SECTION V
operating limitations

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION.

This section includes the engine and aircraft limitations which must be observed during normal operation. Cognizance must be taken of instrument markings, since the limitations stated thereon are not repeated in the text *(figure 5-1)*.

MINIMUM CREW REQUIREMENT.

The minimum crew consists of a pilot and a copilot. Additional crew members, as required, will be added at the discretion of the commander.

INSTRUMENT MARKINGS.

ENGINE POWER INSTRUMENTS.

Refer to figure 5-1 for engine power limitations.

ENGINE LIMITATIONS.

If an engine overspeed condition occurs and the engine exceeds 2950 rpm the engine must be inspected upon landing. If overspeed is in excess of 3400 rpm, the engine must be replaced.

ENGINE OVERBOOST OR EXCESSIVE MANIFOLD PRESSURE.

Overboost above the maximum manifold pressures specified under normal and alternate fuel grade operating limits, this section, is not permitted; however, should overboost occur due to control malfunction, the following limits will apply:

From 5 to 10 inches Hg overboost for 5 to 15 seconds — inspection of engine.

Ten or more inches Hg for any period of time — removal of engine.

Overboost of any magnitude, at or above normal rated power, for periods in excess of 15 seconds — removal of engine.

ENGINE POWER TIME LIMITATIONS.

The engines are approved for 5 minutes of operation at maximum power during takeoff and climb at takeoff speed. There is no time limitation in the use of METO power.

CARBURETOR AIR TEMPERATURE LIMITATIONS.

LOW BLOWER — Max allowable CAT. (without preheat) 55°C.

LOW BLOWER — Max allowable CAT. (preheat applied) 38°C.

HIGH BLOWER Maximum allowable CAT. 15°C.

Note

When preventive preheat is applied, the maximum carburetor air temperature limit in low blower is 38°C. In high blower the maximum CAT is 15°C; however, this limit has been extended to 30°C for cruise up to 1200 brake horsepower at mixture settings of 12 BMEP drop from best power mixture. It is mandatory that these higher CAT limits in high blower, along with the specified BHP, BMEP and CHT (204°C) limits, not be exceeded. If any of these limits are exceeded, the maximum CAT limit reverts to 15°C.

PROPELLER LIMITATIONS.

Refer to figure 5-1 for normal propeller limitations.

AIRSPEED LIMITATIONS.

Note

Limit markings on the airspeed indicator vary with different C-118A aircraft. On some the limits are for indicated airspeed (IAS), while on others the limits are for equivalent airspeed (EAS), which is also referred to sometimes as true indicated airspeed (TIAS).

The maximum permissible indicated airspeeds (IAS) for AF51-3818 through AF51-3835, AF51-17616 through AF51-17661, AF51-17667, AF51-17668, and AF53-3223 through AF53-3234 are as follows:

Maximum dive speed (V_{mo}) — sea level to 12,000 feet .... 329 knots; above 12,000 feet, reduce speed 5 knots per 1000 feet

Maximum speed for normal operation (V_{mo}) — sea level to 17,000 feet .... 246 knots; above 17,000 feet, reduce speed 5 knots per 1000 feet

NORMAL FUEL GRADE OPERATING LIMITS.

The normal operating limits on grade 108/135 or 115/145 fuel are as follows:

Condition	*Rpm*	*Bhp*	*MAX MP (In. Hg)*	**Critical Altitude*	*Bmep*	*MAX CHT.*	*MAX *CAT.*	*Mixture*
Wet Takeoff (5 Minutes) Low Blower	2800 (±25)	2500	62.0 at SL 61.5 at 3800 feet	2600 feet (MP-61.0)	253	260°C	38°C	AUTO RICH
Dry Takeoff (5 Minutes) Low Blower	2800 (±25)	2200	60.0 at SL 59.0 at 5200 feet	4400 feet (MP-57.2)	222	260°C	38°C	AUTO RICH
METO Low Blower	2600	1900	51.5 at SL 50.0 at 7200 feet	7000 feet (MP-48.0)	207	260°C	38°C	AUTO RICH
METO High Blower	2600	1700	50.0 at 10,000 feet 47.5 at 15,900 feet	15,400 feet (MP-46.7)	185	260°C	15°C	AUTO RICH
Maximum Cruise Low Blower	2300	1240	37.3 at SL 33.3 at 15,500 feet	†	153	232°C	38°C	12 Bmep Drop‡
Maximum Cruise High Blower	2300	1200	35.1 at 10,000 feet 34.6 at 22,000 feet	†	147	232°C	15°C	12 Bmep Drop‡

* Critical altitude in climb as determined by flight test.
† Function of gross weight.
‡ With reference to "Best Power" mixtures.
Maximum cruise low blower — 155 bmep (except when at 1240 bhp and 2300 rpm — 153 bmep).

CAUTION

The requirement for 2800 (±25) rpm applies during the takeoff roll only and not during preflight runup or block test.

ALTERNATE FUEL GRADE OPERATING LIMITS.

The operating limits on grade 100/130 fuel are as follows:

Condition	*Rpm*	*Bhp*	*MAX MP (In. Hg)*	**Critical Altitude*	*Bmep*	*MAX CHT.*	*MAX CAT.*	*Mixture*
Wet Takeoff (5 Minutes) Low Blower	2800 (±25)	2400	59.5 at SL 58:5 at 5000 feet	3500 feet (MP-59.0)	242	260°C	38°C	AUTO RICH
Dry Takeoff (5 Minutes) Low Blower	2800 (±25)	1950	53.0 at SL 51.0 at 9800 feet	8200 feet (MP-50.1)	197	260°C	38°C	AUTO RICH
METO Low Blower	2600	1800	48.5 at SL 46.5 at 9200 feet	8700 feet (MP-45.2)	196	260°C	38°C	AUTO RICH
METO High Blower	2600	1700	49.0 at 10,000 feet 47.5 at 15,900 feet	15,400 feet (MP-46.7)	185	260°C	15°C	AUTO RICH
Maximum Cruise Low Blower	2300	1240	37.3 at SL 33.3 at 15,500 feet	†	153	232°C	38°C	12 Bmep Drop‡
Maximum Cruise High Blower	2300	1200	35.1 at 10,000 feet 34.6 at 22,000 feet	†	147	232°C	15°C	12 Bmep Drop‡

* Critical altitude in climb as determined by flight test.
† Function of gross weight.
‡ With reference to "Best Power" mixtures.
Maximum cruise high blower — 150 bmep (except when at 1200 bhp and 2300 rpm — 147 bmep)

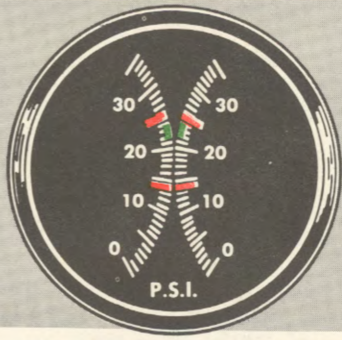
CAUTION

The requirement for 2800 (±25) rpm applies during the takeoff roll only and not during preflight runup or block test.

INSTRUMENT LIMIT

HYDRAULIC PRESSURE GAGE

- (red) 3200 PSI MAXIMUM ALLOWABLE
- (green) 2650 TO 3100 PSI NORMAL OPERATING RANGE



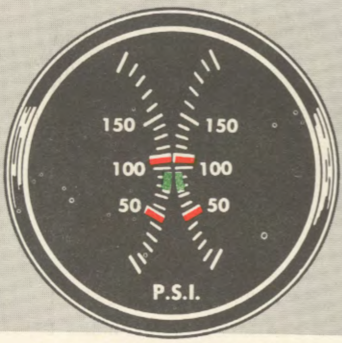
FUEL PRESSURE INDICATOR

- (red) 25 1/2 PSI MAXIMUM ALLOWABLE
- (green) 22 TO 24 PSI NORMAL OPERATING RANGE
- (red) 14 PSI MINIMUM ALLOWABLE, IDLING

WATER PRESSURE INDICATOR

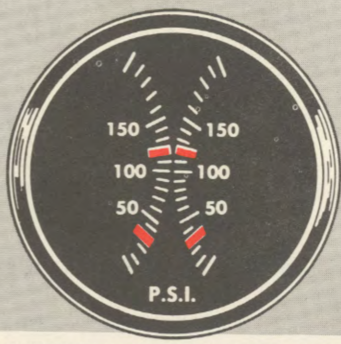
- (green) 22 TO 24 PSI NORMAL OPERATING RANGE
- (red) 19 PSI MINIMUM ALLOWABLE

FUEL GRADE
115/145



OIL PRESSURE INDICATOR

- (red) 110 PSI MAXIMUM ALLOWABLE
- (green) 75 TO 95 PSI NORMAL OPERATING RANGE
- (red) 50 PSI MINIMUM ALLOWABLE (FOR 1400 RPM ONLY)



SUPERCHARGER OIL PRESSURE

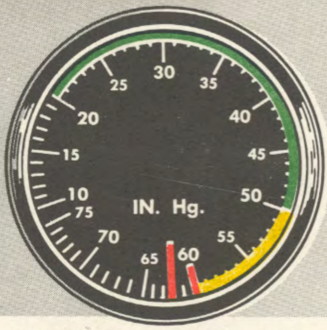
- (red) 120 PSI MAXIMUM ALLOWABLE
- (red) 30 PSI MINIMUM ALLOWABLE

AA1-166

Figure 5-1 (Sheet 1 of 6)

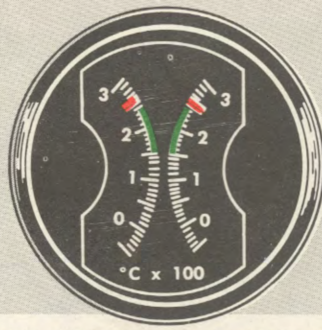
MARKINGS

AF51-3818 THROUGH AF51-3835
AF53-3223 THROUGH AF53-3305



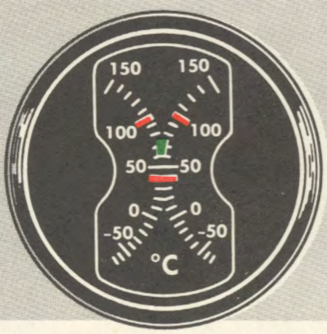
MANIFOLD PRESSURE GAGE

- LONG 62 IN. HG. MAXIMUM OPERATING LIMIT (WET)
- SHORT 60 IN. HG. MAXIMUM OPERATING LIMIT (DRY)
- 50 TO 60 IN. HG. LIMITED OPERATION (CAUTION RANGE)
- 20 TO 50 IN. HG. NORMAL CONTINUOUS OPERATION



CYLINDER HEAD TEMPERATURE INDICATOR

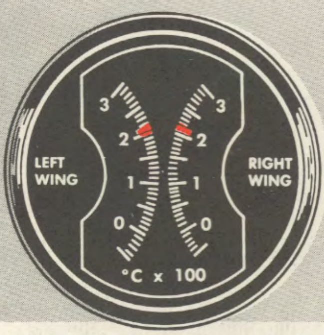
- 260°C MAXIMUM OPERATING LIMIT
- 150°C TO 232°C CONTINUOUS OPERATION
- 190°C TO 200°C DESIRED FOR CRUISE



OIL TEMPERATURE INDICATOR

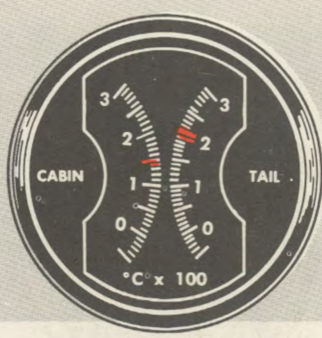
- 100°C MAXIMUM OPERATING LIMIT
- 60°C TO 75°C NORMAL CONTINUOUS OPERATION
- 40°C MINIMUM OPERATING LIMIT

FUEL GRADE
115/145



WING HEATERS TEMPERATURE INDICATOR

- 210°C MAXIMUM OPERATING LIMIT

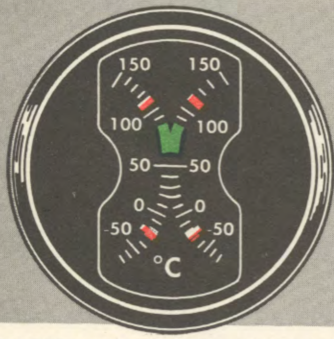


CABIN AND TAIL HEATERS TEMPERATURE INDICATOR

- CABIN HEATER 150°C MAXIMUM OPERATING LIMIT
115°C TO 145°C NORMAL
- TAIL HEATER 210°C MAXIMUM OPERATING LIMIT

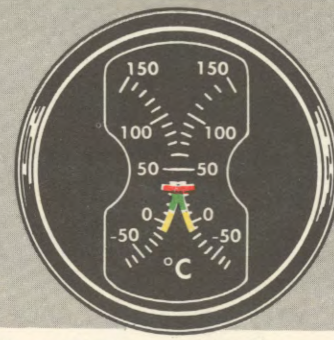
Figure 5-1 (Sheet 2 of 6)

INSTRUMENT LIMIT



SUPERCHARGER OIL TEMPERATURE INDICATOR

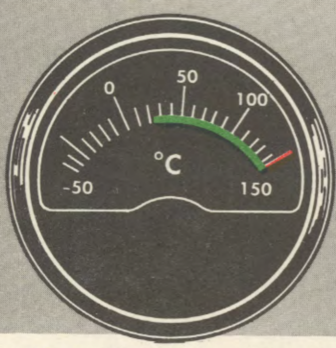
- (Red) 110°C MAXIMUM OPERATING LIMIT
- (Red) −23°C MINIMUM OPERATING LIMIT
- (Green) 60°C TO 80°C NORMAL CONTINUOUS OPERATION



CARBURETOR AIR TEMPERATURE INDICATOR

- (Red) +38°C MAXIMUM OPERATING LIMIT
- (Yellow) −10°C TO +15°C LIMITED OPERATION (CAUTIONARY RANGE; DANGER OF ICING)
- (Green) NORMAL CONTINUOUS OPERATION

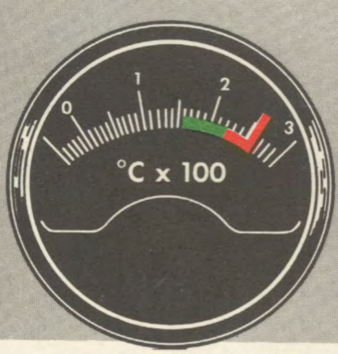
Note:
55°C maximum with low blower and no carburetor heat.



AUXILIARY POWER UNIT OIL TEMPERATURE GAGE

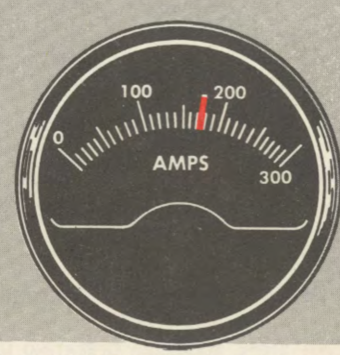
- (Red) 146°C MAXIMUM OPERATING RANGE
- (Green) 21°C TO 146°C NORMAL CONTINUOUS OPERATING RANGE

FUEL GRADE
115/145



AUXILIARY POWER UNIT CYLINDER HEAD TEMPERATURE GAGE

- (Red) 255°C MAXIMUM OPERATING LIMIT
- (Red) 220°C TO 255° LIMITED OPERATION (CAUTIONARY RANGE)
- (Green) 160°C TO 220°C NORMAL CONTINUOUS OPERATION



AUXILIARY POWER PLANT AMMETER

- (Red) 175 AMPS MAXIMUM OPERATING LIMIT

AA1-180

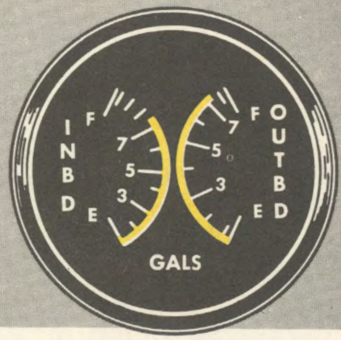
Figure 5-1 (Sheet 3 of 6)

MARKINGS

AF51-3818 THROUGH AF51-3835
AND AF53-3223 THROUGH AF53-3305

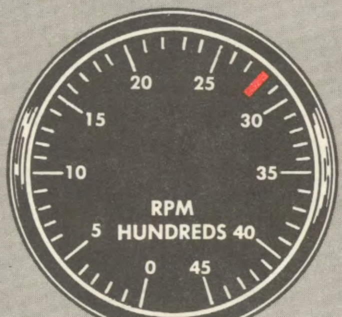
WATER QUANTITY INDICATOR ENGINES 1 AND 2

- (yellow) OUTBOARD 0 TO 7.5
- (yellow) INBOARD 0 TO 7.5



WATER QUANTITY INDICATOR ENGINES 3 AND 4

- (yellow) INBOARD 0 TO 7.5
- (yellow) OUTBOARD 0 TO 7.5

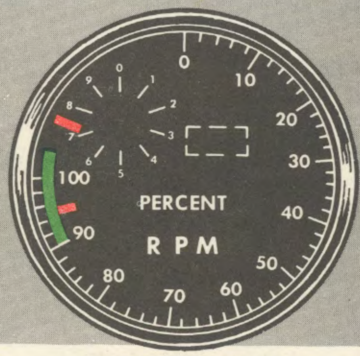


TACHOMETER

- (red) 2800 (± 25) RPM MAXIMUM TAKEOFF LIMIT
- 2600 TO 2800 RPM LIMITED OPERATION
- 1400 TO 2600 RPM NORMAL CONTINUOUS OPERATION

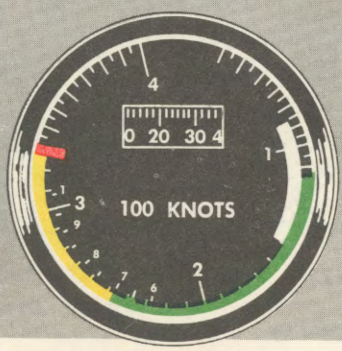
FUEL GRADE

115/145



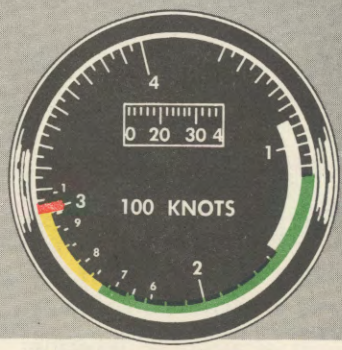
APU TACHOMETER (FOR AIRCRAFT WITH GTP70 APU)

- (green) 90 TO 105% OF RATED RPM
- (red) 95 AND 110% MOMENTARY MAXIMUM



AIRSPEED INDICATOR (AF53-3223 THROUGH AF53-3234)

- (red) 329 KNOTS (IAS) – MAXIMUM PERMISSIBLE INDICATED AIRSPEED
- (yellow) 246 TO 329 KNOTS (IAS) – CAUTION RANGE
- (green) 115 TO 246 KNOTS (IAS) – NORMAL OPERATING RANGE
- (white) 150 KNOTS (IAS) – MAXIMUM PERMISSIBLE INDICATED AIRSPEED WITH FLAPS EXTENDED MORE THAN 30 DEGREES



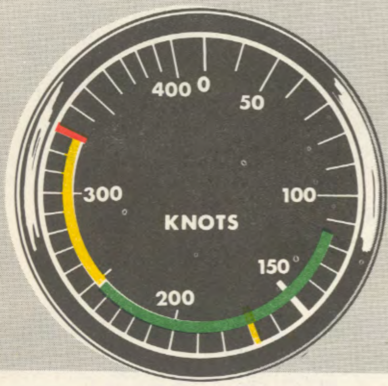
AIRSPEED INDICATOR (AF53-3235 THROUGH AF53-3305)

- (red) 300 KNOTS (EAS) – MAXIMUM PERMISSIBLE EQUIVALENT AIRSPEED
- (yellow) 251 TO 300 KNOTS (EAS) – CAUTION RANGE
- (green) 115 TO 251 KNOTS (EAS) – NORMAL OPERATING RANGE
- (white) 152 KNOTS (EAS) – MAXIMUM PERMISSIBLE EQUIVALENT AIRSPEED WITH FLAPS EXTENDED MORE THAN 30 DEGREES

AA1-176

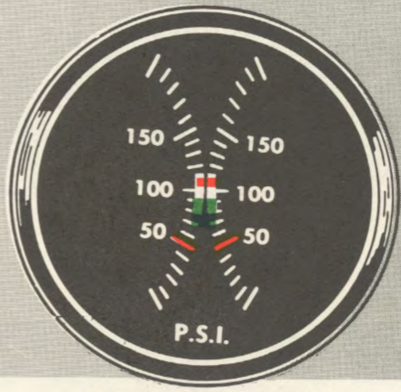
Figure 5-1 (Sheet 4 of 6)

INSTRUMENT LIMIT



AIRSPEED INDICATOR

- (Red) 329 KNOTS MAXIMUM PERMISSIBLE INDICATED AIRSPEED
- (Yellow) 246 TO 329 KNOTS CAUTION RANGE
- (Green) 115 TO 246 KNOTS NORMAL OPERATING RANGE
- (White) 150 KNOTS — MAXIMUM PERMISSIBLE INDICATED AIRSPEED WITH FLAPS EXTENDED MORE THAN 30 DEGREES

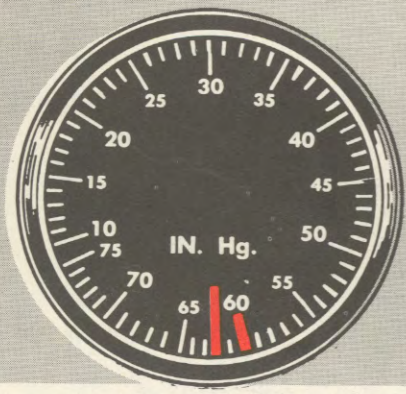


OIL PRESSURE GAGE

- (Red) 110 PSI MAXIMUM ALLOWABLE
- (Green) 75 TO 95 PSI NORMAL OPERATING RANGE
- (Red) 50 PSI MINIMUM ALLOWABLE (FOR 1400 RPM ONLY)

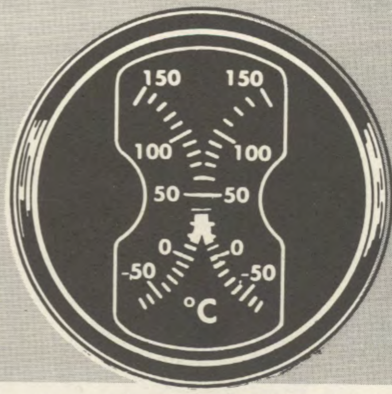
AF 51-3818 THROUGH AF 51-3835
AF 51-17626 THROUGH AF 51-17661
AF 51-17667 THROUGH AF 51-17668

FUEL GRADE
115/145



MANIFOLD PRESSURE GAGE

- (Red) LONG 62 INCHES HG MAXIMUM TAKEOFF PRESSURE (WET)
- (Red) SHORT 60 INCHES HG MAXIMUM TAKEOFF PRESSURE (DRY)



CARBURETOR AIR TEMPERATURE INDICATOR

- (White) +15° TO +38°C NORMAL OPERATION RANGE

AA1-193

Figure 5-1 (Sheet 5 of 6)

MARKINGS

AF51-17626 THROUGH AF51-17661, AF51-17667, AND AF51-17668

OIL TEMPERATURE INDICATOR

- (red) 100°C MAXIMUM ALLOWABLE
- (green) 60°C TO 75°C DESIRED RANGE

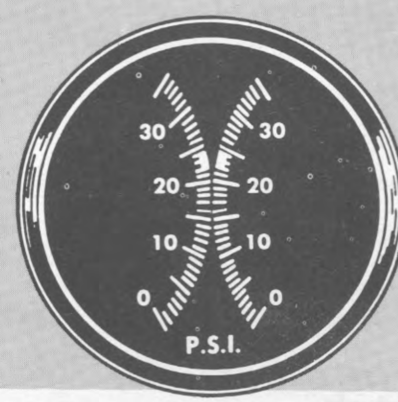
TACHOMETER

- (red) 2800 (±25) RPM MAXIMUM TAKEOFF LIMIT
- 2600 TO 2800 RPM LIMITED OPERATION
- 1400 TO 2600 RPM NORMAL CONTINUOUS OPERATION

FUEL GRADE 115/145

CYLINDER HEAD TEMPERATURE INDICATOR

- (red) 260°C MAXIMUM ALLOWABLE
- (green) 150°C TO 232°C CONTINUOUS OPERATION
- 190°C TO 200°C DESIRED CRUISE



FUEL PRESSURE INDICATOR

- (green) 22 TO 24 PSI NORMAL OPERATING RANGE

AA1-175

Figure 5-1 (Sheet 6 of 6)

Landing gear extended	170 knots
Flaps extended 30 degrees or less	170 knots
Flaps extended more than 30 degrees	150 knots
Landing light extended	152 knots
Propeller unfeathering	135 knots
Fuel dumping	185 knots
Hardover signal for autopilot	210 knots
Propeller Feathering	190 knots
Max Fire Notation Speed	139 knots

For flight in severe turbulence, indicated speeds of 165 knots are recommended for weights under 100,000 pounds and speeds of 175 knots for weights above 100,000 pounds.

The maximum permissible equivalent airspeeds (EAS) for AF53-3235 through AF53-3305 are as follows:

Maximum dive speed (V_{ne}) — sea level to 12,000 feet ..... 300 knots; above 12,000 feet, reduce speed 5 knots per 1000 feet

Maximum speed for normal operation (V_{no}) — sea level to 17,000 feet .... 251 knots; above 17,000 feet, reduce speed 5 knots per 1000 feet

Landing gear extended	174 knots
Flaps extended 30 degrees or less	174 knots
Flaps extended more than 30 degrees	152 knots

MANEUVERS.

The following maneuvers are permitted:

Bank angles up to but not in excess of 60 degrees. Slipping or skidding as required for asymmetric power conditions or for landing approaches, at indicated airspeeds up to but not in excess of 225 knots.

CENTER OF GRAVITY (CG) LIMITATIONS.

Aft limit	33 percent MAC
Forward limits (landing gear up)	
Up to 83,200 pounds	9 percent MAC
83,200 to 103,000 pounds	13 percent MAC
103,000 to 107,000 pounds	13.8 percent MAC
Forward limits (gear down)	
Up to 85,600 pounds	11 percent MAC
85,600 to 102,200 pounds	14.1 percent MAC
102,200 to 103,000 pounds	14.6 percent MAC
103,000 to 107,000 pounds	16.9 percent MAC

Note

MAC limits given may be computed linearly in order to determine the correct limit for a specific gross weight.

Refer to Handbook of Weight and Balance, T.O. 1-1B-40.

OPERATIONAL WEIGHT LIMITATIONS.

Weight has an important effect on the capability and performance of the aircraft. In designing aircraft, weight has always been a primary restrictive factor. Aircraft are designed with sufficient strength to accomplish a certain basic mission without undue allowance for overloading or improper weight distribution. Every effort is made to eliminate unneccessary weight; however, the weight penalty for making an aircraft foolproof is prohibitive. Weight limitations, therefore, are necessarily involved in operation of the aircraft. If these limitations are exceeded, a loss in performance is inevitable and structural failure is quite probable. When the aircraft is loaded beyond the established limits, the ceiling and range are decreased, control forces and stalling speeds become higher, and the rate of climb falls off rapidly as the maximum gross weight is exceeded. The takeoff and landing rolls increase appreciably with an increase in gross weight. Likewise, the brakes may become insufficient to brake the forward momentum of the aircraft, and the wings will become more vulnerable to airloads during maneuvers or flight through turbulent air. These resultant effects can reach serious proportions when the weight limitations are disregarded. In cargo aircraft, the effect produced by weight is much greater than that encountered in aircraft of other types because the cargo itself adds a considerable amount to the weight at which the aircraft is operated. In order that cargo of various sizes may be accommodated, the cargo hold is of such proportions that space is not a restrictive factor; consequently, overloading is entirely possible. Weight limitations must be complied with if the aircraft is to be operated efficiently, economically, and safely. The maximum recommended gross weights for normal operation are as follows:

Takeoff	107,000 pounds
Landing	88,200 pounds
Zero wing fuel	83,200 pounds

War emergency gross weights are as follows:

Takeoff	112,000 pounds
Landing	107,000 pounds
Zero wing fuel	89,900 pounds

The zero wing fuel weight is the gross weight minus the weight of the fuel, oil, and water-alcohol carried in the wings and nacelles. The zero wing fuel determines the maximum weight which can be carried in the fuselage in order to have strength available for the corresponding permissible accelerations. *Since the permissible accelerations are a function of the weight and distribution of fuel, the fuel must be loaded and used as described in figure* 7-2. There are no structural minimum fuel requirements for this aircraft.

WEIGHT AND LOADS.

Due to the effect of gravity on its mass, the aircraft possesses weight. More exactly, this weight is a force which gravity exerts on the material used in the fabrication of the aircraft and which pulls it toward the earth. In any condition of static equilibrium, during straight and level flight or at rest on the ground, the aircraft is subjected to this pull of gravity, the strength of which is called 1 g. As fuel, cargo, crew members, and additional equipment are added in order that the aircraft may accomplish a specific mission, the weight of the aircraft correspondingly increases and the additional weight constitutes a force acting on the aircraft structure. The weight of the aircraft, or the force which gravity imposes on it, may also be considered as a load. On the ground, this load must be sustained by the landing gear; in flight, by the wings. There is a limit to the load which the landing gear is capable of supporting during taxi, takeoff, and landing operations; there is likewise a limit to the load which the wings can sustain in flight.

During maneuvering and flight through turbulent air, additional loads are imposed. These loads, caused by the acceleration of the aircraft, are the result of forces which, in addition to that of gravity, act upon the total mass of the loaded aircraft. Both these forces tend to produce undesirable and potentially dangerous loads on the aircraft structure and its members. This is particularly true of the wings, which must sustain the aircraft in flight. When the weight of the aircraft is increased, the wings become more and more vulnerable to the loads imposed by sudden changes in air currents or manipulation of the controls. The ultimate strength of the aircraft structure is eventually exceeded by the combined forces of weight and airloads. When this condition occurs, structural failure results. The maximum weight which the aircraft can safely carry is dependent upon distribution of the weight throughout the aircraft and its capacity to sustain airloads in accelerated flight.

LOAD FACTORS.

A load factor is the ratio of the load imposed on the aircraft when accelerated in any direction as compared with the load imposed by gravity in any condition of static equilibrium. The load factor denotes the strength of the forces acting on the aircraft because of sudden changes in air currents and manipulation of the controls, and is expressed by the term, g, which is the gravitational force. By definition, then, all aircraft at rest on the ground or in straight and level flight possess a load factor of 1 g because the force acting upon the aircraft under either of these conditions is merely that of gravity. When the aircraft enters a region of turbulent air or the pilot elects to maneuver the aircraft, additional forces are imposed on the structure. The additional load on the wings resulting from these forces is expressed in relation to the gravitational force and is referred to as 0.5 g, 2.0 g, 3.0 g, etc, which means that the forces exerted on the wing structure and its members are ½, 2, or 3 times the force exerted by gravity. For example, if the normal weight of the aircraft is 60,000 pounds and the load factor at some given moment of accelerated flight is 3.0 g's, the total force which the wings must sustain is 180,000 pounds, or 3 times the normal weight of the aircraft in straight and level flight. See Distribution of Load, this section.

CAUTION

The aircraft must have the load distributed so that the wings can safely withstand a load factor of at least 2.0 g's, as structural damage to the wings may result if the aircraft encounters a situation whereby more than 2.0 g's are imposed. Aircraft with combinations of payload and fuel which limit the load factor capability to 2.5 g's must be flown with caution, especially in turbulent air or during turns and pullouts.

MARGIN OF SAFETY.

The margin of safety is the range of forces which exist between two points, one of which is the load factor the aircraft is sustaining at any given moment, and the other the load factor at which structural damage will occur. If, for example, the aircraft is incapable of sustaining a load factor greater than 2.5 g's and during flight through turbulent air is subjected to a force of 1.5 g's, the margin of safety at this particular moment is 1.0 g. When fuel and cargo loads are increased, the margin of safety decreases. This increase in weight actually becomes a component of the forces acting on the aircraft, and, as such, lessens the capacity of the aircraft to sustain further loads due to accelerated flight. For this reason, it is advisable in loading aircraft to maintain a margin of safety which will never be exceeded during any period of flight.

WARNING

If the combined weight of cargo and fuel is such that the aircraft is incapable of sustaining a force of 2.5 g's, turns and pullouts should be made with caution to minimize the resulting airloads.

EXPLANATION OF CHART.

The Weight Limitations Chart *(figure 5-2)* shows graphically the weight-carrying capabilities of the aircraft as defined by the various criteria which provide limits for safe and efficient operation. Through the use of these charts, the flight planner is aided in recognizing the weight limitations which will restrict operation on a specific mission and in determining what margin of safety may be established.

Note

Although the chart indicates the limitations involved in the loading of the aircraft, the authority for operating it at a given gross weight remains the responsibility of the local authority.

GROSS WEIGHTS.

The data in the chart *(figure 5-2)* is based on an initial operating weight of the aircraft exclusive of fuel and cargo. The zero point of the chart at the junction of the fuel and cargo loads axes represents an operating weight of 60,000 pounds. As individual operating weights may vary, it is necessary to adjust the chart for the specific aircraft involved. The operating weight plus the fuel and cargo as required in a mission can be shown by gross weight lines which slope at a 45-degree angle to the axis of the chart. These diagonal lines also indicate various structural and performance limitations. However, any gross weight line may be plotted to obtain a graphic representation of the limitations involved in the fuel-weight combination which a mission may require.

Note

The gross weight of the aircraft should never exceed that required for the mission, since unnecessary risk and wear of the equipment will otherwise result. Takeoff gross weights must also be considered with respect to available runways, surrounding terrain, altitude, atmospheric conditions, mission requirements, and the urgency of the mission.

DISTRIBUTION OF LOAD.

The maximum load that the aircraft can carry is dependent on the way the load is distributed. The weight of an aircraft in flight is supported by the wings; therefore, the more load that is carried in the fuselage, the greater will be the bending moment on the wings. This means that an aircraft might safely carry 30,000 pounds if 12,000 pounds were carried in the fuselage and 18,000 pounds were in the wings. But the same 30,000 pounds might become an unsafe load if the weight distribution were 25,000 pounds in the fuselage and 5000 pounds in the wings, the unsafe condition resulting from the excessive bending moment imposed on the wings by the 25,000 pounds in the fuselage. When carrying cargo, load factor capabilities below 2.5 g's are not considered desirable because the cargo distribution may be critical enough to overload the floor and/or the fuselage shell.

CARGO LOAD.

In any mission, range and fuel consumption directly determine the fuel which must be carried and indirectly the cargo which can be transported. With the necessary fuel for the mission established, cargo loading is variable within the limits established by the strength and performance of the aircraft. The payload, as carried in the cargo compartment, appears in thousands of pounds along the vertical axis of the chart. When fuselage fuel is utilized to increase the range of the aircraft, the combined weight of the fuel and tanks is computed as cargo load.

WING FLIGHT LOAD FACTORS.

Wing flight load factors of 2.0, 2.25, and 2.5 g's are represented. The load factor 2.0 line represents an absolute minimum which should never be violated because of the dangerously small margin of safety; the load factors of 2.25 and 2.5 g's are included for comparative purposes. Notice that the effect of weight distribution is clearly illustrated by the shape of these lines. If the aircraft bas a basic operating weight of 60,000 pounds, a load factor in excess of 2.0 g's may result in structural damage in each of the following instances:

At 100,000 pounds, when no load is carried in the wings.

At 107,000 pounds, when 7000 pounds of fuel is carried in the wings.

At 123,800 pounds, when 23,800 pounds of fuel is carried in the wings.

The airplane will safely withstand a load factor of 2.5 g's in each of the following instances:

At 83,200 pounds, when no load is carried in the wings.

At 88,200 pounds, when 5000 pounds of fuel is carried in the wings.

At 107,000 pounds, when 23,800 pounds of fuel or above is carried in the wings.

See Cautionary Loading Area, this section.

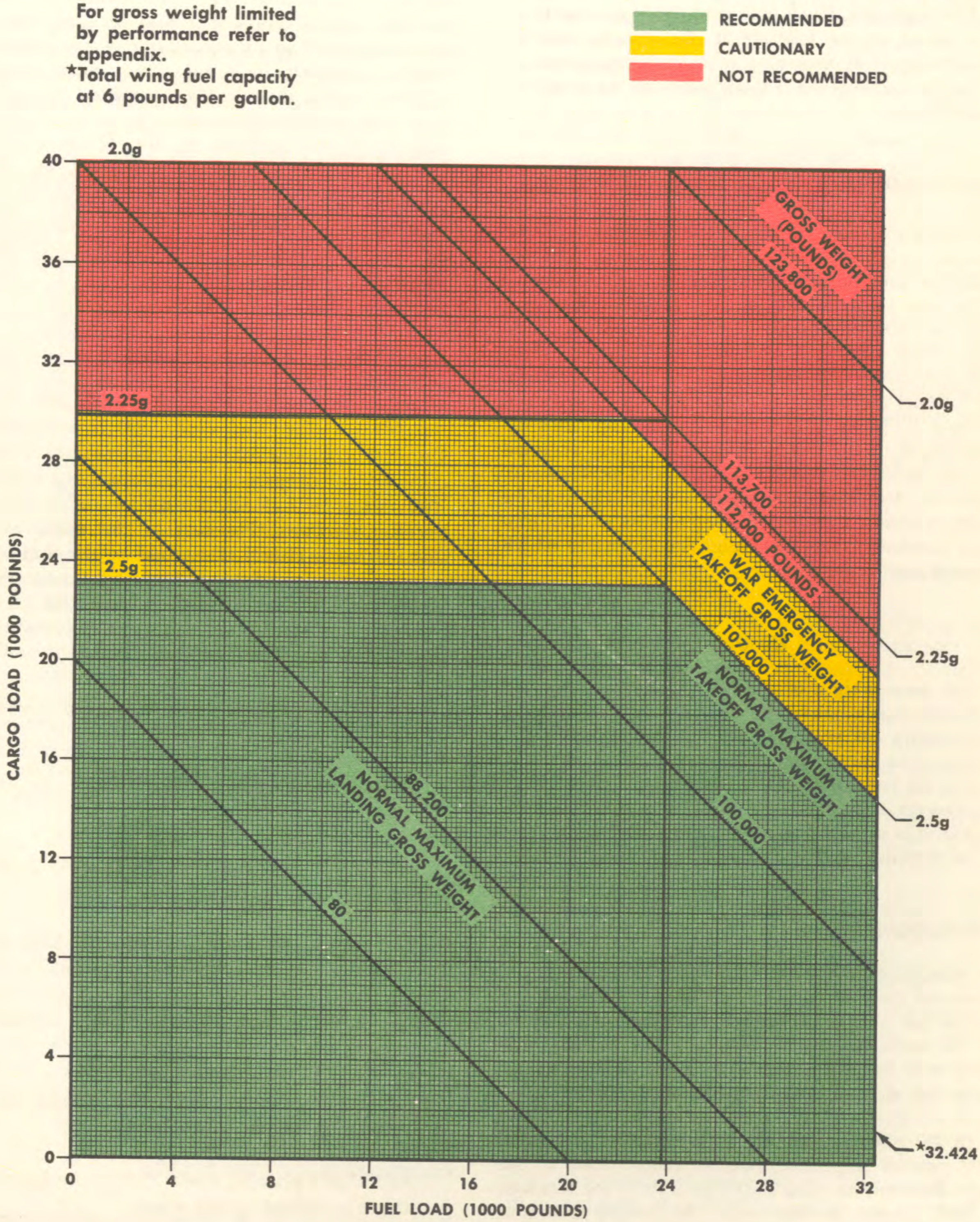
WEIGHT LIMITATIONS CHART

MODEL: C-118A

BASED UPON 60,000 POUNDS BASIC OPERATING WEIGHT (INCLUDES OIL)

ENGINES: R2800-52W
FUEL GRADE 115/145
ALTERNATE FUEL GRADE 100/130

Note:
For gross weight limited by performance refer to appendix.
*Total wing fuel capacity at 6 pounds per gallon.



AA1-213

Figure 5-2

CRUISE SPEEDS.

Caution must also be exercised in selecting the cruise speeds for operation. Load factors result not only from maneuvers instituted by the pilot, but also by encountering atmospheric gusts. At any given speed and gross weight, the larger the gust the higher the load factor. Similarly, at any given gross weight and stated gust intensity, the higher the speed the larger the load factor. The aircraft is basically designed to be able to safely withstand the load factors resulting from a gust of 30 feet per second at 251 knots per hour with 23,200 pounds of cargo. From the chart, it can be seen that, as the cargo weight is increased, the load factor made good is decreased. If a gust of 30 feet per second is also to be made good, then the speed likewise must be decreased.

LANDING GEAR LIMITATIONS.

The landing gear structure is designed for landing during routine operation at a gross weight of 88,200 pounds at a maximum contact sinking speed of 10 feet per second *(figure 5-3)*. This is the maximum recommended landing weight for normal operation. In case of emergency, landings may be made up to 107,000 pounds at a maximum contact sinking speed of 5 feet per second.

PERFORMANCE LIMITATIONS.

In the case of four-engine aircraft, it is generally inherent that structural rather than performance limitations restrict the weight which the aircraft can carry. Obviously, the gross weight must necessarily be limited by the ability of the aircraft to take off within available runway length and clear any obstacles. But the primary consideration is the ability of the aircraft to fly with partial power. Performance with one engine out is not generally a restrictive factor in the normal loading of the aircraft. Note the gross weight lines on the chart, particularly those which separate the loading areas. Each of these lines defines a specific limitation and several of the lines are performance limitations, but the gross weights are sufficiently high for normal operation. These performance limitations are based on the gross weight at which an adequate rate of climb can be maintained under various conditions of power, temperature, and configuration.

POWER LOSS AND PERFORMANCE.

The loss of one engine results in an asymmetric power condition and a decrease in the rate of climb. However, a rate of climb of 50 feet per minute with three engines operating can be maintained with gross weights up to 113,900 pounds on a standard day at sea level with maximum power, wing flaps at the takeoff position, gear down, and inoperative engine windmilling. Power losses due to temperature, humidity, and engine deficiency exert a considerable influence on the rate of climb even when all the engines are operating. It is not difficult to visualize the effect which engine failure will produce on the rate of climb, but it is interesting to note the marked difference in aircraft performance resulting from a rise in temperature and a corresponding fall in air density. The gross weight difference to provide a rate of climb of 50 feet per minute on a hot day as compared to a standard day at sea level is 6,600 pounds, resulting in a maximum gross weight of 107,300 pounds, in order to maintain a rate of climb of 50 feet per minute at sea level on a hot day. For purpose of standardization, the temperature of a standard day is 15°C and that of a hot day, 38°C at sea level. Naturally, variations of temperature and altitude within this range will give similarly graduated values in brake horsepower and rate of climb. The effect of humidity and engine deficiency on brake horsepower, and ultimately the gross weight at which the aircraft may be operated, has not been included in the weight limitations chart because of the extreme number of variable conditions involved. However, the effect of humidity on brake horsepower is shown in the Appendix, part 2.

CONFIGURATION AND PERFORMANCE.

The configuration of the aircraft also imposes a penalty on performance. In other than clean configurations, the increase in drag produces a decrease in the rate of climb and requires a readjustment of the gross weight at which the aircraft may be operated. As with power losses, this condition is most critical at takeoff when of necessity the landing gear is extended, and the cowl flaps and oil cooler flaps are open. The drag created by a windmilling propeller and the extended landing gear during the takeoff roll is such that no attempt to take off should be made unless the critical engine failure airspeed for the gross weight of the aircraft has been attained or exceeded.

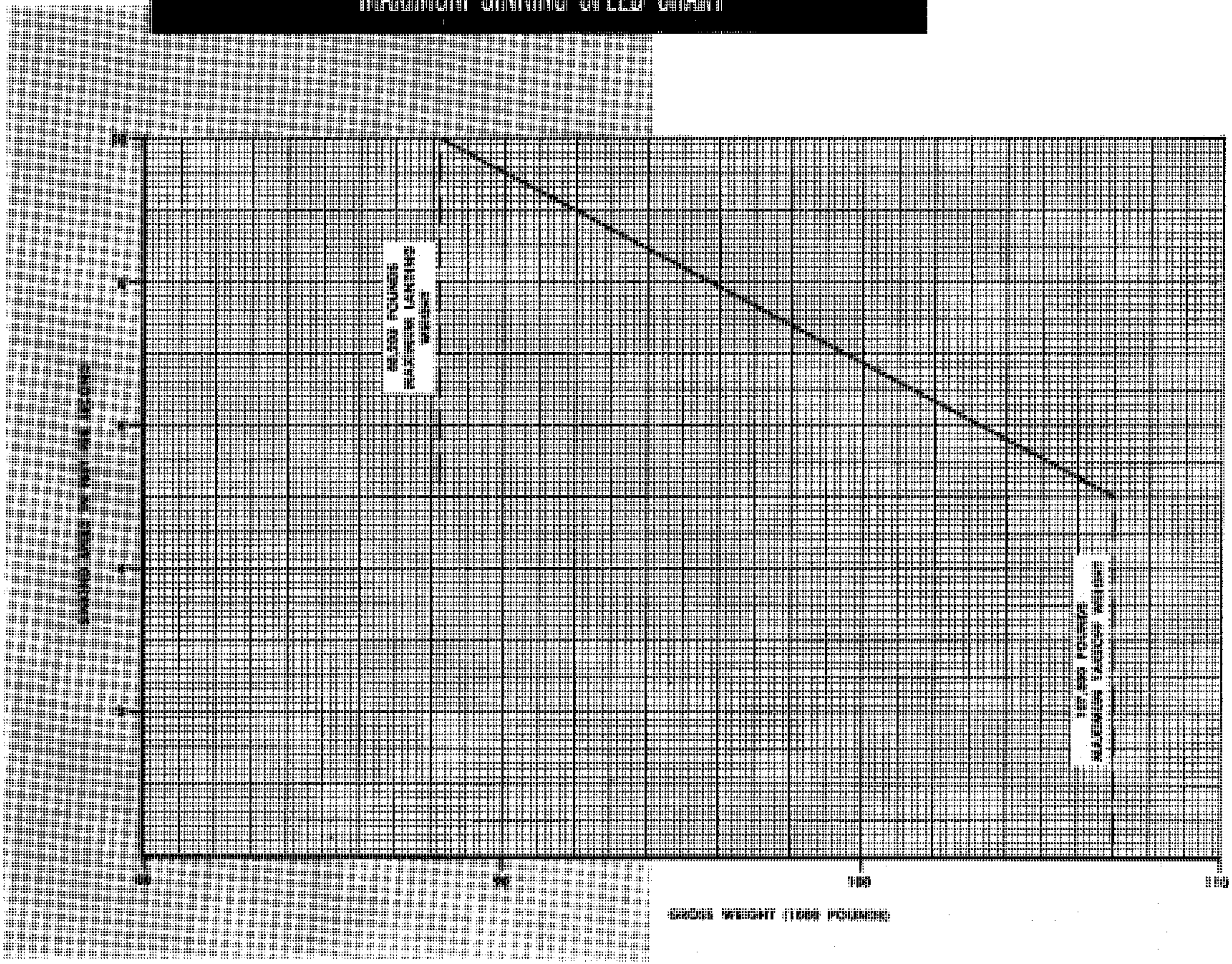
RECOMMENDED LOADING AREA.

The green area on the charts represents the loading conditions that present no particular problem in regard to strength or performance of the aircraft. Operation of the aircraft at weights outside this recommended loading area should be avoided unless the mission requires it. The green area is bounded by the 2.5 g's wingload factor line and the landing gear limitation.

CAUTIONARY LOADING AREA.

The yellow area on the charts represents loadings of progressively increasing risk as the red area is approached. Caution must be exercised because (1) per-

MAXIMUM SINKING SPEED CHART



AA1-214

Figure 5-3

formance with one engine out at these gross weights is marginal depending upon configuration, altitude, and ambient air temperature and (2) the maximum safe load factor is decreased.

LOADING NOT RECOMMENDED.

Note

Whenever flights are conducted at weights shown in the red area of the chart, entry of this fact in Form 781 is required.

The red area represents loadings which are not recommended because of loss of the margin of safety from the standpoint of both performance and structural limitations. Under conditions of extreme emergency when safety of flight is of secondary importance, the commanding officer will determine if the degree of risk warrants operation of the aircraft at gross weights appearing in the red zone.

USE OF WEIGHT LIMITATIONS CHART.

The sample problems shown below may be used to determine the exact position of a loaded aircraft on the Weight Limitation Chart *(figure 5-2)*.

Problem:

Requiring 2000 gallons of fuel to reach a base, what is the maximum cargo that can be carried?

Solution:

Presume that the aircraft weighs 65,000 pounds before the fuel and cargo are added. Enter the chart at a fuel weight of 12,000 pounds (based on fuel weight of 6 pounds per gallon). By moving vertically up the chart to the maximum loading (limit of the yellow area), it is determined that a maximum cargo of 35,000 pounds may be carried. This limitation dictates that the gross weight of the aircraft cannot exceed 107,000 pounds. By adding the operating, fuel, and cargo weights, it is found that the aircraft would weigh 65,000 + 12,000 + 35,000 or 112,000 pounds, which exceeds the permissible limit by 5000 pounds (112,000 — 107,000 = 5000). This weight must be removed, and since the operating and fuel weights are not to be reduced, it becomes necessary to reduce the cargo weight to 35,000 — 5000, or 30,000 pounds. The additional operating weight of 5000 pounds (65,000 — 60,000 = 5000) is simply considered as added alternate cargo, which reduces the maximum cargo first determined. If, for instance, the aircraft weighed 58,000 pounds rather than the 65,000 pounds presumed above, the alternate cargo would be 60,000 — 58,000, or 2000 pounds, and would allow a 2000 pound increase in the maximum cargo first determined.

Problem:

Requiring a 22,000 pound cargo load, what is the maximum amount of fuel that can be carried?

Solution:

Presume that the aircraft weighs 60,000 pounds before the fuel and cargo are added. Since the basic operating weight is 60,000 pounds, the chart can be entered at a cargo weight of 22,000 pounds and the maximum amount of fuel can be read directly from the chart. By moving horizontally across the chart to the maximum fuel load (limit of the green area), it is determined that the maximum fuel that can be carried is 25,000 pounds, or, 25,000 ÷ 6 = 4167 gallons.

TABLE OF TOLERANCES

ADI (Water-Alcohol Inspection) — 27 to 32 psi.
Antiskid brake accumulator pressure — 325 (±25) psi.
Snubbing pressure — 150 $\left(^{+20}_{-0}\right)$ psi.
Oxygen systems pressure — 400 $\left(^{+25}_{-0}\right)$ psi.
D-C Generator Voltage — 27.5 to 28.5 V d-c.
Landing gear operating time —

Down (free fall) 20 seconds
Up 7 to 10 seconds

Wing flaps —

Low Fuel Boost Pressure — 12 to 18 psi
High Fuel Boost Pressure — 21 to 33 psi

Oil Cooler Air Exit Doors — approximately 20 seconds for full range travel.
Emergency air pressure — 1000 (±50) psi.

SECTION VI

flight characteristics

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GENERAL FLIGHT CHARACTERISTICS.

The general flight characteristics are excellent for a cargo-type aircraft. Maneuvering and control of the aircraft does not require undue force by the pilot. The aircraft is very stable and trims out easily. Very little change in trim is required to maintain the desired aircraft attitude. Rudder and aileron control is excellent. Elevator forces are normal at both low and high speeds.

AERODYNAMIC CHARACTERISTICS.

The aircraft is dynamically stable about all axes; that is, if an oscillation is induced about the roll, pitch, or yaw axis of the airplane, it will damp out. Static stability is the tendency of the aircraft to return to its original trimmed condition following a displacement from that condition. From the point of view of control forces, an aircraft is statically stable in pitch (longitudinally) if a push force is required to maintain a speed above trim speed, and a pull force is required to maintain a speed below trim speed. Spiral stability is approximately neutral. As an example, when the aircraft is properly trimmed for a standard rate turn in the instrument approach configuration (gear up, flaps 20 degrees), it will tend to remain in that attitude. Dihedral effect will cause the aircraft to bank automatically into the turn as rudder is applied. This effect is helpful in obtaining maximum maneuverability.

CONTROL FORCE AND EFFECTIVENESS.

Due to the characteristics of the aerodynamic boost system, the control forces and movements required vary throughout the speed range of the aircraft. At high speed, a given rate of roll can be developed with a small force applied to the controls and with a small control movement. To develop the same rate of roll at low speed, both a greater force and movement must be applied to the controls.

The ratio of rudder to aileron displacement required to accomplish a coordinated turn varies with speed. At high speeds, turns may be made primarily with the ailerons, very little rudder being required. As speed decreases, and/or gear and flaps are extended, a greater portion of rudder to aileron displacement is required. This should be taken into consideration when making approaches in gusty air conditions, or with one or more engines inoperative.

At high speed, the elevator is extremely effective and, therefore, requires a small amount of force and movement to maneuver the aircraft. At low speed, such as during the landing approach, elevator effectiveness decreases, requiring a greater movement to maneuver the aircraft. Control force increases with elevator displacement; therefore, both a greater movement and a greater force are required at low speed, as compared to cruising flight.

During landing, the center of gravity position greatly affects the amount of elevator required. The further aft the cg, the less elevator required; the further forward the cg, the more elevator required. If the aircraft is loaded aft of the aft cg limit, it will be unstable; if loaded forward of the forward limit, the amount of elevator control available will probably be insufficient to properly flare the aircraft.

Elevator requirements vary with power. As an example, as power is applied during an overshoot, down elevator is required to counteract for nose-up pitching; conversely, as power is cut during the landing flare, up elevator is required.

EQUIVALENT PARASITE DRAG AREAS.

The following table of drag items is given in square feet of equivalent flat plate area:

Item	*Drag of Item (Square Feet)*
Basic Aircraft	27.3
Landing Gear	38.6
20-Degree Wing Flaps	26.8
30-Degree Wing Flaps	46.3
50-Degree Wing Flaps	83.6
Windmilling Propeller	13.6
+4-Degree Cowl Flaps	5.4
+2-Degree Cowl Flaps	3.5
+-Degree Cowl Flaps	1.7

WING FLAP CHARACTERISTICS.

Wing flaps of the double-slotted type provide the additional lift required for takeoff, and both extra lift and drag for approach and landing. At small angles (20 to 25 degrees), the flaps act primarily as an added lift device, and at large angles (40 to 50 degrees), as both an added lift and drag device. High drag at maximum flap extension is obtained primarily from the amount of extra surface exposed to the airstream. In effect, as the flaps are extended the camber of the wing is increased, giving it a higher lift at any given angle of att. ck. This explains the ballooning of the aircraft as the flaps are extended. Conversely, the opposite occurs as flaps are retracted and the aircraft setttles. Extension of the flaps also reduces the stalling speed of the aircraft. Changes resulting from flap extension are included in the following table:

Flap Position (Degrees)	*Wing Flap Drag Area (Square Feet)*	*Lift Increase (Percent)*	*Equivalent Stall Speed at 88,200 lb (Knots)*
0	0	0	106
10	12.8	7.5	102
20	26.8	26.7	94
30	46.3	46.1	88
40	58.7	56.5	85
45	66.8	60.5	84
50	83.6	64.5	83

Two-speed flap retraction is provided. The faster retraction rate from 50 to 20 degrees (9 seconds) is provided for rapid elimination of high drag present at high flap angles. The slower retraction rate from 20 degrees to up (13 seconds) is provided so that the flight path during takeoff can remain relatively constant as flaps are retracted. This is the result of lift increase due to increasing airspeed balancing lift loss due to flap retraction. At a given speed, the flight path can remain constant during flap extension or retraction, provided the angle of attack is changed to counteract for the lift changes which are taking place in the wing-flap combination, or the speed is changed to compensate for the change in lift at a constant angle of attack.

STALLS.

Stall characteristics of the aircraft are excellent. The aircraft is fully controllable up to the stall, and the pre-stall warning buffet is of sufficient magnitude that it is easily perceptible to the pilot. At the stall, the nose of the aircraft pitches down gently without rolling, allowing stall recovery to be effected with a minimum manipulation of the controls and loss of altitude. Acceleration increases stalling speed. A 15-foot-per-second gust encountered in level flight will raise the stalling speed from 117 to 132 knots EAS. This gust is equivalent to an acceleration of 1.30 g's which can be developed in a coordinated turn at a bank angle of 41 degrees. Figure 6-1 is based on the effect of acceleration and gives the change in stalling speed for gross weight, gear and flap positions, and for all bank angles up to 60 degrees. The use of this chart is illustrated by the dashed lines drawn on its face. Due to the slipstream effect over the wing, power-on stalling speeds are lower than zero thrust stalling speeds by approximately 5 to 10 knots at approach power, and 10 to 15 knots at maximum power. This difference is not taken into consideration in calculating performance speeds based on stalling speeds, but instead is available as an extra margin of safety.

RECOVERY FROM STALL.

When the aircraft is stalled, recovery should always be made by nosing the aircraft slightly down, and applying power as required. At all times, abrupt pullouts should be avoided so as to eliminate the possibility of excessive g forces and a resultant secondary stall.

SPINS.

Spins are one of the prohibited maneuvers and must never be done intentionally. However, if a spin is entered accidentally, use normal recovery procedure to regain level flight; that is, nose down and apply corrective control to stop the spin.

FLIGHT CONTROLS.

The flight controls are very effective under all conditions of flight, and there is no unusual reaction of the flight controls under any flight condition.

LEVEL FLIGHT CHARACTERISTICS.

The level flight characteristics of the aircraft are excellent under the various speed conditions of slow flight, cruising flight and high speed flight.

MANEUVERING FLIGHT.

The characteristics of the aircraft during acceleration on takeoff and in flight are excellent and do not require undue force on the part of the pilot.

DIVING.

Diving speed is limited as mentioned in Section V. Avoid abrupt pullouts at any time. Do not allow the IAS pointer to exceed the limit marking on the airspeed indicator (*figure 5-1*).

LIMITING DESIGN SPEEDS.

The criteria for establishing the limiting speeds of the aircraft from a structural standpoint may be explained as follows:

A. The load exerted on a body in a moving stream of air depends on the density of the air and on the speed of the air with respect to that body.

B. Mach number effect is caused by changes in airflow around an aircraft which may result in control force, control effectiveness and stability irregularities. For this reason, a maximum Mach number limitation is established.

The maximum speed demonstrated is based on two design limits of the aircraft: first, the ability to withstand a 15-foot-per-second gust at the maximum permissible indicated airspeed with no permanent deformation; and, second, no control force, control effectiveness, or stability abnormalities. The aircraft has been demonstrated to a maximum Mach number of 0.65. At Mach numbers at or below the maximum demonstrated value, no undesirable flight characteristics occur.

At the maximum normal operating speed (V_{no}) and at any combination of gross weight and fuel weight within the stated limitations, the aircraft is designed to withstand the gust load factors resulting from at least a 30-foot-per-second gust with no permanent deformations.

Note

The aircraft is capable of withstanding higher accelerations (gusts) with the wing flaps retracted; therefore, it is necessary that all cruising and descent operation be with the flaps retracted during flight in turbulent air conditions.

SECTION VII
systems operation

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LIST OF ILLUSTRATIONS

FUEL SYSTEM MANAGEMENT.

All takeoffs, landings, and ground operations should be made with each engine receiving fuel from its respective main tank. A vapor vent return line connected to each carburetor returns all vapor plus fuel to the No. 2 main tank for engines No. 1 and 2, and to the No. 3 main tank for engines No. 3 and 4. The normal return flow is less than 2 gallons per engine per hour; however, if the vent float sticks or is damaged, it is possible to obtain a maximum flow of 20 to 30 gallons per engine per hour. For this reason, the fuel levels of No. 2 and 3 main tanks must be checked periodically to avoid overflowing. When selecting a new fuel supply for an engine, the new supply should be selected before shutting off the old supply or before the old supply is depleted, in order to minimize fuel surge to the carburetor (which can result in ruptured diaphragms or collapsed vapor vent floats), and the fuel booster pump should be turned to LOW. If a fuel supply is completely depleted before selecting a new source, *retard the throttle* of the affected engine before selecting a new supply to prevent fuel surge to the carburetor, and also to prevent the possibility of overspeeding, which can result from the sudden resumption of power following a momentary power loss. Figures 7-1 and 7-2 graphically show the fuel flow and the control lever positions for various combinations of fuel system management. See figure 7-3 for fuel quantity data.

CAUTION

Maximum wing strength must be maintained by using fuel as recommended in the Fuel System Management Table (*figure 7-1*). After selecting alternate fuel tanks, the main fuel tank fuel quantity indicator should be monitored to prevent possible overfilling of the main tanks through the vapor vent return system in case of malfunctioning carburetors. The maximum unbalanced fuel load permissable, without restriction on speed or gross weight, is 1050 lbs between inner wing tanks. These cross ship fuel unbalances must not occur simultaneously.

RECOMMENDED USE OF FUEL BOOSTER PUMPS.

It is recommended that the electric fuel booster pumps be operated in LOW boost under the following conditions:

A. For engine start.

B. For takeoff.

C. When climbing.

D. When selecting a new fuel supply source.

E. For fuel conditioning.

F. When fuel pressure drops below 22 psi or fluctuates.

G. For oil dilution.

WARNING

Always shut booster pumps off one at a time, and make certain that pressure is maintained by the engine-driven pumps.

Since the boiling point characteristics of fuel vary with each production run, and each run varies with age and the conditioning the fuel receives, it is difficult to predict the exact moment and condition under which booster pumps should be applied. Conditioning the fuel for 1½ hours by booster pump agitation covers most of the critical fuel conditions that may occur in the fuel system. It is realized that this 1½-hour period will be extremely liberal in a great many instances. With OAT. below 24°C (75°F), it should be remembered that, with high altitudes and/or high OAT., it will be necessary to condition the fuel for longer periods. Therefore, make the following test for fuel stability:

A. After the aircraft has been stabilized at the cruise altitude, momentarily turn one of the selected booster pumps off and at the same time watch the fuel pressure.

B. If the fuel pressure drops or fluctuates, leave the booster pump in operation for a longer period.

C. If the pressure remains steady, the booster pump may be turned off.

D. Repeat this procedure for the remaining booster pumps.

USE OF HIGH BOOST PUMP PRESSURE.

In the event of engine fuel pump failure or an extreme cold weather start, where LOW boost does not supply sufficient pressure, HIGH boost may be used, provided LOW boost is first used to pressurize the system up to the carburetor. When shifting from LOW boost to HIGH boost, make the switch as rapidly as possible.

PRECAUTIONS.

A. Crossfeed and selector valves should be in their OFF positions unless flow of fuel is expected through them.

B. No tank will be run dry.

C. Apply boost pump pressure before opening the valves to a new source.

FUEL SYSTEM MANAGEMENT TABLE
8-TANK SYSTEM
TOTAL USABLE FUEL — 5404 GALLONS

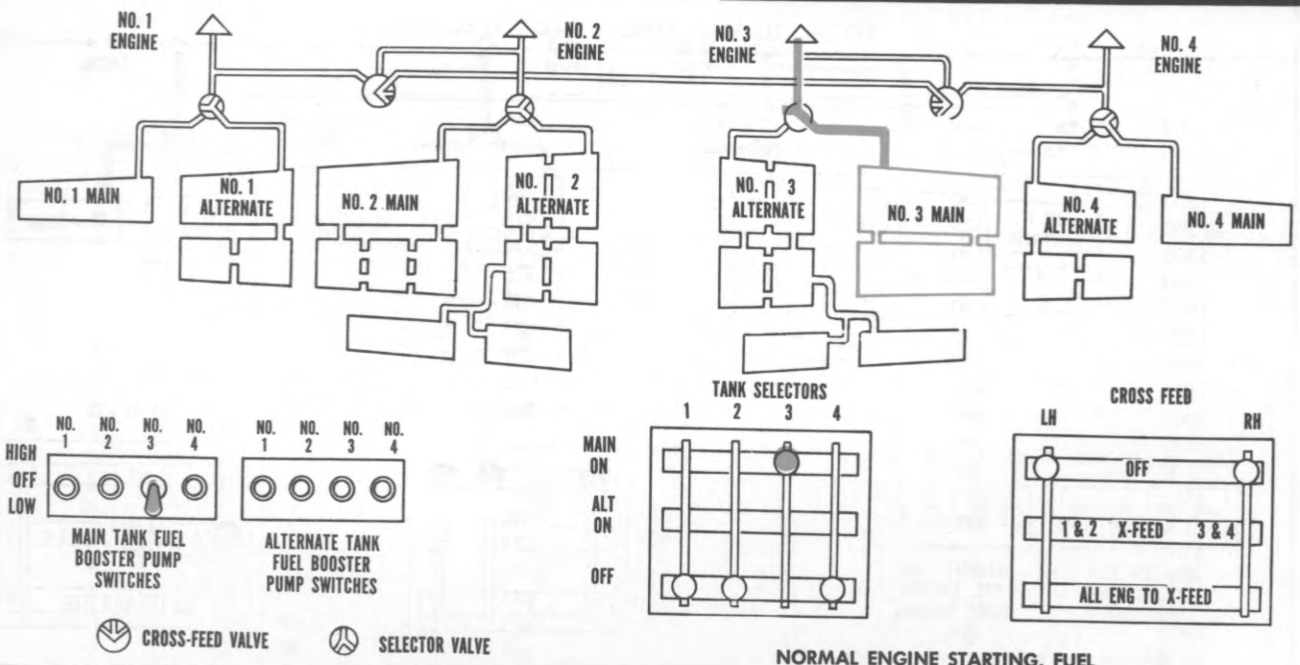
	Tanks				
Fuel Load	*1 and 4 Main*	*1 and 4 Alternate*	*2 and 3 Main*	*2 and 3 Alternate*	**Usage*
1200	300		300		4
1300	325		325		4
1400	350		350		4
1500	375		375		4
1600	400		400		4
1700	425		425		4
1800	450		450		4
1900	475		475		4
2000	500		500		4
2100	525		525		4
2200	550		550		4
2300	575		575		4
2400	600		600		4
2500	625		625		4
2600	650		650		4
2700	675		675		4
2800	695		625	80	1-3-4
2900	695		675	80	1-3-4
3000	695		675	130	1-3-4
3100	695		675	180	1-3-4
3200	695		675	230	1-3-4
3300	695		675	280	1-3-4
3400	695		719	286	1-3-4
3500	695		719	336	1-3-4
3600	695	200	719	186	1-2-4
3700	695	218	719	218	1-2-4
3800	695	243	719	243	1-2-4
3900	695	268	719	268	1-2-4
4000	695	293	719	293	1-2-4
4100	695	318	719	318	1-2-4
4200	695	343	719	343	1-2-4
4300	695	368	719	368	1-2-4
4400	695	393	719	393	1-2-4
4500	695	418	719	418	1-2-4
4600	695	443	719	443	1-2-4
4700	695	468	719	468	1-2-4
4800	695	493	719	493	1-2-4
4900	695	526	719	510	1-2-4
5000	695	526	719	560	1-2-3-4
5100	695	526	719	610	1-2-3-4
5200	695	526	719	660	1-2-3-4
5300	695	526	719	710	1-2-3-4
5404	[illegible]	526	719	762	1-2-3-4
Undumpable	116	0	108	54	
Unstickable	140	160	140	80	

*Usage:

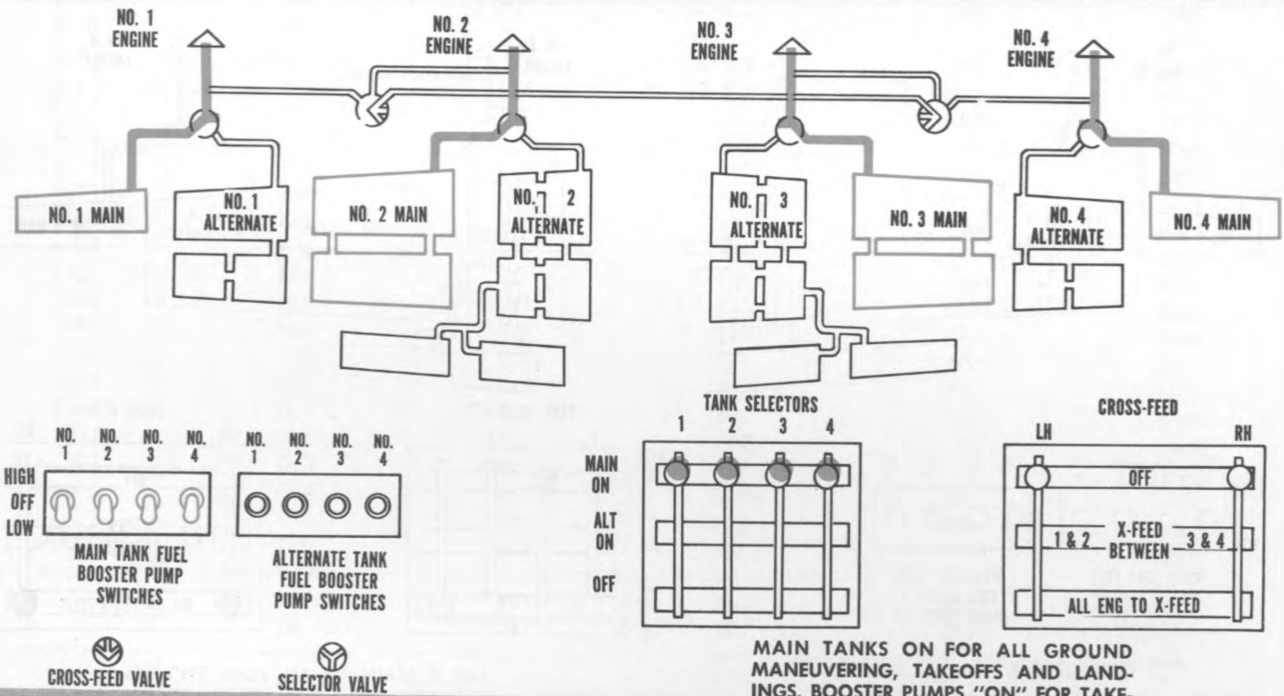
1. Main tanks to respective engines (switch to next step after 75 gallons [450 pounds] are used from each main tank or at completion of initial climb).
2. Alternate tanks to respective engines until 100 pounds remain.
3. No. 2 and 3 alternate tanks to respective sides (crossfeed) until 100 pounds remain.
4. Main tanks to respective engines.

Figure 7-1

FUEL SYSTEM



NORMAL ENGINE STARTING, FUEL FLOW "OFF" TO INOPERATIVE ENGINES, BOOSTER PUMP "LOW" TO ENGINE NO. 3

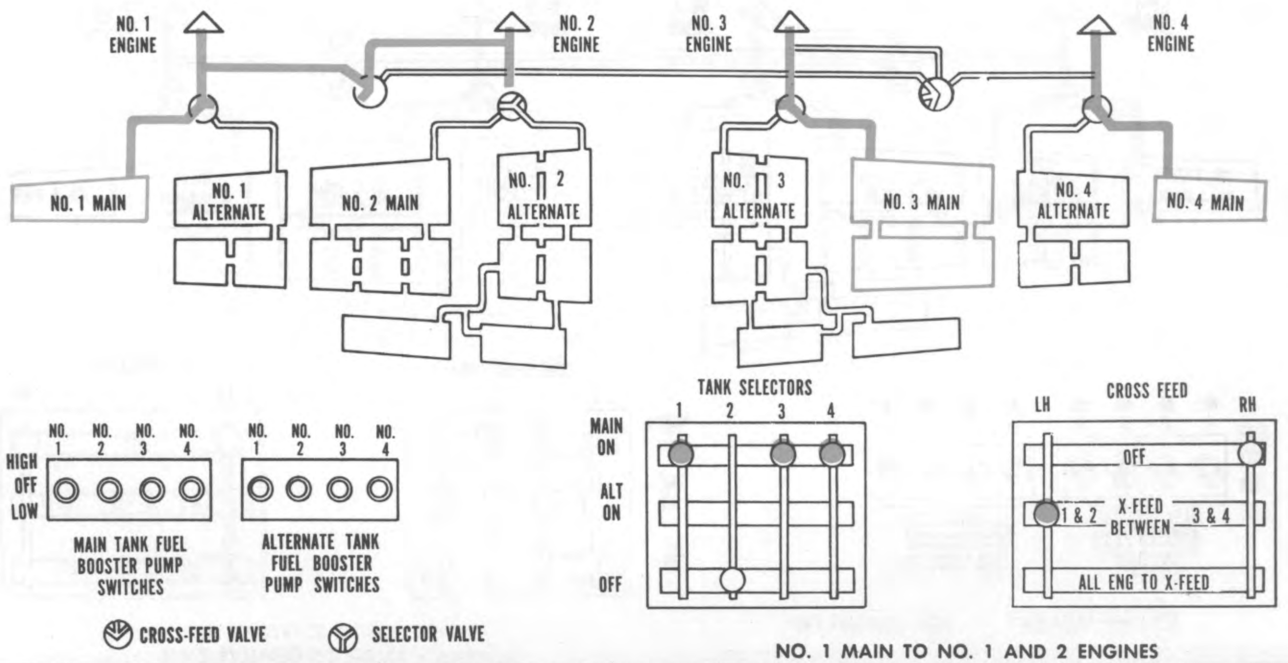


MAIN TANKS ON FOR ALL GROUND MANEUVERING, TAKEOFFS AND LANDINGS. BOOSTER PUMPS "ON" FOR TAKEOFFS AND LANDINGS AND WHENEVER NECESSARY TO MAINTAIN PRESSURE.

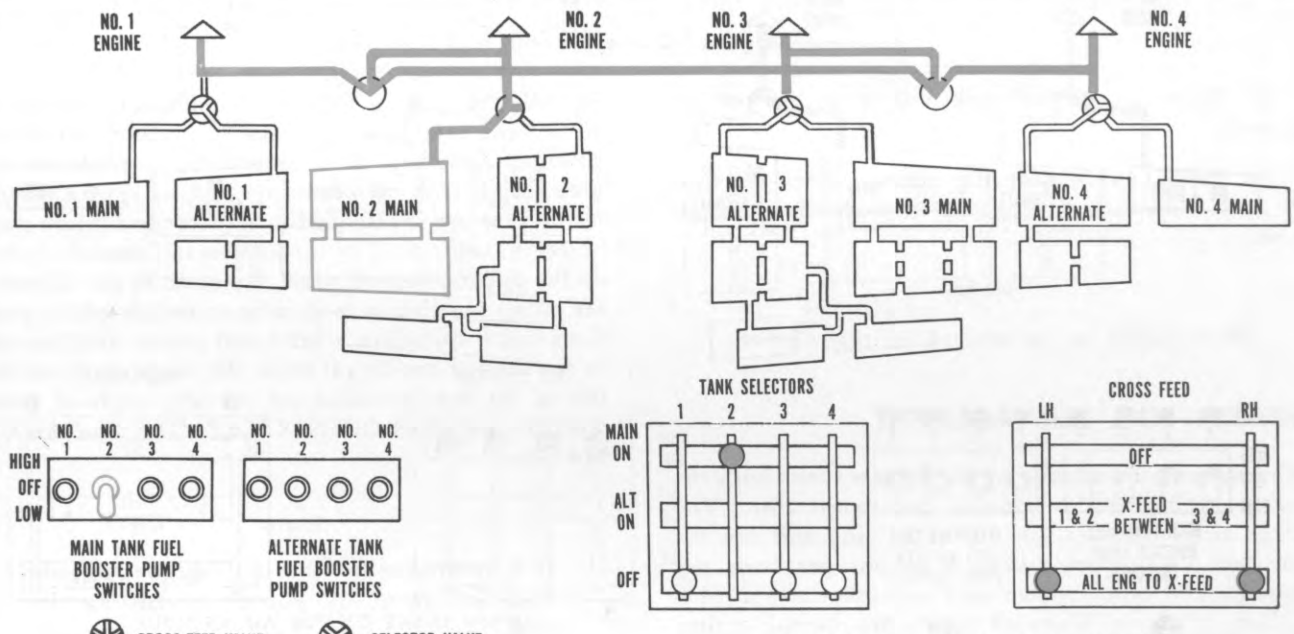
AA1-16B

Figure 7-2 (Sheet 1 of 3)

MANAGEMENT



NO. 1 MAIN TO NO. 1 AND 2 ENGINES NO. 3 AND NO. 4 MAIN TO RESPECTIVE ENGINES, BOOSTER PUMPS "OFF" UNLESS NECESSARY TO MAINTAIN PRESSURE



NO. 2 MAIN TO ALL FOUR ENGINES THROUGH CROSS FEED SYSTEM BOOSTER PUMP "ON" TO MAINTAIN PRESSURE

AA1-169

Figure 7-2 (Sheet 2 of 3)

FUEL SYSTEM MANAGEMENT

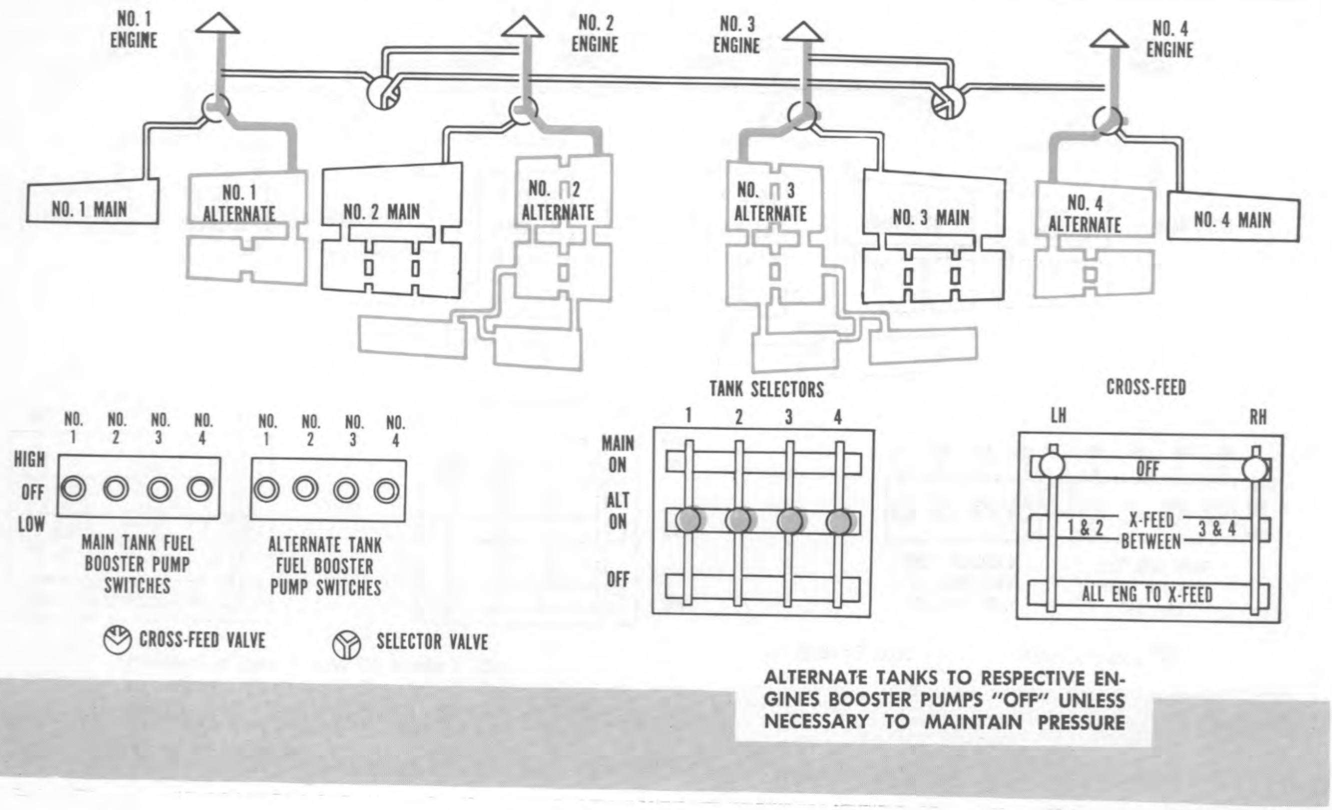


Figure 7-2 (Sheet 3 of 3)

AA1-170

D. Normally, no fuel tank will be used below 100 pounds.

E. Prior to runup, during taxiing, check the flow of fuel from each source and through the crossfeed system.

Note

Fuel cannot be transferred in this aircraft.

HEATER FUEL MANAGEMENT.

The amount of fuel used by the heaters varies with the heater cycling due to altitude and temperature. The three airfoil heaters, one for each wing and one for the tail, use approximately 5 gallons per hour per heater. The cabin heater uses approximately 2 to 4 gallons per hour. When all heaters are operating, they will use a total of approximately 17 to 19 gallons per hour.

OIL SYSTEM MANAGEMENT.

The capacity of each nacelle oil tank is 35 usable gallons plus 2.5 gallons in reserve for propeller feathering. In addition, the auxiliary oil tank located in the left fillet provides a total of 26 gallons consisting of 50 percent 1100 grade oil and 50 percent 100 octane gasoline. Auxiliary oil is transferred to a selected engine nacelle tank by means of a transfer system. Transfer oil pressure is provided by a motor and pump combination, controlled by a momentary contact switch on the upper overhead panel. Adjacent to the oil transfer pump switch is a tank selector switch which positions the 4-way selector valve and directs auxiliary oil to the desired nacelle oil tank. Oil temperature is controlled by four switches on the aft overhead panel with the positions OPEN, CLOSE, OFF, and AUTOMATIC.

Note

It is recommended that no takeoff be made with less than 110 pounds in any nacelle tank.

It is desirable but not necessary that auxiliary oil be transferred to a nacelle tank when the level of oil drops to 110 pounds. The procedure should be as follows:

A. Position the tank selector switch to the required nacelle tank.

FUEL QUANTITY DATA TABLE

FUEL AT 6 POUNDS PER GALLON (BASED ON STANDARD DAY CONDITIONS)

TANK	NO.	USABLE FUEL LEVEL FLIGHT (EACH TANK)		TOTAL FUEL GROUND ATTITUDE (EACH TANK)	
		GALLONS	POUNDS	GALLONS	POUNDS
1 AND 4 MAIN	2	695	4170	700.3	4201.8
2 AND 3 MAIN	2	719	4314	722.6	4335.6
1 AND 4 ALTERNATE	2	526	3156	531.0	3186.0
2 AND 3 ALTERNATE	2	762	4572	773.7	4642.2
TOTAL		5404	32,424	5455.2	32,731.2

Figure 7-3

B. Depress the auxiliary oil tank pump switch. Release the switch when the desired amount of oil has been transferred, as indicated by the oil tank quantity indicator.

C. After oil has been transferred, the transfer system lines should be evacuated by reversing the pump actuating switch (approximately 1 minute) to avoid the possibility of oil congealing in the transfer line.

Note

Nacelle oil tanks must not be filled above the 150-pound level by use of the oil transfer system due to excessive foaming when the diluted oil enters the tank. In the event of an emergency condition, the engine can be continuously operated down to 35 pounds of oil (15 percent of normal quantity). When operating with a low oil quantity, the oil temperature and oil pressure should be monitored closely.

D. The oil temperature normally is regulated automatically. However, if automatic oil temperature control becomes inoperative, the oil cooler door can be positioned manually by using the oil cooler door air exit switch on the aft overhead panel in either the OPEN or CLOSE positions, as required. These are momentary positions. When the switch is centered, a brake keeps the door locked in position. Refer to Section V for Operation Limits.

SPARK PLUG ANTI-FOULING PROCEDURES.

GENERAL.

Spark plug fouling is a principal cause of ignition trouble, which in turn is one of the most common engine maintenance and operating problems with aircraft engines using 115/145 or 100/130 grade fuel. These grades of fuel may contain a relatively high lead content, up to 4.6 cc per gallon. Such fouling might be defined as an accumulation of deposits which cause misfiring or prevent firing across the spark plug electrodes. The most common types of fouling are lead fouling and carbon fouling, with lead fouling the main trouble-maker. Cause, prevention, and cure of spark plug fouling are all linked to the chemistry and physics of the combustion cycle, which in turn are subject to wide variation under different ground and flight engine operating conditions. A logical treatment of the problem involves separate discussion of each aspect of typical engine operation including ground running, takeoff, cruise, and descent. Prevention is the most profitable line of attack to the problem.

IMPORTANT FACTORS.

Tetraethyl lead is the most important basic cause of lead fouling. Scavenger agents such as bromine in the tetraethyl lead are provided to combine with the lead during combustion, removing it with the exhaust gases. However, under certain conditions of temperature and pressure, the lead will condense out on the spark plug insulator as lead oxide or lead bromide. In the presence of excess carbon as a reducing agent, these may form metallic lead particles. All such deposits can prevent ignition or firing. Other pertinent factors which influence plug misfiring include the type of ignition system, spark plug characteristics and age, water injection operation (dry or wet takeoffs), general engine conditioning including the care and handling of spark plugs, the operating requirements and characteristics of the particular engine installation, and the specific engine operating conditions.

In general, spark plug fouling involves a buildup of deposits through prolonged operation under a fixed set of conditions. Prevention and remedy for plug fouling, therefore, depend on taking action to vary these conditions, upset the chemistry of the fouling cycle, and restore good ignition.

IDLE MIXTURE CHECK.

Idle mixture adjustment is one of the most important factors to be considered in providing protection against fouled spark plugs. When performing a postflight check, the flight engineer must check the idle mixture at minimum idle rpm and at the most commonly used ground idle rpm for a rise not to exceed 10 rpm. Too much emphasis cannot be placed on slow movement of the manual mixture lever during the check. Best power mixture must be obtained and held for at least five seconds. Best power is when a maximum rise in rpm is noted. Any further movement past this point will cause a drop in rpm; therefore, the engineer should move the mixture lever slowly until he has obtained maximum rpm and the rpm has started to decrease. The mixture lever should then be moved very slowly back to the point where the maximum rpm rise was obtained. After ascertaining that the best power mixture has been obtained and maximum rpm rise has been noted, return the mixture control to the appropriate setting. If no rpm rise was noted when slowly moving the mixture lever toward IDLE CUT-OFF, the mixture is too lean. If over a 10 rpm rise is noted, the mixture is too rich and the mixture should be manually leaned to obtain best power or maximum rpm. If the rpm rise was less than 10 rpm the mixture control may be placed in either the AUTO LEAN or AUTO RICH position. It must be remembered that cylinder head temperature has a direct bearing upon the results obtained; therefore, the engineer must have a cylinder head temperature between 160°C and 180°C when performing an idle mixture check. When the aircraft is at the home station and the idle mixture is found to be out of adjustment, it is recommended that corrective maintenance be performed prior to releasing the aircraft for flight.

Idle mixture strength does change with altitude changes. Therefore, when an aircraft is operating away from its home station, the idle mixture could be too rich and cause fouling of the spark plugs. Naturally, this will be noted by the flight engineer when he performs the idle mixture check. This will not be cause for rejection of the aircraft, as the mixture will be correct when the aircraft is returned to the home station. In these cases, the flight engineer will manually lean the mixture for any extended periods of ground operation. The mixture will be manually leaned to obtain maximum rpm, which will be best power mixture. Further, a minimum of 150°C cylinder head temperature should be maintained. The most critical fouling range for the R-2800 engine is between 900 and 1100 rpm.

SPARK PLUG CLEANOUT FOR GROUND OPERATION.

During extended periods of ground idling it is recommended that mixtures be manually leaned to obtain maximum rpm. After each 10 minutes of ground operation at low rpm, the throttles shall be advanced slowly (3 to 5 seconds per 100 rpm) to a manifold pressure 5 inches above field barometric pressure, with a concurrent scan of combustion patterns on the ignition analyzer. This power shall be held for one minute; however, maximum ground operating cylinder head temperature will not be exceeded. If a fouled pattern appears on the engine analyzer, the operator must decrease power to a manifold pressure one inch below the power at which the spark plug resumes firing and operate for at least 10 seconds; then, resume the cleanout procedure. Repeat the gradual increase and reduction of power in this maneuver until reaching 35" MAP, checking all analyzer patterns for satisfactory combustion.

Note

If an engine analyzer is not available to scan spark plug patterns during the preceeding procedures, another ignition check will be performed just prior to takeoff, when time since the last engine runup ignition check exceeds 10 minutes.

GROUND DEFOULING PROCEDURES.

Whenever low BMEP is noted and the analyzer indicates low resistance patterns (fouled spark plugs), proceed as follows:

A. Props — Full Increase RPM.

B. ADI — OFF.

C. Mixture — AS REQUIRED.

NOTE

In colder temperatures it is permissable to place mixture control in auto lean until desired CHT is reached, then return to auto rich.

D. Operate Engine (or engines) at field barometric pressure until cylinder head temperature reaches 180° to 190°.

E. Using the same technique described under Spark Plug Cleanout for Ground Operation, this section, advance power slowly to 40 inches Hg while noting analyzer patterns and BMEP output. If analyzer patterns indicate some degree of combustion in all cylinders, power may be further advanced 45″ MAP for a maximum of 30 seconds in order to compare actual BMEP against that which a normal engine should produce under existing conditions of temperature, humidity and altitude. Do not exceed maximum ground operating cylinder head temperatures.

F. If spark plugs are still not cleared after using the ground defouling procedures twice, the necessary corrective maintenance must be performed.

INFLIGHT PREVENTION.

A periodic change in engine conditions will usually prevent lead fouling during cruise. The engine analyzer should be used to check ignition patterns at least once each hour and, after each hour at cruise settings, one of the following procedures should be used to prevent fouling:

A. The use of auto-rich mixture for a two-minute period.

B. Engine blower shift.

C. A change in power of 3 to 5 inches of manifold pressure or a change of 100 rpm. A reduction in the power level followed by an increase in the power level appears to be the most effective approach to prevention of fouled spark plugs.

INFLIGHT DEFOULING.

If spark plug fouling occurs in flight the rich-mixture method of prevention should be tried first. If this is not effective reduce manifold pressure slowly until plugs resume firing and maintain this power for approximately one minute. Slowly increase power, while scanning analyzer and repeating the previous process until all plugs have resumed firing and manifold pressure has been increased to the desired cruise setting. Plugs which cannot be cleared should be recorded for corrective maintenance after landing.

DESCENT.

Best power mixture is favorable to clean ignition and provides minimum tendency for plug fouling. Therefore, it is recommended that best power mixture setting be maintained during descent.

CAUTION

When flying conditions require a large reduction in power, reduce rpm as well as manifold pressure. It is important to cushion the high inertia loads on the master rod bearings which occur under these conditions. As a rule of thumb, each 100 rpm requires at least 1 inch Hg manifold pressure (for example, 23 inches Hg at 2300 rpm). Operation at high rpm and low manifold pressure should be kept at a minimum.

USE OF LANDING WHEEL BRAKES

To reduce maintenance difficulties and accidents due to wheel brake failure, the importance of properly using aircraft landing wheel brakes should be emphasized.

It is absolutely necessary that aircraft brakes be treated with respect. Consideration must also be given to the wheel brake antiskid system. Although the antiskid system will give consistently shorter landing distances on dry runways, it would not be used to its maximum potential to purposely make all landing rolls as short as possible.

It is generally known that operating personnel stop the aircraft as quickly as possible regardless of the length of the runway, use the brakes consistently for speeding up turns, and drag the brakes while taxiing. To minimize brake wear, the following precautions should be observed insofar as is practicable.

A. When the antiskid system is inoperative use extreme care when applying brakes immediately after touchdown or at any time there is considerable lift on the wings, to prevent skidding the tires and causing flat spots. A heavy brake pressure can result in locking the wheel more easily if brakes are applied immediately after touchdown, than if the same pressure is applied after the full weight of the aircraft is on the wheels. A wheel once locked in this manner, immediately after touchdown, will not become unlocked as the load is increased as long as brake pressure is maintained. Proper braking action cannot be expected until the tires are carrying heavy loads.

a. Brakes themselves can merely stop the wheel from turning, but stopping the aircraft is dependent on the friction of the tires on the runway. For this purpose it is easiest to think in terms of coefficient of friction which is equal to the frictional force divided by the load on the wheel. It has been found that optimum braking occurs with approximately a 15 to 20 per cent rolling skid; i.e. the wheel continues to rotate but has approximately 15 to 20 per cent slippage on the surface so that the rotational speed is 80 to 85 per cent of the speed which the wheel would have were it in free roll. As the amount of skid increases beyond this amount, the coefficient of friction decreases rapidly so that with a 75 per cent skid the friction is approximately 60 per cent of the optimum and, with full skid, becomes even lower.

b. There are two reasons for this loss in braking effectiveness with skidding. First, the immediate action is to scuff the rubber, tearing off little pieces which act almost like rollers under the tire. Second, the heat generated starts to melt the rubber and the molten rubber acts as a lubricant.

c. NACA figures have shown that for an incipient skid with an approximate load of 10,000 pounds per wheel, the coefficient of friction on dry concrete is as high as .8, whereas the coefficient is of the order of .5 or less with a 75 per cent skid. Therefore, if one wheel is locked during application of brakes there is a very definite tendency for the aircraft to turn away from that wheel and further application of brake pressure will offer no corrective action. Since the coefficient of friction goes down when the wheel begins to skid, it is apparent that a wheel, once locked, will never free itself until brake pressure is reduced so that the braking effect on the wheel is less than the turning moment remaining with the reduced frictional force.

B. Antiskid systems are intended to prevent skids at high speed under light wheel loads. Therefore, brakes equipped with an antiskid system may be applied immediately after touchdown, but this should be done only when definitely necessary. The antiskid system will function to prevent tire skidding if it is operating properly, however, it is not designed to **perform as an automatic braking system. Continuous braking from the point of touchdown will result in considerable overworking of the antiskid system beyond design limits in addition to causing excessive wear and extreme heating of the brakes.**

C. If maximum braking is required after touchdown and the antiskid system is inoperative, lift should first be decreased as much as possible by raising the flaps and dropping the nose before applying brakes. This procedure will improve braking action by increasing the frictional forces between the tires and the runway. Propeller reversal should be used whenever possible to reduce braking action required.

D. For short landing rolls, a single, smooth application of the brakes with constantly increasing pedal pressure is most desirable. This procedure applies equally well for operation of emeregency braking system.

E. With or without use of the antiskid system it is recommended that a minimum of 15 minutes elapse between landings where the landing gear remains extended in the slip stream, and a minimum of 30 minutes between landings where the landing gear has been retracted, to allow sufficient time for cooling between brake applications. Additional time should be allowed for cooling if brakes are used for steering, cross-wind taxiing operation, or a series of landings are performed.

F. On all landings, the full landing roll should be utilized to take advantage of aerodynamic braking and to use the brakes as little and as lightly as possible.

G. After the brakes have been used excessively for an emergency stop and are in the heated condition, the aircraft should not be taxied into a crowded parking area or the parking brakes set. Peak temperatures occur in the wheel and brake assembly from 5 to 15 minutes after a maximum braking operation. To prevent brake fire and possible wheel assembly explosion, the specified procedures for cooling brakes should be followed.

H. The brakes should not be dragged when taxiing, and should be used as little as possible for turning the aircraft on the ground.

SECTION VIII

crew duties

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INTRODUCTION.

This section contains those functions of the crew which are in addition to the primary responsibilities of a crew member. It is assumed that each individual crew member is fully aware of the primary responsibilities of his job.

PILOT.

It will be the responsibility of the pilot to insure that a thorough inspection of the aircraft and all equipment is properly conducted in sufficient time prior to departure to permit correction of discrepancies without incurring delays. The inspection checklists are covered in detail in Sections II and III.

VISUAL INSPECTION.

The responsibility of conducting the visual inspection may be assigned by the pilot to the copilot, navigator, crew engineer, or radio operator. When conducting these visual inspections, each item of the checklist will be inspected for the condition and/or the position described thereon. The radio operator will, upon completion of the inspection, report to the copilot that everything is in order, or state any discrepancies. The copilot will then report completion of all checklists to the pilot.

RADIO OPERATOR (AF51-17626 THROUGH AF51-17661, AF51-17667, AND AF51-17668).

The radio operator, in addition to checking out the equipment described in Section IV, will also assume the following responsibilities:

A. Have a thorough knowledge of the emergency equipment.

B. Inspect the emergency radio (AN/CRT-3) for correct stowage and current inspection dates.

C. Be familiar with cabin fire procedure.

D. Be able to give passenger briefing on bail-out and ditching procedures.

RADIO OPERATOR'S PREFLIGHT CHECKLIST.

Note

On aircraft without the services of a radio operator, these items will be checked by a pilot crew member.

EXTERIOR INSPECTION.

Nose to Belly Scoop.

A. VHF and/or UHF antennas – CHECK SECURENESS AND GENERAL CONDITION.

B. ADF loop housings – CHECK SECURENESS AND GENERAL CONDITION.

C. ADF sensing antennas – CHECK SECURENESS AND GENERAL CONDITION.

Right Wing Fillet and Root-to-Tail Right Side Check.

A. H/F antenna (liaison) – GENERAL CONDITION AND SECURENESS.

B. Antennas - CHECK ALL ANTENNAS FOR TAUTNESS AND SECURENESS (IFF, RADIO ALTIMETER, FLAT TOP ANTENNA). CHECK COVER OVER MARKER BEACON ANTENNA FOR CRACKS AND MAKE SURE IT IS NOT PAINTED.

INTERIOR INSPECTION.

Main Cargo Compartment.

A. Interphone and public address system – CHECK TELEPHONE, AND INTERPHONE AND PUBLIC ADDRESS SYSTEM FOR OPERATION.

B. Emergency radio – CHECK THAT THE EMERGENCY RADIOS ARE PROPERLY SECURED. TYPE, NUMBER, AND LOCATION WILL VARY WITH CONFIGURATION AND MISSION.

C. IFF (if installed) – CHECK AND SET.

Crew Compartment Check.

A. Emergency transmitter – CHECK THAT THE URC-4 EMERGENCY TRANSMITTER (S) ARE INSTALLED AND PROPERLY SECURED, (IF APPLICABLE).

NAVIGATOR.

The navigator will aid the pilot in all matters pertaining to flight planning and will perform any other duties assigned.

NAVIGATOR'S PREFLIGHT CHECKLIST.

EXTERIOR INSPECTION.

Nose to Belly Scoop.

A. Driftmeter (if installed) – CHECK LENS AND LENS HOUSING FOR CLEANLINESS, GENERAL CONDITION, AND HOUSING SECURED.

B. Flare chute – CHECK FOR GENERAL CONDITION.

INTERIOR INSPECTION.

Crew Compartment Check.

A. Navigator's equipment – CHECK THAT NAVIGATOR TABLE IS IN STOWED POSITION; DRIFTMETER IS CAGED AND OFF; LORAN, RADIO ALTIMETER, AND RADAR OFF; DRIFT FLARES STOWED; VERY PISTOL EMPTY, IN PLACE, AND SECURED; PISTOL SIGNALS ABOARD AND SECURED; DRIFT FLARE CHUTE CLOSED; STAR SIGHTING WINDOW CLEAN; NAVIGATOR'S STOOL SECURED; PERISCOPIC SEXTANT ABOARD; AND NAVIGATION PUBLICATIONS, KITS, AND FLASHLIGHTS ABOARD.

B. Magnetic compass – REMOVE ANY METAL OBJECTS FROM IMMEDIATE VICINITY OF MAGNETIC COMPASS. SHAKE BOWL AND CHECK FLUID LEVEL AND FREEDOM OF CARD.

FLIGHT ATTENDANT.

FLIGHT ATTENDANT'S PREFLIGHT CHECKLIST.

INTERIOR INSPECTION.

Main Cargo Compartment.

A. Lavatories – INSPECT BOTH LAVATORIES FOR NEATNESS AND CLEANLINESS. CHECK INSPECTION WINDOW ON PRESSURE BULKHEAD FOR SECURENESS. (SCREWDRIVER INSTALLED FOR EMERGENCY USE.) CHECK WATER FLOW FROM LAVATORY FAUCETS.

B. Wasb water tank valve – CHECK THAT VALVE IS ON NORMAL POSITION.

C. First aid kits – CHECK THAT FIRST AID KITS ARE INSTALLED AND THAT SEALS ARE UNBROKEN.

D. Buffet – INSPECT BUFFET FOR CLEANLINESS. CHECK THAT ELECTRICAL CONNECTOR BEHIND BUFFET IS PLUGGED IN AND SECURED. CHECK OPERATION OF HOT CUP RECEPTACLE BY OPERATION OF SWITCHES ON BUFFET PANEL. AMBER LIGHTS ON PANEL INDICATE POWER TO RECEPTACLE. CHECK WATER HEATER AND TOILET LIGHTS. BUFFET CEILING LIGHT WILL DIM NOTICEABLY WHEN WATER HEATER IS TURNED ON. CHECK THAT RELEASE PINS ON BUFFET ARE INSTALLED AND SECURED.

E. Water tanks – CHECK THAT THE AFT 10-GALLON WATER TANK IS PROPERLY SECURED.

F. Liferafts and vests – CHECK FOR SUFFICIENT RAFTS AND LIFE VESTS TO ACCOMODATE ALL PERSONNEL ABOARD AIRCRAFT. CHECK CONDITION OF ALL RAFTS AND MAKE SURE THEY ARE SECURED. NUMBER OF RAFTS WILL VARY WITH CONFIGURATION.

G. Emergency slide – CHECK FOR INSTALLATION, STOWAGE, AND GENERAL CONDITION.

H. Ditching rope – CHECK THAT DITCHING ROPE AT MAIN CABIN DOOR HAS RED RIBBON SECURELY ATTACHED, AND IS FASTENED TO SNAP SECURELY.

I. Safety belts, oxygen masks, and smoke masks – ONE SAFETY BELT FOR EACH PERSON, EITHER PASSENGER OR CREW, AND ONE OXYGEN MASK FOR EACH CREW MEMBER. AIR EVACUATION PATIENTS WITH LUNG OR RESPIRATORY AILMENTS WHO ARE TO BE CARRIED SHALL BE PROVIDED WITH AN OXYGEN MASK (NORMALLY SUPPLIED BY AIR EVACUATION MEDICAL TEAM).

J. Distribution and secureness of cargo – IF CARGO IS LOADED, CHECK DISTRIBUTION AND SECURENESS. PASSENGERS SHALL NOT BE SEATED FORWARD OF CARGO. ADEQUATE SAFETY SHALL BE PROVIDED AND CARGO SHALL BE LOADED TO PROVIDE UNOBSTRUCTED AND OPERABLE EMERGENCY EXITS IN ACCORDANCE WITH LOCAL DIRECTIVES. ALSO CHECK THAT LOWER COMPARTMENT VIEWER ACCESS DOORS ARE CLEAR OF CARGO OR BAGGAGE, IF POSSIBLE.

K. General condition of cabin – CHECK CLEANLINESS, SECURENESS, AND THAT DITCHING PLACARDS ARE INSTALLED.

L. Nameplates (if required) – INSTALL CREW NAMEPLATES.

Crew Compartment Check.

A. First aid kits – CHECK THAT FIRST AID KITS ARE MOUNTED ON THE AFT SIDE OF VOLTAGE REGULATOR PANEL AND THAT SEALS ARE UNBROKEN.

SECTION IX

all weather operation

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION.

This section contains only those procedures which differ from, or are in addition to, the normal operating instructions covered in Section II, except where repetition is necessary for emphasis, clarity, or continuity of thought. Operation of the various aircraft systems is described in Section VII.

NIGHT FLYING.

Night flying procedure is conventional and there is no special technique required in the use of any of the aircraft equipment. However, it is recommended that landing lights be turned off prior to retraction.

OPERATION UNDER INSTRUMENT FLIGHT CONDITIONS.

The aircraft has excellent qualities in regard to instrument flying. Stability in all axes is excellent, and the aircraft can be trimmed to fly "hands off." Takeoff characteristics are satisfactory. Maneuverability on GCA and ILS is excellent. Before attempting an instrument flight, check that all radios and flight instruments are operating properly.

INSTRUMENT TAKEOFF.

Use the following procedure when making an instrument takeoff:

A. Check all radios and flight instruments for proper operation.

B. Make certain the control-surface lock is off and that the controls are free.

C. Set the altimeters for correct barometric pressure.

D. When takeoff clearance is received, align the aircraft on the centerline of the runway and proceed with the specified takeoff.

E. Raise the landing gear as soon as positive climb is established.

F. Climb until clear of obstacles and accelerate to en route climb speed. (See Appendix for climb speeds.)

INSTRUMENT CLIMB.

Climbing airspeed and attitude are easily maintained and the aircraft handles satisfactorily up to and during maximum rate of climb. Climbing turns should be limited to bank angles of 30 degrees.

CRUISING UNDER INSTRUMENT CONDITIONS.

The aircraft should be handled in the same manner as during VFR flight. (See the Appendix for cruising speeds.) In addition, the following checks should be made periodically:

A. Check directional indicators and attitude indicators for proper indication, cross-checking all flight instruments.

B. Check pitot heaters and surface deicing equipment for proper operation during icing conditions.

SNOW, RAIN, ICE CRYSTAL, OR CORONA RADIO STATIC.

When radio static is encountered en route, turn the radio volume down until conditions improve. When nearing the destination, the following may improve reception:

Reduced airspeed.

Lowered radio volume.

Keying the transmitter.

Radio compass in LOOP (wing tip position).

Changing rpm.

DESCENT.

To descend from altitude, use the same procedure as during VFR flight down to the minimum safe altitude for the range being used and in accordance with instructions received from the airway traffic controller.

HOLDING PROCEDURE.

Holding is normally accomplished by using the traffic pattern configuration (rpm 2100, flaps 20 degrees, 140 knots). However, if prolonged holding is expected or fuel is considered critical, fly the aircraft clean in accordance with Maximum Endurance Power Charts.

INSTRUMENT APPROACHES.

The general qualities and capabilities of the aircraft on instrument approaches are excellent and there is no special technique required in the handling of the aircraft.

AUTOMATIC APPROACH.

The procedure to be used when flying an automatic approach is as follows:

A. Automatic approach selector switch — AUTO-PILOT.

B. Autopilot — ENGAGED.

C. Altitude control switch — ON.

D. Prior to or when over outer marker outbound, reduce airspeed to 140 knots (161 mph) and call for the maneuvering descent checklist.

One minute after crossing the outer marker outbound, execute a standard procedure turn by using the autopilot turn control knob.

E. On the inbound heading, which in most cases will be 45 degrees from the localizer heading, turn the automatic approach selector switch to LOCALIZER when the vertical needle of the course indicator just leaves the stops.

F. When steady on the localizer, the glide slope should be monitored by means of the cross pointer indicator. Just prior to glide path interception (approximately 30 seconds or one mile) extend wing flaps to 30 degrees and allow airspeed to taper to the approach airspeed. Set rpm at 2400. When the cross pointer indicator shows one-half to one dot above center, extend the landing gear and complete the Before Landing checklist.

G. When the cross pointer indicator centers, turn OFF the automatic altitude control, adjust the pitch knob to effect the approximate rate of descent, and then turn the automatic approach selector switch to APPROACH position. (Check to see that approach-ready light is illuminated.)

H. Check cross pointer indicator to be sure that the correct glide slope is being held. Adjust power as necessary to maintain 120 knots. Just prior to reaching minimum approach altitude, the pilot depresses autopilot release switch on his control wheel, states "Servos out", and assumes control of the aircraft to complete the landing or missed approach as applicable. Crew engineer disengages autopilot servos on pilot's command.

CIRCLING APPROACHES.

It must be remembered, that a circling approach is not an IFR maneuver, and visual contact with the runway and/or terrain should be maintained throughout. The minimum circling altitude guarantees a clearance of only 300 feet above obstacles within 1.7 nautical miles from the airfield boundaries.

Note

Circling approaches should be conducted in strict observance of circling approach minimums. A circling approach in the maneuvering configuration takes a radius of turn of approximately 1.5 miles.

MANEUVERING CONFIGURATION.

The maneuvering configuration for four-engine circling approaches will normally be rpm 2100, flaps 20 degrees, and airspeed 140 knots.

VOR, ADF, AND RANGE APPROACH PROCEDURE — FOUR-ENGINE (STRAIGHT-IN FINAL).

A. Just prior to high station, pilot reduces airspeed and calls for rpm 2100, flaps 20 degrees, and the maneuvering Descent checklist.

B. Maintains 140 knots and flaps 20 degrees from high station throughout procedure turn. If necessary, 2400 rpm may be used.

C. Just prior to low station, pilot may extend flaps to 30 degrees. At low station rpm 2400, gear down, flaps 30 degrees and complete Before Landing checklist. Maintain 120 knots until runway is in sight.

VOR, ADF, AND RANGE APPROACH PROCEDURE — THREE-ENGINE (STRAIGHT-IN FINAL).

A. Just prior to high station, pilot reduces speed and calls for rpm 2400, flaps 20 degrees, and the maneuvering Descent checklist.

B. Rpm 2600 may be used if necessary.

C. Just prior to low station, pilot may extend flaps to 30 degrees. At low station, rpm 2600, gear down, flaps 30 degrees, ADI-ON, and complete Before Landing checklist. Maintain 120 knots until runway is in sight.

VOR, ADF, AND RANGE APPROACH PROCEDURE — TWO-ENGINE (STRAIGHT-IN FINAL).

A. Just prior to the high station, pilot reduces airspeed and calls for rpm 2600 and the maneuvering Descent checklist.

B. Rpm 2800 may be used if necessary.

C. Over low station, rpm 2800, flaps 20 degrees. Maintain 140% Vs.

Note

When the distance from the low station to the airfield prohibits immediate descent, the flaps should remain UP until starting descent. This will prevent using prolonged high power when the station is a considerable distance from the airfield.

LOW FREQUENCY RANGE, OMNI AND ADF PROCEDURES (STRAIGHT-IN)

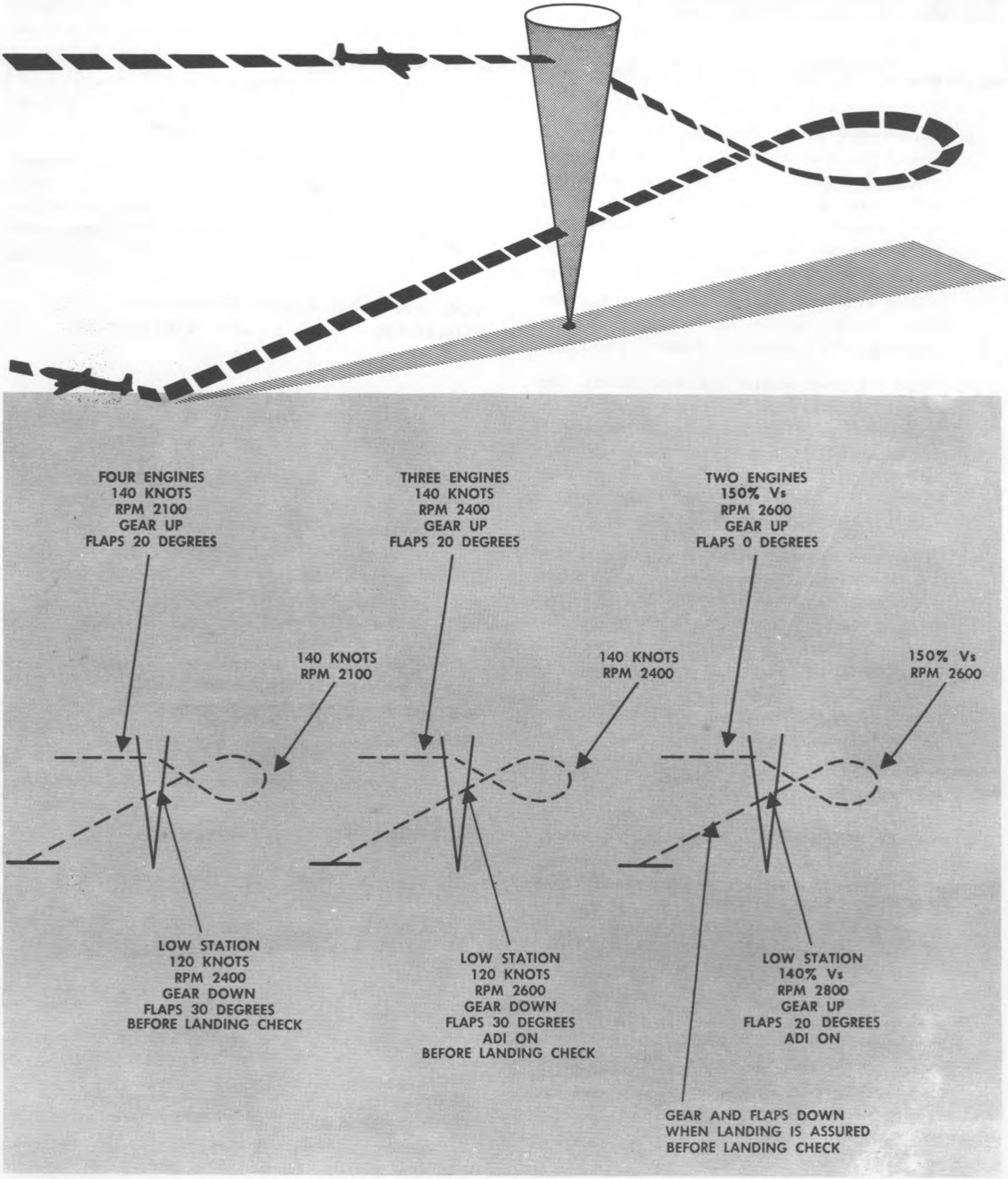
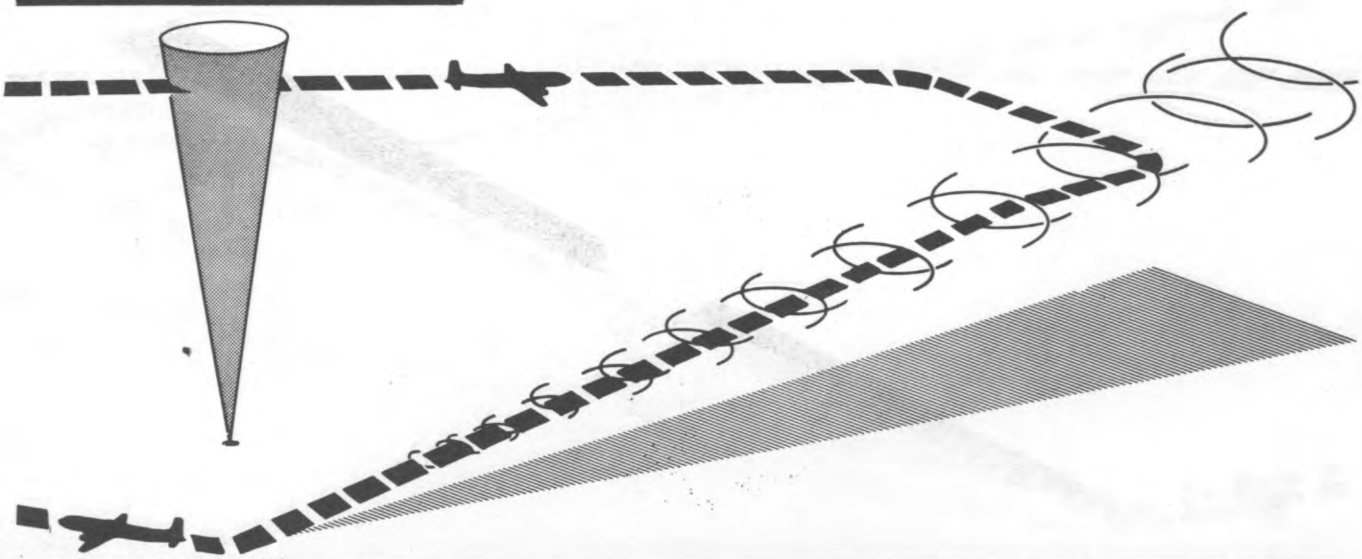


Figure 9-1

GCA PROCEDURE



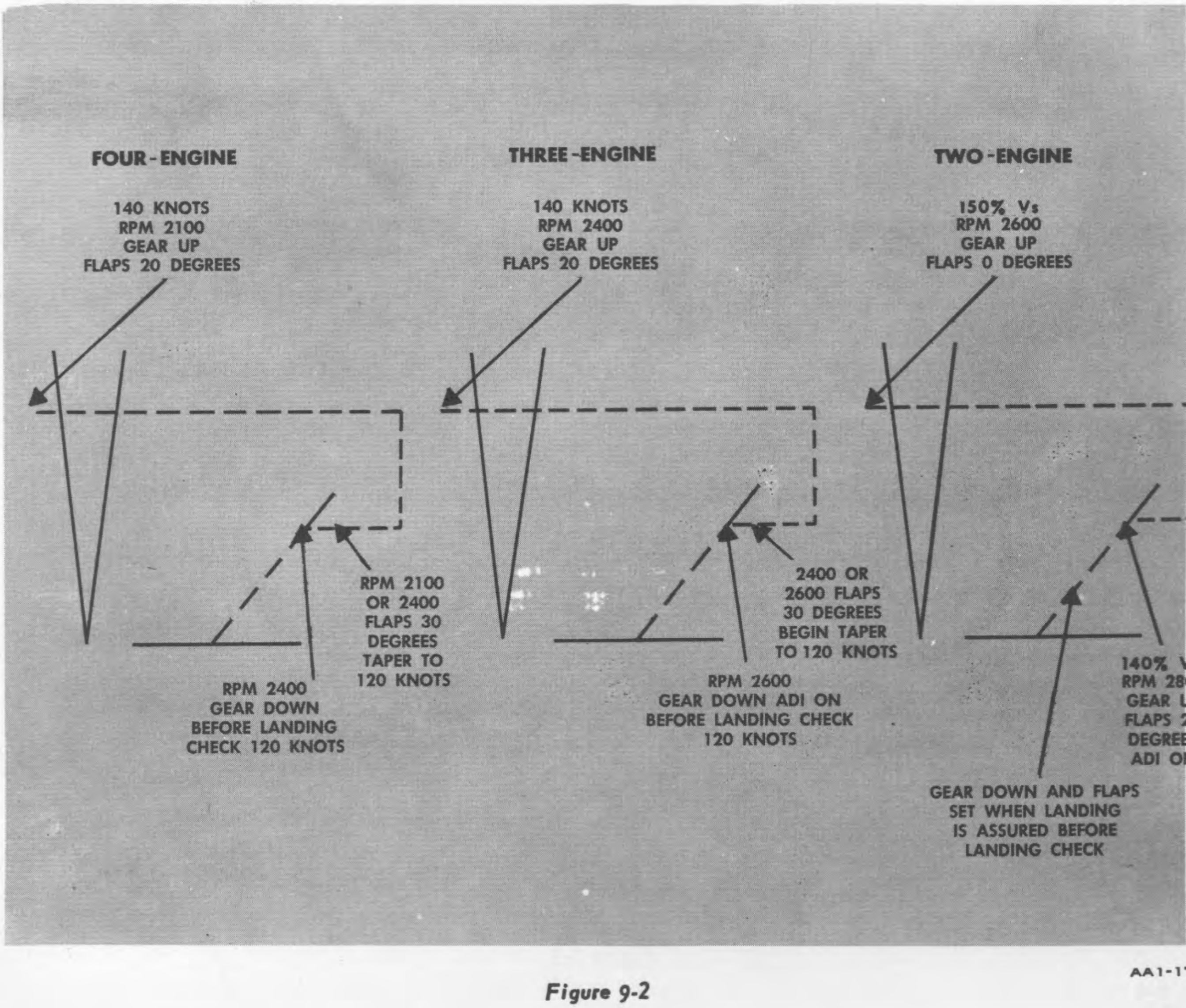


Figure 9-2

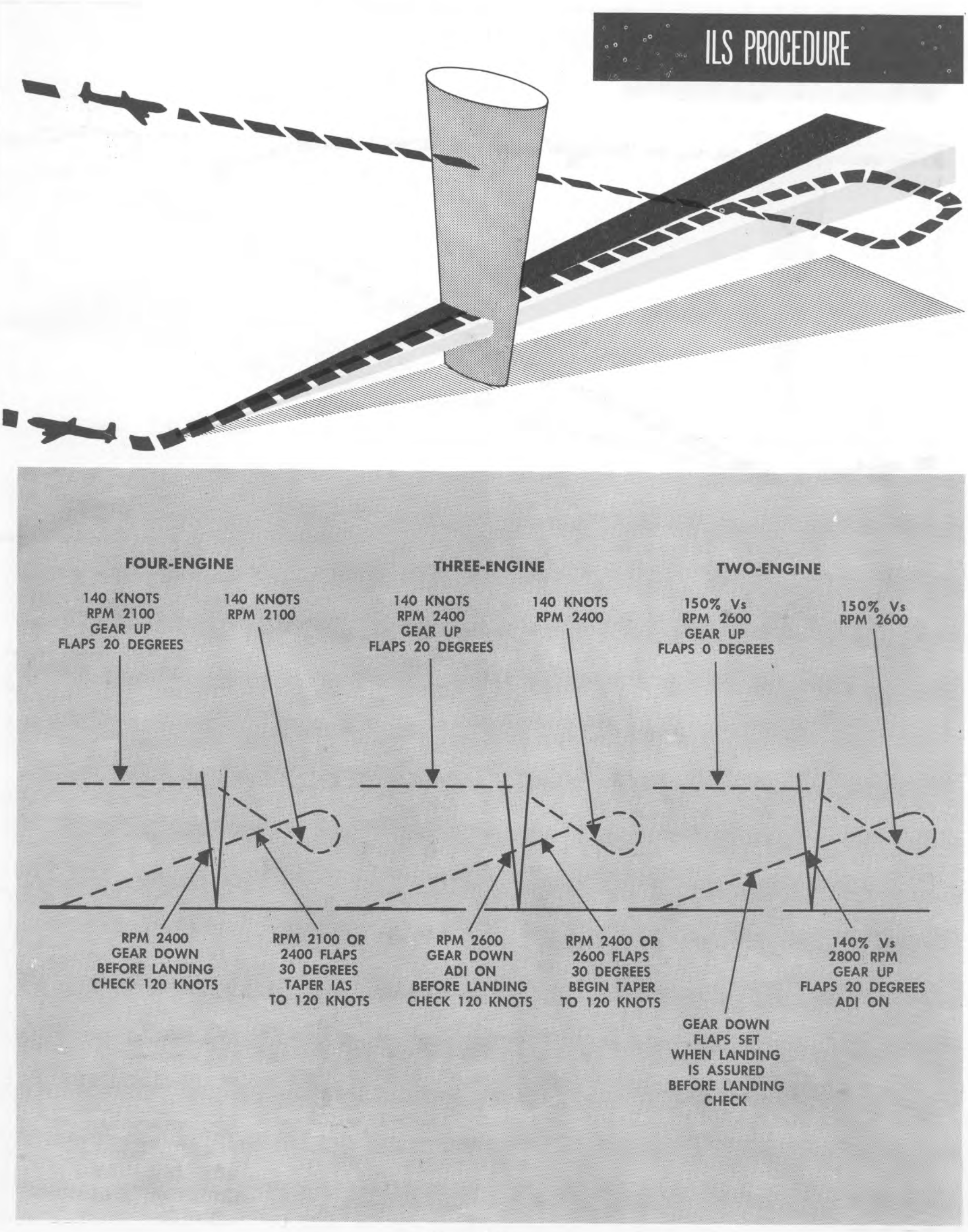

ILS PROCEDURE
FOUR-ENGINE
140 KNOTS
RPM 2100
GEAR UP
FLAPS 20 DEGREES
140 KNOTS
RPM 2100
RPM 2400
GEAR DOWN
BEFORE LANDING
CHECK 120 KNOTS
RPM 2100 OR
2400 FLAPS
30 DEGREES
TAPER IAS
TO 120 KNOTS
THREE-ENGINE
140 KNOTS
RPM 2400
GEAR UP
FLAPS 20 DEGREES
140 KNOTS
RPM 2400
RPM 2600
GEAR DOWN
ADI ON
BEFORE LANDING
CHECK 120 KNOTS
RPM 2400 OR
2600 FLAPS
30 DEGREES
BEGIN TAPER
TO 120 KNOTS
TWO-ENGINE
150% Vs
RPM 2600
GEAR UP
FLAPS 0 DEGREES
150% Vs
RPM 2600
140% Vs
2800 RPM
GEAR UP
FLAPS 20 DEGREES
ADI ON
GEAR DOWN
FLAPS SET
WHEN LANDING
IS ASSURED
BEFORE LANDING
CHECK

Figure 9-3

TACAN PROCEDURE -Typical

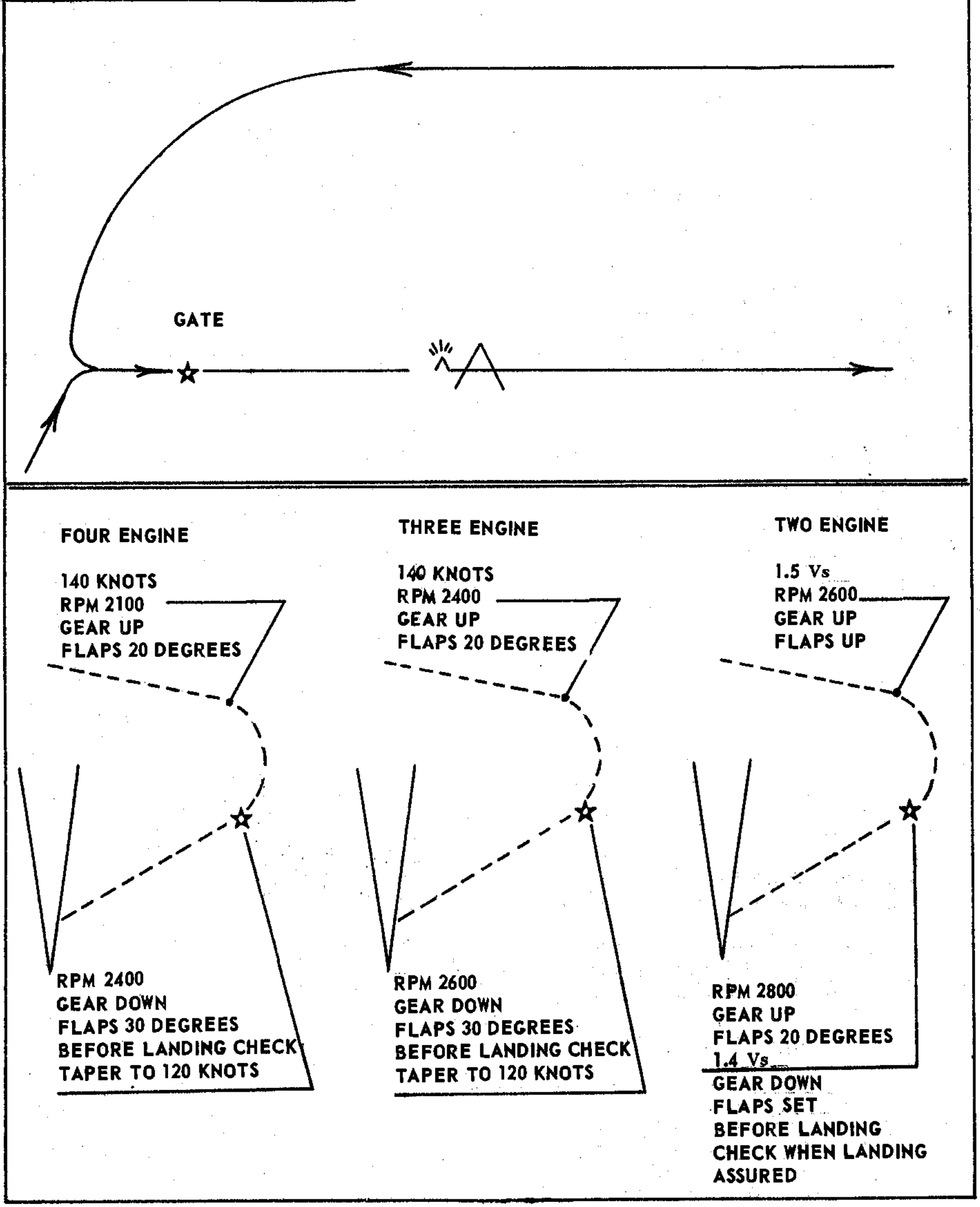


Figure 9-4

D. Maintains an airspeed of at least 140% Vs.

E. Do not extend gear or wing flaps beyond 20 degrees until certain that landing will be completed. Complete Before Landing checklist and ADI-ON.

Note

At normal landing gross weights, it is impossible to maintain altitude even with maximum power on two engines with either the gear down and zero flaps or the flaps down and gear up. Maintain a speed of 140 knots IAS during approach until certain that a landing will be accomplished (see the paragraph, Go-Around With Two Engines Inoperative, Section III). The pilot must remember that considerably more power will be required on the good engines during the two-engine approach. It is important to remember that normal relationships of power, trim, and control do not apply with two engines out on one side. During approach with two engines inoperative on one side, it is better to control manually, at least in part, the directional and lateral attitudes of the aircraft, rather than to apply full trim tab to rudder and aileron. This will obviate a drastic trim change and/or reduce the forces necessary to maintain control when power is reduced for landing.

VOR, ADF, AND RANGE APPROACH PROCEDURE — FOUR-ENGINE (CIRCLING FINAL).

A. Just prior to the high station, pilot reduces airspeed and calls for rpm 2100, flaps 20 degrees, and the maneuvering Descent checklist.

B. Rpm 2400 may be used if necessary.

C. After turning base leg, pilot calls for rpm 2400 gear down, flaps 30 degrees and the Before Landing checklist. (Refer to Circling Approaches, this section, for additional information.)

VOR, ADF, AND RANGE APPROACH PROCEDURE — THREE-ENGINE (CIRCING FINAL).

A. Just prior to the high station, pilot reduces airspeed and calls for rpm 2400, flaps 20 degrees and the maneuvering Descent checklist.

B. Rpm 2600 may be used if necessary.

C. After turning base leg, pilot calls for rpm 2600, gear down, flaps 30 degrees, and the Before Landing checklist (water-alcohol — ON).

VOR, ADF, AND RANGE APPROACH PROCEDURE — TWO-ENGINE (CIRCLING FINAL).

A. Just prior to the high station, pilot reduces airspeed and calls for rpm 2600 and maneuvering Descent checklist.

B. Rpm 2800 may be used if necessary.

C. When certain that landing can be completed, pilot calls for rpm 2800, gear down, flaps set, and the Before Landing checklist (water-alcohol — ON).

GCA AND ILS APPROACH PROCEDURE — FOUR-ENGINE.

NOTE

When necessary to make a circling approach, maintain maneuvering configuration and airspeed (140 knots) on glide path and until after turning on base leg.

A. Just prior to reaching the radio fix used in conjunction with GCA or ILS, the pilot reduces airspeed and calls for rpm 2100, flaps 20 degrees, and the maneuvering Descent checklist.

B. Maintains 140 knots, flaps 20 degrees, and rpm 2100 on GCA downwind leg or outbound on ILS.

C. Just prior to glide path interception (approximately 30 seconds or 1 mile) extend flaps to 30 degrees, allowing airspeed to taper to approximately 120 knots at glide path interception. When flaps are set 30 degrees, rpm may be advanced to 2400 for stabilization, if desired. Upon glide path interception, rpm 2400, gear down, Before Landing checklist. Maintain 120 knots.

GCA AND ILS APPROACH PROCEDURE — THREE-ENGINE.

NOTE

When necessary to make a circling approach, maintain maneuvering configuration and airspeed (140 knots) on glide path and until after turning on base leg.

A. Just prior to reaching the radio fix used in conjunction with GCA or ILS, the pilot reduces airspeed and calls for rpm 2400, flaps 20 degrees, and the maneuvering Descent checklist.

B. Maintain 140 knots, flaps 20 degress, and rpm 2400 on GCA downwind leg or outbound on ILS.

C. Just prior to glide path interception (approximately 30 seconds or 1 mile) extend flaps to 30 degrees, allowing airspeed to taper to 120 knots at glide path interception. When flaps are set 30 degrees, rpm may be advanced to 2600 for stabilization if desired. Upon glide path interception, rpm 2600, gear down, ADI-ON, and complete Before Landing checklist. Maintain 120 knots.

TWO-ENGINE GCA AND ILS APPROACH PROCEDURE.

A. Just prior to reaching the radio fix used in conjunction with GCA or ILS, the pilot reduces airspeed and calls for rpm 2600 and the maneuvering Descent checklist.

B. Maintain 150% Vs (minimum), flaps UP, and rpm 2600 on GCA downwind leg or outbound on ILS.

C. When intercepting the glide path on GCA or ILS, pilot calls for rpm 2800 and flaps 20 degrees, and maintains 140% Vs.

D. When certain that the landing can be completed, pilot calls for gear down, flaps set, and the Before Landing checklist (ADI-ON).

TACAN APPROACH PROCEDURE

FOUR ENGINE

A. Just prior to reaching the inbound TACAN Gate, the pilot reduces airspeed to 140 knots, calls for RPM 2100,' flaps 20 degrees and maneuvering descent checklist.

B. Maintains 140 knots, maneuvering configuratlon until reaching TACAN Gate. RPM may be increased to 2400 RPM for stabilization, if desired.

C. Upon interception of the TACAN Gate, pilot calls for RPM 2400, gear down, flaps 30 degrees and before landing check. Tapers airspeed to and maintains 120 knots.

THREE ENGINE _ TACAN APPROACH

A. Just prior to reaching the inbound TACAN Gate, the pilot reduces airspeed to 140 knots, calls for RPM 2400, flaps 20 degrees and maneuvering descent checklist.

B. Maintains 140 knots, maneuvering configuration until reaching TACAN Gate. RPM may be increased to 2600 RPM for stabilization, if desired.

C. Upon interception of the TACAN Gate, pilot calls for RPM 2600, gear down, flaps 30 degrees and before landing check. Tapers airspeed to and maintains 120 knots.

TWO ENGINE – TACAN APPROACH

A. Just prior to reaching the inbound TACAN Gate, the pilot reduces airspeed to 1.5 Vs, calls for RPM 2600 and maneuvering descent checklist.

B. Maintains 1.5 Vs, flaps UP, and RPM 2600 to the TACAN Gate.

C. Upon interception of the TACAN Gate, pilot calls for RPM 2800, 20 degrees flaps and decreases airspeed to 1.4 Vs. Maintain 1.4 Vs until certain a landing can be completed. Pilot will call for gear down, flaps set and before landing check at this time. (ADI–ON)

Note

Maneuvering descent configuration may be maintained beyond the TACAN GATE if the distance from this point to the airfield missed approach point is considered excessive.

FLIGHT IN THUNDERSTORMS.

Note

Should circumstances force a flight into a zone of severe turbulence, the following recommended techniques aid in reducing structural strain on the aircraft.

For flight in severe turbulence, see Section V for the recommended range of airspeeds. If possible, do not operate on fuel tanks that have less than 1000 pounds; return each engine to its own fuel supply. Place the mixture in AUTO RICH and turn the booster pumps on low. When operating in icing or severe cold, mixtures may be adjusted to *best power* to maintain cylinder head temperatures within limits. When slowing to penetration speed to reduce the effect of turbulence, it is desirable to reduce power and wait for the speed to drop without simultaneously pulling up the aircraft. The reason for this is to avoid combining the acceleration due to the pull-up with those accelerations resulting from the turbulence. It is imperative that the aircraft be prepared as follows prior to entering severe turbulence:

A. Autopilot altitude control switch — OFF.

B. Power — REDUCE TO OBTAIN PENETRATION SPEED.

Note

For flight in severe turbulence, speeds of 165 knots under 100,000 pounds, and 175 knots over 100,000 pounds are recommended.

C. Hydraulic bypass lever — DOWN.

D. Gear lever — UP.

E. Mixture controls — AUTO RICH.

F. Booster pumps — LOW.

G. Carburetor heat — SET.

H. Heater and de-icers or anti-icers — ON.

I. Gyro instruments — CHECKED.

J. Safety belts — TIGHTENED.

K. Cockpit lights — SET.

L. Seat belt light — ON.

Note

For night operations, the cockpit lights may be turned to full bright to minimize the blinding effects of lightning.

WARNING

Do not lower the wing flaps. Refer to wing flap stresses, Section VI.

PENETRATING STORM.

Penetrate the storm as follows:

A. Establish power to provide recommended penetration speed before entering the storm.

B. Devote all attention to flying the aircraft. Concentrate principally on holding a level attitude by reference to the artificial horizon and maintaining as constant an altitude and airspeed as possible.

Note

Normally, the least turbulent area in a thunderstorm will be an altitude of 6000 feet above the terrain. Altitudes between 10,000 and 20,000 feet are usually the most turbulent.

C. Use as little elevator control as possible in maintaining altitude in order to minimize the stresses imposed on the aircraft.

COLD WEATHER PROCEDURES.

Most cold weather operating difficulties are encountered on the ground. The most critical periods in the operation of the aircraft are the postflight and preflight periods. Proper diligence on the part of crew members concerning ground operation is the most important factor in successful arctic operation. The following actions should be taken when temperatures reach 0°F and lower.

BEFORE ENTERING AIRCRAFT.

A. Apply external heat to the engines and accessory sections. An extra heater duct should be directed to the auxiliary power unit if the unit is to be used. The following list of time requirements for engine heating at various temperatures gives rough estimates which will vary with wind velocities and percentage of engine oil dilution. The tabulation is based on an oil dilution of approximately 25 percent and no wind.

−6° to −18°C (20° to 0°F) .... ½ hour (approximately)

−18° to −32°C (0° to −25°F) ...... ½ to 1 hour

−32° to −40°C (−25° to −40°F) .. 1 to 2 hours

−40° to −54°C (−40° to −65°F) .... 1½ to 2½ hours

B. Check the oil drains for oil flow. If no oil flow is obtainable, apply external heat to the drains and oil tanks. In addition to external heating, oil immersion heaters may be used. If the immersion heaters are to be effective in keeping the oil warm during the night, they should be placed in the oil tanks immediately after engine shutdown.

C. Start the cabin heater as soon as possible to heat the flight instruments, defrost the windshields, and warm the radios, dynamotors, inverters, and other equipment within the aircraft. At −54°C (−65°F), the cabin heater may not operate unless radome heat is turned ON first. If the cabin heater still fails to operate, check for a frozen fuel solenoid in the landing gear well. Cabin superchargers should be preheated at temperatures below −40°C (−40°F).

D. Remove all covers from the aircraft, including the pitot covers, and inspect for ice.

E. Clean the shock struts and landing gear actuating cylinders of ice and dirt. Check inflation of the landing gear struts, and, if necessary, service with *dry* air.

F. Check for engine stiffness periodically to determine when sufficient heat has been applied. Generally, if an engine is stiff enough to require more than three men to move a propeller, it is considered too stiff to start.

G. Check for operation of cowl flaps. If the cowl flaps to not operate, apply heat as necessary.

H. Check for proper flow of windshield deicing fluid and for quantity of fluid in tanks.

I. If oxygen is to be used, check the system and portable oxygen bottles for proper operating pressure.

J. Check the emergency airbrake pressure for normal operating pressure, which should be 1000 (±50) psi.

K. Check all accumulators for proper operating pressure. The nosewheel steering accumulator air pressure should be 50 (+5,—0) psi. The hydraulic accumulator air pressure should be 1000 (+200, —0) psi.

L. Check the operation of the main cargo door. If it operates sluggishly at −29°C (−20°F) and lower, apply heat to the actuating cylinders.

M. Check the operation of the hydraulic accessories compartment door. If it fails to close, apply heat to the door seals.

BEFORE STARTING ENGINES.

Before starting the engines, perform the following:

A. Remove the oil immersion heaters, if used.

B. Remove the ground heater ducts.

C. Remove all covers.

STARTING ENGINES.

Start the engine by the normal procedure (Section II), except for the following variations:

A. Rather than short, rapid actuation of the primer switch, hold the switch in the PRIME position for a longer period to provide effective priming.

Note

High boost may be used if necessary, provided low boost is used first.

B. Oil may be diluted slightly if pressure is too high for a prolonged period.

C. Carburetor heat should be applied immediately after starting, in order to assist vaporization and combustion. Do not exceed a carburetor air temperature of 38°C (100°F).

D. Check all instruments for proper operation.

E. If the oil pressure gage does not indicate minimum pressure within 30 seconds, shut down the engine and check for a frozen oil pressure transmitter. If the transmitter is frozen, apply heat as necessary.

F. Operate wing flaps through at least one cycle.

G. Check the movement of the control surfaces.

WARMUP AND GROUND TESTS.

Use the procedure outlined in Section II.

TAXIING INSTRUCTIONS.

Use the same procedure outlined in Section II, only taxi more slowly and use more caution when applying brakes.

BEFORE TAKEOFF.

Make a thorough check for ease and proper operation of all controls important to a cold weather takeoff. These controls include carburetor heat, cowl flaps, oil cooler, cabin heater, and trim tabs.

WARNING

Remove all frost, snow, and ice accumulations before flight.

TAKEOFF.

A. The cabin heating system should be operating, and the windshield anti-icing system should be utilized during takeoff.

B. Pitot heaters and propeller and airfoil de-icers should be ON if precipitation is encountered or if icing conditions are anticipated immediately after takeoff.

C. The pilot should be cognizant of the fact that the flight indicators are not very reliable at temperatures below —20°C (—4°F). Also, all flight instruments should be cross-checked.

Note

At temperatures below −7°C (+20°F) the landing gear lever should remain in the UP position until a safe altitude has been attained, because there is danger of the landing gear extending due to uplatches not engaging when gear lever is placed in NEUT position. The gear lever may be moved to NEUT position after climbing to a safe altitude; however, the pilot should be aware that the gear may free fall.

DURING FLIGHT.

Adjust the cowl flaps as required in order to maintain proper cylinder head temperatures. Cross-check all flight instruments and be alert for any erroneous indication.

PREPARATION FOR ICING.

Icing conditions may be anticipated by a close study of the weather map, weather forecasts, and indications en route. Prepare the aircraft for icing prior to entering any possible icing zone.

CARBURETOR PREHEAT.

When icing conditions are anticipated, carburetor preheat should be used. A carburetor air temperature of 15°C will prevent severe power loss when entering heavy precipitation if preheat is applied several minutes in advance. The automatic mixture control requires up to 5 minutes to adjust to large changes in temperature, and may tend to overcompensate for temperatures appreciably above standard. It is therefore desirable to richen mixtures prior to the application of carburetor preheat, and then delay resetting the chart brake mean effective pressure (bmep) drop until 5 minutes after the throttles have been opened or rpm has increased to the new chart value. At any fixed position of the carburetor preheat control carburetor air temperature (CAT.) will fluctuate with power, airspeed, cowl flap opening, and air moisture content. It will be necessary to monitor the CAT. in order that sufficient heat for ice prevention be maintained, and that the maximum temperature limits of 38°C in low ratio and 15°C in high ratio not be exceeded, except as noted in the following paragraph.

Should carburetor icing occur, it is usually first indicated by a loss of bmep and fuel flow, not necessarily accompanied by engine instability or loss of manifold pressure. The indication is the same as would be obtained by moving the mixture control toward IDLE CUTOFF. Corrective action for this most common type of icing (the presence of which is confirmed by loss of both bmep and fuel flow) consists of AUTO RICH mixture, full carburetor heat for 30 seconds, and then slowly reduced heat to 15°C when it is established that cooler CAT. increases fuel flow and bmep, thus indicating that ice has been eliminated. When advanced stages of leanness have occurred, full prime may be of assistance in restoring power. The addition of carburetor preheat reduces bmep, and this is not to be contsructed as further icing. When ice has been thoroughly eliminated and the CAT. stabilized for 5 minutes, the mixture may be reset to chart bmep drop. It is possible in some circumstances for ice to form in the airscoop, on the carburetor upper deck screen, or in the supercharger intake throat in such a manner as to restrict airflow and therefore cause a loss of manifold pressure, as well as fuel flow and bmep. Corrective action is the same as above, with the addition of rpm and/or high blower ratio, if necessary to generate the required heat.

Another less common type of carburetor icing may be encountered when descending through warm moist air with cold fuel in the tanks. The fuel, acting as a refrigerant, may cause ice to form and create a restriction between the air chambers of the carburetor, thus inducing excessive fuel flow, with resultant bmep loss. Full carburetor preheat should be applied, but the mixtures in this case should be leaned to best power as indicated by bmep. Monitor both bmep and fuel flow in this condition, since mixtures will lean out rapidly as ice is dispelled. Restore normal CAT. and mixture as before. With the — 16 carburetor, this type of icing is more likely to occur under other conditions, but it can be dispelled much more readily. Carburetor de-icing alcohol has been helpful in ice elimination, particularly ice of the latter type; however, preheat is a more effective remedy.

Because of the reaction time required by the automatic mixture control to large temperature changes, the sudden removal of carburetor heat will cause mixture to lean severely. For this reason, the mixture controls should be placed in AUTO RICH and CAT. reduced in increments. Allow temperatures to stabilize for 5 minutes before adjusting mixtures to desired value.

CARBURETOR ALCOHOL DEICING.

If the presence of ice is still suspected after applying carburetor preheat or if the carburetor preheat is inoperative, return the carburetor air temperature controls to full COLD position, and operate the carburetor alcohol deicing system for a period of 1 minute.

Note

As a last resort, backfire the engine by manually leaning.

PROPELLER DEICING.

Ice is prevented from forming on the propeller blades by electrical heating elements mounted on the blade leading edge. The propeller deicing system is controlled by a single ON-OFF master switch on the heater control panel. Operation of the system is either automatic or manual. When the system is operated automatically, each propeller, one at a time, receives electrical current for a period of 20 seconds. Each propeller is heated once every 80 seconds. For manual operation, position the individual propeller selector switches to MANUAL and rotate the ammeter selector switch in sequence to the four ON positions. When manually deicing, it is recommended that the time period for each propeller not exceed 60 seconds ON and 180 seconds OFF.

Before entering any possible icing conditions, turn the propeller deicing system ON. Generally, automatic operation will be sufficient to keep the propeller blades free of ice.

Note

- The lack of cooling airstream over the propeller blade surfaces, when the engines are inoperative, is the limiting factor for ground operation. One complete cycle should be sufficient for ground checks. Any one propeller may be isolated from the automatic system by turning its manual switch ON and keeping the selector switch OFF. This may be desirable if any one propeller vibrates, because one blade is not receiving proper heating. Electric heating is available when any propeller is in the feathered position.
- When making a ground check, the propeller deicing switch should be turned ON and the propeller deicing ammeter checked for a 20-second cycle for each propeller. The switch should then be placed in the OFF position. The desired amperage during this check is 150-225 amperes. A reading below 150 amperes may indicate a malfunction and should be thoroughly checked by maintenance.

PITOT, STATIC, AND AIRSCOOP DEICING.

The pitot heads, static vents, and the airscoops incorporate electrical heating elements to prevent the accumulation of ice. An ON-OFF switch, which operates the system, is mounted on the upper instrument panel.

Note

Do not operate the pitot heaters for extended periods on the ground, as the lack of cooling airstream will result in damage to the pitot heads. The pitot heater should be turned ON when icing conditions prevail and when flying through rain or clouds.

WINDSHIELD HEAT.

By setting the windshield heat selector switch to the temperature range in which the aircraft is flying, the windshield will remain at a temperature which will probably melt any ice that is encountered. In the event of severe icing, the windshield heat selector can be turned to the ANTI-ICING position to supply the maximum amount of heat from the cabin heater directly to the windshield.

WINDSHIELD ALCOHOL DEICING.

If the windshield heat does not keep the windshield clear, apply windshield de-icing fluid. Normally, this can be delayed until the aircraft is out of the icing zone, since the ice will usually evaporate or melt during descent.

AIRFOIL ANTI-ICING.

Turn ON the airfoil anti-icing heater switch 3 to 5 minutes prior to entering icing conditions to allow time for the airfoil leading edges to heat to maximum temperature. If unable to anticipate icing, turn system ON when first accumulation of ice is noted. Accumulated ice should melt and blow off. Leave the airfoil anti-icing heaters ON continuously when flying in and out of intermittent icing conditions.

It is permissible to operate the airfoil anti-icing heaters on the ground prior to and during takeoff, when climbing into known icing conditions. The heaters should be manually turned OFF after landing, rather than depending upon the automatic controls. If one wing airfoil heater fails to operate, turn both heaters OFF, in order to maintain wing symmetry. If the tail airfoil heater is inoperative, it is permissible to continue operation of the wing airfoil heaters for anti-icing. Normal cruising speed is permissible in light icing conditions, provided that long duration in the icing does not result in accumulations in excess of 1 inch on the engine cowling, propeller domes, and antennas. Fragments of ice, 1 inch or more in thickness, may cause appreciable damage to the horizontal stabilizer after breaking loose from the inboard engine cowling at high speeds.

If severe icing conditions are encountered, a percentage of the water striking the leading edge will not evaporate because of insufficient heat and will run back along the airfoil a few inches and refreeze over the fuel tank area where the local temperature is below 0°C. Runback will usually be observed first in the nacelle-to-nacelle wing sections and the horizontal stabilizers, in the wing sections outboard of the outer-engines, and progressively approaching the wing tips as the severity of the icing increases.

TRUE ALTITUDE.

When flying in subzero temperatures, constantly refer to the temperature correction chart and determine the true altitude, since the actual altitude will always be considerably less than the indicated altitude. This is especially important when flying over rough terrain, such as the Greenland Ice Cap, and when making instrument approaches.

ALTIMETER ERROR.

There has been considerable discussion regarding the altimeter error due to mountain top vortices, caused by winds of high velocity over mountain ranges or other rough terrain. There are several different lines of thought as to the magnitude of this error. It is known that altimeter errors do exist from this source, and there is enough evidence to justify maintenance of altitudes of not less than 2000 feet above the highest terrain during periods of high wind velocities and turbulence.

WARNING

The altimeter should be checked closely to assure that the 10,000-foot pointer is reading correctly. Due to previous settings of the altimeter, the setting knob could have been rotated until eventually the numbers reappeared in the altimeter setting window from the opposite side, thus indicating a 10,000-foot error.

ST. ELMO'S FIRE.

St. Elmo's Fire is static electricity of pale blue color, which appears on propeller hubs and blades and around the cockpit. It is recommended that all radios be turned off except VHF and UHF (conditions permitting) to prevent a discharge through the set; otherwise, it is usually harmless. St. Elmo's Fire does not affect the VHF or UHF equipment.

APPROACH AND LANDING.

During descent for landing, monitor engine temperatures closely. Temperature inversions are common in winter, and ground temperature may be 15° to 30°C colder than at altitude. Therefore, keep cylinder head temperatures above 150°C by maintaining sufficient power and closing cowl flaps to assure good fuel vaporization, thus minimizing the danger of backfiring and cutting out. The oil temperature should be maintained over 50°C. Monitor airspeed. The stalling speed of the aircraft increases when ice has formed on the wings. Maintain shallow angles of bank when making an approach with an iced-up aircraft.

Note

At low temperatures, inadvertent asymmetrical propeller reversing is possible, and an alternate procedure must be used if the propellers do not reverse or will not reverse together.

A. Upon completion of landing roll, the oil cooler doors should be opened so that the oil will cool sufficiently while taxiing to the ramp and permit oil dilution.

B. Emergency airbrake pressure should be visually checked in order to ascertain whether or not the system will function, if needed.

CLEARVIEW WINDOW.

In the event that windshield hear has been inoperative and alcohol supply exhausted, it may be necessary to open the clearview window in order to provide adequate visibility for landing. Proceed as follows:

A. Depressurize.

B. Compute a minimum final approach speed in accordance with the degree of icing on airfoils and aircraft surface.

C. Make all turns shallow.

D. Commands will not be audible in the cockpit after the clearview window has been opened. Therefore, plan to give and receive all instructions by use of the interphone system.

E. Perform a thorough crew briefing before opening the window. The briefing should include the copilot calling airspeeds and altitude over the interphone during final approach, leaving enough interval to allow the pilot to interpose commands for manifold pressure adjustments.

F. Accurate depth perception will be more difficult than normal. Therefore, do not attempt to touch down in a nose-high attitude.

G. The tendency will be to land in a slight crab to the right due to having to lean the body slightly to the left in order to look through the window opening.

STOPPING OF ENGINES.

Oil dilution is required if the expected minimum temperature is below 2°C (35°F).

OIL DILUTION PROCEDURE.

The aircraft is equipped with a system of oil dilution to facilitate cold weather starting. When a cold weather start is anticipated, the engine oil should be diluted with fuel before stopping the engines, provided that the engine oil temperature is maintained below 50°C (122°F). Above this temperature, dilution may not be effective, since the fuel introduced into the system will vaporize. When the oil temperature exceeds 50°C (122°F) during the dilution period, stop the engine and wait until oil temperatures have fallen below 40°C (104°F) before again starting the engine and resuming the dilution operation. During conditions of extremely low OAT., it may be necessary to break the dilution period up into two or more short periods. If it is necessary to service the engine section oil tanks, the oil dilution period must be divided so that part of the dilution is accomplished before the oil tanks are serviced and the remainder after the tanks are serviced. In order to allow for addition of the fuel, the oil tanks should not be completely filled.

Perform the oil dilution operation as follows (operation of the oil dilution system is indicated by a slow drop in oil pressure):

Note

For operating temperatures above 1.7°C (35°F), use 1100 engine oil; for temperatures below 1.7°C (35°F), use grade 1065 engine oil. If grade 1065 is not available, preheat must be used and if preheat is not available, dilute oil as outlined in item 3 of paragraph 4, following. When using grade 1065 oil and temperatures below −17.8°C (0°F) are predicted, use preheat; if preheat is not available, dilute oil as outlined in item 3 in the following.

A. Turn the fuel booster pump switches to LOW to supply adequate fuel pressure.

B. Operate each engine at 1000 to 1200 rpm.

C. Maintain oil temperature below 50°C (122°F), stopping any engine for a short period if the temperature exceeds this limit.

D. Operate the oil dilution switches for the following periods and temperatures:

Temperature	*Time*
2° to −12°C (35° to 10°F)	3 minutes
−12° to −29°C (10° to −20°F)	6 minutes
−29° to −40°C (−20° to −40°F)	9 minutes
−40° to −54°C (−40° to −65°F)	12 minutes

E. When the dilution is complete, shut the engine down in a normal manner, continuing to hold the oil dilution switch ON until the engine has stopped. Exercise the propellers at 1500 rpm from low to high pitch three times to dilute the oil in the propeller system. Reverse the propellers at least once during oil dilution.

F. When warming up an engine after oil dilution, it is preferable to allow the oil temperature to rise above 60°C (140°F) and to increase the engine speed during the runup to dissipate as much of the dilutant fuel as possible and allow the oil to return to its normal viscosity. Below this temperature, and at low engine speeds, very little gasoline will be driven out of the oil. It is also good practice to run the propellers to full increase and decrease at least three times to heat the oil in the propeller domes. It is advisable to reverse the propellers at least once during the warmup period. Recheck the engine section oil tanks for proper quantity.

DESERT PROCEDURES.

Wind-blown sand is the main concern of operation in the desert. Many of the malfunctions which occur will be found to originate because of improper care on the ground. Since most of the procedures given in Section II apply as well to Desert Procedures, only specific information for care of the aircraft during ground and flight operation will be given in this section.

GROUND OPERATION.

The aircraft must be given special treatment when based in the desert if the operation is to be successful. In order to minimize costly maintenance, adhere to the following instructions:

A. Hold ground operation of the aircraft to a minimum.

B. Cover all air intakes and ducts as soon as possible after landing to prevent entrance of blowing sand.

C. Keep all equipment free of sand, dirt, or moisture.

D. Keep the aircraft dispersed as much as possible. The engines of one aircraft can add hours to maintenance problems of another when proper precautions during taxiing or ground operation are not followed.

FLIGHT OPERATIONS.

Hot weather operation requires that you be more cautious of stalling speeds and temperature limitations. Also, keep the following in mind when operating in hot weather.

Note

If CAT. limit must be exceeded, reduce manifold pressure limit 1 inch Hg for each 6° above normal CAT. limit.

A. Keep cylinder head temperatures as low as possible before takeoff.

B. Longer takeoff distances are required.

C. Use the brakes sparingly.

D. Climb at not less than the speed shown in the climb charts (see the Appendix).