SECTION V
OPERATING LIMITATIONS

TABLE OF CONTENTS

INTRODUCTION.

This section includes the engine and aircraft limitations that must be observed during normal operation. The instrument markings *(figure 5-1)*, which form a part of these limitations, must be referred to, as they are not necessarily repeated in the text.

Company policy for C-47 operation has been determined to be in accordance with the Air Force TO-1C47-1 with certain exceptions. Where noted below the following items to Air Force T.O. are the company accepted exceptions. In all cases the Company Flight Manual of Operations may, or may not, reflect the figures given below. Action is being taken to correct the Flight Manual where discrepancies occur.

MINIMUM CREW REQUIREMENT.

The minimum crew for a flight is a pilot and a copilot. Additional crew members, as required, will be added.

INSTRUMENT LIMIT MARKINGS.

The limits marked on the aircraft instruments are shown in figure 5-1.

NOTE

The limitations marked on the instruments apply to flight conditions and are not intended to indicate ground operating limits.

ENGINE LIMITIONS.

Refer to figure 5-1 for normal operating limits. Overspeed limitations on the engine are 2900 rpm for complete inspection and above 3050 rpm for replacement. Note all conditions of overspeed on aircraft log book.

ENGINE POWER TIME LIMITATIONS.

The engines are approved for 2 minutes of operation at maximum power during takeoff and climb at takeoff speed. There is no limitation in the use of METO power.

ENGINE (OVERBOOST OR) EXCESSIVE MANIFOLD PRESSURE.

Use of manifold pressures in excess of those specified under normal and alternate fuel grade operating limits, this section, is not permitted. If excessive manifold pressure is experienced, the following limits apply:

1. At or above METO power an excessive manifold pressure over 15 seconds duration requires engine removal.
2. At any power setting 10 or more inches Hg excessive manifold pressure required engine removal.
3. Below METO power 5 to 10 inches Hg excessive manifold pressure from 5 to 15 seconds duration required engine inspection.

ALTERNATE FUEL GRADE OPERATING LIMITS.

The alternate fuel grade is 115/145. Operating limits for 115/145 grade fuel are the same as those specified for 100/130 grade fuel.

ENGINE OIL PRESSURE LIMITS (GROUND OPERATION ONLY).

Oil pressures that are not within the following limits during ground operation should be noted on the aircraft log book.

Desired 80-90 psi at 2200 rpm 60°C oil inlet temperature.
Normal Operating Range:

RPM	MIN.		MAX.
2550-2700	80	-	110 psi
2000-2200	65	-	100 psi
1600-	55	-	90 psi
1400-	45	-	85 psi
Idle	15	-	psi min

AIRSPEED LIMITATIONS.

Item	26,000 Lb Gross Wt	29,000 Lb Gross Wt	31,000 Lb Gross Wt	33,000 Lb Gross Wt
Max level flight (indicated)	177 Knots (204 mph)	169 Knots (195 mph)	148 Knots (171 mph)	129 Knots (149 mph)
Max allowable	221 Knots (255 mph)	202 Knots (233 mph)	170 Knots (196 mph)	140 Knots (160 mph)
Max for extending landing gear (indicated)	140 Knots *(160 mph)			
Max for extending full wing flaps (indicated)	97 Knots *(112 mph)			
Max for extending ½ wing flaps (indicated)	100 Knots *(115 mph)			
Max for extending ¼ wing flaps (indicated)	104 Knots *(120 mph)			

*Not Affected By Gross Wt.

PROHIBITED MANEUVERS.

All acrobatic flight maneuvers are prohibited.

CENTER OF GRAVITY LIMITATIONS.

Gear down	Forward 11% MAC	Aft 28% MAC
Gear up	Forward 11% MAC	Aft 28% MAC

OPERATIONAL WEIGHT LIMITATIONS.

Weight, more than any other single factor, will determine the capability and performance of your aircraft. In designing an aircraft, weight has always been a primary restrictive factor as it has a direct effect on aircraft configuration, power, and range. 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 unnecessary weight; however, the weight penalty for making an aircraft foolproof is prohibitive. Weight limitations, therefore, are necessarily involved in the operation of the aircraft. If these limitations are exceeded, a loss in the performance of the aircraft is inevitable and structural failure is quite probable. When an aircraft is loaded beyond the established limits, 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 take-off and landing rolls increase appreciably with an increase in gross weight. Likewise, the braking power is insufficient for checking the forward momentum of the aircraft and the wings are more vulnerable to airloads during maneuvers or flight through turbulent air. These effects can reach serious proportions when the weight limitations of a specific aircraft are disregarded. In cargo aircraft, particular attention must be paid to the weight problem. In order that cargo of various sizes may be accommodated, the cargo compartment is of such proportions that space is not usually a restrictive factor; consequently, overloading is entirely possible and weight limitations must be complied with if the aircraft is to be operated efficiently, economically, and safely. A consideration of the weight factors involved, particularly as they apply to this aircraft, appears in the succeeding paragraphs.

WEIGHT AND LOADS.

Due to the effect of gravity on the mass of your aircraft, 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 the aircraft 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 spoken of as 1G. As fuel, cargo, passengers, crew members, and additional equipment are added in order that the aircraft may accomplish a specific mission, the additional weight constitutes a force acting on the aircraft structure. The weight of the aircraft, or the force that gravity imposes on the aircraft, 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, take-off, 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 on the aircraft. 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 types of force 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. Since 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, an understanding of weight limitations is required to accomplish a mission successfully.

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 on the aircraft by gravity in any condition of static equilibrium. The load factor denotes the strength of the forces acting on the aircraft as a result 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 1G 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 0.5G, 2.0G, 3.0G, etc, which mean that the forces exerted on the wing structure and its members are .5, 2, or 3 times the force exerted by gravity. For example, if the normal weight of the aircraft is 25,000 pounds and the load factor at some given moment of accelerated flight is 3.0G, the total force which the wings must sustain is 75,000 pounds, or three times the normal weight of the aircraft in straight and level flight.

MARGIN OF SAFETY.

The margin of safety is the range of forces which exist between the load factor the aircraft is sustaining at any given moment and the load factor at which structural damage will occur. If, for example, the aircraft is incapable of sustaining a load factor greater than 3.0G, and during flight through turbulent air is subjected to a force of 1.5G, the margin of safety at this particular moment is 1.5G. 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 an aircraft to maintain a margin of safety that 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 3.0G, turns and pull-outs should be made with caution to minimize the resulting airloads.

EXPLANATION OF CHART.

The weight limitations chart *(figure 5-2)* is intended to present graphically the weight-carrying capabilities of the aircraft as defined by the various criteria which provide limits for safe and efficient operation. The chart will help the flight planner to recognize the weight limitations that will restrict operation in a specific mission and to determine 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 the aircraft at a given gross weight remains the responsibility of the local authority.

GROSS WEIGHTS.

The data in this chart 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 load axes represents an operating weight of 20,000 pounds. Because individual operating weights may vary, it will be necessary to adjust the chart for the specific aircraft involved. The operating weight plus the fuel and cargo required in a mission can be shown by gross weight lines that 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 that 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. Take-off gross weights must also be considered in the light of available runways, surrounding terrain, altitude, atmospheric conditions, and the requirements and urgency of the mission.

WING FUEL LOAD.

At the base of the chart along the horizontal axis, the weight of the fuel normally carried in the wing tanks is indicated in thousands of pounds.

INSTRUMENT MARKINGS

OIL TEMPERATURE

- 40°C Minimum
- 60°C To 80°C Normal
- 100°C Maximum

OIL PRESSURE

- 55 psi Minimum for flight (1700-2000 rpm)
- 65 to 110 psi Normal
- 110 psi Maximum
- 15 psi Minimum for idle
- 80 psi Minimum above 2500 rpm

** NOTE: An increase of up to 1.5 in. hg. is permitted for horsepower loss due to humidity.

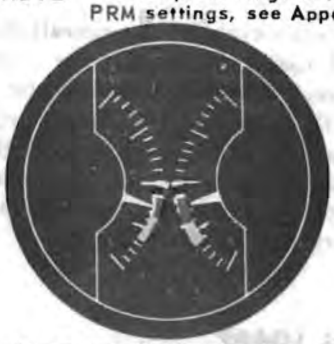
MANIFOLD PRESSURE

- * 30.2 In. Hg 2050 RPM 600 BHP-AL Permitted
- 32.8 In. Hg 1900 RPM 600 BHP-AL Permitted
- 32.8-42.5 In. Hg-A.R. Reqd. 42.5 In. Hg or above A.R. Reqd. (5 Min Limit).
- 42.5 In. Hg-Meto Power
- ** 48 In. Hg-Maximum

* NOTE: For complete range of MP limits at various PRM settings, see Appendix, Part II.

TACHOMETER

- 1300 To 1700 RPM - Dangerous Empennage Vibration
- 1700 To 2050 Rpm - A.L. Permitted
- 2050 To 2550 Rpm - A.R. Reqd
- Above 2550 Rpm - 2 Min Limit A.R. Reqd
- 2550-Meto Power
- 2700 Rpm - Maximum



CARB AIR TEMPERATURE

- -10°C To 15°C - Possible Icing
- 15°C To 38°C - Normal
- 50°C - Detonation

NOTE: 38°C maximum with carb. heat.

CYL-HEAD TEMPERATURE

- 150°C - 232°C - A.L. Permitted
- 232°C To 270°C - A.R. Reqd
- 270°C - Maximum

NOTE: 232°C maximum for ground oper.

Figure 5-1 (Sheet 1 of 2)

FUEL PRESSURE

16 psi — Minimum for flight
16 to 18 psi — Normal
20psi — Maximum

AIRSPEED-KNOTS

97 Knots—Full flaps
221 Knots-Maximum allowable

COMPANY

HYDRAULIC PRESSURE

800 psi - Minimum
800 - 1000 psi - Normal
1050 psi - Maximum

AUTOPILOT OIL PRESSURE

105 psi — Minimum
110 to 130 psi — Normal
140 psi — Maximum

VACUUM GAGE

3.75 in. Hg — Minimum
3.75 to 4.25 in. Hg — Normal
4.25 in. Hg — Maximum

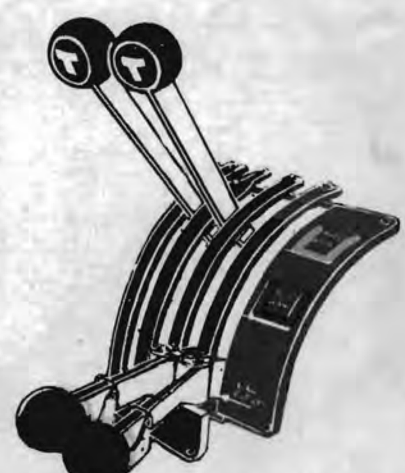
DE-ICING PRESSURE

8.0 to 8.5 psi—Normal
9 psi — Maximum

AIR FORCE

HYDRAULIC PRESSURE

600 psi — Minimum
600 to 875 psi — Normal
900 psi — Maximum



MIXTURE CONTROL QUADRANT

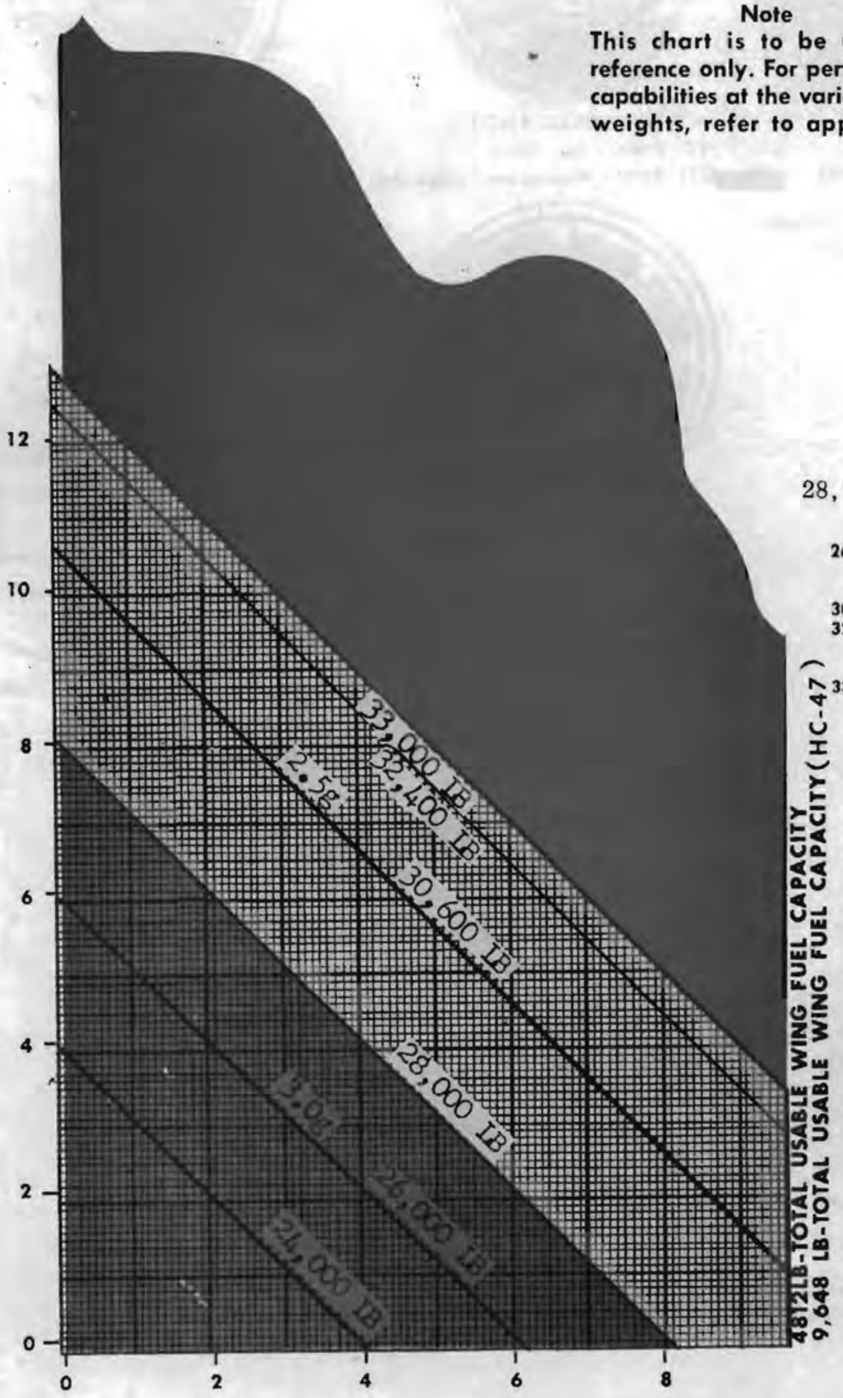
Auto — Lean
Auto — Rich

Figure 5-1 (Sheet 2 of 2)

WEIGHT LIMITATIONS CHART - TYPICAL

BASIC OPERATING WEIGHT OF 20,000 LB

Note
This chart is to be used for reference only. For performance capabilities at the various gross weights, refer to appendix I.



28,000 - Maximum company authorized takeoff weight.

26,000 – DESIGN GROSS WEIGHT AT 3.0g WING LOAD FACTOR. NORMAL LANDING WEIGHT.

30,600 – 2.5g WING LOAD FACTOR.

32,400 – 100 FPM, SL, HOT DAY, SINGLE ENGINE, CLEAN CONFIGURATION, MAXIMUM POWER.

33,000 – 100 FPM, SL, STANDARD DAY, SINGLE ENGINE, CLEAN CONFIGURATION, MAXIMUM POWER, MAXIMUM RECOMMENDED LANDING WEIGHT.

RECOMMENDED

CAUTIONARY

NOT RECOMMENDED

Figure 5-2

LONG-RANGE FUEL LOAD.

When long-range fuel tanks are installed in the main cabin to increase the range of the aircraft or to transport fuel, the total weight of this fuel and the tanks should be computed as cargo load. By computing the fuel in the long-range tanks as cargo load, detailed chart work is eliminated, as are the individual calculations involved in adding the weight of the long-range fuel to the fuel load and the weight of the long-range tanks to the cargo load. Whenever long-range fuel is carried, a reduction in the cargo load is necessary to compensate for the weight of the long-range fuel and tanks.

CARGO LOAD.

In any mission, range and fuel consumption directly determine the fuel that must be carried, and indirectly the cargo that 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 long-range fuel is utilized to increase the range of the aircraft, the combined weight of the fuel and tanks should be computed as cargo load.

WING LOAD FACTORS.

The loads which the wing will sustain under different weight conditions are represented by the wing load factor lines on the chart. Under most loading conditions, which are normally limited by single-engine performance, the margin of safety provided by the wing load factors is very small. However, when flight through turbulent air is anticipated, the highest practical wing load factor is desirable.

SPEED.

The loads on the wing increase as the gross weight increases. This effect may be largely nullified by a reduction in speed. Refer to the paragraph on Airspeed Limitations, this section, for recommended speeds at various gross weights.

LANDING GEAR LIMITATIONS.

The landing gear structure is designed for landing during routine operation at a gross weight of 26,000 pounds at a maximum contact sinking speed of 9 fps limit. This is the maximum recommended landing weight for normal operation. The maximum recommended landing weight under emergency conditions is 33,000 pounds. This weight is based on the fact that the landing gear fittings become critical at this weight when landing in the tail down attitude. Therefore, when landing at weights in excess of 26,000 pounds, the tail down attitude should be avoided if at all possible. At a landing weight of 33,000 pounds, the brakes are good for 100 stops. The main wheels and tail wheel and tire become critical for strength at 33,000 pounds gross weight.

PERFORMANCE LIMITATIONS.

In the case of 2-engine aircraft, it is generally inherent that performance rather than structural limitations restricts 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. Single-engine performance, then, is the major restrictive factor in the 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 wholly performance limitations. 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.

On this aircraft, the effect of an engine failure on performance is immediate. The loss of half the total thrust normally developed by both power plants and the asymmetric power condition that results produce a marked decrease in the rate of climb. The significance of gross weight and configuration immediately becomes apparent, for the aircraft with partial power is unable to maintain an adequate rate of climb at gross weights above 33,000 pounds, or in a configuration where the landing gear and wing flaps are extended. Power losses due to temperature, humidity, and engine deficiency exert a considerable influence on the rate of climb, even when both 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 remarkable difference in aircraft performance resulting from a rise in temperature and a corresponding fall in air density. As the weight limitations chart illustrates, the difference between a standard day and a hot day requires a cargo adjustment of approximately 600 pounds. For purposes of standardization, the temperature of a standard day is 15°C (59°F) and that of a hot day, 38°C (100.4°F) 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, on the gross weight at which the aircraft may be operated, has not been included in the weight limitations chart because there are so many variable conditions involved.

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 take-off 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 take-off roll is such that no attempt to take off should be made unless the safe single-engine airspeed for the aircraft gross weight has been achieved.

RECOMMENDED LOADING AREA.

The green area on the chart represents the loading conditions that present no particular problem in regard to the strength or performance of the aircraft. Operation of the aircraft at weights outside this recommended loading area should be avoided unless the dictates of the mission require it. The green area is bounded by the 2.5G wing load factor line. No aircraft will be operated outside of green area without prior approval of DFD.

CAUTIONARY LOADING AREA.

The yellow area on the chart represents loadings of progressively increasing risk as the red area is approached. Caution must be exercised because single-engine performance at these gross weights is marginal, depending upon configuration, altitude, and ambient air temperature. This area is defined by the gross weight diagonal which indicates a rate of climb of 100 feet per minute at sea level on a standard day with one propeller feathered, gear and flaps up, and maximum power on the operative engine.

LOADING NOT RECOMMENDED.

The red area represents loadings which are not recommended because the margin of safety, from the standpoint of both performance and structural limitations, is something less than the most desirable or practical. Under conditions of extreme emergency when safety of flight is of secondary importance, DFD will determine whether the degree of risk warrants operation of the aircraft at gross weights appearing in the red zone.

USE OF CHART.

A sample problem is presented to illustrate the application of the chart.

1. Assume that a C-47 aircraft calls for a 10,500-pound payload and 3000 pounds of fuel. Starting with the operating weight of 20,000 pounds at "0," proceed along the vertical axis to 10,500 pounds; this increases the gross weight to 30,500 pounds. Next proceed along the horizontal axis to 3000 pounds and project a line vertically to intersect the horizontal projection of the 10,500 pound line. By interpolation, the intersection will indicate a gross weight of 33,500 pounds. This value is above the maximum recommended gross weight, and in order to keep within the cautionary envelope, the cargo or fuel must be reduced by 500 pounds.

2. Another example to demonstrate a problem where the operating weight of the aircraft is greater than that shown on the chart: assume an operating weight of 22,000 pounds instead of 20,000 pounds, or a difference of 2000 pounds. Using the same requirements as in the previous example and proceeding as before, the gross weight will be found to be 33,500 pounds by interpolation; but, to this value, 2000 pounds must be added to the cargo scale to correct the chart for the heavier aircraft. This increases the total gross weight to 35,500 pounds. This value is above the maximum recommended gross weight, and in order to keep within the cautionary envelope, the cargo or fuel must be reduced by 2500 pounds.

MANIFOLD PRESSURE CORRECTION FOR HUMIDITY.

Maximum manifold pressure under part throttle conditions may be increased up to 1.5 in.hg. to correct for reduction in air displaced by humidity. This has no harmful effect on the engine since the increased manifold pressure only returns mass air flow to the amount expected in dry air at standard temperature. Horsepower developed does not exceed engine rating as a result of this correction. Reference Pyschometric Chart (Figure A1-8) Appendix Page A1-14.

NOTE

Overboosting is more serious than underboosting The pyschometric chart must be utilized to obtain an accurate correction, therefore, if accurate temperature and due point information is not available, 48 in. hg. should not be exceeded for takeoff.

C-47 MINIMUM EQUIPMENT GO NO-GO LIST

A. General

The following list contains listings of certain instruments and accessories which may be inoperative and still not reduce the safety of operation of the aircraft below minimum limits. This list should eliminate last minute delays if items may be "held over" to a station where both time and equipment will be more readily available.

B. Continuation of Flight With Inoperative and/or Defective Equipment

1. Main Maintenance Base

An aircraft will not be dispatched from the main or Sub-Base with inoperative or defective equipment or with any uncorrected Flight Log report that affects the air worthiness of any system required to meet the basic operating specifications approved by the Company. However, a flight may be dispatched for ferry or non-revenue flight from either base provided the defective or inoperative unit is repaired or replaced prior to origination of schedule or revenue flights.

2. Line Stations

An aircraft may be dispatched with inoperative or defective equipment provided that the units are within the limits prescribed in the appropriate Minimum Equipment List.

3. Minimum Requirements

a. The appropriate list will be used as a guide in determining the items of serviceable flight equipment required under circumstances where all the normal complement of flight equipment is not operative. The final decision of whether to proceed with an unserviceable unit within the minimums as listed must be left to the discretion of the Captain of the flight.

b. After investigation of the Flight Log report, if a decision is made to continue the flight with a unit inoperative, it must be determined that the unit is rendered free from the possibility that further extension of the damage or defect could cause a fire hazard or a mechanical failure, either internally or to its drive, mounting connections, allied assembly or system which could endanger the safety of the aircraft in flight.

c. The inoperative or malfunctioning system must be adequately placarded at the appropriate control or gauge, and the control of an inoperative system must be saftied in the OFF or NEUTRAL position to prevent inadvertant operation. A log book entry, relative to the inoperative unit or system, must be made.

C. Minimum Operative Instruments, Communications, Navigation & Equipment.

1. The items listed are only those which may be defective at the departure of aircraft from an outlying station. Replacement or repair must be effected at the next base having the facilities to perform the work.

2. Any instrument, communication unit, navigational unit or any other equipment which is not listed below and is required by FAR or CCAR, as appropriate, must be complete and operational for continuation of flight.

C-47 GO NO-GO LIST

ITEM	EQUIPMENT	1. EQUIPMENT INSTALLED	2. MINIMUM EQUIPMENT REQUIRED FOR ALL FLIGHT CONDITIONS:	
	I AIR CONDITIONING			
1	Cockpit heater	1		Not required when inflight ambient temperature is + 10°C or above.
2	Cabin heater	1		Same as for cockpit heater above.
	II COMMUNICATION EQUIPMENT			
1	HF transmitter/receiver	2	1	One HF may be inoperative if two are installed for flight outside local area.
2	VHF transmitter/receiver	2	1	One VHF may be inoperative if two are installed or one HF and UHF is operative.
3	UHF transmitter/receive (If Installed)	1		Not required if one HF and one VHF is operative.
4	Interphone jack box	3	2	One may be inoperative.
5	Headset	3	2	One may be inoperative.
6	Microphone	3	2	One may be inoperative.
	III ELECTRICAL POWER			
1	Inverter	2	1	One may be inoperative for day VFR operations.
2	AC voltmeter	1	1	
3	Generator	2	1	One may be inoperative if it is removed and a pad installed. NOTE: Monitor electrical load as necessary to prevent overloading the remaining operative generator.
4	Battery	2	1	

C-47 GO NO-GO LIST

ITEM	EQUIPMENT	1. EQUIPMENT INSTALLED	2. MINIMUM EQUIPMENT REQUIRED FOR ALL FLIGHT CONDITIONS:	
5	Ammeter (If Installed)	2	2	If no voltmeters
6	Voltmeter	2	2	If no ammeters
7	Generator warning lights	2	2	Not required if ammeters or voltmeters are operative.
	IV EQUIPMENT FURNISHINGS			
1	Safety belts			One for each person aboard.
2	First aid kit	1	1	
3	Fire axe	1	1	
	V FIRE PROTECTION			
1	Fire detection system including lights and bell			
	Engine	2	2	
	Heater (If installed)	1		May be inoperative if heaters are not to be used.
2	Engine fire extinguisher system	2	2	
3	Portable fire extinguisher	2	2	
	VI FLIGHT CONTROLS			
1	Flap position indicator	1		May be inoperative if V_{fe} (97 KIAS) is observed for any flap operation.
	VII FUEL SYSTEM			
1	Booster pumps	2	2	
2	Engine driven fuel pump	2	2	
3	Cross-feed system (If installed)	1	1	

ITEM	EQUIPMENT	1. EQUIPMENT INSTALLED	2. MINIMUM EQUIPMENT REQUIRED FOR ALL FLIGHT CONDITIONS:	
4	Firewall shut-off valves	2	2	
5	Fuel quantity gauges	4	4	If at point of origin or no dip-stick available if all tanks are to be used. Gauges are only required on tanks to be used. Not required if away from point of origin and dip-stick is available for flight back to point of origin.
7	Fuel tanks	4	2	One required for each engine.
	VIII HYDRAULIC POWER			
1	Main accumulator	1	1	
2	Hydraulic pumps			
	Engine driven	2	1	For one time flight to point of origin only. Any other flight, two are required.
	Hand pump	1	1	
3	Hydraulic system pressure gauge	1	1	
4	Landing gear down pressure gauge	1	1	
5	Sight gauge	1	1	
	IX ICE AND RAIN PROTECTION			
1	Surface de-icing system	1		Only required for flight in geographical icing regions.
2	Carburetor alcohol anti-icing system	1		Same as above.
3	Carburetor heat controls	2	2	
4	Pitot heat	2	2	One may be inoperative in VFR. Required on the operative airspeed indicator.

ITEM	EQUIPMENT	1. EQUIPMENT INSTALLED	2. MINIMUM EQUIPMENT REQUIRED FOR ALL FLIGHT CONDITIONS:	
5	Windshield wipers	2	2	Required for flight in precipitation in terminal areas.
6	Windshield anti-icing system	1		May be inoperative if icing conditions will not exist along the route of flight.
	X INSTRUMENTS			
1	Clock with sweep second hand	2	1	Not required for VFR if one crew member has a sweep second hand watch.
2	Free air temperature gauge	1		Required for flight in geographical icing regions.
	XI LANDING GEAR			
1	Landing gear warning system	1	1	
	XII LIGHTS			
1	Instrument lights			For all night operations red and white lighting must be provided to clearly illuminate all instruments and controls.
2	Position light system	1	1	May be inoperative for day operation.
3	Landing lights	2	1	One may be inoperative at night if returning to point of origin. Both may be inoperative for day operation.
4	Anti-collision light	1		May be inoperative to next station where repairs can be made if all three position lights are operative in "flash" position.
5	Flasher unit	1		May be inoperative if anti-collision light is operative.
6	Passenger warning lights	2		May be inoperative if public address system and stewardess call box are working during passenger operations.
	XIII NAVIGATION			
1	Altimeter	2	1	One may be inoperative for day VFR.

ITEM	EQUIPMENT	1. EQUIPMENT INSTALLED	2. MINIMUM EQUIPMENT REQUIRED FOR ALL FLIGHT CONDITIONS:	
2	Vertical velocity indicator	1	1	
3	Airspeed indicator	2	1	One may be inoperative for day VFR.
4	Attitude indicator	2	1	One may be inoperative for day VFR.
5	Directional indicator	2	1	One may be inoperative for day VFR.
6	Magnetic compass with correction card.	1	1	
7	Turn and bank indicator	1	1	One may be inoperative for day VFR.
8	ADF receivers	2	1	One may be inoperative if VOR system is operative. Only one required for day VFR.
9	VOR receiver (If Installed)	1	1	Not required if both ADF receivers are operative or for day VFR.
10	Flux gate compass	1	1	Not required if both directional indicators are operative.
	XIV OXYGEN			
1	Flight crew oxygen	0	0	Not installed in SEA.
2	Flight crew oxygen masks	0	0	Not installed in SEA.
	XV VACUUM			
1	Vacuum pumps	2	1	One may be inoperative for day VFR.
2	Vacuum gauge	2	1	
	XVI PROPELLER			
1	Propeller governor and control	2	2	
2	Propeller feathering pumps and motors	2	2	
	XVII POWER PLANT			
1	Cowl flaps (If installed)			

ITEM	EQUIPMENT	1. EQUIPMENT INSTALLED	2. MINIMUM EQUIPMENT REQUIRED FOR ALL FLIGHT CONDITIONS:	
	XVIII ENGINE FUEL AND CONTROL			
1	Fuel pressure indicators	2	2	
2	Fuel tank selector valves	2	2	
	XIX ENGINE INDICATING			
1	Tachometer indicating systems	2	1	One may be inoperative provided the manifold pressure gauge is operating on affected engine.
2	Manifold pressure gauges	2	1	One may be inoperative provided the tachometer is operating on affected engine.
3	Cylinder head temperature gauges	2	1	One may be inoperative provided the oil temperature gauge is operating on affected engine.
4	Carburetor air temperature gauges	2	1	One may be inoperative. Use operative instruments for reference during carburetor icing conditions.
	XX OIL			
1	Oil temperature gauges	2	1	One may be inoperative provided oil pressure and cylinder head temperature gauges are operative on affected engine.
2	Oil pressure gauges	2	2	
3	Oil temperature controls (If installed)	2	2	
	XXI STARTING			
1	Starters			
	Direct drive	2	2	
	Energize/engage type	2		Engaging mechanism can be inoperative if starters can be engaged manually for flight to point of mechanical repair.

SECTION VI

FLIGHT CHARACTERISTICS

TABLE OF CONTENTS

GENERAL.

The flight characteristics are normal for a twin-engine transport aircraft. The aircraft is very stable around all axes and is easily trimmed to fly *hands off.* Very minor trim changes are required to maintain the desired aircraft attitude. Control forces required for maneuvering throughout the speed range are normal. Rudder and aileron control is excellent and elevator forces are normal at high and low airspeeds.

STALLS.

The power-off stalling characteristics for this aircraft are normal. Stall warning comes in the form of a comparatively mild buffeting of the horizontal stabilizer. Stalling speed increases with the degree of bank and increase in gross weight, as shown in figure 6-1. The ailerons are effective up to the point of stall. No violent rolling action either precedes or accompanies the power-off stall under any flap setting. However, as in the case of most multi-engine aircraft, stall encountered with power on will probably cause violent rolling movements. The extended landing gear has no appreciable effect on the stalling characteristics. Recovery from a stall is normal and should be made by nosing the aircraft down and applying power. Apply power smoothly and avoid an abrupt pull-out.

PRACTICE APPROACH TO STALLS.

Practice approach to stalls at a safe altitude, applying the principles discussed in the above paragraph. Minimum altitude for practicing approach to stalls is 5000 feet above the terrain.

SPINS.

Intentional spins are prohibited. However, in case a spin is entered into accidentally, use normal spin recovery procedure to regain level flight. If the normal spin recovery procedure does not stop the spin, a *blast of power* on the inside engine may expedite the recovery. This is not a normal procedure, however, since the thrust from the blast of power may increase airspeed beyond the maximum design structure limits.

DIVING.

Placarded airspeed should not be exceeded in a dive. Recovery from a dive should be accomplished smoothly, and abrupt pull-outs avoided.

APPROXIMATE STALLING SPEEDS – POWER OFF

MPH AND KNOTS IAS

Note: The extended landing gear has no appreciable effect on the stalling characteristics.

GROSS WEIGHT (POUNDS)	0 FLAP LEVEL KNOTS	0 FLAP FLIGHT MPH	0 FLAP 30 DEG KNOTS	0 FLAP BANK MPH	0 FLAP 45 DEG KNOTS	0 FLAP BANK MPH	1/4 FLAPS LEVEL KNOTS	1/4 FLAPS FLIGHT MPH	1/4 FLAPS 30 DEG KNOTS	1/4 FLAPS BANK MPH	1/4 FLAPS 45 DEG KNOTS	1/4 FLAPS BANK MPH
33,000	76	88	82	95	91	105	71	82	77	89	86	99
31,000	73	85	79	91	88	101	69	79	75	86	83	96
29,000	71	81	76	88	85	98	67	77	72	83	80	92
27,000	68	78	73	84	82	94	64	74	69	80	77	89
25,000	65	75	70	81	78	90	62	71	66	77	74	85
23,000	62	72	67	77	75	86	59	68	63	73	71	82
21,000	59	68	64	74	71	82	56	64	60	70	68	78

GROSS WEIGHT (POUNDS)	1/2 FLAPS LEVEL KNOTS	1/2 FLAPS FLIGHT MPH	1/2 FLAPS 30 DEG KNOTS	1/2 FLAPS BANK MPH	1/2 FLAPS 45 DEG KNOTS	1/2 FLAPS BANK MPH	FULL FLAPS LEVEL KNOTS	FULL FLAPS FLIGHT MPH	FULL FLAPS 30 DEG KNOTS	FULL FLAPS BANK MPH	FULL FLAPS 45 DEG KNOTS	FULL FLAPS BANK MPH
33,000	68	78	73	83	81	92	65	75	70	81	79	90
31,000	65	75	70	81	78	89	63	72	68	78	76	87
29,000	63	72	68	78	75	86	61	70	66	76	73	84
27,000	61	70	65	75	72	83	59	67	63	73	70	81
25,000	58	67	62	72	69	79	56	65	60	70	68	78
23,000	55	64	60	69	66	76	53	62	58	69	64	74
21,000	53	61	57	65	63	72	51	59	55	63	61	71

Figure 6-1

SECTION VII
SYSTEMS OPERATION

TABLE OF CONTENTS

CARBURETOR ICING.

Immediately prior to beginning the take-off roll, advance the throttles sufficiently to make carburetor heat available. Hold the control column full back to prevent nose over. Set the carburetor air controls to FULL HOT to obtain temperatures within the continuous operating range as indicated by the instrument markings. Maintain this temperature for the time required to insure complete removal of any ice previously formed in the induction systems. The increase in CAT. will be accompanied by a drop in MP of an inch or two. If an appreciable quantity of ice has formed in the vicinity of the throttle valve, the MP will increase an inch or so as the ice is removed. If no rise in MP is observed, either no throttle icing existed or the ice has not yet melted. The pilot will have to decide which circumstance exists. Turn the carburetor alcohol deicer switch ON (the carburetor deicing control valve handle must also be ON). Observe that a drop in CAT. occurs. When satisfied that no ice remains in the induction system, move the carburetor air controls to the full cold (RAM) position.

NOTE

Allow two minutes for carburetor stabilization prior to applying power for the take-off roll.

When the aircraft is airborne and power is reduced to climb settings, adjust the CAT as required to operate outside the probable carburetor icing range, as indicated by the instrument markings, and turn the carburetor deicing system OFF. A gradual loss of manifold pressure greater than that expected due to increase in altitude, without the throttles being moved, is an indication of carburetor icing. Apply carburetor deicing fluid as required until the ice has been eliminated, as indicated by recovery of the manifold pressure. Readjust the CAT to avoid further carburetor icing.

CAUTION

Conserve the carburetor alcohol supply for momentary use during flight, for use during landing, or for an emergency.

BACKFIRING.

To prevent backfiring during starting, movement of the mixture control from IDLE CUT-OFF to AUTO-RICH should occur slightly before ceasing to prime, in order to allow the carburetor to come up to operating pressures and start functioning in a normal manner. The transition should be smooth.

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 100/130 or 115/145 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 a 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 FACTS.

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 condition of the ignition system, spark plug characteristics and age, 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 operation 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, upsets 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 post-flight check, the pilot must check the idle mixture at minimum idle rpm and 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 pilot 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 a rise of more than 10 RPM or a drop in manifold pressure exceeding 1 4 inch Hg. is noted, the idle RPM fuel-air ratio is too rich and the mixture should be manually leaned to obtain best power or maximum RPM. This condition will be noted in Form 781. If the rpm rise was less than 10 RPM the mixture control may be placed in either the AUTO LEAN or AUTO RICH position. This condition will be noted on log book. It must be remembered that cylinder head temperature has a direct bearing upon the results obtained; therefore, the pilot 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 pilot 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 pilot 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-1830 engine is between 900 and 1100 rpm.

SPARKPLUG CLEANOUT FOR GROUND OPERATION.

Whenever excessive rpm drop is noted during power and ignition check proceed as follows:

1. Propellers – FULL INCREASE.
2. Mixture – RICH.
3. Operate engine at Field Barometric Manifold Pressure until CHT reaches 180-200°C.
4. Advance power slowly to 5 inches above field barometric and hold for one minute.
5. Recheck ignition.
6. If spark plugs are not cleared after this procedure has been tried twice, corrective maintenance must be performed. 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. This power shall be held for one minute; however, maximum ground operating cylinder head temperature will not be exceeded.

NOTE

Another ignition check will be performed just prior to takeoff, when time since the last engine runup ignition check exceeds 10 minutes.

INFLIGHT PREVENTION.

A periodic change in engine conditions will usually prevent lead fouling during cruise. After each hour at cruise settings, one for the following procedures should be used to prevent fouling:

1. The use of auto-rich mixture for a two-minute period.
2. 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 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, and repeat the previous process until all plugs have resumed firing and manifold pressure has been increased to the desired cruise setting.

CAUTION

Whenever appreciable power changes are made 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.

CHANGING POWER CONDITIONS DURING FLIGHT.

The most economical engine operation at low power can be obtained by operating at low engine rpm and high manifold pressure up to the maximum bmep limit (see Appendix).

To prevent excessive cylinder pressures when changing power conditions, use the following procedure:

INCREASING POWER.

1. Mixture controls – At the proper setting for the desired power condition.
2. Propeller controls – Adjust to obtain the desired engine rpm.
3. Throttles – Adjust to obtain the desired manifold pressure.

REDUCING POWER.

1. Throttles – Adjust to obtain the desired manifold pressure.
2. Propeller controls – Adjust to obtain the desired engine rpm.
3. Throttles – Readjust as necessary.
4. Mixture controls – Adjust to the proper setting for the desired cruising condition.

CAUTION

When maneuvering with low power or during descent with low power, it is important to cushion the high inertia loads on the master rod bearings which occur at high rpm and low manifold pressure. As a rule of thumb, each 100 rpm requires at least 1 inch Hg manifold pressure. Use high rpm and low manifold pressure only when necessary.

FUEL SYSTEM MANAGEMENT.

FUEL TANK SELECTION.

When the engines are operated, the main fuel tanks or the auxiliary fuel tanks can be selected to supply fuel to a single engine or to both engines. During flight, the long-range fuel tanks (if installed) can be selected, through the shutoff valves at the front tanks, to supply fuel to either or both engines. The fuel tank selectors, used with fuel booster pumps, make selection from all tanks possible *(figure 7-1)*.

NORMAL FUEL TANK PROCEDURE.

When running fuel tanks empty in flight, keep a close check on the fuel pressure gage. It is advisable to switch to another tank as soon as the fuel pressure begins to drop. If a tank is allowed to run dry to the extent that the engine slows down, the throttle should be moved toward the CLOSE position before the fuel tank selector is moved, in order to prevent the engine from overspeeding. All take-offs and landings should be made with the fuel tank selector set to the fullest (main or auxiliary) tanks.

CAUTION

Unless the fuel is required to complete the mission, it is advisable to select a new fuel supply before running a tank empty (approximately 20 gallons remaining) in order to prevent engine failure because of fuel starvation.

NOTE

It is very important upon reaching a cruising altitude that fuel be consumed from main tanks first and auxiliary tanks last. This procedure is necessary, since the majority of the return flow will be routed to the main tanks. This procedure will also permit using a minimum amount of elevator tab to trim the aircraft.

SWITCHING FUEL TANKS

1. Place booster pump ON for desired engine.
2. Select desired fuel tank.
3. Turn booster pump OFF after assuring proper engine operation.

LONG-RANGE FUEL TANK OPERATION.

To prevent drawing air into the fuel supply lines, which will result in a fuel system air lock, take-off is not permitted with less than 25 gallons of fuel in each long-range tank.

CAUTION

Take-off is not permitted using fuel from the long-range fuel supply. The long-range shut-off valves must be turned OFF prior to take-off.

The long-range fuel tank shutoff valves *(figure 1-20)* will be turned to the OFF position in sufficient time to maintain a minimum of 25 gallons of fuel in each tank. Since the fuel booster pumps are installed down-stream from the main, auxiliary, and long-range tanks, they have a tendency to pump air from the empty tanks or leaking valves; therefore, the fuselage tanks should not be permitted to run dry in flight unless the fuel is needed for emergency purposes.

NOTE

If the long-range fuel tanks run dry and the engines are allowed to slow down, move the throttles toward the CLOSE position before moving the right and the left fuel tank selectors from the OFF positions. This will prevent the engines from overspeeding. Turn ON the booster pumps until the engine runs smoothly.

In the event that air locks occur with the fuel boost pumps operating, the condition will in all probability be aggravated; however, a new fuel supply should be selected immediately. For long-range fuel tank operation, proceed as follows:

1. When cruising altitude has been reached, turn the long-range fuel shutoff valves ON.
2. Turn the right and left engine fuel tank selectors OFF.
3. When the fuel supply in the long-range fuel tanks becomes low, turn the left and right fuel tank selectors to the LEFT MAIN and the RIGHT MAIN positions respectively.
4. Turn the long-range fuel shutoff valves OFF.

CAUTION

Do not operate with both normal and long-range fuel systems on at the same time; turn OFF the long-range fuel system shutoff valves when operating on main or auxiliary tanks to prevent air locks. Do not climb at a steep angle when operating on the long-range fuel system and the fuel level is low in the tanks, since air locks will occur from fuel being trapped in the tanks.

FUEL SYSTEM MANAGEMENT.(HC-47 SERIES A/C)

FUEL TANK SELECTION.

Each engine is supplied independently by the tanks in the corresponding wing. The fuel may be supplied from the main tank, auxiliary tank or the outer wing tank but cannot be used from any tank to the opposite engine without using the cross-feed. It is advisable that both engines be operated from their respective wing tanks to maintain proper balance. Fuel management will vary with the mission to be flown, aircraft gross weight and distribution of the fuel load. When the normal fuel load is carried (204 gallons in each main tank, 50 in each auxiliary tank, and 200 gallons in each outer wing tank), the main tanks will be used for take-off, climb, and circumstances permitting, in cruise until 100 gallons remain in each main tank (figure 7-1).

CAUTION

Whenever possible maintain sufficient fuel in the main and auxiliary tanks to permit flight to an emergency landing field should the necessity arise to dump outer wing tank fuel.

When a mission requires more fuel than the normal fuel load, the outer wing tanks will be serviced to capacity before servicing the auxiliary wing tnaks.

NORMAL FUEL TANK PROCEDURE.

Should it be necessary to completely exhaust fuel in the outer wing and auxiliary tanks in order to consolidate fuel available in the main tanks, use fuel from the outer wing and auxiliary tanks until 50 gallons remain in each tank. Next, use fuel from the outer wing tank until 20 gallons remain in each outer wing tank. At this time place one selector on the main tank and continue using fuel from the outer wing tank for one engine. Note the time and monitor the fuel pressure on the engine using fuel from the outer wing tank. When a drop in pressure is noted switch the selector to the main tank position. When fuel pressure is again normal note the time and place the other selector to outer wing tank position. Monitor the fuel pressure on the engine on the outer wing tank and when a drop in fuel pressure is noted turn the selector to the auxiliary tank position again noting the time. When fuel pressure is again normal place the other fuel tank selector to the auxiliary position and repeat this procedure with the main and auxiliary tanks, when the fuel level reaches 20 gallons in the auxiliary tanks. By checking time to run tanks dry an accurate fuel consumption rate can be determined.

CAUTION

Do not completely exhaust fuel in any tank at less than 1000 feet above the terrain except when necessary.

NOTE

If a tank is allowed to run dry to the extent the engine slows down, the throttle should be closed before the tank selector is moved in order to prevent the engine from overspeeding. Operate fuel booster pump until the engine runs smoothly.

SWITCHING FUEL TANKS

1. Place booster pump ON for desired engine.
2. Select desired fuel tank.
3. Turn booster pump OFF after assuring proper engine operation.

CROSSFEED SYSTEM.

The cross-feed system can be used to equalize the fuel load in each wing and in case of fuel system failure or damage. To use the cross-feed:

1. Select the tank from which fuel is to be used by both engines.
2. Turn the booster pump ON for the engine which is to receive fuel from the opposite side of the aircraft.
3. Turn the cross-feed valve ON, then return to NEUTRAL when the indicator light goes out.

NOTE

The cross-feed indicating light indicates when valve motor is energized in both opening and closing operation. The time lapse for either is one second.

4. Turn the fuel selector OFF for the engine which is to receive fuel from the opposite side of the aircraft.
5. Turn the booster pump OFF. When fuel has been consumed to the desired level:
   a. Turn the booster pump ON for the engine which is receiving fuel from the opposite side of the aircraft.
   b. Turn the fuel selector for the engine receiving fuel from the opposite side of the aircraft to the desired tank.
   c. Turn the cross-feed valve OFF then return switch to NEUTRAL when the indicator light has gone out.
   d. Turn the booster pump OFF.

FUEL DUMP.

The following procedure will be used to dump fuel from the outer wing tanks;

NOTE

Fuel dumping should be considered as an emergency procedure only, since the aircraft can be landed at weights up to 33,000 pounds if proper precautions are taken.

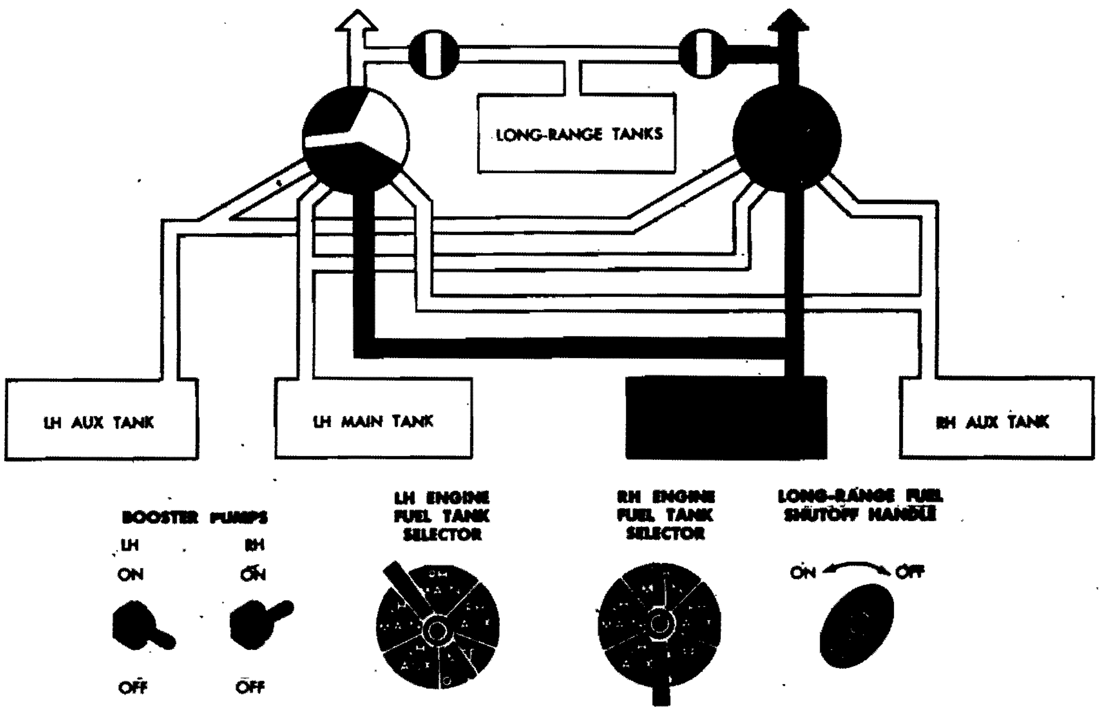
1. Select tanks other than outer wing tanks for engine operation.
2. Check the wing flaps UP.

CAUTION

Never dump fuel with flaps in DOWN position.

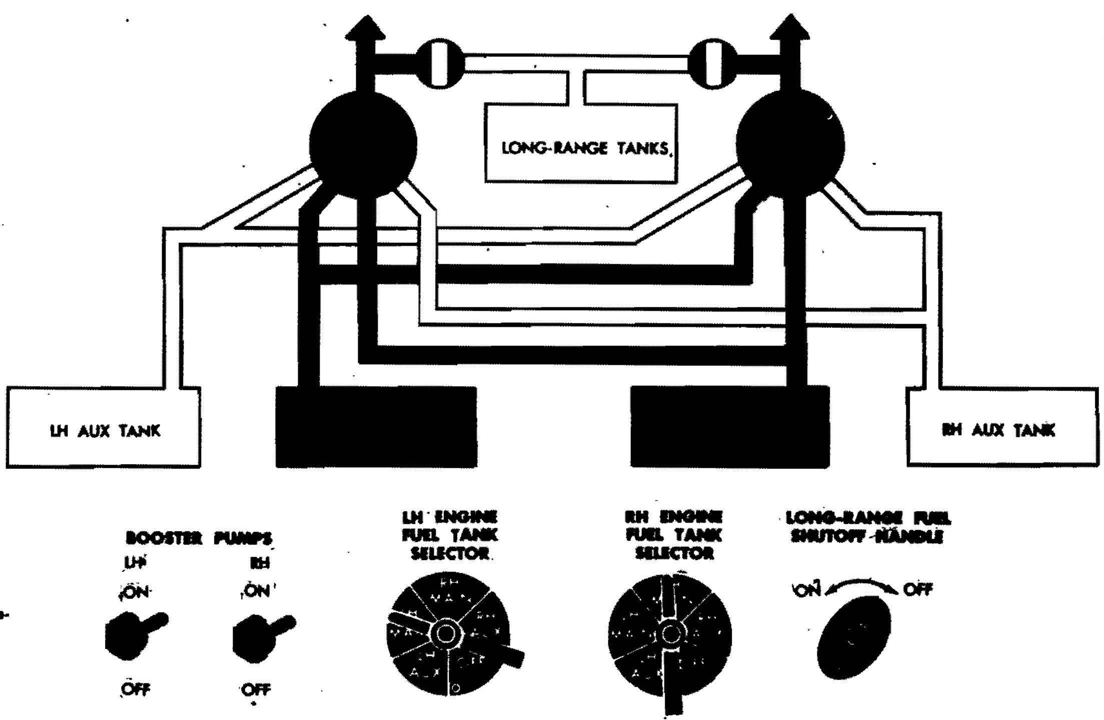
3. Reduce airspeed to 100 knots (115 mph).

FUEL SYSTEM MANAGEMENT



NORMAL ENGINE STARTING OPERATION.
BOOSTER PUMP ON TO ENGINE BEING STARTED.

Note:
OFF during ground operation.

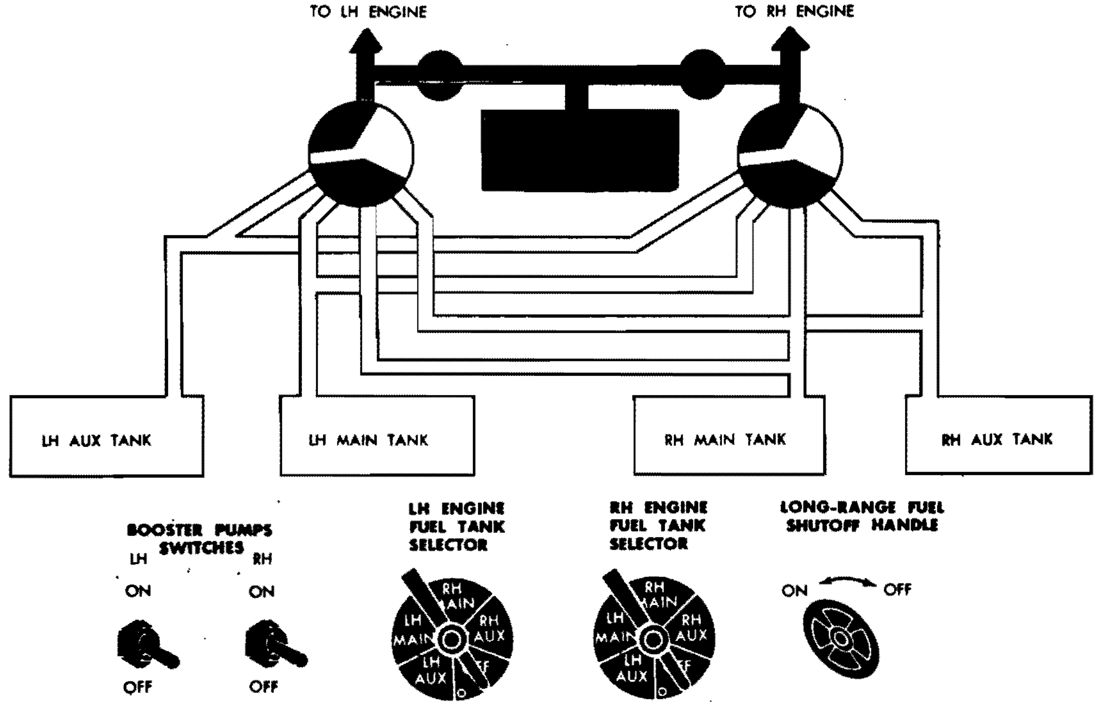


TAKE-OFF, LANDING, AND GROUND OPERATION.
FULLEST TANKS TO RESPECTIVE ENGINES.

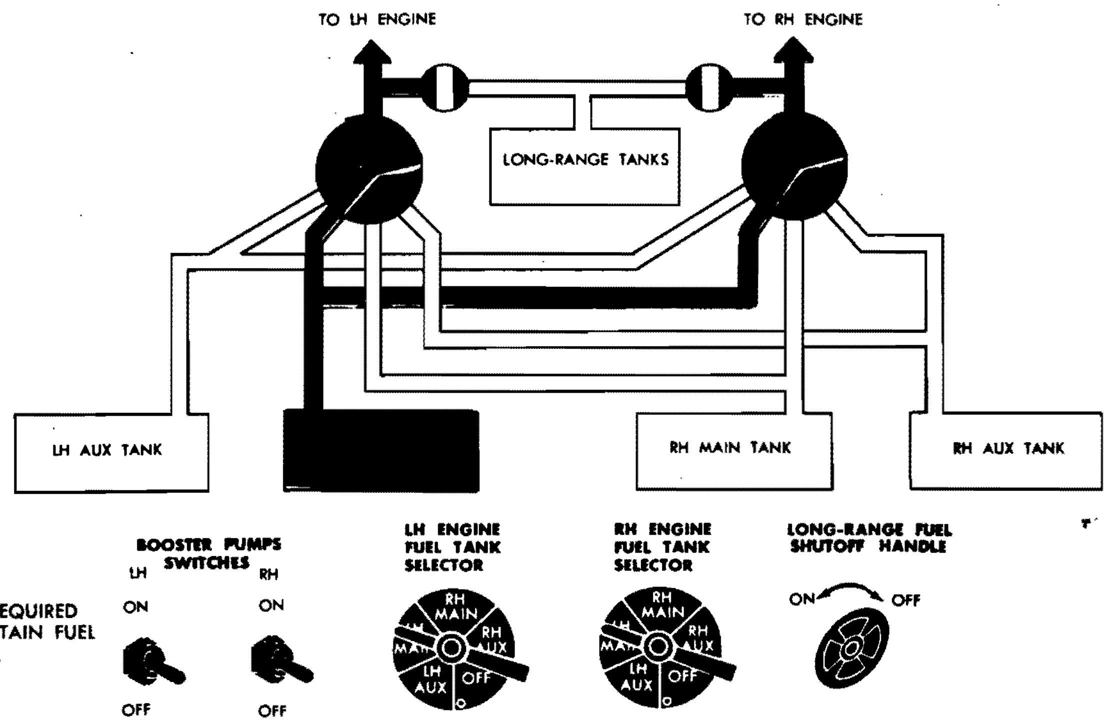
Note: If all tanks are full, use main tanks first.

Figure 7-1 (Sheet 1 of 2)

FUEL SYSTEM MANAGEMENT



CRUISE — LONG-RANGE TANK OPERATION.
LONG-RANGE TANKS SUPPLYING FUEL TO BOTH ENGINES.



NOTE:
ON AS REQUIRED TO MAINTAIN FUEL PRESSURE.

ONE-TANK OPERATION.
LH MAIN TANK SUPPLYING FUEL TO BOTH ENGINES.

Figure 7-1 (Sheet 2 of 2)

NOTE

Best dumping rate is realized at an air speed below 100 knots (115 mph). At this air speed, entire outer wing fuel can be dumped in approximately 3½ minutes.

4. Place both dump switches in ON position.
5. Visually check dump opening to make sure valve is operating.

NOTE

Dumping can be discontinued at any time by placing the switches in the CLOSED (full down) position. After valve is CLOSED, turn switch to the OFF position.

BRAKE OPERATION.

Use extreme care when applying brakes immediately after touchdown, or at any time when there is considerable lift on the wings, to prevent skidding the tires and causing flat spots. Heavy brake pressure can result in locking the wheel more easily immediately after touchdown, than when 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.

Although brakes can stop the wheel from turning, 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 rolling friction which is 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 a full skid, becomes even lower.

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

NACA figures have shown that, for an incipient skid with an approximate load of 10,000 lbs 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.

The following procedures will apply for brake operation:

1. If maximum braking is required after touchdown, lift should first be decreased as much as possible by raising the flaps before applying brakes. This procedure will improve braking action by increasing the frictional force between the tires and the runway.

CAUTION

Immediately following maximum braking while landing, little or no braking action may be available because of brake fade.

2. For short landing rolls, a single, smooth application of the brakes with constantly increasing pedal pressure is most desirable.
3. When the brakes are used to stop the aircraft, 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.
4. 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.
5. 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

FUEL SYSTEM DIAGRAM - SOME SC-47 AIRCRAFT

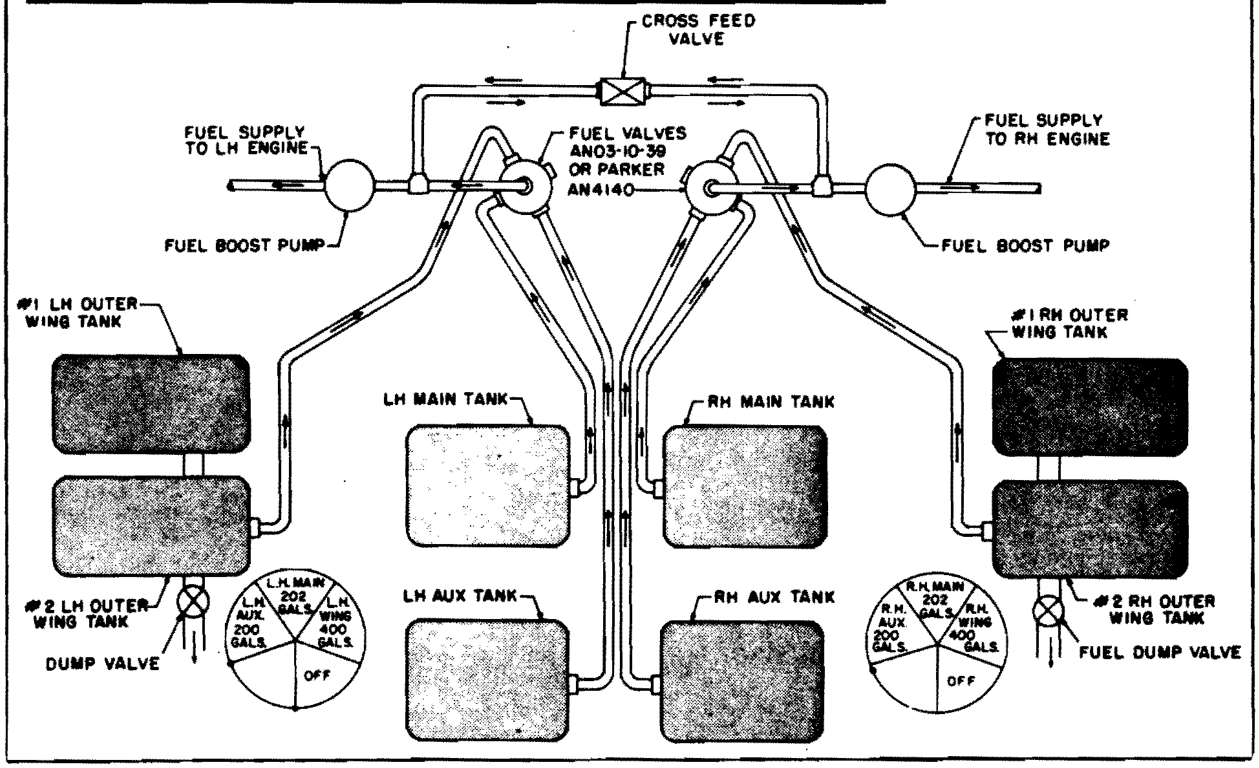


Figure 7-2

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.

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

NOTE

Taxiing with one engine inoperative is not recommended.

SECTION VIII
CREW DUTIES

TABLE OF CONTENTS

INTRODUCTION.

This section lists duties, other than primary functions, performed by crew members.

NOTE

During all critical phases of flight, the flight instruments will be cross checked for proper indications. The pilot not flying the aircraft will closely monitor the instruments and will advise the pilot at the controls of any malfunction of instruments or deviation from published procedures. Both pilots will be thoroughly familiar with the departure, holding, letdown, low approach, and missed approached phases of the flight.

PILOT.

It will be the duty of the pilot to insure that a thorough inspection of the aircraft and all equipment it conducted before departure. The pilot will personally inspect all items of bail-out, ditching, and survival equipment. The check lists for the pilot are covered in detail in Section II and III.

CO-PILOT.

The co-pilot will aid the pilot, as directed, to accomplish the assigned mission.

PASSENGER BRIEFING CHECKLIST.

Passenger information and an emergency diagram are provided at the end of this section as a reproducible page. This page will be reproduced by the operating commands and prepared as plastic covered cards to be located at passenger stations within the aircraft.

PREDEPARTURE BRIEFING.

1. Crew Introduction
2. Destination
3. Estimated time enroute
4. Flight altitude
5. Weather (enroute and destination)
6. Demonstrate use of oxygen equipment
7. Demonstrate use of parachutes
8. Demonstrate use of seat belt
9. Indicate location of emergency equipment
10. Describe procedures to be used during an inflight emergency
11. Advise passengers of information cards and describe warning signals
12. Instruct passengers in smoking restrictions and use of seat belts
13. Caution passengers against use of electronic equipment

OVERWATER BRIEFING.

1. Describe applicable emergency equipment
2. Describe ditching procedures

ARRIVAL BRIEFING.

1. Announce arrival time
2. Instruct passengers in smoking restrictions and use of seat belt
3. Provide additional information as applicable.

ROUTES OF ESCAPE AND EMERGENCY EXITS

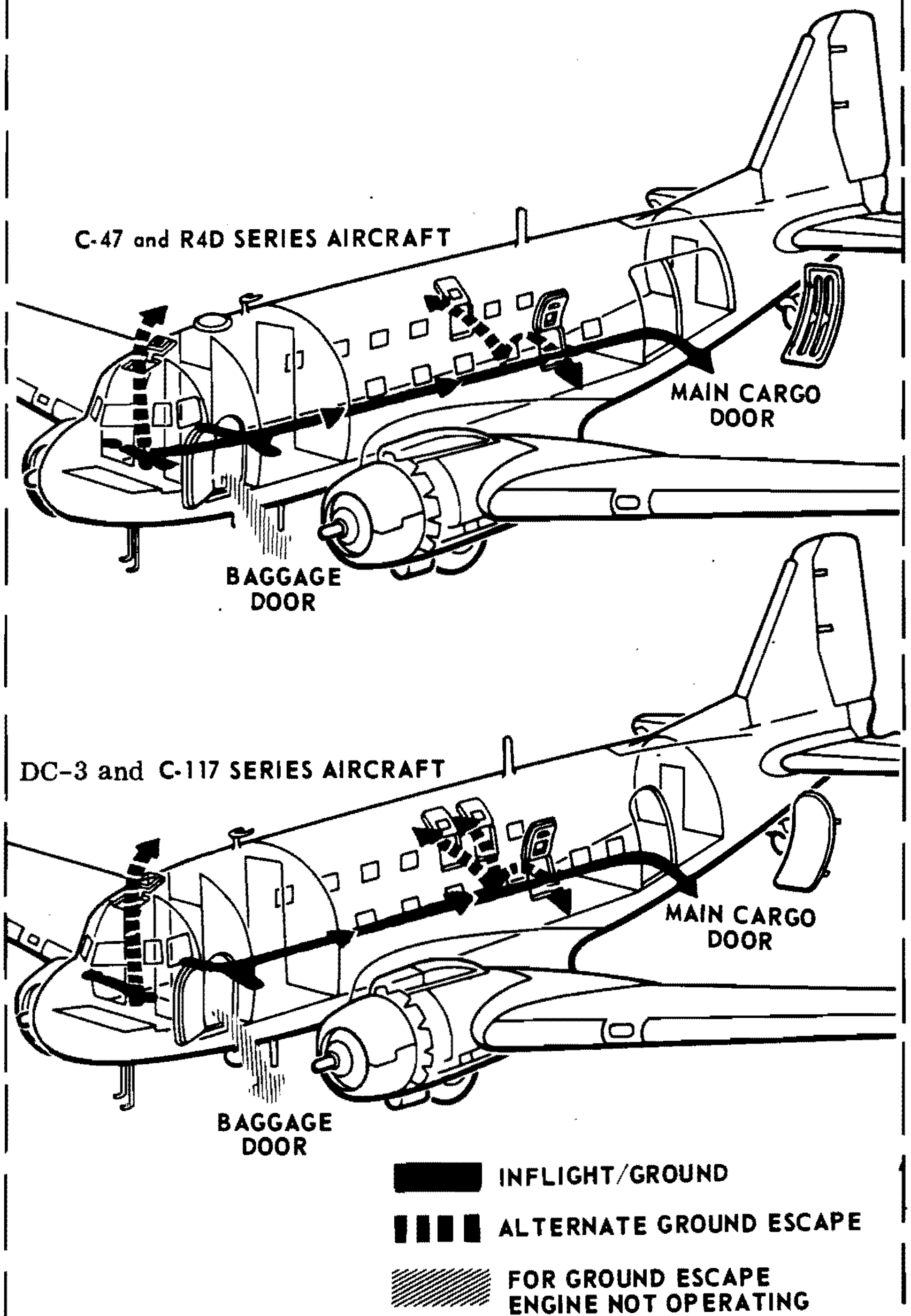


Figure 8-1.

PASSENGER INFORMATION

1. Seat belts will be fastened during takeoff and landing and as instructed by the pilot. Smoking is prohibited during all ground operations, during and immediately after takeoff and before landings, and at any time during flight as instructed by the pilot.

2. In the event of an inflight emergency, remain seated with the seat belt fastened and follow the pilot's or crew members instructions.

3. Emergency exits and escape routes are shown in Figure 8-1.

BAIL OUT

1. If the pilot decides that Bail Out is necessary, he will alert the crew and passengers with three short rings on the alarm bell.

2. A crew member will instruct the passengers on bail out procedures, and help adjust the parachutes.

3. The pilot will give the bail out signal; one sustained ring of the alarm bell, and the crew will supervise bail out proceedings.

CRASH LANDING OR DITCHING

1. If a crash landing or ditching situation has developed, the pilot will alert the crew and passengers with six short rings of the alarm bell.

2. Fasten seat belt securely.

3. Remove cords, ties, straps; loosen collar, and parachute harness, don life vest (if applicable) but do not inflate.

4. If blankets or pillows are available, use to protect face.

5. Just prior to impact, the pilot will alert the crew and passengers with one sustained ring of the alarm bell.

6. Brace for impact.

7. Hold crash landing positions until after the airplane has stopped moving.

8. Remove seat belt and follow the crews instructions.

SECTION IX
ALL-WEATHER OPERATION

TABLE OF CONTENTS

INTRODUCTION.

Except for some repetition necessary for emphasis, clarity, or continuity of thought, this section contains only those procedures that differ from, or are in addition to, the normal operating instructions covered in Section II. Discussions relative to systems operation are covered in Section VII.

Instrument Flight Procedures

The aircraft has excellent maneuverability characteristics for instrument flying. Stability in all axes is excellent. Maneuverability on Ground Control Approach and Instrument Landing System is very good. Before attempting any instrument flight, check that all radios, radio aids, and flight instruments are operating properly.

INSTRUMENT TAKE-OFF.

CAUTION

Take-off should be avoided when both temperature and dew point are within the area of 31° to 33°F and the runway is wet or rain or snow is falling. When the above conditions exist, ice may accumulate on the empennage during runup and take-off, and wing and carburetor icing may occur immediately after take-off.

Planning for instrument take-off should include the possibility of return to the field, and suitable precautions should be taken, including the monitoring of the take-off by GCA or other instrument facilities.

INSTRUMENT CLIMB.

Climbing airspeed and attitude are easily maintained. Banks in excess of 30° are not recommended.

CRUISING.

Cruising under instrument conditions does not differ from cruising under VFR conditions; however, the following checks should be made:

1. Check the directional indicators periodically with the standby compass.
2. Before entering known or suspected icing or visible moisture, turn on the pitot heat and be alert for propeller, wing, and carburetor ice. If ice starts to form on unheated parts of the windshield, it is an indication that ice is forming on the propeller. Turn on the propeller deicing system.

CAUTION

If deicer boots are used, do not operate them continuously, since this may result in ballooning the ice immediately over the boots and render them ineffective. Allow the ice to build up to approximately ¼ inch thickness, then turn the boots on to remove it. After the ice is removed, turn the boots off until the ice builds up again.

SPEED RANGE.

Stability and flight characteristics are good throughout the full range of speed, and instrument flight should be conducted in accordance with the power charts (see Appendix).

DESCENT.

To descend from altitude, use the same procedure as during VFR flight to the minimum instrument altitude for the range being used and in accordance with instructions received from Air Traffic Control.

HOLDING.

Hold with the landing gear and wing flaps up, and use enough power to maintain an IAS of 105 knots (121 mph).

INSTRUMENT APPROACHES.

The general qualities and capabilities of the aircraft are excellent for instrument approaches. A study of all approach procedures must be made before starting the initial approach. Complete the prelanding checks before final approach, so that full attention can be given to flying during the approach.

RADIO RANGE APPROACH.

See Section 9.60D

GROUND CONTROLLED APPROACH (GCA).

There is very little difference between a GCA and range approach. The approach is accomplished by reference to basic instruments and execution of instructions issued by a ground controller.
See Section 9.60D

INSTRUMENT LANDING SYSTEM (ILS).

An ILS differs from a GCA only in that the required procedures must be interpreted from instrument presentation. See Section 9.60D

AUTOMATIC DIRECTION FINDER (ADF) APPROACH.

See Section 9.60D

OMNI-RANGE (VOR) APPROACH.

See Section 9.60D

TACAN APPROACH.

See Section 9.60D

Ice and Rain

Rain without icing conditions presents no particular problems other than restricted visibility. When icing conditions are encountered, the following procedure will apply:

1. Known regions of moderate icing will be avoided.
2. Before entering an icing region, turn on the pitot heaters and check deicer system pressure.

NOTE

Climb or cruise at 10 to 15 knots above normal during icing conditions; reducing the angle of attack minimizes the accumulation of ice on under surfaces.

3. Regulate carburetor heat to maintain CAT within limits and adjust the cowl flaps as required to maintain proper CHT during flight through the icing region.
4. Operate the wing and empennage deicer system as required (see the paragraph on Wing and Empennage Deicing System Operation, Section IV).
5. If ice forms on the wing area aft of the deicer boots, change the flight path and leave icing region.

WARNING

Ice accumulation on the aircraft will result in higher stall speeds due to the change in aerodynamic characteristics and increased weight of the aircraft due to ice build-up. Approach and landing speeds must be increased accordingly.

Flight in Turbulence and Thunderstorms

WARNING

Flight through a thunderstorm or clear air turbulence should be avoided if at all possible. However, should circumstances force a flight into a zone of severe turbulence, the desired penetration airspeed of the aircraft, which is 52 Kts (60 mph) above the stalling speed for its gross weight, should be established before entering the storm. The following recommended techniques aid in reducing structural strain to the aircraft.

Power settings and propeller pitch are the keys to proper flight technique in turbulent air. (Severe turbulence is defined as a condition of sufficient disturbance to make the safety of the aircraft and its occupants the pilot's primary concern.) In selecting a speed for operation in severe turbulence, a compromise must be made between the desire to keep the speed low enough to permit the structure to withstand the greatest possible gusts and the desire to keep the speed high enough to prevent closely approaching the stalling point.

APPROACHING STORM.

It is imperative that the aircraft be prepared as follows before entering the zone of turbulence (if the storm cannot be seen, its proximity may be detected by radio crash static).

1. Disengage the autopilot.

2. Reduce airspeed as required.
3. Mixture controls – AUTO-RICH.
4. Propeller controls – 2350 rpm.
5. Pitot heater switch – ON.
6. Carburetor heat – As required.
7. Throttles – As required.
8. Check the power source and gyro stabilized instruments settings.
9. Safety belt (and shoulder harness if installed)– Tightened. (Check with crew members.)
10. Turn off any radio equipment rendered useless by static.
11. Turn the cockpit lights full bright to minimize the blinding effect of lighting.

CAUTION

Do not lower the flaps or gear, since structural damage may occur.

PENETRATING STORM.

Penetrate the storm as follows:

1. Maintain the power and pitch settings established before entering the storm to hold the airspeed constant, regardless of an erratic airspeed indication caused by heavy rain partially blocking the pitot heads.
2. Devote full attention to flying the aircraft. Concentrate principally on holding a level attitude by reference to the attitude indicator and maintaining as constant an altitude as possible.

CAUTION

Do not chase the airspeed indicator or altimeter since undue stress might be imposed on the aircraft.

3. The altimeter is unreliable in severe turbulence because of differential barometric pressures. A gain or loss of several thousand feet may be expected, and allowance for this error must be made in determining minimum safe altitude.

NOTE

Altitudes nearest the freezing level are usually the most turbulent.

4. Do not attempt to keep up with the airspeed indicator, which may be off as much as 60 knots as a result of heavy rain partially blocking the pitot heads.
5. Use as little elevator control as possible in maintaining attitude in order to minimize the stresses imposed on the aircraft.

Night Flying

On aircraft not equipped with landing light shields, a glare from the landing lights will be noticed in the cockpit.

Cold-Weather Procedures

The following operating instructions are written to supplement the instructions in Section II and should be complied with when cold weather conditions are encountered. The success of extreme weather operation depends greatly on the preparation made during engine shutdown as outlined in this section; upon this depends the success of the next day's starting operation. 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 cold weather operation.

WARNING

To prevent engine oil starvation due to congealed oil in the engine oil tanks, the procedures for oil preheat and oil dilution must be strictly adhered to. Oil in the tank must be heated to −12°C (+10°F) or above before starting engines.

BEFORE ENTERING AIRCRAFT.

WARNING

All ice, frost, and snow must be removed before flight is attempted.

Apply external heat to the engines and accessory sections. Preheat the engine nacelle until cylinder head temperatures reach 4°C. The time requirements on the following list are rough estimates for engine heating at various temperatures. These requirements will vary with wind velocities and percentage of engine oil dilution. The tabulation below is based on an oil dilution of approximately 25 per cent and no wind.

—6.7° to —18°C (20° to 0°F)............ ½ hour (approx)

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

—32° to —40°C (—25° to —40°F)....1½ to 2½ hours

Check the oil drains for oil flow. If no oil flow is obtainable, continue preheat until oil flow is readily obtained. In addition to external heating, oil immersion heaters may be used; however, no special fittings are provided in the oil tanks for immersion heaters on some aircraft. 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 landing. Use a portable heater to heat the flight instruments, defrost the windshields, and warm the radios, the dynamotors, the inverter, and other equipment within the aircraft. Remove all external coverings, pitot head covers, wing covers, etc. Clean the shock struts and landing gear actuating cylinders of ice and dirt, and check the struts for proper inflation. The hydraulic system is limited to —40°C (—40°F) and will not operate below this temperature. 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.

ON ENTERING AIRCRAFT.

1. Operate all the flight control surfaces and tabs through full travel three or four times to check ease of operation. When lowering flaps during normal preflight, the flaps should be lowered in approximately 10-degree increments to check ease of operation.
2. Check functioning of those instruments that can be checked without engine operation.

WARNING

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

3. Exert light pressure on the brake pedals several times before setting parking brakes to assure adequate pressure for parking brake operation.

BEFORE STARTING ENGINES.

Before starting the engines, perform the following:

1. Remove the oil immersion heaters.
2. Remove the ground heater ducts.
3. Remove the engine nacelle shields (or covers, if installed).
4. Pull the propellers through 15 blades by hand.

STARTING ENGINES.

1. If the oil pressure is not within limits after 30 seconds running, or if the pressure drops below limits after a few minutes of ground operation, shut down and check for blown lines or coolers and recheck for congealed oil or ice at the drains.

NOTE

Oil congealing in a radiator produces unusual and often misleading indications. The usual indication is high oil temperature together with a reduction in pressure, often followed by a sudden drop in oil temperature accompanied by high pressure as the congealed oil is forced into the system.

2. Carburetor air preheat (not to exceed carburetor air temperature limits), should be applied immediately after starting in order to assist vaporization and combustion.
3. Check all instruments for proper operation.
4. Operate the wing flaps at least once.
5. When warming up an engine after an oil dilution operation, 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 fuel as possible to allow the oil to return to its normal viscosity. Below this temperature and at low engine speeds, very little fuel will be dissipated from the oil.

WARM-UP AND GROUND TESTS.

Use the procedure under Engine Runup, Section II.

TAKE-OFF.

Carburetor heat may be required so that the fuel will vaporize properly at extremely low temperature. Monitor and regulate the carburetor heat to maintain carburetor air temperature within the proper limits during engine runup, climb and cruise (see the paragraph on Carburetor Icing, Section VII).

The heating system should be operating so that the windshield defrosting can be utilized during take-off, if necessary, and so that the flight instruments will not cool and give erroneous indications. Pitot heaters should be ON if precipitation is encountered or if icing conditions are anticipated immediately after take-off. Remember that the flight indicators are not very reliable at temperatures below −43°C (−45°F) and that all flight instruments should be cross-checked.

CAUTION

Do not use surface de-icers during take-off because of resultant disturbance of air flow spoiling the lift of the wing.

AFTER TAKE-OFF.

After take-off, cycle the gear several times to remove slush and snow and to prevent the gear from freezing in the retracted position.

DURING FLIGHT.

Periodically exercise prop controls to provide a supply of warm oil in the prop dome.

APPROACH AND LANDING.

Follow normal prelanding procedures. Apply carburetor heat as required, to prevent carburetor icing and to keep engine running smoothly. At extremely low temperatures it would be wise to use a power-on approach, thus helping keep the cylinder head temperature from becoming critically low. Whenever carburetor heat is used, allowance must be made for the power reduction associated with application of heat. Drain the water supply systems.

ENGINE SHUTDOWN.

Oil dilution is preferred, if the expected minimum temperature is below 4°C (40°F), in order to minimize the requirement for preheat prior to the next engine start.

OIL DILUTION PROCEDURE.

The aircraft is equipped with an engine oil dilution system to facilitate cold weather starting. When a cold weather start is anticipated, the engine oil should be diluted with fuel before the engines are stopped, provided that the engine oil temperature is maintained below 50°C (122°F). Above this temperature, dilution is not 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 because of oil temperature limits for dilution.
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.

If the oil tank is full and more than 3 minutes dilution time is required, some oil should be drained from the tank to prevent overflowing during the dilution period of subsequent engine run.

Perform the oil dilution operation as follows (operation of the oil dilution system is indicated by a drop in fuel pressure, followed later by a drop in oil pressure):

1. Operate each engine at 1100 to 1200 rpm.
2. Maintain oil temperatures below 50°C (122°F), stopping an engine for a short period if the temperature exceeds this limit.
3. Turn booster pumps ON.
4. Operate the oil dilution solenoid switches for the following periods for indicated anticipated temperatures:

   4° to −12°C (40° to 10°F) .... 2 minutes

   −12° to −29°C (10° to −20°F) ...... 4 minutes

   −29° to −46°C (20° to −50°F) ...... 7 minutes
5. Move the propeller controls from INCREASE to DECREASE three times to dilute oil in the propeller domes. The time required to actuate the propeller controls from INCREASE RPM to DECREASE RPM three times should not exceed 1 minute total time. This 1 minute will be dilution time in addition to the time required to dilute for each anticipated ambient temperature.

6. To dilute oil in the propeller feathering system, push right feathering button and allow for 200 RPM drop, then pull out feathering button. Dilute oil in left propeller feathering system using same procedures.
7. A short acceleration period of approximately 10 seconds at the end of the dilution run will usually clear the spark plugs of any fouling condition resulting from the prolonged idling.

After the oil has been diluted as specified above, and the propeller feathering system checked out during dilution, position the carburetor mixture controls to IDLE CUT-OFF, and continue to hold the oil dilution switch ON until the propeller stops turning.

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 from 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. Carburetor air filters may be required for all operations.

Unless absolutely necessary do not take off during sand or dust storms.

HIGH ALTITUDE PROCEDURES.

The following procedures are recommended when operating from fields with an elevation that results in density altitudes of approximately 6000 to 16,000 feet.

STARTING.

The engine is more prone to flooding upon starting at density altitudes above 6000 feet, due primarily to reduction in density of the air flowing through the carburetor. The following techniques should be employed when starting at these altitudes.

1. Use larger throttle openings when starting.
2. Start in low blower.
3. When bringing in the mixture, move it to the AUTO-LEAN position.

TAXIING.

Above 6000 feet density altitude, taxiing should be done at 1200 rpm in AUTO-LEAN. If necessary, manually lean mixtures to achieve a smooth idle.

ENGINE RUNUP.

Normal runup procedures will be used at altitudes below 10,000 feet density altitude. At altitudes above 10,000 feet, where high blower will be used for takeoff, eliminate normal sequence of high blower check. Shift to high blower at 1700 rpm, just prior to advancing throttles for takeoff.

TAKEOFF.

At altitudes below 10,000 feet, use low blower and normal takeoff procedures. Above 10,000 feet altitude, high blower should be used.

APPROACH AND LANDING.

Normal low altitude traffic patter, approach and threshold-indicated airspeeds are recommended; however, bear in mind that true airspeed increases with altitude for the same indicated airspeed and consequently, the landing ground roll will be appreciably extended at high elevations. Another factor to consider is the decrease in ground cushioning effect during the flare out. Close adherence to the recommended approach speeds and flap settings are mandatory for the successful completion of either a landing or go-around. After touchdown place mixture in AUTO-LEAN and blowers in LOW.

APPENDIX
PERFORMANCE DATA

TABLE OF CONTENTS

PART ONE
INTRODUCTION

TABLE OF CONTENTS

LIST OF CHARTS

GENERAL INFORMATION.

The information in the Appendix is presented to assist operating personnel to a better understanding of the performance capabilities and limitations of the aircraft. The objective of the Appendix is to provide specific performance values in graphical form covering all reasonable conditions under which the aircraft will be operated to enable operating personnel to utilize the aircraft efficiently.

DISCUSSION OF CHARTS.

The take-off charts are presented in such a manner that performance may be determined for any set of atmospheric conditions. The climb data is presented for standard day and hot day atmospheric conditions. Range performance may be determined for any atmospheric temperature condition by considering the altitude specified in the charts as density altitude. The performance charts are identified according to their type and condition of operation by colored page borders conforming to the following code:

Normal Operation ....Plain Corner
Emergency Operation .... Red Corner
Hot Day Operation .... Yellow Corner

DEFINITION OF TERMS

AIRSPEED – the speed of the aircraft relative to the air through which it is moving.

AMBIENT CONDITIONS – conditions of the air surrounding the aircraft at any given time under consideration.

AUTO-LEAN – the mixture control lever at the lean detent.

AUTO-RICH – the mixture control lever at the rich detent.

CALIBRATED AIRSPEED – indicated airspeed corrected for instrument and position error.

COMPRESSIBILITY ERROR – an error in the airspeed indicator reading and the outside air temperature indicator reading caused by air being slightly compressed by the moving aircraft.

DENSITY ALTITUDE – the altitude obtained from a standard density altitude chart for any given pressure altitude and temperature or for any density ratio factor ($1/\sqrt{\sigma}$).

DEW POINT – the temperature at which consensation occurs in a cooling mass of air.

DRY BULB TEMPERATURE – the air temperature as indicated by a thermometer with a dry bulb (true air temperature).

EFFECTIVE WIND (HEAD OR TAILWIND) – The component of the existing wind condition which acts opposite to or in the direction of travel. For takeoff or landing, this component will be computed from the take-off and landing crosswind chart.

EQUIVALENT AIRSPEED – calibrated airspeed corrected for compressibility.

INCHES HG – a measure of air pressure which compares it to the weight of a column of mercury.

INDICATED AIRSPEED – airspeed indicator reading uncorrected (assuming the mechanical error in the instrument is negligible).

LOW BLOWER – the engine supercharger in low gear ratio.

NAUTICAL MILES PER POUND – the number of nautical miles traveled while consuming a pound of fuel.

OPERATING WEIGHT EMPTY – the weight of the aircraft and its contents, not including payload, fuel or regular engine oil, when the aircraft is equipped with all provisions necessary to complete a mission.

POSITION ERROR – the error in the airspeed indicator reading and the altimeter reading caused by the inability of the static orifices to experience the true ambient air pressure.

PRESSURE ALTITUDE – the altitude obtained from a standard atmosphere table, for any given value of air pressure (measured in inches Hg). This is the altitude that an altimeter will show (after correcting for position error) when set to 29.92 inches Hg.

RAM – the increase in air pressure at the entrance to an airscoop due to the speed of the aircraft.

RECOMMENDED LONG RANGE CRUISE SPEED – the speed at which it is recommended to fly the aircraft when long range is of more concern than high speed.

REFUSAL DISTANCE – the distance required to accelerate to the refusal speed.

REFUSAL SPEED – maximum speed to which the aircraft can accelerate and then stop in the available runway length.

RELATIVE HUMIDITY – the ratio of the amount of water vapor in a given mass of air to the maximum amount of water vapor that the mass of air could hold at the same temperature.

SPECIFIC HUMIDITY – the ratio of the amount of water vapor in a given mass of air to the mass of dry air, measured in pounds.

SPECIFIC RANGE – nautical miles per pound of fuel.

STANDARD ATMOSPHERIC CONDITIONS – an arbitrarily selected set of atmospheric conditions chosen to approximate the average atmosphere of the world.

STANDARD DAY – a day on which standard atmospheric conditions are assumed to exist.

THRESHOLD SPEED – the speed at which the aircraft crosses the end of the runway during a normal landing (120 percent of the stall speed for wing flaps in the landing position).

TOUCHDOWN SPEED – the speed at which the aircraft comes in contact with the runway during a normal landing (110 percent of the stall speed for wing flaps in the landing position).

TRUE AIRSPEED – the true speed of the aircraft relative to the air through which it is moving (equal to EAS time $1/\sqrt{\sigma}$).

TRUE ALTITUDE – altitude above sea level.

VAPOR PRESSURE – the partial pressure of water vapor existing in the air.

$V_{L/D}$ – the speed for maximum lift to drag ratio.

Vso – the zero thrust stalling speed with wing flaps in the landing configuration.

Vto – takeoff speed (110 percent of the stalling speed with the wing flaps in the takeoff configuration).

WET BULB TEMPERATURE – the temperature indicated by a thermometer whose bulb has been kept moist with water and which has been circulated in the air. This temperature, along with the dry bulb temperature, is used in conjunction with a psychrometric chart to determine the degree of humidity.

LIST OF ABBREVIATIONS

Alt.	Altitude
BHP	Brake horsepower
BMEP	Brake mean effective pressure
°C	Degrees Centigrade
CAS	Calibrated airspeed
CAT	Carburetor air temperature
CHT	Cylinder head temperature
Crit.	Critical
EAS	Equivalent airspeed
Eng.	Engine
°F	Degrees Fahrenheit
Fld.	Field
Ft.	Feet
Hg.	Mercury
IAS	Indicated airspeed
ICAO	International Civil Aviation Organization
In.	Inch
Kts.	Knots
Lbs.	Pounds
MP	Manifold pressure
METO	Maximum except takeoff
Min.	Minute
OAT	Outside air temperature
PSI	Pounds per square inch
Pt.	Point
RPM	Revolutions per minute
S. L.	Sea level
Std.	Standard
T	Absolute temperature
TAS	True airspeed
V_{CO}	Climbout speed
$V_{L/D}$	Speed for maximum lift to drag ratio
V_{MC}	Minimum control speed
V_{NE}	Maximum dive speed
V_{NO}	Maximum speed for normal operation
V_R	Refusal speed
V_S	Stalling speed
V_{SO}	Stalling speed with zero thrust and wing flaps in landing configuration
V_{TO}	Takeoff speed
Wt.	Weight
δ	Delta; ratio of ambient air pressure to standard sea level air pressure
σ	Sigma; ratio of ambient air density to standard sea level air density

AIRSPEED TERMINOLOGY

Airspeed terminology used in this Appendix is defined as follows:

TERM	ABBREVIATION	DEFINITION
Indicated Airspeed	IAS	*Airspeed Indicator reading uncorrected.
Calibrated Airspeed	CAS	Indicated airspeed corrected for position error.
Equivalent Airspeed	EAS	Calibrated airspeed corrected for compressibility.
True Airspeed	TAS	$TAS = EAS \times 1/\sqrt{\sigma}$

*IAS is used in this Appendix as though the mechanical error in the instrument is zero.

All airspeeds of importance in takeoff and landing procedures are shown in this Appendix as indicated airspeed (IAS).

All airspeed data relating to take-off and landing procedures are given as indicated airspeed. Indicated airspeed for ground run is based on an estimated position error equal to zero. Since all cruise and climb data is given as calibrated airspeed, the airspeed position error charts are included to obtain the corresponding indicated airspeed. The characteristic take-off speeds chart and the characteristic landing speeds chart give indicated airspeed based on inflight calibrations. The take-off performance--ground run chart and the take-off performance--refusal speed chart give indicated airspeed based on negligible ground run position error.

AIRSPEED POSITION ERROR CORRECTION.

This chart (figure A1-1) shows the correction that must be applied to the indicated airspeed to determine the calibrated airspeed.

CALIBRATED AIRSPEED CORRECTION FOR COMPRESSIBILITY.

The calibrated airspeed correction for compressibility chart (figure A1-2) is used in determining EAS from CAS. A sample problem on the chart illustrates its use.

TEMPERATURE CORRECTION FOR COMPRESSIBILITY CHART.

This chart (figure A1-3) shows the correction that must be subtracted from the outside air temperature indicator reading to determine the true outside air temperature. For example, assume that the airplane is cruising at 125 knots CAS (point A) at an altitude of 10,000 feet (point B). The chart shows that the correction is 2.5°C (point C). This amount must be subtracted from the indicated air temperature to determine the outside air temperature. If the instrument read 6°C, then the outside air temperature would be 6-2.5, or 3.5°C. If the instrument read −12°C, then the outside air temperature would be −12-2.5, or −14.5°C.

DENSITY ALTITUDE CHART.

The density altitude chart (figure A1-4) is used in determining the density altitude and the value $1/\sqrt{\sigma}$ for any pressure altitude and ambient temperature.

SAMPLE PROBLEM:

(A) Free air temperature -8 C

(B) Pressure altitude 18,000 ft.

(C) Density altitude 19,400 ft.

(D) $1/\sqrt{\sigma} = 1.356$

ICAO STANDARD ATMOSPHERE TABLE.

The ICAO standard altitude table (figure A1-5) presents the density altitude factor tabulated for thousands and hundreds of feet; and the values of sigma (σ), the density ratio of ambient air to standard sea level air, tabulated for thousands of feet. The value $1/\sqrt{\sigma}$ is chiefly used in obtaining the true airspeed (TAS) from equivalent airspeed (EAS) by the relationship, TAS = EAS X $1/\sqrt{\sigma}$.

TEMPERATURE CONVERSION CHART.

The temperature conversion chart (figure A1-6) is provided to facilitate the conversion of either Fahrenheit temperatures to Centigrade, or Centigrade temperatures to Fahrenheit.

PSYCHROMETRIC CHART.

The Psychrometric Chart (Figure A1-8) graphically relates the various measures of water vapor in the atmosphere. Although it is the dew point which is commonly furnished the pilot, occasionally humidity may be available as wet and dry bulb temperatures, and less often, as relative humidity. To meet all such situations the psychrometric chart provides a means of converting from one variable to another. Three examples for obtaining specific humidity are given below which differ as to which quantities are known.

Example 1:

Given: Pressure altitude = 5000 ft.

Dew Point = 54.5°F

Find: Specific humidity

1. Locate 54.5°F dew point temperature on curved line for 100% relative humidity (point B). This point can be found either by interpolation between 50°F and 60°F along curved line or by entering at 54.5°F on dry bulb temperature scale (point A) and projecting vertically upward to curved line for 100% relative humidity.

2. From point B, proceed horizontally to left base line and then follow along curved path interpolated between guide lines to 5000 ft. pressure altitude (point C).

3. Project horizontally to specific humidity scale at extreme left (point D) and read .0108.

4. If vapor pressure is desired, project horizontally from point B to extreme right (point E) and read 0.425 inches Hg.

Example 2:

Given: Pressure altitude = 5000 ft.

Wet bulb temperature = 17°C

Dry bulb temperature = 26°C

Find: Dew point and specific humidity

1. Enter with 26°C dry bulb temperature (point F) and proceed vertically upward to intersection with imaginary slant line for 17°C wet bulb temperature (point G). Note that the 17°C wet bulb temperature line can be located by interpolation between the 15°C and 20°C wet bulb lines for 5000 ft. altitude. To assist interpolation, the upper end of this line can be located by entering the dry bulb temperature scale at 17°C (point H) and projecting vertically upward to the 100% relative humidity line (point I). Draw slant line through point I parallel to 5000 ft. wet bulb dashed lines to intersection (point G) with vertical projection of point F.

2. From point G, project horizontally to left to dew point scale (point B) and read dew point, 54.5°F.

3. Continue left as in Example 1 (points C and D) to obtain a specific humidity of .0108.

4. From point G, project horizontally to right to obtain 0.425 inches Hg vapor pressure (point E).

Example 3:

Given: Relative humidity = 43%

Dry bulb temperature = 26°C

Find: Dew point and specific humidity

1. Enter dry bulb temperature scale at 26°C (point F) and proceed vertically upward to intersection with 43% relative humidity line, interpolated between 40% and 60% (point G).

2. Project horizontally to the left to the dew point scale (point B) and read dew point, 54.5°F.

3. To obtain specific humidity project horizontally to left base line and continue as in example 1 (points C and D) to read .0108.

4. From point G project horizontally to right to obtain 0.425 inches Hg vapor pressure (point E).

FUEL DENSITY TABLE.

The fuel density table (figure A1-9) presents variations in fuel density of 100/130 and 115/145 grades fuel as related to variations in temperature.

AIRSPEED POSITION ERROR CORRECTION

(NO INSTRUMENT ERROR INCLUDED)

BASED ON: FLIGHT TEST DATA
DATA AS OF: 11 JULY 1957

MODEL(S): C-47, C-117 AND R4D

ENGINE(S): (2) A-1830-90C (HIGH BLOWER INOPERATIVE) -90D AND -92

THIS CHART APPLIES TO ALL FLAP AND LANDING GEAR CONFIGURATIONS

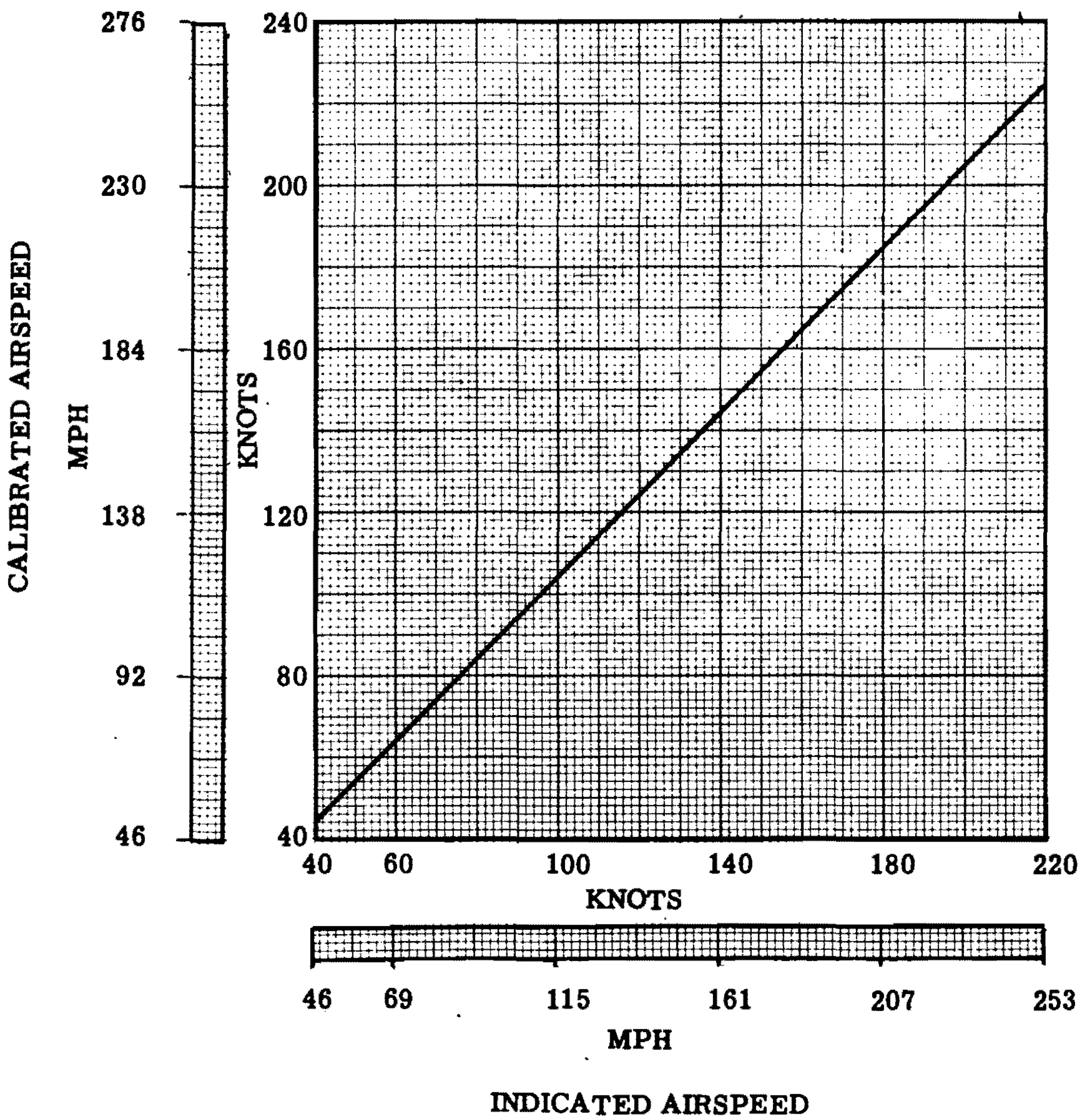


Figure A1-1. Airspeed Position Error Correction.

CALIBRATE AIRSPEED CORRECTION FOR COMPRESSIBILITY

SAMPLE PROBLEM

GIVEN: PRESSURE ALTITUDE = 15000 FEET
CALIBRATED AIRSPEED = 120 KNOTS

A = ENTER CHART AT 120 KNOTS
B = AT 15000 FEET READ CORRECTION
C = CORRECTION = 0.6 KNOTS OR MPH

NOTE
SUBTRACT CORRECTION FROM CALIBRATED AIRSPEED TO OBTAIN EQUIVALENT AIRSPEED

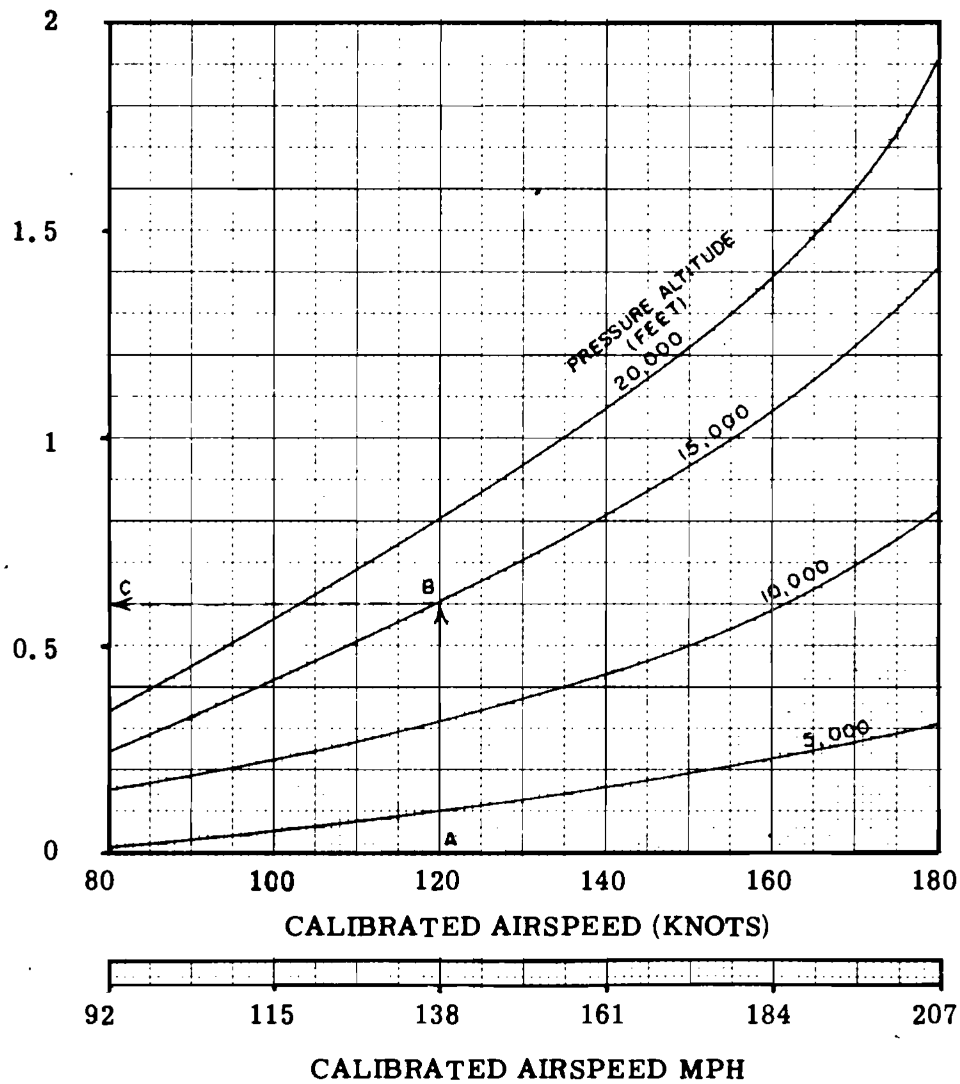


Figure A1-2. Calibrate Airspeed Correction For Compressibility.

TEMPERATURE CORRECTION FOR COMPRESSIBILITY

NOTE:
A SUBTRACT CORRECTION FROM INDICATED AIR TEMPERATURE TO OBTAIN FREE AIR TEMPERATURE °C OR °F
B TEMPERATURE RECOVERY COFFICIENT 80%

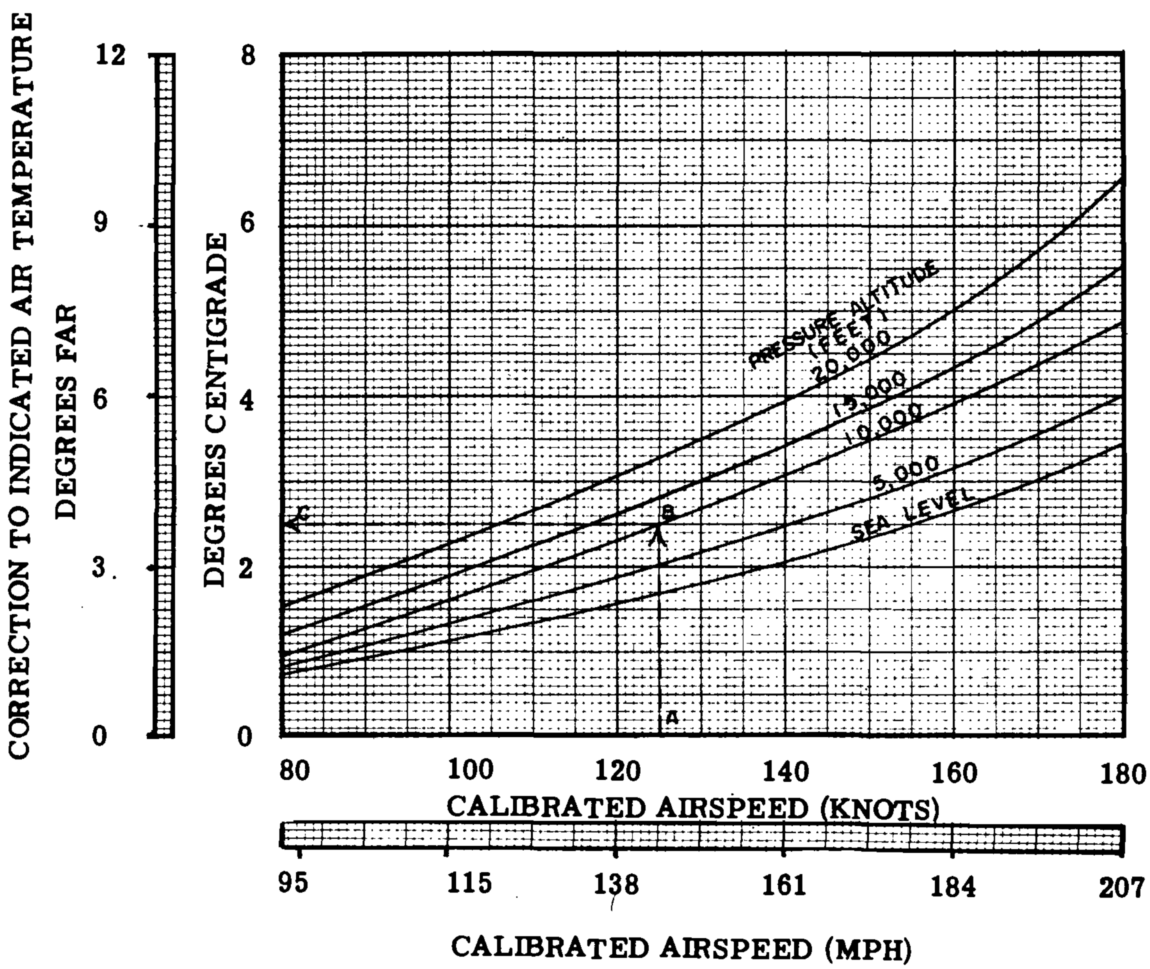


Figure A1-3. Temperature Correction For Compressibility.