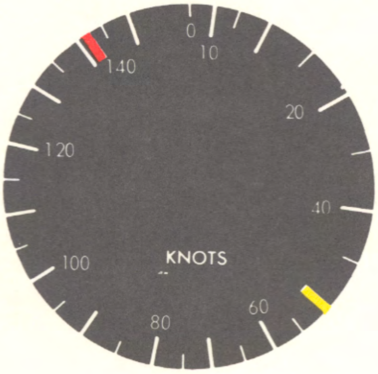
**NOTE**

If any of the limits included in this section of the flight manual are exceeded, remarks concerning the degree to which the limits were exceeded and the time duration should be entered on CG-4377.

## INSTRUMENT RANGE MARKINGS

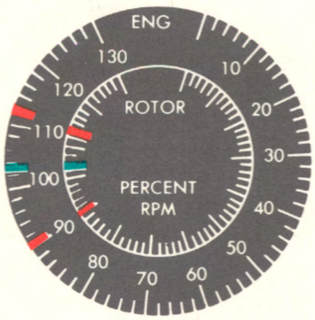
Instrument markings shown in figure 5-1 and other operating limitations in this section are not repeated elsewhere in the manual. The instrument markings used in figure 5-1 are explained in the following paragraphs:

HH-3F HELICOPTERS — T58-GE-5 ENGINES




**AIRSPEEDS**

| | | |
|---|---|---|
| YELLOW RADIAL | 50 KNOTS | LANDING GEAR CHECK |
| RED RADIAL | 142 KNOTS IAS MAXIMUM | |




**TRIPLE TACHOMETER**

POWER TURBINE ($N_f$) TACHOMETER

| | | |
|---|---|---|
| RED RADIAL | 91% $N_f$ | MINIMUM-POWER ON |
| GREEN RADIAL | 103% $N_f$ | NORMAL POWER ON |
| RED RADIAL | 112% $N_f$ | MAXIMUM NO LOAD CONDITION |

ROTOR TACHOMETER

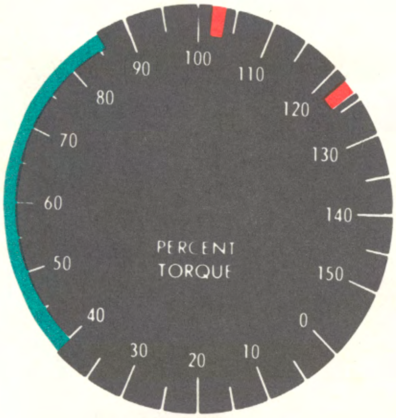
| | | |
|---|---|---|
| RED RADIAL | 91% $N_r$ | MINIMUM POWER OFF |
| GREEN RADIAL | 103% $N_r$ | NORMAL POWER ON |
| RED RADIAL | 112% $N_r$ | MAXIMUM-POWER OFF |

S 8681.1 (C3)

**Figure 5-1. Range Markings (Sheet 1 of 4)**

HH-3F HELICOPTERS

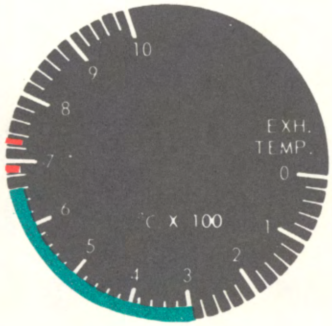
T58-GE-5 ENGINE




## TORQUEMETER

| | | |
|---|---|---|
| GREEN ARC | 40-86% Q | NORMAL OPERATING RANGE |
| RED RADIAL | 103% Q | MAXIMUM TWIN ENGINE POWER |
| RED RADIAL | 123% Q | MAXIMUM SINGLE ENGINE POWER |

NOTE: The 86% limit is established by the main gear box maximum continuous input limit. The main gear box is rated @ 2100 HP maximum continuous power.



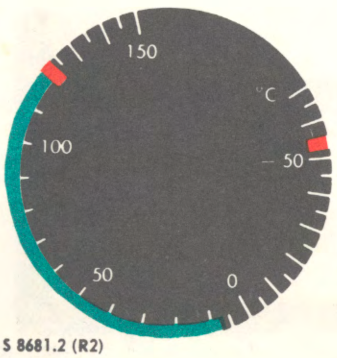

## POWER TURBINE INLET TEMPERATURE $T_5$

| | | |
|---|---|---|
| GREEN ARC | 300-660°C $T_5$ | NORMAL OPERATING RANGE |
| RED RADIAL | 696°C $T_5$ | END OF 30 MINUTE LIMIT RANGE |
| RED RADIAL | 721°C $T_5$ | END OF 5 MINUTE LIMIT RANGE (MAXIMUM EXCEPT FOR STARTING AND TRANSIENT CONDITIONS) |


## GAS GENERATOR ($N_g$) TACHOMETER

| | | |
|---|---|---|
| YELLOW RADIAL | 56% $N_g$ | (GROUND IDLE ± 3%) |
| GREEN ARC | 70-100% $N_g$ | NORMAL OPERATING RANGE |
| RED RADIAL | 102.7% $N_g$ | MAXIMUM |

* THESE INSTRUMENTS ARE POSITIONED SO THAT UNDER NORMAL OPERATING CONDITIONS THEIR NEEDLES ARE AT APPROXIMATELY THE 12 O'CLOCK POSITION.




*

## ENGINE OIL TEMPERATURE

| | | |
|---|---|---|
| RED RADIAL | -54°C | MINIMUM |
| GREEN ARC | 7°TO 121°C | NORMAL RANGE |
| RED RADIAL | 121°C | MAXIMUM |

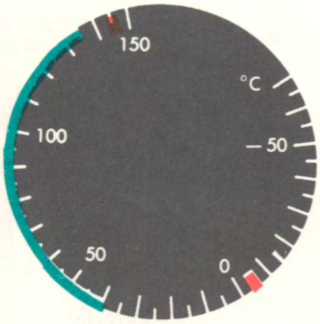
S 8681.2 (R2)

**Figure 5-1. Range Markings (Sheet 2 of 4)**

HH-3F HELICOPTERS T58-GE-5 ENGINES


## ENGINE OIL PRESSURE

| | | |
|---|---|---|
| RED RADIAL | 10PSI | MINIMUM |
| GREEN ARC | 24 TO 64 PSI | NORMAL RANGE |
| RED RADIAL | 75 PSI | MAXIMUM |




## TRANSMISSION OIL TEMPERATURE

THE TRANSMISSION OIL TEMPERATURE INDICATOR IS CONNECTED TO AN OIL TEMPERATURE BULB ADJACENT TO THE MAIN GEAR BOX OIL OUTLET PORT.

| | | |
|---|---|---|
| RED RADIAL | -6.7°C | MINIMUM |
| GREEN ARC | 40° TO 135°C | NORMAL |
| RED RADIAL | 145°C | MAXIMUM |


## CAUTION LIGHT

THE TRANSMISSION OIL TEMPERATURE CAUTION LIGHT WILL COME ON WHEN THE TRANSMISSION OIL TEMPERATURE REACHES 120°C (248°F) AT THE MAIN GEAR BOX OIL INLET PORT.


## TRANSMISSION OIL PRESSURE

TRANSMISSION OIL PRESSURE INDICATOR IS ACTUATED BY A PRESSURE TRANSMITTER CONNECTED TO MAIN GEAR BOX OIL INLET PORT.

| | | |
|---|---|---|
| RED RADIAL | 12 PSI | MINIMUM |
| GREEN ARC | 35-90 PSI | NORMAL OPERATING RANGE |
| RED RADIAL | 100 PSI | MAXIMUM |


## CAUTION LIGHT

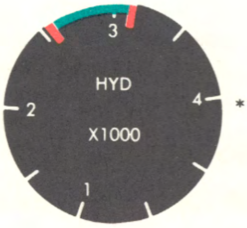
TRANSMISSION OIL PRESSURE CAUTION LIGHT COMES ON WHEN THE MAIN GEAR BOX OIL PRESSURE DROPS BELOW APPROXIMATELY 4 PSI AS IT ENTERS THE LAST OIL PRESSURE JET IN THE GEAR BOX

* THESE INSTRUMENTS ARE POSITIONED SO THAT UNDER NORMAL OPERATING CONDITIONS THEIR NEEDLES ARE AT APPROXIMATELY THE 12 O'CLOCK POSITION.

S 8681.3 (C1)

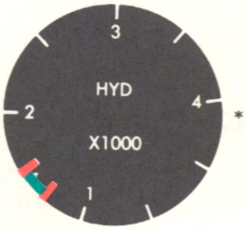
**Figure 5-1. Range Markings (Sheet 3 of 4)**

HH-3F HELICOPTERS — T58-GE-5 ENGINES




**UTILITY HYDRAULIC PRESSURE**

| | | | |
|---|---|---|---|
| (red) | RED RADIAL | 2600 PSI | MINIMUM |
| (green) | GREEN ARC | 2600 TO 3150 PSI | NORMAL RANGE |
| (red) | RED RADIAL | 3150 PSI | MAXIMUM |

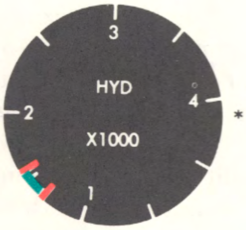



**AUXILIARY HYDRAULIC SERVO PRESSURE**

| | | | |
|---|---|---|---|
| (red) | RED RADIAL | 1300 PSI | MINIMUM |
| (green) | GREEN ARC | 1300 TO 1600 PSI | NORMAL RANGE |
| (red) | RED RADIAL | 1600 PSI | MAXIMUM |


**CAUTION LIGHT**

THE AUXILIARY SERVO PRESSURE CAUTION LIGHT WILL COME ON WHEN PRESSURE DROPS BELOW 1000 PSI.




**PRIMARY HYDRAULIC SERVO PRESSURE**

| | | | |
|---|---|---|---|
| (red) | RED RADIAL | 1300 PSI | MINIMUM |
| (green) | GREEN ARC | 1300 TO 1600 PSI | NORMAL RANGE |
| (red) | RED RADIAL | 1600 PSI | MAXIMUM |


**CAUTION LIGHT**

THE PRIMARY SERVO PRESSURE CAUTION LIGHT WILL COME ON WHEN PRESSURE DROPS BELOW 1000 PSI.

* THESE INSTRUMENTS ARE POSITIONED SO THAT UNDER NORMAL OPERATING CONDITIONS THEIR NEEDLES ARE AT APPROXIMATELY THE 12 O'CLOCK POSITION.

S 8681.4 (R1)

**Figure 5-1. Range Markings (Sheet 4 of 4)**

#### LOWER RED RADIAL

The red radial having the lowest numerical value on an instrument indicates that a dangerous condition would exist if the pointer should drop to or below that value during flight.

#### YELLOW ARC OR RADIAL

A yellow arc or radial indicates that danger may exist under certain specified conditions. These conditions are noted on figure 5-1 or covered in the text.

#### GREEN ARC

A green arc indicates the region for continuous inflight operation.

#### UPPER RED RADIAL

The red radial having the highest numerical value on an instrument indicates that a dangerous condition would exist if the pointer should reach this value and that operation above this point is prohibited.

#### UNMARKED AREAS

Unmarked or blank areas between upper and lower radials, or between a green arc and red radial, or between red radials indicate regions that should be avoided except for transient conditions such as starting, ground operation, single engine, etc.

#### INDEX MARK

A white index mark appears on all instruments having range markings to indicate possible movement of the glass and subsequent incorrect interpretations of the markings.

## POWER LIMITATIONS

Power is limited by the engines and the main transmission. The limit reached first during normal operations is the limit that must be observed. Generally, power is limited by the transmission at temperatures below 0°C FAT and by the engines at temperatures above 0°C FAT. Power limitations are shown in figure 5-1.

**CAUTION**

Maximum power will not be used if the mission can be performed using military power. Extended use of the maximum power will result in reduced engine life.

**NOTE**

Torque may exceed 103%Q on one engine to a maximum of 123%, provided that the power of the other is reduced so that the total torque for both engines does not exceed 206%Q, and that Ng and T5 limits are not exceeded. The governing parameter is the limit which occurs first. If any of the above limits are exceeded appropriate entry should be made on CG-4377.

**NOTE**

The 86% torque limit is due to the maximum continuous main gear box rating.

#### POWER TURBINE SPEED (Nf)

The lower unmarked area on the Nf tachometer indicates a precautionary range for transient operation with engine power on. The upper unmarked area is a transient power range used during ground checks, reduced power operations, and prior to takeoff to allow for engine droop.

**CAUTION**

During reduced or partial power descents, and practice autorotations with minimum collective pitch, Nf may exceed 103% up to a maximum of 112%, at which time the rotor (Nr) and Nf pointers should split if the rotor speed is increased above 112% Nr. If the Nf pointer does not split at this point, indicating failure of the free power turbine drive shaft to properly disengage from the transmission, collective should be applied to bring Nf within limits. Appropriate entry should be made on CG-4377.

#### GAS GENERATOR SPEED (Ng)

The maximum Ng is 102.7%. During the topping check it is permissible to operate the engine above 102.7% to 106% for 28 seconds. Do not operate above 106%.

## POWER LIMITATIONS
### (Sea Level Standard Day Conditions at 103% Nf)

**ENGINE LIMITATIONS**

| Power | Gas Generator Speed - % Ng | Power Turbine Inlet Temp °C T5 | * Time Limit |
|---|---|---|---|
| Transient maximum (during engine topping check) | 106 | 735 | 28 sec |
| ~~Maximum power~~ | 102.7 | 721 | 5 min |
| ~~Military power~~ | 102.7 [redacted] | 696 | 30 min |
| Normal (~~maximum continuous~~) power | N/A | 660 | none |

**TRANSMISSION LIMITATIONS**

| Power | Torque % Q | * Time Limit |
|---|---|---|
| Transient maximum | 120 each engine<br>150 single engine | 5 sec |
| Maximum power | 103 each engine<br>123 single engine *can't exceed during topping check* | 30 min |
| Normal (maximum continuous) power | 86 each engine<br>103 single engine | none |

* CONSECUTIVE, NOT MISSION ACCUMULATED TIME

S 44069 (C2)

**Figure 5-2. Power Limitations Table**

**POWER TURBINE INLET TEMPERATURE ($T_5$)**

During start, if $T_5$ rises above 735°C, a notation of the maximum temperature and time shall be entered on CG-4377. Transient operations between 840°C and 950°C are permissible during an aborted start. If $T_5$ exceeds 950°C, an overtemperature inspection is required and additional engine starts should not be attempted. During the topping check it is permissible to operate the engine from 721° to 735°C for 28 seconds. Do not operate above 735°C.

**CAUTION**

During compressor stalls or any other overtemperature condition, if maximum $T_5$ is not observed, it is to be assumed that the limits have been exceeded.

**TORQUEMETER (Q)**

The upper unmarked area on the torquemeter between the green arc and the first red radial indicates the 30-

minute operating limit range between normal and military power, when operating with both engines. The second red radial indicates the limit for a single engine input to the transmission. For relationship between torque and engine limits, see **POWER LIMITATIONS.**

## TRANSMISSION LIMITATIONS

Main gear box oil temperatures and pressures are shown in figure 5-1. In addition, the transmission system has input torque limits which require certain actions when exceeded. These are provided for information.

### MAIN GEAR BOX OIL TEMPERATURE

Maximum continuous main gear box oil temperature is 135°C. If free air temperature is above 41°C, stabilized oil temperatures can be expected to be above 135°C. Operation between 135° and 145°C is permissible. The temperature and time period at these temperatures shall be noted on Form CG 4377. Main gear boxes operated above 145°C for any time period must be replaced.

### MAIN GEAR BOX OIL PRESSURE

Main gear box oil pressure fluctuations of 2 to 3 psi are normal; however, fluctuations up to ±5 psi are allowable provided no indications of a malfunction are apparent.

### TWO ENGINES OPERATING

Transient operation between 206% and 240% total torque is permissible for periods not exceeding 5 seconds. Operation between 206% and 240% total torque for more than five seconds, or over 240% torque for any time period, requires removal and overhaul of the main gear box.

### ONE ENGINE OPERATING

Transient operation between 123% and 150% for more than 5 seconds, or over 150% for any time period, requires removal and overhaul of the main gear box.

## ROTOR LIMITATIONS

Normal rotor limitations are shown in figure 5-1. During autorotation, do not operate below 91% or above 112% Nr. Overspeed of the main rotor subjects components to abnormal forces which may cause damage.

MAXIMUM AIRSPEED TABLE
VARIATION OF MAXIMUM SPEED (KNOTS IAS)
WITH DENSITY ALTITUDE AND GROSS WEIGHT

103% ROTOR SPEED

GROSS WEIGHT – LBS

| DENSITY ALTITUDE | 22,000 | 20,000 | 18,000 | 16,000 | 14,000 |
|---|---|---|---|---|---|
| 0 | 138 | 142 | 142 | 142 | 142 |
| 2000 | 127 | 139 | 142 | 142 | 142 |
| 4000 | 115 | 127 | 140 | 142 | 142 |
| 6000 | 103 | 116 | 129 | 142 | 142 |
| 8000 | 92 | 104 | 118 | 131 | 142 |
| 10,000 | 81 | 93 | 106 | 120 | 135 |
| 12,000 | 70 | 82 | 95 | 109 | 124 |

**Figure 5-3. Maximum Airspeed Table**

**WARNING**

If the main rotor has been operated above 112% $N_r$, the helicopter should be landed as soon as practicable to enable a thorough inspection by qualified maintenance personnel in accordance with maintenance manual procedures to determine if there has been any damage sustained to the main rotor system, drive train or any of the components. A notation should be made on the CG-4377.

## AIRSPEED LIMITATIONS

**CAUTION**

In helicopters where the ability to monitor blade integrity during flight does not exist (defective IBIS Circuit) the maximum operating limits are changed to limit forward airspeed to a maximum of 110 knots indicated airspeed and to limit maximum flight endurance to 6 hours. Before and after each flight, the main rotor blade IBIS indicators will be visually checked. The Commanding Officer of aviation units may authorize flights with a defective IBIS circuit in excess of the above restriction in case of urgent SAR, provided an additional helicopter is not available.

Maximum airspeed at design gross weight of 19500 pounds, for sea level, standard day conditions, is 142 knots IAS. Maximum airspeed at maximum gross weight of 22,050 pounds for sea level, standard day conditions is 138 knots. Sideward flight is limited to 35 knots. Rearward flight is limited to 30 knots. Flight with auxiliary flotation bags/collars inflated is limited to 70 knots. Determination of maximum airspeed with varying gross weights and various density altitudes may be made using figure A-36. Maximum airspeeds for maneuvering flight are determined by using the blade stall chart, figure A-35.

## MANEUVERS

The helicopter is restricted to normal flying maneuvers. No acrobatics are permitted and flight controls must not be moved abruptly. Hovering turns should not exceed a rate of 360° in 15 seconds. Maximum angles of bank, dependent on airspeed and blade load factors, are determined using blade stall chart, figure A-35. The maximum angle of bank is 50°.

**WARNING**

Helicopters are limited to no PRIMARY SERVO OFF operation except for functional check flights. This limitation is necessary to minimize the vibratory loads to the mixer unit.

## ACCELERATION LIMITS

The maximum permissible acceleration is 1.5g. Minimum acceleration is 0.2g. Variation of limit load factor with airspeed and angle of bank is shown in blade stall chart, figure A-35.

## CENTER OF GRAVITY LIMITATIONS

It is possible to exceed the CG limits if the helicopter is not properly loaded. To determine placement of load for anticipated mission, refer to **LOAD ADJUSTER,** Section IV. The CG limitations will vary according to the gross weights of the helicopter. To determine the most fore-and-aft CG limits for a given gross weight, see figure A-37. The takeoff and anticipated landing gross weight should be obtained prior to each mission and determined to be within specified limitations. If a locally standardized weight and balance clearance form which shows the helicopter to be within limits is not on file, the load adjustor will be used to determine that the helicopter is within limits. If the adjustor shows the helicopter to be in the critical (yellow shaded) load condition, the load must be adjusted. For additional information refer to **LOAD ADJUSTER** in Section IV, and **WEIGHT LIMITATIONS,** in this section.

## WEIGHT LIMITATIONS

The basic design gross weight of the helicopter for structural analysis is 19,500 pounds at a limit load factor of 2.5 G's. The maximum gross weight is 22,050 pounds at a limit load factor of 2.21 G's.

### MARGIN OF SAFETY AND LOAD FACTORS

It must be realized that as a structure is loaded to higher weights, its ability to withstand additional loads resulting from maneuvers or gust conditions becomes increasingly less. The margin of safety is the amount of additional load that the structure will sustain before failure occurs. When planning any helicopter mission, consideration must be given to the fact that the maximum permissible weight may depend on the margin of safety desired for the various supporting structures (main rotor, fuselage, landing gear, flooring, etc.). Should the mission require excessive maneuvering or flight through turbulent air, it would be advisable to maintain a larger margin of safety than if smooth level flight were contemplated. However, the larger the margin of safety, the lower the maximum permissible weight will be. Flight load factors are used as an indication of the margin of safety available for helicopters. Therefore, the structural margin of safety will be equal to the difference between the limit load factor, determined for the gross weight, and the flight load factor the helicopter is sustaining at any given moment. For example, should the helicopter be loaded so that it is capable of making good a limit load factor of 2.5, and during various phases of flight, flight load factors (G loads), due to maneuvers or gusts of 1.5 and 2.0 are imposed on the helicopter, the margins of safety during these phases would be 1.0 and 0.5 flight load factors, respectively. Therefore, it is of prime importance that the maximum flight load factors that will be encountered during a mission be anticipated in order that the helicopter will be loaded in such a manner that the load limit factor it was designed for will never be exceeded during any phase of the flight.

**NOTE**

Due to the blade stall characteristics of the rotor system, maximum blade loading will normally be reached before structural limits can be exceeded. (Refer to blade stall chart, figure A-35.)

## LANDING GEAR LIMITATIONS

There are no structural limits affecting the extension or retraction of the landing gear in flight; however, for operational use, the landing gear shall be down and locked at all times when over land below 300 feet AGL. The maximum touchdown sink rate with gross weights up to 19,500 pounds is 480 feet per minute. At gross weights above 19,500 pounds, touchdown sink rates should be lower and maximum sink rate should not exceed those on maximum sinking on landing chart, figure A-38. Maximum speed on touchdown is 40 knots.

## EQUIPMENT LIMITATIONS

1. Aft ramp shall not be operated in flight at airspeeds above 115 knots.

2. The cargo door and/or cockpit windows should not be moved during flight at airspeeds above 115 knots.

## SLOPE LIMITATIONS

### HOVER LIMITS

**One wheel on slope.**

| CONDITION | SLOPE LIMIT |
|---|---|
| Nose-upslope | 30° |
| Nose-downslope | 10° |
| Left or right side downslope | 25° |

### LANDING AND SHUTDOWN LIMITS

CG listed is the most critical which would apply for each slope condition.

| CONDITIONS | SLOPE LIMIT | MOST CRITICAL CG |
|---|---|---|
| Nose-upslope | 8° | 280 inches |
| Nose-downslope | 10° | 254 inches |
| Left or right side downslope | 10° | 254 to 280 inches |

**NOTE**

A 20-knot downslope wind condition will reduce nose-up and right or left side downslope capability by approximately 1°. Effects of a moderate upwind slope or cross-slope will be negligible.

# SECTION VI
# FLIGHT CHARACTERISTICS

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## INTRODUCTION

The helicopter is capable of flight over a speed range extending from approximately 30 knots rearward to approximately 142 knots forward, and sideward up to 35 knots. The automatic flight control system (AFCS) improves the helicopter's basic flying qualities. The rotor can be safely engaged and stopped in winds up to 60 knots. Collective, cyclic and tail rotor pitch provide taxi capability in winds from any direction. The tricycle landing gear provides stable ground maneuvering 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. Two control system characteristics are incorporated which simplify coordination of controls when lifting to a hover. As increasing collective pitch results in an increase in main rotor torque, an increase in tail rotor anti-torque thrust is accomplished automatically by a mechanical coupling within the control system which alters tail rotor pitch as a function of collective pitch. 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 left 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. Small adjustments to speed selectors will be required to compensate for a slight droop which occurs after power changes.

**CAUTION**

Use caution while flying rearward at airspeeds greater than 15 knots to insure adequate control margin is available at all times to correct for external disturbances.

## 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 damped within one cycle with the AFCS operating. With AFCS off, the oscillations are mildly divergent but are easily controlled by the pilot. During 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 required, but control is easily maintained. During climb, control is positive about all axes and best rate of climb speed is easily maintained.

The heading will be maintained in all flight conditions with the yaw channel of the AFCS operating. If yaw is induced by a gust, the AFCS will return the helicopter to the original heading without overshoot. Without the yaw channel operating, any disturbance in yaw can be dampened with the tail rotor control pedals in a few cycles. When entering slideslips, 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 pitch available to accomplish any desired directional maneuvering. In the speed range from 50 knots to Vmax, a forward cyclic application will be required to increase airspeeds. The helicopter will always exhibit a tendency to return to trim following a disturbance in pitch, roll or yaw with AFCS engaged. With the AFCS off, any oscillations in pitch and roll can be dampened in a few cycles. At higher rotor speeds, disturbances in pitch and roll will be dampened most quickly and control margins are greater. No violent helicopter motions are encountered when entering autorotation in forward flight; however, some cyclic trim change will be required with the amount dependent upon airspeed at the time of autorotational entry. At high forward speeds, some right lateral and aft longitudinal trim changes are required with the amount decreasing at lower airspeeds. RPM decay rate after a sudden reduction of power is rapid if collective pitch is not lowered quickly. However, rotor rpm builds up again on reduction of collective pitch. Adequate tail rotor thrust is available during autorotation to accomplish all maneuvering, and directional control is positive in sideslip. If recommended rotor speed is maintained in autorotation, there is adequate rotor inertia for an effective flare to reduce airspeed and rate of descent. Power off touchdown is made in a slightly nose high attitude. Power on approaches and vertical landings are accomplished using normal techniques. Run-on landings can be made on properly prepared surfaces, with final approaches and touchdowns made in a near level attitude. When hovering or flying at low speed, and an increase of forward speed is desired, the cyclic stick is moved forward. With rapid acceleration momentary settling may occur, but the helicopter will begin to climb as translational lift is encountered. If you desire to maintain a constant altitude, as the helicopter accelerates to approximately 50 knots IAS, collective pitch must be steadily decreased. To maintain this same altitude at more than approximately 60 knots IAS, collective pitch must be increased until maximum speed is reached. At maximum speed, a higher collective pitch setting is required than for hovering and power turbine speed should be 103%, depending on where there is the least vibration. As forward speed increases, the helicopter will assume a proportional nose down attitude. As the main rotor blade tip-path plane is tilted forward to increase forward speed, the centrifugal 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 stable cruising speed control.

**NOTE**

As the helicopter is decelerated from cruise condition, power required decreases until an airspeed of 50-80 knots is attained. Below this airspeed, power required increases as airspeed decreases. 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. 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.

## STALLS

Stalls, as applied to a fixed-wing aircraft, do 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 is most likely to occur when operating with high values of speed, gross weight, density altitude and torque, and with relatively low rotor rpm. Maneuvers, acceleration, or turbulent air which increase the G load factor also contribute to blade stall, and reduce the airspeed at which blade stall will occur. When any one or a combination of the conditions which contribute to blade stall are present, it will most likely occur when excessive or abrupt control deflections are made. Blade stall occurs initially at the tip of the retreating blade on the left side of the helicopter. This initial flow separation is called drag divergence (blade tip stall). The only noticeable effect on the helicopter at this point is a slight increase in the power required. If blade pitch is increased (as with forward cyclic stick), or the forward speed is increased, the stalled portion of the rotor disc is enlarged, and the stall progresses from the tip toward the hub of the retreating blade. Each main rotor blade will stall as it passes through the stall region and will create a five per rev vibration. If blade stall is allowed to fully develop (approximately 40 knots faster than blade tip stall), a complete 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 angle of attack of the retreating blade. A load factor of 0.1G will reduce by approximately 10 knots the maximum airspeed at which blade stall occurs. There is a speed range of approximately 40 knots between the beginning of blade tip stall and control difficulties. The blade stall chart (figure A-35) represents speeds approximately 20 knots above blade tip stall, and at these speeds reasonable maneuvers or mild turbulence can be tolerated. However, severe turbulence or abrupt maneuvers at these speeds will increase the severity of the stall and the helicopter will become more difficult to control. To allow for turbulence, mild maneuvers, and necessary control inputs to maintain the desired flight attitude, the blade stall chart establishes a maximum recommended airspeed approximately halfway between the beginning of tip stall and beginning of control difficulties.

#### METHODS OF ELIMINATING ROUGHNESS CAUSED BY BLADE STALL

Vibrations of the helicopter during high speed flight or when maneuvering at lower speeds caused by blade stall may be reduced or eliminated by accomplishing one or any combination of the following:

1. Decrease collective pitch.
2. Increase rotor rpm.
3. Decrease the severity of the maneuver.
4. Gradually decrease airspeed.
5. Descend to lower altitude.

#### BLADE STALL CHART

The function of the blade stall chart (figure A-35) is to provide a rapid means of determining the speed at which blade stall occurs under various altitudes, RPM, gross weight, and angle of bank conditions.

### POWER SETTLING

At high altitudes, and high gross weights, or when operating with reduced power, it may not be possible to maintain level flight, and settling will occur. The settling is normally of minor consequence, except at high rates of descent and low forward speed, where it is extremely critical. When a critical power settling condition occurs, extreme vibration and a partial loss of control may occur. The vertical velocity of the downward airflow through the main rotor is extremely high while at or near hovering attitude. Under certain power and rate-of-descent combinations, the rotor downwash recirculates 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 rotate continually in their own turbulent airstream. The velocity of the recirculating air mass may become so high that full high collective pitch will not produce sufficient lift to control rate-of-descent, which can rapidly build up to 3500 ft/min. Further increase of collective pitch and/or power will further aggravate the turbulent airflow. To recover from this condition, increase forward airspeed, decrease collective pitch, or even enter autorotation if altitude permits. Flight conditions causing power settling should be avoided at low altitudes because considerable altitude will be lost before the condition is recognized and recovery is completed.

### FLIGHT CONTROLS

#### FLIGHT CONTROL SERVOS

Both the primary servos at the rotor assembly and the auxiliary servos at the mixing unit are in operation at all times. Because of the damping and boost effects of the servo units, control forces are light and constant throughout their full range. This may cause a tendency to over-control, 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. Either servo system may be turned off; however, the switching system provided prevents both servos from being turned off at the same time. If the primary servo system, which physically controls the lower swashplate, is turned off, movement of the lower controls and swashplate is accomplished through the auxiliary servo system, which is located in the broom closet near the cockpit controls. In this instance, the feel of control remains almost unchanged except for small differences due to increased friction and lost motion in the control system. If the auxiliary servo system is turned off, the pilot physically moves the push-pull rods and bell cranks up to the primary servo system. In this instance, a friction force of several pounds is noticeable and stability augmentation through the AFCS is lost.

#### COORDINATION OF FLIGHT CONTROLS

Climb and descent of this 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 climb, additional torque is developed by the main rotor. This torque can be compensated for by the use of the tail rotor pedals. Minor changes are accomplished by the yaw compensator, a mechanical coupling within the flight control system that changes tail rotor pitch proportionately with a change in the main rotor collective pitch. 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. For sideward flight 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 on the original heading. 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 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 flight, less pedal displacement is necessary to accomplish turns.

#### PILOT INDUCED COLLECTIVE BOUNCE (COLLECTIVE RESONANCE)

Since the flight control servo system provides force free operation of the flight controls, a condition of collective bounce can occur if collective friction is not used. Collective bounce can occur in flight as well as on the ground. Rapid vertical displacement of the helicopter may cause a neutrally balanced, friction-free collective to move out of phase with the helicopter's vertical motion. The pilot in an attempt to correct this condition by holding the collective, may inadvertently increase the amplitude of the collective bounce with a possibility of the helicopter's motion becoming divergent. This condition is sometimes referred to as collective resonance. To preclude collective bounce some collective friction should be used at all times.

### 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 and it would be difficult for the pilot to completely separate all the types of vibrations encountered. Generally, these are divided into three categories; namely, low, medium, and 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. It 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 on form CG-4377. 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.

c. Improperly indexed rotor head and/or blades.

2. Worn or loose control rod end bearings. If the vibration is present in a hover only, the cause could be the same as above, plus:

a. Main rotor blade dynamic balance beyond tolerances.

3. Malfunctioning blade dampener.

**Ground Roll**

This 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:

1. Static balance of the main rotor blades.

2. Improper servicing of the landing gear struts.

**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. Flight conditions under which pitch lag instability may be encountered are:

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.

Immediate corrective action is to reduce collective pitch, increase $N_r$, and reduce airspeed and/or the severity of the maneuver. If 2/3-per-revolution vibrations should be experienced within the normal flight envelope, but felt only during the above conditions, it should be noted in the CG-4377.

**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 and can be induced by flying in a right slip in the speed range of 50-80 knots, especially with an aft CG loading.

## MEDIUM FREQUENCY VIBRATIONS

**Five Times Main Rotor Speed (Five-Per-Revolution)**

This most common inherent 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 during transition to a hover by leveling the helicopter just prior to applying collective pitch, and by planning the approach so that the hover can be attained with a slow rate of final pitch application. 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 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. Any vibration felt should be noted on form CG-4377.

#### One Times Tail Rotor Speed

This vibration (1280 cycles-per-minute at 103% $N_r$) is usually due to tail rotor blade pattern dissymmetries and is not easily identifiable by the pilot. Since this frequency is close to five-per-revolution (1050 cycles per minute), the two frequencies sometimes modulate (beat) at a frequency of 230 cycles-per-minute which is felt as a shudder throughout the helicopter and is hard to distinguish from one-per-revolution (210 cycles-per-minute). Excessive vibration encountered in any regime of flight should be noted on CG-4377.

### HIGH FREQUENCY VIBRATIONS

These 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 on the ground run and in flight. The most important cue, by far, to high frequency vibration will be the associated sounds.

#### 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 level gear and free wheeling units. These vibrations are generally heard rather than felt. 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 with 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 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 noisy engine during shutdown. Any unusual noises or a rapid coast-down time noted during engine coast-down should be entered on CG-4377.

## 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. External loads which have aerodynamic characteristics may cause oscillations to the extent that the load may strike the rotor blades and/or fuselage. Oscillations can usually be controlled by slowing the forward speed of the helicopter.

# 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 accomplishes 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 lead - lag servo system which dampens the effect of power transients, and the control governor which maintains power turbine speed ($N_f$) within the specified 8.5% droop limit at full forward 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, 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 weight flow of fuel ($W_f$) 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 (flameout). During deceleration, if fuel flow (which is decreasing) drops below a given amount, a lean flameout 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, an 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 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 minimum $W_f/P_3$ ratio to sustain normal combustion.

#### DROOP

Actual power turbine speed varies approximately 8.5% 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.

#### 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 (figure 7-1).

#### POWER AVAILABLE CHECK

This check provides the pilot a way of determining the maximum torque available on each engine at 103% $N_f/N_r$. This check will normally be done in a hover. If unable, it may be accomplished at altitude with a comfortable cruise speed.

**NOTE**

> With foreign object defector installed, maximum power available in forward flight will be less than that available when the foreign object deflector is not installed. The approximate power losses realized at corresponding airspeeds are as follows: At 60 KIAS the maximum torque will be 3% less, at 80 KIAS the maximum torque will be 5% less, at 100 KIAS the maximum torque will be 6% less, at 120 KIAS the maximum torque will be 7% less, and at 140 KIAS the maximum torque will be 9% less.

To check the number one engine proceed as follows.

1. Place the No. 1 speed selector full forward.

2. Retard the No. 2 speed selector until $N_g$ and $T_5$ on the No. 1 engine no longer increase. Continue to retard the No. 2 speed selector until $N_f/N_r$ decrease 2% more to ensure that the No. 1 engine is at topping. Do not exceed maximum engine or transmission limitations. If the engine is not properly topped, proceed with an engine topping adjustment.

3. Advance the No. 2 speed selector until the No. 1 engine $N_g$ just starts to fall off. Read $N_f/N_r$. This is the

maximum $N_f$ governing and should be not less than 103%. If $N_f/N_r$ is less than 103%, a notation should be made on CG-4377.

**NOTE**

A decrease in fuel flow on the No. 1 engine gives an advance indication of when $N_g$ will just start to fall off. At this time, closely monitor the $N_g$ gage.

4. Readjust the No. 2 speed selector to restore the small $N_g$ decrease. At this point the torque observed on the No. 1 engine is the maximum power available if that engine is properly topped.

5. Advance the No. 2 speed selector full forward.

6. Check the No. 2 engine in the same manner.

**NOTE**

If the torque reading obtained during the power available check with the engine anti-ice ON is 7% or more below the calculated torque available (TOLD), repeat the check with the anti-ice OFF. If the torque reading is still 7% or more below the calculated torque available, abort the flight.

### TOPPING CHECK

This check will normally be accomplished in a hover but under certain temperature conditions it may be necessary to take the helicopter to altitude to top the engines. During all of the following procedures, be constantly aware of the engine and transmission limitations· namely 721° $T_5$, 102.7% $N_g$ and 123% torque (single-engine gear box limitation). Engine topping should be checked any time a 20°C ambient air temperature change occurs.

Using the following table as a guide the pilot can accurately determine the proper topping $N_g$ value for a number of ambient air temperatures.

**MAX $N_g$ LIMITS FOR EXISTING TEMPERATURES**

| FAT | $N_g$ |
|---|---|
| 4.5°C and below | 102.7 |
| 10°C | 102.7 |
| 15°C | 102.7 |
| 20°C | 102.2 |
| 25°C | 101.9 |
| 30°C | 101.7 |
| 35°C | 101.6 |
| 40°C and above | 101.5 |

The following procedure describes the topping check for the No. 2 engine. The check for the No. 2 engine will be accomplished in the same manner.

**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**

When ambient temperatures are below 10°C (50°F), the anti-icing system should be turned on when the topping check is performed. 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 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 $T_5$ limit. 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 ambient temperature has increased sufficiently to affect the temperature limits. Power available will increase approximately four percent.

1. Observe FAT. Using the above table determine what the value of $N_g$ should be.

2. Place the No. 1 speed selector full forward.

3. Retard the No. 2 speed selector until $N_g$ and $T_5$ on the No. 1 engine no longer increase. Continue to retard the No. 2 speed selector until $N_f/N_r$ decreases 2% more to ensure that the No. 1 engine is at topping.

NOTE: OS-22 replaced by OS-29

Do not exceed maximum engine or transmission limitations. Note the Ng and T5 readings on the No. 1 engine. These are the topping readings. An adjustment to topping is not required if either of the following conditions are met:

For the recorded FAT:

a. Ng is not more than 0.5% below the figure determined from the chart and T5 is less than 721°C.

b. T5 is 716°C to 721°C and Ng does not exceed the maximum operational limit as determined from the chart. SEE OS-22 SEE OS-29

4. If T5 is less than 716°C and Ng is more than 0.5% below the figure shown for the recorded FAT proceed as follows:

a. Reduce power on No. 1 engine until Ng is at least 2% below topping.

b. Direct the flight mechanic to rotate the topping adjustment clockwise, being careful not to exceed T5 limit. One full turn (36 clicks) clockwise increases topping approximately 2-1/4% Ng (16 clicks, about 1% Ng, and 1 click equals about 1° T5).

c. Repeat steps 2 and 4 until one of the conditions in step 3 are met. If on days when ambient temperatures are below 25°C (77°F), and no increase in Ng is noted after the topping adjustment has been increased, reset the adjustment to its original position. The engine is operating on its maximum fuel flow limit and it is necessary to take the helicopter to higher altitudes in order to perform the check. See following values.

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

5. If T5 exceeds 721°C or Ng exceeds the figure shown for the observed FAT, proceed as follows:

a. Reduce power on No. 1 engine until Ng is at least 2% below topping.

b. Direct the flight mechanic to rotate the topping adjustment counterclockwise. One full turn (36 clicks) counterclockwise decreases topping approximately 2-1/4% Ng (16 clicks, about 1% Ng, and 1 click equals about 1° T5).

SEE OS-22

c. ~~Repeat steps 2 and 5 until one of the conditions in step 3 are met.~~ SEE OS-22

SEE OS-29

## 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 selector 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. Two start fuel valves, one for each engine, are located on the engine compartment and are installed between the engine fuel control and flow divider. When the valve is actuated during the start cycle of either engine, the flow of auxiliary bypass fuel is blocked. This blockage decreases the total amount of fuel flow during starting, thus reducing the possibility of an overtemperature condition due to excessive fuel flow.

**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 minimum $N_f$ governing, 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 Normal Operating ($N_f$ 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 selector advancement.

**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 cam contours to avoid compressor stall, rich or lean flameout, 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 $N_g$ does not drop below 91% $N_g$, will yield a deceleration not affected by feedback. The fuel flow/compressor-discharge pressure ($W_f/P_3$) 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 control 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.

**Governing Range**

In the governing range, the engine drives the helicopter rotor at the speed and power level selected by the pilot. For normal operation, a power turbine speed within the governing range of 87% to 107% may be selected. 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.

**Mixing of Fuels**

The mixing of fuels is not recommended because of problems encountered with fuel control settings. The effects of the combinations of fuel, fuel control settings, and fuel flow divider settings on starting will be apparent on (figure 7-1) Fuel, Fuel Control and Divider Settings Vs Start to Expect Chart. After using JP-4 and refueling with JP-5, in the initial start, with no changes to the fuel control or flow divider, a normal start will result because of JP-4 fuel remaining in the fuel control and flow divider. If the fuel control and fuel flow divider, were adjusted for JP-5, with JP-4 remaining in the control and divider a probable hot start may result because of the JP-4 remaining in fuel controls and lines. Subsequent starts should be normal. For a one-time use of JP-5 fuel the settings should not be changed as the only probable effect will be probable cold hang-up. If this condition exists, refer to COLD HANG-UP Section III.

| 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 |

**Figure 7-1. Fuel, Fuel Control and Divider Setting Vs Start to Expect Chart**

## FUEL SYSTEM

(figure FO-5.)

### FUEL SYSTEM MANAGEMENT

(figure 7-2.)

For normal operation, the forward fuel tank supplies fuel to the No. 1 engine and the aft fuel tank supplies fuel to the No. 2 engine. For operation under unusual conditions, the fuel cross-feed system provides a flexible operating system. During single-engine operation, fuel may be used from both tanks at the same time. 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 shutting off the boost pumps in the tank that is not to be used. When operating on crossfeed and one tank runs dry, both engines will continue to operate provided the boost pumps are 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.

**WARNING**

The boost pumps in the 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 automaticallly shut the pumps off if the temperature of the pump rises to 205°C (400°F), due to the lack of lubrication. This temperature is considerably lower than the spontaneous flash point of the fuel and/or vapors.

**NOTE**

When securing crossfeed operation, turn a boost pump ON in the tank not being used prior to closing the crossfeed switch.

## OPERATION OF FUEL SYSTEM

### BOTH ENGINES OPERATING

| CONDITION | CROSSFEED SWITCH | FUEL SHUT-OFF VALVES | BOOST PUMP SWITCHES |
|---|---|---|---|
| Normal Operation – Fwd tank to left engine and aft tank to right engine. | CLOSED | Both – OPEN | 1 pump – ON for each tank |
| Both tanks to both engines. | OPEN | Both – OPEN | 1 pump – ON for each tank |
| Either tank to both engines. | OPEN | Both – OPEN | Tank in use – BOTH – ON. Tank not in use – BOTH – OFF. |

1. Fuel transfers from the forward auxiliary tank to forward main tank is accomplished by fuel ejectors, when motive flow is obtained from the boost pump output.

2. Fuel from the aft auxiliary tank may be transferred to either the forward or aft main tanks by use of ejectors. Overfilling of either main tanks is prevented by use of float valves. Complete control by the pilot of fuel transfer is achieved by use of three electrically-operated gate valves located in the fuel ejector motive flow lines.

### ONE ENGINE OPERATING

| CONDITION | CROSSFEED SWITCH | FUEL SHUT-OFF VALVES | BOOST PUMP SWITCHES |
|---|---|---|---|
| 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 is use – BOTH – OFF |
| Both tanks to either engine. | OPEN | Good engine – OPEN. Failed engine – CLOSED | 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 – BOTH – OFF. |

**Figure 7-2. Operation of Fuel System Table**

# SECTION VIII

# CREW DUTIES

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## NORMAL CREW ASSIGNMENTS

The normal crew will consist of a pilot, copilot, flight mechanic and avionicsman. The minimum crew will consist of a pilot, copilot and flight mechanic.

## CREW DUTIES

### PILOT IN COMMAND

The pilot in command is responsible for the safe and orderly conduct of the flight. His responsibility and authority exist from the time he enters the aircraft preparatory to flight until he leaves it upon completion of the flight or mission. He shall be responsible for ensuring that his crew and passengers are properly briefed. Responsibility for all phases of the flight rests with the pilot in command. The pilot in command shall perform the duties of copilot in flight while not operating the flight controls.

### COPILOT

The copilot's duty is to assist the pilot. His general duties are:

1. Act as a safety pilot.

2. Monitor helicopter instruments.

3. Operate communication and navigation equipment.

4. Navigate.

5. Make required reports in normal and emergency situations.

6. Ensure that he receives an adequate briefing from the pilot for and during the flight and to question anything he fails to understand.

7. Assist the pilot in performing exterior and interior inspections of the helicopter.

8. Assist the pilot in mission planning.

9. Assist the flight mechanic in determining the cargo and passenger distribution and computing the CG of the helicopter.

### FLIGHT MECHANIC

The duties of the flight mechanic normally include but are not limited to the following:

1. Routine mechanic duties such as servicing and maintenance when away from home base.

2. Supervising all activities in the cabin.

3. Operating the rescue hoist and platform.

4. Supervising cargo loading and offloading.

5. Operating the manual fuel dump valves and actuating the auxiliary flotation equipment as directed.

6. Searching.

7. Performing duties of the radioman, as required, when one is not assigned.

8. Conduct safety check after takeoff and every 30 minutes. Prior to conducting a safety check the flight mechanic shall either close the cargo door or, with the seat in the forward locked position, swivel the seat inboard before releasing the shoulder harness. This check includes but is not limited to the following items.

a. Engine and transmission gages - check for normal indication.

b. Cockpit overhead circuit breaker panels - check for popped circuit breakers.

c. AUX servo broom closet - check for leaks and for security of servo unit, control rods and mixing unit.

d. Helicopter exterior - check for leaks, loose cowling, and for security of long wire antennas.

e. Deck fittings and outboard deck channels - check for evidence of leaks.

f. Engine and transmission deck drain lines - check for leaks.

g. Airframe fuel filter inlets and outlets - check for leaks.

h. Radio rack - check for overheating.

i. Heater fuel control - check for leaks.

j. General cabin area - check for leaks and security of equipment.

k. Advise pilot to crosscheck compasses and check fuel quantity.

9. Remove landing gear pins during preflight.

#### AVIONICSMAN

The duties and responsibilities of the avionicsman include but are not limited to the following:

1. Operating all communication and navigation equipment at his position.

2. Maintaining inflight logs, records and navigation plots as required.

3. Searching.

4. Maintaining hover position when directed through use of the hover trim stick.

5. Assisting the flight mechanic as required.

### CREW BRIEFING GUIDE

The following briefing guide is provided to assist the pilot in conducting briefings, as applicable to the type of mission assigned.

1. Mission requirements.

2. Flight plan.

3. Fuel load.

4. Emergency - survival equipment.

5. Weather.

6. Crew duties and responsibilities.

### PASSENGER BRIEFING GUIDE

The pilot in command shall insure that all passengers embarked receive an adequate briefing. The briefing shall encompass at least the following:

1. No smoking and seat belt rules and signals.

2. Emergency exits.

3. Action required in case of ditching or crash landing (signals and exits).

4. Use of life jackets.

5. Use of parachutes.

6. Use of other emergency equipment.

7. Movement within helicopter.

## CREW COORDINATION

Safe and efficient operation of the helicopter requires precise crew coordination and discipline due to its performance capabilities, the type and quantity of equipment installed, the size and location of exits, and the cargo and passenger capacity of the cabin.

## SAFETY BELTS

During routine landings and takeoffs and when directed, the flight mechanic and avionicsman will be seated with seat belts and harnesses fastened and seats facing forward. During flight, each crewman and passenger shall be seated with belt fastened except when necessary to move about or when the pilot has granted permission. The cargo door safety strap shall be secured across the door opening whenever the door is open in flight, except when operational necessity dictates otherwise such as during hoist or platform operations.

## ICS COORDINATION

The pilot shall be informed prior to a crewmember disconnecting from the ICS.

# SECTION IX

# ALL WEATHER OPERATION

## TABLE OF CONTENTS



## INTRODUCTION

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

## INSTRUMENT FLIGHT PROCEDURES

Flight in this helicopter, during instrument conditions, is possible and 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. A minimum speed of approximately 40 knots IAS should be observed to maintain normal flight characteristics associated with forward flight. Cruising flight turns should be limited to bank angle of 20°. Standard rate turns are recommended below approximately 6000 feet MSL. At higher altitudes, half standard rate turns are recommended.

**WARNING**

To preclude the possibility of ice ingestion engine failure, the helicopter will not be flown in known icing conditions or in visible moisture when temperatures are at or below 5°C (41°F) without the foreign object deflector installed.

**WARNING**

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

**WARNING**

When planning instrument flights, minimum enroute altitudes should be closely checked. Single-engine flight altitudes are severely limited by high gross weight and density altitudes. Inability to maintain terrain-clearance altitudes, if engine failure occurs, can result in a dangerous condition, particularly if ceilings do not permit transition to visual condition before reaching single-engine flight altitudes. Refer to Service Ceiling Charts, Figure A-27 for single-engine altitudes.

**WARNING**

Flight at night or in an instrument environment without an operable AFCS shall not be attempted. Use of the cyclic trim release under these conditions should be avoided.

**NOTE**

When operating in visible moisture turn on the pitot heat to prevent water buildup in the pitot tubes.

## INSTRUMENT TAKEOFFS

In addition to those conditions which normally require an instrument takeoff (precipitation, low ceilings, 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. Normal checks of flight controls, engines, and AFCS should be accomplished. For instrument takeoffs, the attitude indicator should be adjusted by setting the pitch trim knob triangle at the zero trim dot.

### Normal Instrument Takeoff

With feet on the deck, initiate a smooth application of collective to 95% - 103% torque, maintaining a nose on the horizon, wings level attitude by overriding cyclic trim, as necessary, and maintain this attitude until a positive rate-of-climb has been established. After passing through 50 to 75 feet, position the nose to approximately 3° down and continue to accelerate. Approaching 70 KIAS, position the nose to approximately 3° nose up, to maintain an 80 KIAS climb.

### Running Instrument Takeoff

This takeoff is a visual running takeoff. When airborne continue as described above for normal instrument takeoff.

## INSTRUMENT CLIMB

Climb-out may be accomplished in the HDG mode. Maneuvering the helicopter to center the steering pointer will result in turning to and maintaining the selected heading. Recommended climb speed is 80 KIAS with maximum continuous power. For short duration climbs during cruise, increase collective pitch to obtain desired climb rate while maintaining cruise airspeed.

### VOR/TACAN Airway Navigation

**Selecting and Converging on the Radial** Tune the navigation receiver to the TACAN or VOR station, and ensure the VOR-TACAN switches are properly positioned. Set the course arrow to the desired course. The course bar shows the position of the selected course relative to the helicopter. Monitor the relation of symbolic aircraft to course bar to intercept and track on the radial.

**Holding** Prior to entering holding, set the inbound holding course in the course display window and set the heading marker to the outbound course, corrected for wind. Recommended holding airspeed is 80 knots.

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

## INSTRUMENT APPROACHES

Use standard instrument approach procedures. Utilizing cruise airspeeds through the approach will reduce the effects of wind. An airspeed of 80 knots is recommended for final approach phase. During the final approach phase it is important that the airspeed remain constant to control drift and maintain a constant groundspeed. Speed selectors should be placed full forward and wheels rechecked down at 300 feet

AGL or minimums, whichever is higher. It is recommended that prior to the final approach phase of all instrument approaches, the heading marker be set to the initial missed approach heading and the mode selector knob be turned off. Prior to commencing an instrument approach the pilot will brief the safety pilot and the crewmen on the necessary particulars of the approach. The brief will include as a minimum the following items when they apply:

1. The frequencies of the navigation aids to be used during the approach.

2. The courses to be set in course display windows.

3. Approach minimums.

4. Minimum altitudes for each phase of the approach.

5. Missed approach timing.

6. Missed approach procedures.

7. Designation of pilot to handle communications.

8. Designation of pilot to monitor the navigation aid used for the approach.

9. Procedures to be followed after the safety pilot is visual.

**ADF/VOR and TACAN Approaches**

During ADF/VOR and TACAN full pattern approaches, (Figures 9-1 and 9-2), the steering pointer in the HDG mode may be used to facilitate procedure turn maneuvering.

**ADF Approaches** Use normal ADF instrument approach procedures, ensuring that the RMI pointer selector switch is in the LF/ADF position.

**WARNING**

HF transmissions during an ADF approach will cause erratic fluctuations of the number 1 needle.

**VOR/TACAN Approaches** Use normal VOR/TACAN instrument approach procedures. Set the published inbound course in the course display window for tracking both outbound and inbound. Exceptions to this procedure occur on teardrop approaches or when the final inbound course differs from the inbound course to the approach fix. It is recommended that the VOR-TACAN selector switches be positioned to provide both pilots with the same instrument approach information, i.e., pilot VOR MASTER; copilot VOR SLAVE.

**ILS Approach** Use normal ILS instrument approach procedures, (Figure 9-3). Always set the published inbound localizer front course in the course display window. This will ensure correct course indicator displays for both front and back course approaches. The VOR-TACAN selector switches must be placed in their respective VOR positions.

**Radar Approach** Use normal PAR/ASR instrument approach procedures, (Figure 9-4).

**Missed Approach Procedure** Initiate a missed approach using the following procedures:

1. Announce missed approach.

2. Recheck speed selectors full forward.

3. Increase power and commence climb. Once a climb has been established, comply with missed approach instructions.

4. The steering pointer in the HDG mode may be used when established in the climb.

5. Complete the AFTER TAKEOFF CHECKLIST.

**PRECISION APPROACH TO A COUPLED HOVER (PATCH)**

**General**

The purpose of this maneuver is to transition the helicopter into a coupled hover under conditions where positive visual contact with the surface cannot be established by 150 feet. The PATCH technique (Figure 9-5) provides positive control of the descent and may preclude flying into the surface. The pattern prior to reaching the gate may be modified or abbreviated as required. The computer may be used to navigate the aircraft to the gate. Use of the computer to navigate to the gate is recommended for winds greater than 30 knots.

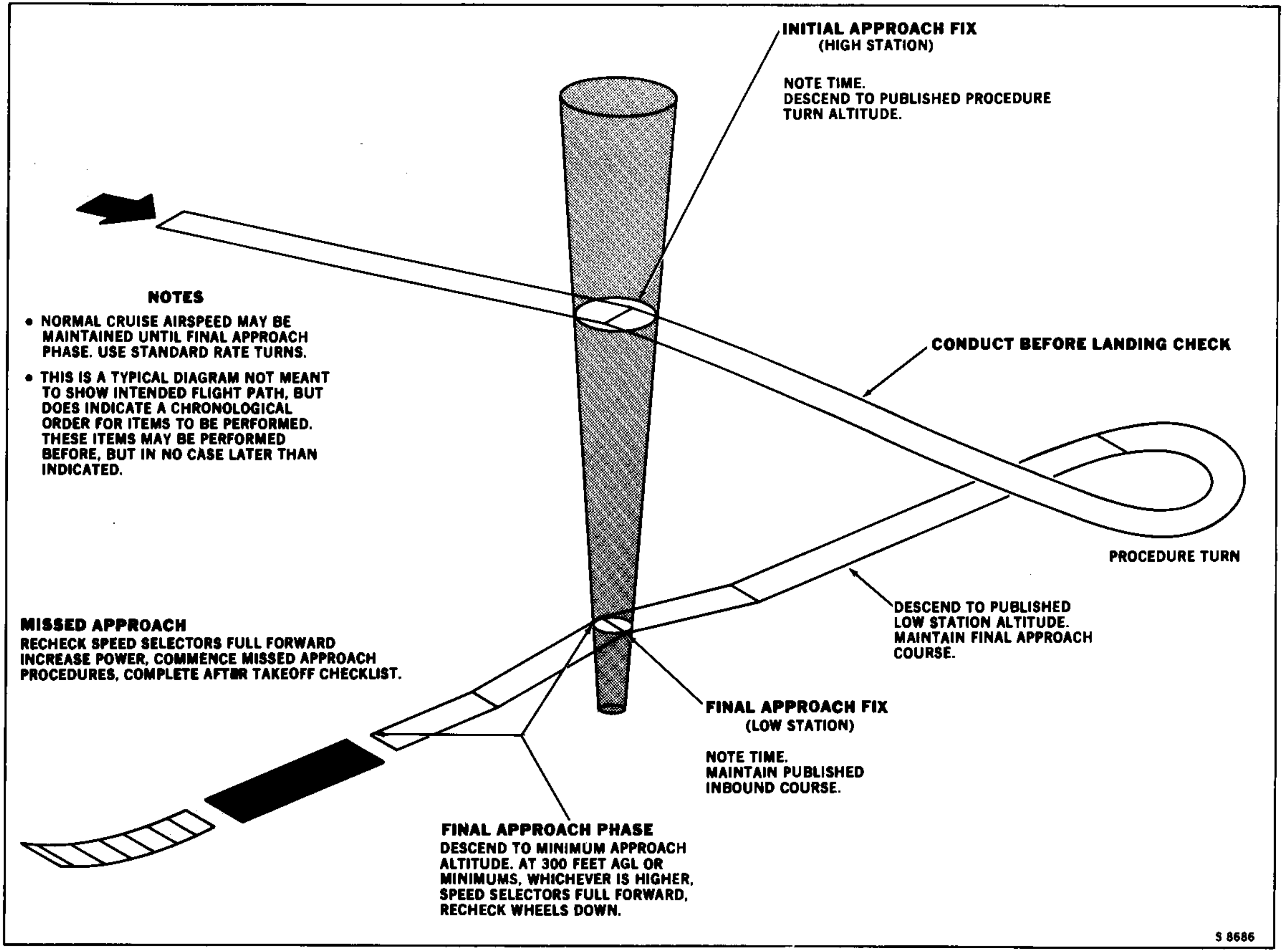


Figure 9-1. ADF, VOR Approach (Normal and Single Engine)

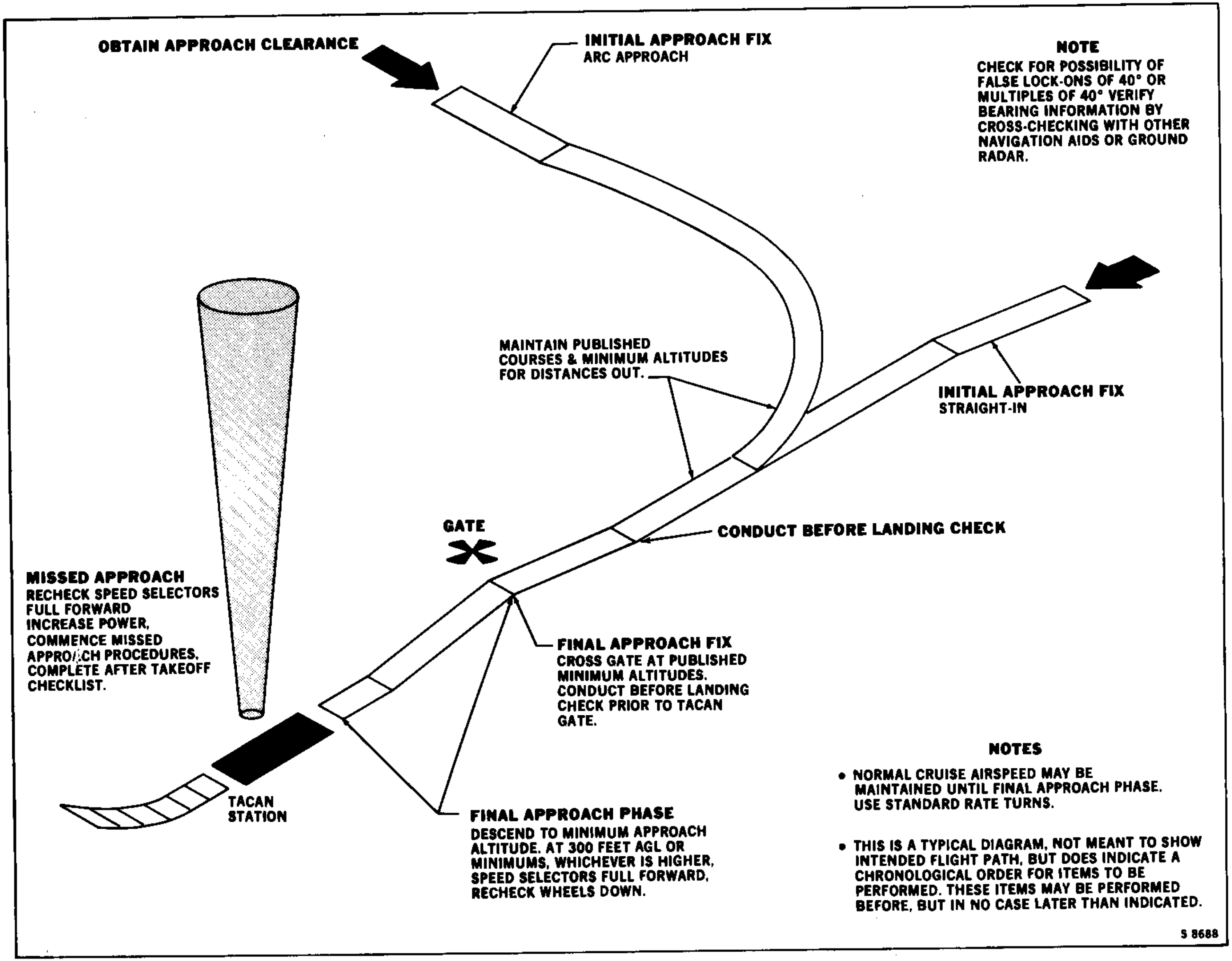


Figure 9-2. TACAN Approach (Normal and Single Engine)

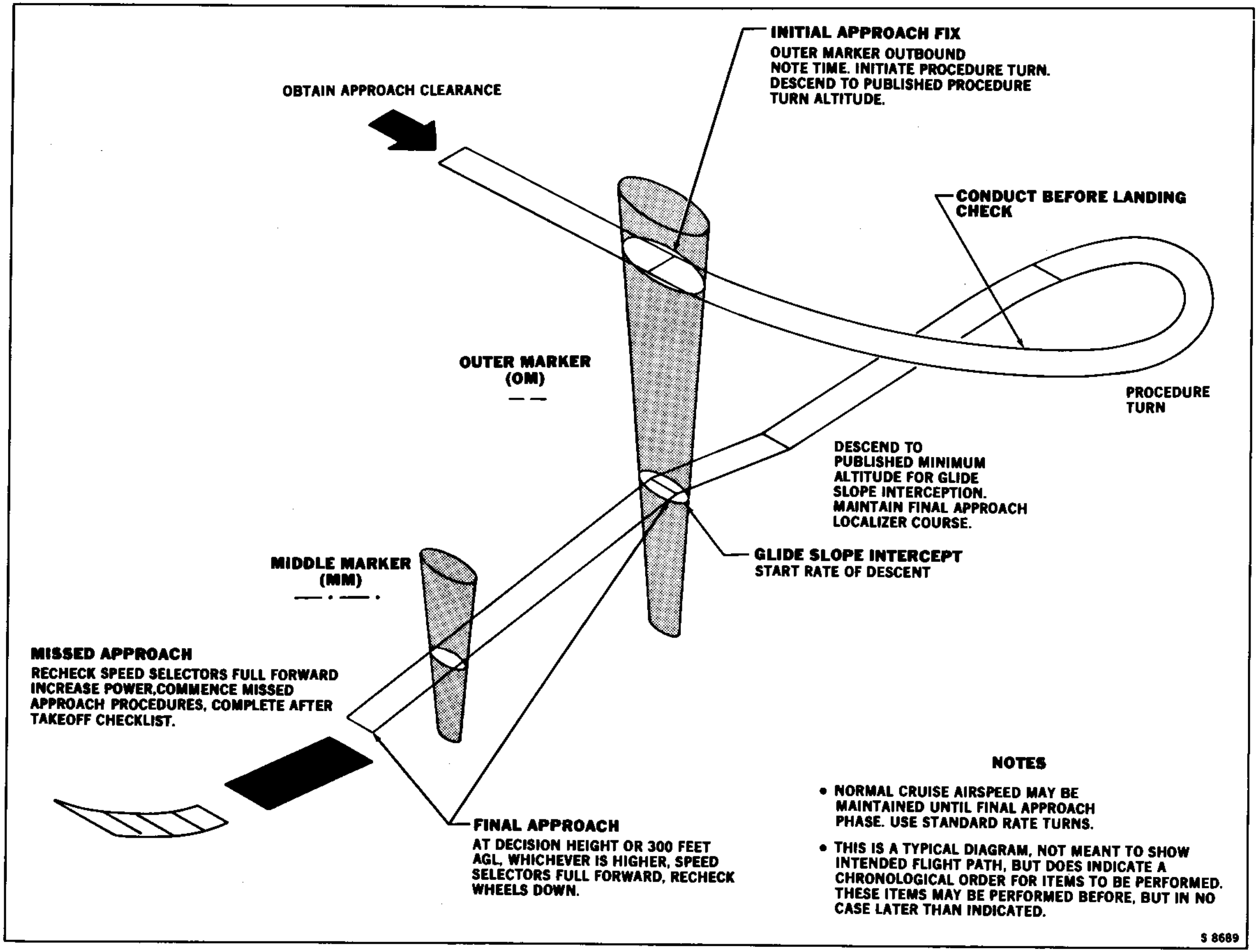


**Figure 9-3. ILS Approach (Normal and Single Engine)**

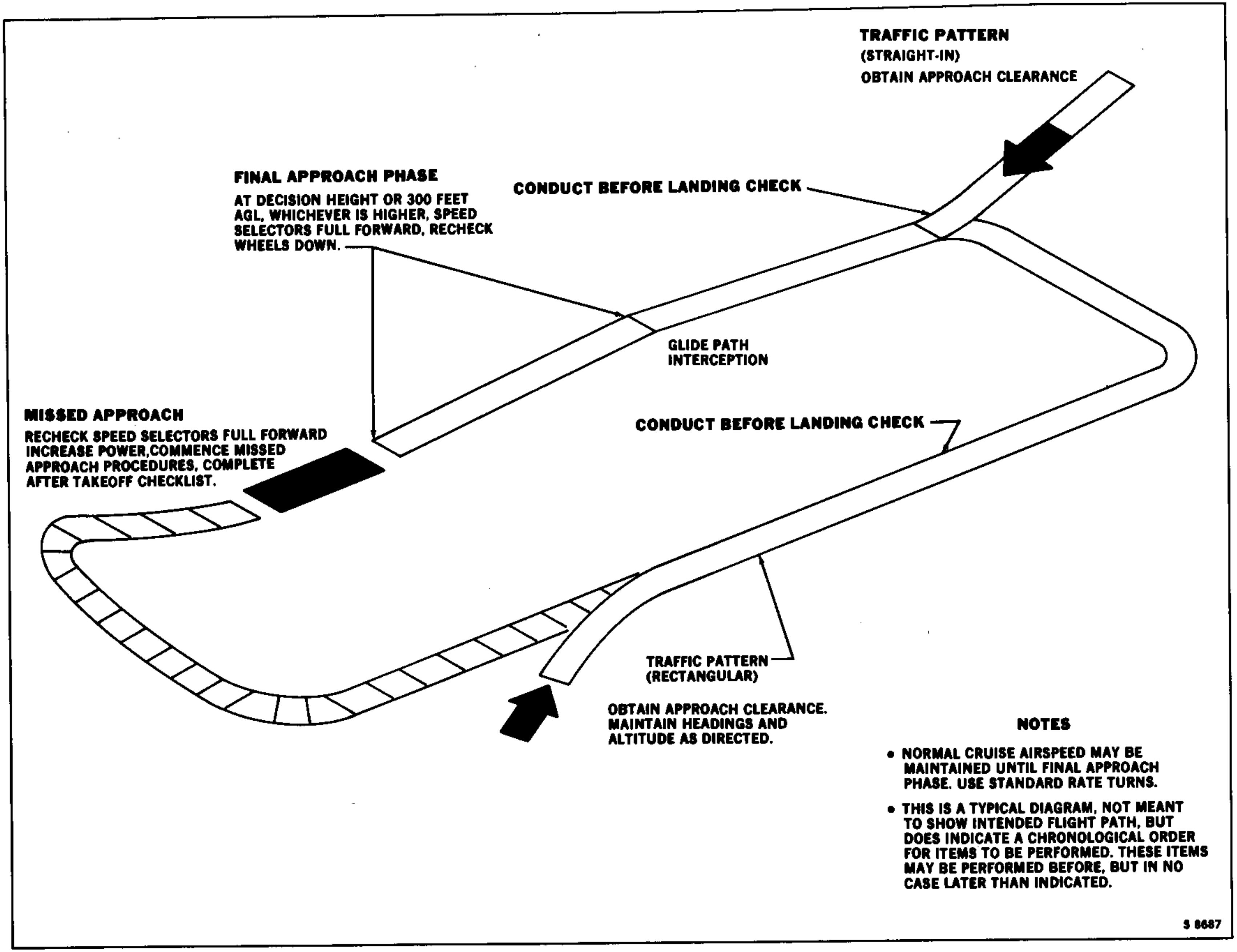


**Figure 9-4. RADAR Approach (Normal and Single Engine)**

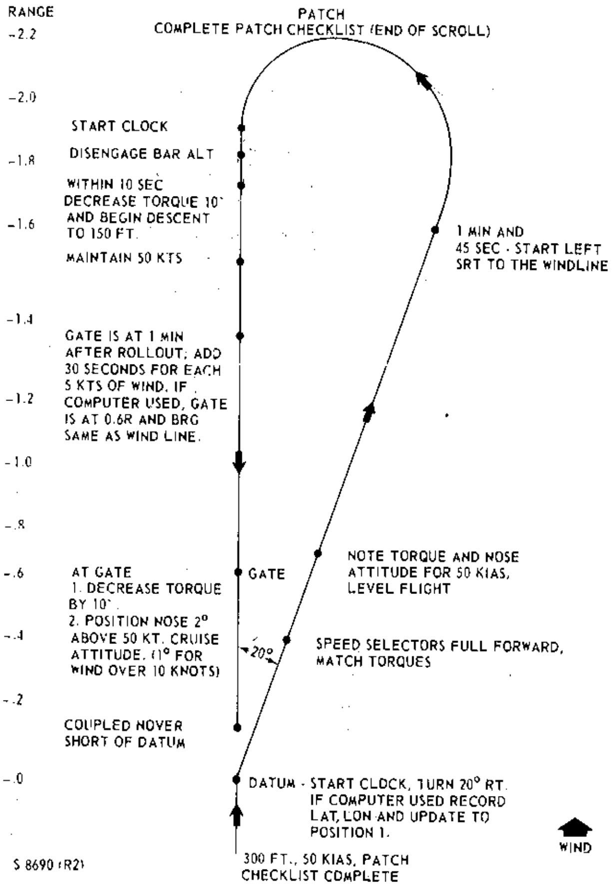


**Figure 9-5. Precision Approach to a Coupled Hover (PATCH)**

**CAUTION**

A PATCH should not be attempted if the aircraft is too heavy to hover out of ground effect.

**Procedures and Crew Duties**

**NOTE**

The pilot actually in control is called the pilot. The other pilot is called the safety pilot.

**Patch Checklist** Conduct the following checklist prior to crossing datum:

1. Conduct the "before landing" checklist except for speed selectors.

1.A. CARGO DOOR OPEN. Conditions permitting. (SEE MSG 091730 JUN 80)

2. Check Coupler Speed and Drift Pots - CENTERED
   Cockpit and cabin positions.

3. Coupler Altitude Set Pot - 50 FEET
   Higher if obstacle clearance requires.

4. Altitude Coupler Switch - ON.

5. Attitude indicators cross-checked with pitch trim knobs on center index.

6. Mode Selector Knobs - OFF.

7. Set Radar Altimeter Bugs - 50 FEET.

8. Radar Altimeters - CROSS CHECKED.
   Adjust barometric altimeters to match the radar altimeters.

9. HDG markers set to the wind line.

10. Cockpit Hot Mike Listen - ON.

11. Set Searchlight - AS DESIRED.

12. When Stabilized at 50 KIAS Check CG Trim Bar - CENTERED.

13. Hover Indicators - D MODE.

14. Doppler - ON.

If Computer Used

1. Record LAT LON of datum.

2. Select DOPP as a sensor.

3. Display R, BRG.

4. Place ID SELECT knob in any position except PP or LOR.

5. Update when over datum.

**NOTE**

If doppler or manual DR are the only available sensors, the computer should be updated to the LAT LON of datum prior to departing datum.

**Patch Pattern** 1. Turn and adjust the flight path to cross datum on a downwind heading at 300 feet and 50 KIAS at 103% Nf/Nr.

**NOTE**

Engage AFCS BAR ALT when stabilized at 300 feet and 50 KIAS. With BAR ALT engaged collective friction should be removed so as not to inhibit collective movement. The safety pilot will advise the pilot if the aircraft descends below 300 feet before the aircraft is turned on to final.

2. Passing over datum, start the elapsed time clock and make a 20° turn to the right. If the computer is used, update to position selected and display R, BRG to position selected.

3. Speed selectors full forward, match torques.

4. During the downwind leg note the nose attitude and the average torque required for level flight at 50 KIAS. The pilot must make an accurate determination of the nose attitude as it will be an essential factor in the final phases of the maneuver.

5. At one minute and 45 seconds after datum, start a left standard rate turn. (Approximately 10° angle of bank) to the windline.

6. After rollout, the safety pilot will start the clock, disengage the BAR ALT, and adjust the collective friction as the pilot directs. The pilot may elect to use the momentary BAR ALT release from 300 feet to 150 feet rather than reengaging the BAR ALT at 150 feet for long final legs. The pilot will place his feet on the deck and let AFCS control the heading.

7. Within 10 seconds after rollout, the pilot will decrease torque to 10% less than required for 50 KIAS cruise and commence a descent to 150 feet, maintaining 50 KIAS.

**CAUTION**

Do not let the rate of descent exceed 400 feet per minute.

8. The safety pilot will monitor the descent and advise the pilot when approaching 150 feet on the radar altimeter.

9. In no wind conditions, the gate is arrived at one minute after roll-out on the windline. An additional 30 seconds is added for each 5 knots of wind. If the computer is used, gate is at a range of 0.6 mi and the bearing should be the same as the windline. Under higher wind conditions the pattern may be shortened to avoid excessively long final legs. In this situation the computer would be used to navigate to gate. The pilot may elect to have the BAR ALT reengaged for excessively long final legs. The BAR ALT shall be disengaged prior to the gate.

**NOTE**

It is recommended that the outside lights be turned on prior to arrival at the gate.

10. At the gate, decrease the torque to 10% less than that required for 50 knot cruise and position the nose 2° higher than that of the 50 KIAS cruise attitude. If the wind is 10 knots or greater, the nose will be positioned only 1° higher than the 50 KIAS cruise attitude. During the descent from 150 feet to 75 feet, maintain a constant torque, keeping the wings level. The selected aircraft attitude is maintained by applying pressure to the cyclic and trimming as desired to relieve the control forces.

11. At approximately 75 feet, slowly increase torque to prevent the aircraft from descending through 50 feet; use cyclic pressure to continue to maintain the selected nose attitude with the wings level. Continuous small cyclic changes will be required during this part of the maneuver to maintain the selected attitude.

12. If the aircraft does not decelerate with the selected nose attitude, position the nose up an additional 1° to 2°. Do not exceed 10° noseup.

13. As the aircraft approaches zero ground speed, position the aircraft to the hover attitude. Under no wind conditions, the helicopter hovers slightly left wing down and about 4° nose up. Zero ground speed is normally determined by reference to the hover indicator.

14. When the aircraft is stabilized in the hover attitude and torque is approximately that required for HOGE (±10%), the safety pilot shall couple the altitude as directed by the pilot:

a. "Standby to couple; couple altitude"(P) - "altitude is coupled."(CP)

15. If the safety pilot is not visual at this point, the pilot shall trim the helicopter to elimate drift (by reference to the hover indicator if the doppler is operating). When the aircraft is in a stable, zero ground speed hover, and the pilot desires to couple the cyclic, the safety pilot will engage the CYCLIC COUPLER as directed by the pilot:

a. "Standby to couple cyclic; couple the cyclic"(P) - "cyclic is coupled."(CP)

**WARNING**

Do not transmit in the 3.0 to 3.6 MHz range during doppler or coupler hover operation. Transmission in this range will result in erratic helicopter attitude.

16. Safety pilot adjust SPEED and DRIFT pots as necessary.

17. The pilot will continue monitoring the instruments until the safety pilot reports visual contact with the surface and is given control of the aircraft. If required, at the direction of the pilot, the safety pilot shall commence cranking the aircraft down slowly with the ALTITUDE SET POT.

**WARNING**

Do not crank down below 15 feet on the RAD ALT.

18. After the safety pilot establishes visual contact, the following procedure will be used:

a. The safety pilot will advise the pilot, "I'm visual."

b. The pilot will relinquish control of the aircraft by saying, "You have it", and will continue to monitor the controls until the safety pilot acknowledges, "I have it."

c. The pilot shall then transfer his scan to outside the aircraft to establish visual contact. After establishing visual contact, he will report; "I'm visual," and the transfer of the aircraft will be accomplished as in step b.

19. After the pilot has resumed control of the aircraft, check and record T5 for each engine at a specified torque. Recheck T5 frequently to ensure early detection of excessive salt ingestion.

20. When the pilot elects to disengage the coupler (for landing, hoist, ITO, etc.), he shall advise the safety pilot: "Standby to disengage the BAR ALT." The pilot should simultaneously depress the COUPLER RELEASE and the MOMENTARY BAR ALT RELEASE buttons on the collective and advise the safety pilot: "Disengage the BAR ALT." The safety pilot replies, "BAR ALT disengaged."

**NOTE**

Do not disengage the BAR ALT by using the BAR OFF button until safely established in a climb.

**WARNING**

The safety pilot will visually check the position of the BAR ALT RELEASE, rather than feeling for it to avoid possibility of inadvertent movement of CG trim control.

## IN-FLIGHT ICING

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. Engine inlet icing may also be encountered, but not necessarily concurrent with rotor blade icing. The greatest dangers caused by ice accumulations 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 freezing. 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 may occur without blade icing.

**WARNING**

To preclude the possibility of ice ingestion engine failure, the helicopter will not be flown in known icing conditions or in visible moisture when temperatures are at or below 5°C (41°F) without the foreign object deflector installed.

**WARNING**

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

**NOTE**

If power requirements become critical during approach to landing, a running landing should be made if terrain permits.

## TURBULENCE AND THUNDERSTORMS

### TURBULENT AIR OPERATION

The helicopter handles very well in light to moderate turbulence. As turbulence levels increase from trace to light buffeting, cruise airspeeds should be reduced for comfort, ease of control, and reduced blade stall effects. Flying under conditions of moderate or heavy turbulence should be avoided. Descents should be made at low rate of descent and comfortable cruise speeds.

**NOTE**

The BAR ALT should be disengaged if strong updrafts or downdrafts cause the helicopter to be displaced more than 200 feet from the engaged altitude. Pressure differential in excess of 200 feet displacement may damage the barometric altitude controller.

### THUNDERSTORMS

Flight through or near thunderstorms should be avoided. If thunderstorms are encountered during flight, the radar should be used to aid in best flight path selection. If practical, land and wait for the storms to pass since violent turbulence and restricted visibility may be encountered in thunderstorms. When lightning is encountered at night, the dome light, spotlight, and instrument lights should be turned to full intensity to preclude temporary blindness.

## 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. Flight control hardovers have been induced on the aircraft by the freezing of condensate in the primary servos. If this condition exists and the APU is started, the flight controls may be in a hardover condition and remain there until the hydraulic system attains normal operating temperatures. Do not attempt to engage the rotor system if the above condition is suspected to exist.

Pilots should be cognizant of the fact 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. The problems encountered when operating from snow covered surfaces are compounded when operating from other than an operational air base. When hovering in loose or powdery conditions all ground references may be lost due to blowing snow. Smoke markers will assist in providing reference and determining wind.

**WARNING**

Static electricity generated by the helicopter should be dissipated prior to 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. Use care not to break contact as the static charge will rebuild immediately.

**NOTE**

Rotor wash or wind will have a supercooling effect, which may reduce the efficiency of exposed personnel. 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 engine inlets, 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.

Check that fuel tank vents, battery compartment vent tube, and pitot tubes (including static ports) are free of snow and ice; that landing gear struts and tires are properly inflated; and that a warm well-charged battery has been installed, if practicable. Check the engines for ice and snow. If ice or snow is found, the engine must be thawed out with hot air prior to attempting to start.

**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

The lower the temperatures, the greater will be the amount of accumulator pressure required for a start. At -54°C (-65°F) a pressure of approximately 4000 psi is required to start the APU.

## WARMUP AND GROUND TESTS

At termperatures below freezing, immediately after APU start, turn on the cabin heater and windshield anti-ice system, close the cargo door and remove the rubber transmission access panel. Check the transmission oil pressure and temperature. When engaging the rotor head, be careful not to exceed the transmission oil pressure limitations.

**CAUTION**

A longer warmup period during cold weather is required to bring engine and transmission oil temperatures up to desired operating range. When ambient temperature is below -6.7°C (20°F), operate the APU until the main transmission oil temperature gage indicates -6.7°C (20°F) before rotor engagement is accomplished. In the event of a rotor brake failure, do not start engines until this warmup period is completed to prevent damage to the main transmission.

**CAUTION**

When starting the APU with low ambient temperature, clutch engagement time will increase due to greater breakaway torque levels among the accessories. The APU should be shut down if acceleration between 76% and 80% hangs up more than 6 seconds. Refer to **BEFORE STARTING ENGINES** in Section II.

### ENGINE STARTING

At extremely low temperatures, it is possible that the engine oil pressure will go to a maximum value during an engine start. Ensure 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.

#### Alternate Engine Starting/Rotor Engagement With APU Inoperative, Below -6.7°C (20°F)

Should the APU be inoperative, the number one engine should be started and the rotors engaged by utilizing the procedures outlined in **ENGINE START WITH APU INOPERATIVE** and **ROTOR ENGAGEMENT WITH APU INOPERATIVE** in Section II. When the ambient temperature is -6.7°C (20°F) or less, 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. |

4. After the above preheat is accomplished, start the No. 1 engine with rotor brake on. When oil pressure stabilizes and the transmission oil temperature gage maintains an indication of -6.7°C (20°F) or warmer, rotor speed may slowly increase to 100% $N_r$.

### TAXIING INSTRUCTIONS

The helicopter can be taxied in snow. Increased collective pitch may improve steering. Snow-covered surfaces may contain hidden obstructions or hazards. A lower pitch and higher ground speed, to get ahead of the blowing snow, may improve visibility. At temperatures below -0°C (32°F) wheel braking action is fair to good. However, as temperatures rise increased caution must be exercised.

**WARNING**

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

### 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. Execute "no hover take off" and climb as outlined in Section II when snow is present.

### DURING FLIGHT

During flight, use the cabin heater, engine inlet anti-icing, and windshield anti-ice protective systems, as required. 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. After takeoff from water, wet snow, or slush covered field, operate the landing gear through several complete cycles to preclude their freezing in the retracted position. (Expect slower operation of the landing gear in cold weather due to thickening of all lubricants.)

**WARNING**

If the free-air temperature is -18°C (0°F) or below, and the engine anti-icing switches have been turned on, the caution lights will illuminate to indicate that electrical heating is not sufficient to raise the duct temperature at the sensor to 37.8°C (100°F), which is the temperature necessary to ensure that ice does not form in the inlet duct. If the free-air temperature is -18°C (0°F) or above and the anti-icing system is on, illumination of the caution lights indicates the possibility of system failure. However, under certain conditions of high speed and high power settings, the caution lights may illuminate when the OAT is as high as -5°C (23°F) without a malfunction. If the engine inlet anti-ice caution light should illuminate in flight at temperatures above -10°C (14°F), reduce engine speed to 80% $N_g$ on the affected engine and airspeed to 65 KIAS or less. If the light does not go out, system failure is indicated. If the system is found to be operational the pilot may, at his discretion. continue the mission. If system failure is indicated and he elects to continue a mission with the caution light illuminated, he must exercise caution to avoid any visible moisture and be constantly aware of any increase in $T_5$ since he does not have adequate anti-ice capability for any condition which causes the caution light to illuminate. At the lower temperatures where this may occur, icing conditions are not usually encountered due to lack of liquid moisture in the air. At temperature above -18°C (0°F) the light should not illuminate during ground operation. The system receives power from the ac primary buses through circuit breakers, marked ENGINE INLET ANTI-ICE, located on the overhead circuit breaker panels. A thermal switch, located in the air inlet duct, closes to permit power from the dc primary bus to illuminate the anti-ice caution lights.

### 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. Landings are accomplished in a normal manner, except the approach must be accomplished with a minimum hover before touchdown, to minimize the rotor wash on loose powdery snow with reduced visibility. After contacting the surface, maintain maximum rpm, while slowly reducing collective pitch 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. Providing there are no obstructions, the tail rotor will be clear when the fuselage rests on a level 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 and tail rotor 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 missed approach.

### STOPPING OF ENGINES

Make a normal engine shutdown, as outlined in Section II. As soon as the helicopter is parked, chock the wheels and release the brakes. At extreme low temperatures the collective pitch lever friction lock should be left in the OFF position during shutdown, since, 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 cockpit 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 the 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 door, ramp windows, and maintenance platforms. Clean landing gear oleo struts of dirt, snow, and ice, with a clean cloth soaked in hydraulic fluid. If the helicopter is to remain outside for a period more than 4 hours at below freezing temperatures, or less than 4 hours at temperatures below -25°C (-13°F), remove the battery and store in a heated room. Check that protective covers have been installed. If the helicopter is secured on a snow-packed or ice-covered surface, the use of ice chocks should be considered.

NEW

## HOT WEATHER PROCEDURES

Hot weather operation, as distinguished from desert operation, generally means operation in a hot, humid atmosphere. High humidity usually results in the condensation of moisture throughout the helicopter. Possible results include malfunctioning of electrical equipment, fogging of instruments, rusting of metal parts, and the growth of fungi in vital areas of the helicopter. Further results may be 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 Appendix I. 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.

### AFTER LANDING

When the helicopter is parked, the doors and windows, except the cockpit windows, should be opened if weather permits. The cockpit windows should remain closed to prevent unexpected rain showers from pooling water on control panels which could possibly create short circuits.

## 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 Appendix I. 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, WARMUP, AND GROUND TESTS

If possible, engine starting and ground operation should be accomplished from a hard, clean surface. Accomplish the normal engine start, warmup, and ground tests as outlined in Section II, but limit ground operation to a minimum, as the downwash 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 "no hover takeoff" and climb as outlined in Section II.

**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 procedure to minimize blowing sand and dust is a running landing. If the terrain does not permit a running landing, an approach should be made to a no hover landing accomplished with a minimum of forward speed.

**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 cabin. 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 THE HELICOPTER**

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