CHAPTER 10

Mission Planning and Flight Logging

This chapter is presented in two parts for purposes of discussing (1) essential preliminary information and (2) the entries required on the Aircraft Performance Log/Plan (AF Form 796). You may use the form either as a flight plan during the planning stage of a mission or as a performance log during the actual flying of the planned mission.

From the entries made on the flight plan copy, using applicable performance charts from your -1 flight manual, you have a record of the planned mission data to compare with the actual aircraft performance in flight. This provides you with a sound basis for analysis of the aircraft performance after flight.

This chapter discusses first, the entries made on the form before flight in the planning stage and later, the inflight logging of performance data and after-flight analysis. Although the Aircraft Performance Log/Plan serves a two-fold purpose as suggested by its title, we refer to it as the flight plan in our discussion of flight planning.

The success of any mission depends largely upon how well it is planned. With all the complexities of our modern bombers and transports, mission planning involves many people and many technicalities. Since the flight engineer is, in effect, the "powerplant manager" of the aircraft, he is deeply concerned with the planning of the mission.

The importance of adequate planning to the successful performance of any mission is well known. However, we limit the scope of this discussion of mission planning to considerations of aircraft performance and associated planning procedures. Equal importance must be attached to other phases of mission planning such as navigation plans, communications schedules, loading management, and weight-balance checking, but these are treated in detail in other publications. The mission planning procedures suggested by the examples which follow facilitate safe operation of the airplane in all phases of the mission and enable the crew to use better judgment and take quicker action in an emergency.

Mission planning serves two purposes. First, taking into account all foreseeable conditions you can determine in advance the initial, the intermediate, and the final airspeeds to be flown. Also, the altitudes, headings, elapsed time and distance for the takeoff, the climb and cruise, the descent, and the landing can be planned. Secondly, mission planning determines the maximum cargo that can be delivered to a given point and the maximum range of the aircraft. Then, too, the mission planning determines the fuel necessary to safely accomplish a mission for which cargo and distance are known. The charts in this chapter provide basic data from which you can accomplish a detailed mission plan.

The procedures in the various phases of mission planning are based on the experience of tactical organizations in actual operation, and constitute the best methods to reduce mission failures, crew fatigue, and aircraft maintenance. Local considerations may require that you vary the exact sequence to meet a given situation. However, the principles and fundamentals described in this chapter are generally applicable to any mission.

This chapter sets forth procedures applicable to the flight engineer's position. Procedures for other crew members, however, are dealt with as necessary to coordinate them with the flight engineer's function.

The procedure for the accomplishment of a specific mission of considerable importance and magnitude is usually staged in three phases: (1)

general mission planning. (2) formal briefings. and (3) detailed briefing.

GENERAL MISSION PLANNING

General mission planning is usually initiated at wing level. An operations order from that level then prescribes the specific planning that must be done by the individual squadrons involved in the mission. The final details of the mission are the responsibility of the individual crew. The exact requirements for mission planning are set forth in Air Force. major command. and local directives with which the crew should be familiar.

When more than one aircraft is involved in a tactical mission, a master plan is made up by tacticians of the appropriate command headquarters. The master plan is then detailed for each crew specialty with mimeographed instructions. graphs. charts. overlays, and so forth. These instructions are called flimsies, and when assembled for complete aircraft, they are called the aircraft commander's flimsy. The whole operation from tactical planning to preparation of flimsies is called an operations order.

Think of the general mission plan as a coordinated, collective effort to establish the overall requirements of the mission. From there, the operations order goes to the mission participants to be explained in formal briefings.

FORMAL BRIEFING

For the formal briefing, the crews must be assembled by the aircraft commanders and notified of the impending flight. At this time, the crews learn which aircraft are to be flown. the purpose of the mission. and the time schedule.

Formal briefing, like general mission planning. is an important function of all planning staffs. Formal briefing is the result of the collective efforts of units to work out detailed data for flying each phase of the mission. Flimsies should be distributed to each crew and checked for adherence to altitudes. airspeeds. and tactics called for by the master plan. The briefer must point out and discuss any special operating procedure or technique that has been devised to meet new or special problems. The engineer's flimsy should specify the points to be considered in preparation and operation of the aircraft to obtain the desired results.

Formal briefing is usually accomplished on the day before the planned mission. or at least 24 hours before the mission. Overall. the formal briefing is to acquaint all crew members with the intended or proposed mission. and to advise them of their part in the plan. Points in question should be discussed at this time to assure complete understanding and to correct any false information relative to the particular mission. Then with the major points of the mission clearly fixed in mind. the individual crews can efficiently work out the finer points in their detailed briefing.

DETAILED BRIEFING

The individual aircraft mission is nearly always planned. briefed. and executed by the crew. In this manner. the process may be simplified although the responsibility has been increased. The responsibility of individual crew management rests with the aircraft commander. but the appropriate crew members form the planning staff. The principles of good planning do not change. Regardless of the preplanning done by others. the crew is responsible for the successful completion of the mission. Many things remain to be done; therefore. usually immediately after the formal briefing. a detailed briefing is held with the crew.

With preliminary coordination out of the way, each member of the crew is then ready to complete his phase of the mission planning. During the detailed briefing. the crew members will coordinate all the known information with one another. so that each may plan his part of the mission. For example. the pilot's and engineer's duties would be as follows.

Pilot's Duties

Initiate and complete the following forms: clearance forms. flight orders. loading lists. weather briefing. and the like.

Study the operations order to determine tacties and communications to be employed on the mission.

Engineer's Duties

Confirm all operating conditions previously agreed on.

1. Establish a more exact relationship between

load, distance, and altitude, consistent with the required safety reserve.

2. Check on any possible less-than-normal engine operation, so that a fuel reserve can be accurately established.

3. Using the altitude profile and the mission previously determined, acquire information that may be used for the flight plan.

To further assist you in flight planning, many times the basic weight and other pertinent information on a specific aircraft can be obtained from the flight log files in Base Operations, or from engineers who have previously flown the particular aircraft.

With these duties before him, the engineer uses the tools of the trade to work out the details.

MISSION PLANNING DEVICES

Detailed mission planning is greatly simplified by an understanding of the tools and devices used by the planner. The flight engineer needs the following to complete his mission planning:

Mission Profile

The mission profile is a graph of altitude plotted against time and/or distance with general notations concerning terrain elevation, temperatures, wind aloft, and destination distance. This profile may be drawn in detail and entered on the flight plan in the Remarks block or retained on a separate sheet for use in flight.

Standard Planning Factors

This is a locally devised listing of data (SOP) to provide standardization in planning missions for items such as warmup, taxi, takeoff, normal fuel required, reserves required, and so forth. Suggested fuel requirements for these items are in this chapter; however, exact amounts vary with local command.

Operational Data

These are charts and graphs depicting the aircraft performance characteristics. Current operating data are found in the Appendix 1 of the flight manual for the particular aircraft. Information on the aircraft, if other than standard, must also be acquired for planning purposes.

Slide Rule or Computer

These are simple labor-saving devices based upon logarithmic principles. The slide rule and computer were discussed in Chapter 2.

Engineer's Scale

This is a three-sided 12-inch rule marked with six scales from one-tenth to one-sixtieth of an inch. Although this scale is not a required item, it is helpful when you interpolate accurately from charts.

Dividers

A standard set of dividers is extremely useful in arriving at pinpoint accuracy when interpolating values from the performance charts.

Flight Plan and Flight Log (AF Form 796)

These forms are used for the orderly collection and recording of predicted data and of actual performance data before and during the flying of the mission. The flight plan is discussed in the first part of this chapter and the flight log in the latter part.

FINAL BRIEFING

The detailed briefings discussed above are concise and adequately cover all major points of the mission. Before flight, however, a final briefing is made to decide the following:

1. Times and places for any additional meetings, plus crew inspection, station times, takeoff time, etc.
2. Arrangements for messing or inflight lunches.
3. Transportation facilities.
4. Items of personal and crew equipment requirements.
5. Resolution of any questions arising.

After dismissal, each crew member attends to individual equipment requirements and completes any detailed planning dictated by the mission review and local SOPs.

PREFLIGHT INSPECTIONS

Immediately following the detailed briefing a ground safety check and an operational preflight inspection are made on the aircraft.

Ground Safety Check

The ground safety check consists of a visual inspection of the aircraft to insure that cowling and safety locks are in place; appropriate protective covers and gust locks are removed; and that adequate maintenance stands, power units, wheel chocks, fire equipment, and other items such as ground-handling equipment are readily available. A check to assure that the aircraft status is properly entered on the AFTO Form 781, Aircraft Flight Report and Maintenance Record, must be made. The crew chief and his assistants must know your requirements and understand communications and signals for use during the engine start, runup, and taxi operations.

Operational Preflight

Following the ground safety check, the operational preflight is performed. This inspection involves the efforts of all members of the crew, with each man having definite responsibilities and duties.

Using established checklists, the crew completes an operational check of all equipment to be used during the flight. The flight engineer, being the coordinator between operations and maintenance, should check on the aircraft status with the crew chief and should be briefed on any existing discrepancies.

For engineers, Section II (Normal Procedures) of the appropriate -1 technical order flight handbook should amplify and reflect a complete check of the aircraft and all its systems and controls which contribute to the physical act of flying. Section VIII of the same technical order (Crew Duties) should break down by crew specialty the preflight checks for the different systems. These sections of the technical order should be constantly reviewed by crew members for technical correctness and for the best way of doing the job.

The first portion of this running preflight is called an operational equipment check. It is a preflight inspection, the purpose of which is to check every item of equipment aboard the aircraft from a safety standpoint, as well as for assuring its successful operation during any phase of the subsequent mission. It must be a complete preflight check and should be amplified and alined in such a manner that it can replace preliminary engine runup. The need for this flexibility is obvious when the time factor or nature of the mission indicates the desirability of a single preflight runup just before takeoff. One purpose of this procedure is to lessen crew fatigue prior to nonscheduled transition, aircraft ferry, or test flights.

Following the operational preflight check, the servicing, the loading of the aircraft, and the disposition of any critical maintenance items noted on the preflight inspection discrepancy list should receive particular attention from responsible crew members.

At this point, the aircraft is ready for flight, having been inspected, fueled, and having had discrepancies corrected. The crew must only recheck flight safety items at "First Station" time to see that nothing has been disturbed before the flight.

The flight engineer is ready to make his detailed flight plan, since he knows what aircraft he is to fly, its configuration, its average ΔF value from the previous flight, its weight, and the information contained in the mission profile.

ADJUSTING PERFORMANCE DATA TO MEET EXPECTED CONDITIONS

Before actually planning a detailed predicted flight plan, the engineer must have an understanding of the variables he will have to consider in preparing his flight plan. By considering the variables, he can make calculations to insure that the aircraft will attain maximum efficiency for the conditions under which the mission is to be flown.

As you recall from chapter 9, the performance data charts that are used to predict the flight plan are based on standard day conditions and standard aircraft configuration. From this, you can see that considerable emphasis must be placed on nonstandard conditions when you work out the details of your flight plan.

Adjusting for Atmospheric Conditions

Standard sea-level atmospheric conditions are a common standard to which, and from which, actual conditions must be adjusted. Since the atmospheric condition often varies from standard, a density altitude chart which expresses the relationship of density, pressure, and temperature is used to determine the degree of variation. Later in this chapter, the chart shown in figure 10-19 is used for convenience in determining the smoe factor, which is the reciprocal of the square root of the density ratio $\frac{1}{\sqrt{\sigma}}$ for any pressure altitude (H_p) and ambient air temperature (OAT). The smoe factor bears a direct relationship to density altitude (H_d). The power and true airspeed required for a condition vary according to density altitude. The use of the smoe factor makes possible mathematical conversions of the power and true airspeed required for any atmospheric condition.

Standard atmosphere also accounts for average specific humidity. Power schedule curves are based on standard values of specific humidity. The effect of variable humidity is plotted in conjunction with the takeoff performance data chart. In cruise, the effect of humidity is negligible.

Adjusting for Variations in Powerplant Efficiencies

Density of the input fuel charge varies with temperature and pressure as indicated by carburetor air temperature (cat) and absolute manifold pressure (MP). Bmep power schedules are based on a given value for cat. Recommended MP corrections for variations of cat are indicated on these schedules. When fuel-air ratio curves are provided, corrected MP must be correlated with specific values of density altitude and rpm, and calibrated fuel flow must result in fuel-air ratios that fall within the accepted range, particularly under best economy operation obtained through the manual leaning process. Valid fuel-air ratios, coupled with the manual leaning process, result in the maximum engine economy consistent with long engine life.

The factors rpm, MP, fuel flow, cat, CHT, and exhaust back pressure are controllable factors representing engine input. Combinations of these produce various bmep, fuel-air ratio, and bhp—indicated by torque-indicating systems—as engine output. Brake specific fuel consumption (BSFC) is the measure of engine efficiency and thus a measure of your ability to prepare and operate the engines efficiently. BSFC, by definition, is the pounds of fuel consumed per bhp/hour. Since fuel flow in lbs/hr and bhp/hr are easily determined, BSFC can be easily found by dividing the first factor by the second and finding BSFC in terms of fuel flow in lbs/bhp.

Propeller efficiency (η) varies with propeller rpm, true airspeed (V_t), and other variables. Propeller efficiency remains fairly constant between 80% and 85% in the optimum cruising range, including cruise descents. The propeller efficiency can be checked in the -1 flight manual. During takeoff, climb, high-rpm, high-altitude, and high-airspeed cruises, propeller efficiency drops off significantly. As the equivalent speed of the tips of the blades approaches the speed of sound, a sharp increase in drag and decrease in lift of the blades occur. Propeller shaft bhp times propeller efficiency equals thrust horsepower ($\text{bhp} \times \eta = \text{thp}$).

Substituting thp for bhp in the specific fuel consumption (SFC) formula, we can compute thrust specific fuel consumption (TSFC). TSFC is a measurement of overall powerplant efficiency excluding the drag induced by variable engine cooling flaps. Cooling requirements are considered during engine operation, but the resultant cooling drag is treated as a part of the total aircraft drag since total drag equals parasite drag plus induced drag. Adjusting all of these variables to produce the power required (thrust), while obtaining the best TSFC with the least induced cooling drag within specified engine operating limits, sets the stage for achieving maximum aerodynamic efficiency.

Adjusting for Aircraft Correction Factors

Assuming that acceptable standards for aircraft and engine conditioning, aerodynamic cleanliness, and weight and balance control have been met and the adjustments indicated above have been properly considered and applied, then we have a final adjustment to compensate for nonstandard aircraft performance. This adjustment is called the aircraft correction factor.

Correction factors to compensate for apparent variations from standard aircraft configuration are needed to predict performance accurately. Addition or subtraction of external drag items, such as wing tanks or tip tanks, jet pods, antennas, refueling booms and receptacles, and the like, obviously causes the actual performance to differ from charted performance. The equivalent flat plate area for such drag items must be computed and the result is called the delta F factor. This factor is then used to determine the delta F bhp required for all conditions.

The information for correction factors must be computed and used in predicting the flight plan.

A previous log on the specific aircraft would furnish the information needed. By means of in-flight analysis, the previous engineer will have established any unknown correction factors in the form of delta F or delta F bhp that you can use in predicting your mission. If no information is available, then during the walkaround preflight inspection, you should note any part of the configuration that is other than standard on the aircraft and use this information in computing the predicted flight plan.

DETAILED PREFLIGHT MISSION PLANNING

There are three general categories of missions: (1) maximum load missions, (2) given pay load missions, and (3) given time and distance missions.

Maximum Load Missions

The maximum load mission is restricted by four main factors.

- Aircraft design
- Rate of climb at liftoff
- Runway length
- Obstacle clearance

Under maximum load missions there are two types of missions: maximum pay load to destination mission, and maximum off-load mission.

MAXIMUM PAY LOAD MISSION. After determining the maximum takeoff weight with the existing conditions, such as runway length, temperature, obstructions, etc., the flight plan is worked forward from takeoff to destination. In this way the fuel required for the mission is determined. The difference between the operating weight plus fuel required and the start engines gross weight is the amount of cargo that can be carried on the mission.

MAXIMUM OFF-LOAD MISSION. This type of mission includes two types of operations: a cargo mission or a refueling mission. The prime objective of this type of mission is either to carry a maximum cargo load to a cargo drop zone, or to carry the maximum fuel off-load to a refueling point. We must know: (1) how the mission can best be accomplished, and (2) the maximum off-load or cargo off-load that can be carried. By combining forward and reverse planning, the maximum off-load can be determined. Again the maximum takeoff weight is determined by local conditions, runway length, obstructions, and so forth. The fuel required for the mission up to the refueling point or drop zone is then determined.

After you determine the amount of fuel required up to this point, you determine the ending gross weight. Then determine the amount of fuel required for the return flight by working a reverse plan from destination backward to the refueling point or drop zone. You can find the weight of the cargo or of the off-load fuel that can be carried by subtracting the gross weight anticipated for the end of the forward part of the flight plan from the beginning weight of the backward flight plan. The fuel required for rendezvous procedures or drop zone procedures depends on local SOPs.

Given Pay Load Missions

Under this category of mission there are also two general types: off-load and given load to destination. In both of these types of missions the exact weight of the cargo is known, but the amount of fuel required to fly the mission is unknown. The takeoff gross weight is therefore unknown. The flight plan cannot be computed forward, since performance is determined by gross weight, so these are reverse planning-type missions. The minimum landing gross weight can be determined by using the operating weight (including cargo) at traffic pattern altitude over destination. With this weight known, you can find the required fuel reserve and then work the flight plan backwards from destination to takeoff. After this is done, compute the fuel required for the mission and calculate the take-off weight.

Given Time and Distance Missions

These types of missions are generally used for patrol work. They fall into three categories: given time, given distance, and maximum time or distance. Given time and given distance missions are backward planned types. A time or distance is furnished, but the amount of fuel required is unknown. Working the plan backward for the time or distance to find the fuel required establishes the takeoff weight.

Maximum time and maximum distance missions are forward planned missions. Either full or partially full tanks are used and the aircraft is flown the maximum time or distance for the fuel on board.

Standard Factors in Mission Planning

The previous information shows that the different types of missions require different planning procedures. However, to provide as much standardization as possible in mission planning, each wing or separate squadron should set forth valid and tested information peculiar to organizational equipment and procedures not reflected in current handbooks. Accepted methods of allotting fuel for starting engines, runup, taxi, takeoff, and landing, and establishing fuel reserves are necessary factors.

Another check on planning is the quick prediction. The use of long-range summary curves and long-range prediction for distance and time curves provides a fairly accurate check for detailed planning. By this procedure, a check and balance of the detailed flight plan may save a costly and time-consuming error.

DATA RECORDING PROCEDURES

Any mission may be divided into the following periods: warmup and taxi, takeoff, climb, cruise, descent, and landing and taxi. Similarly, the flight plan is divided into conditions covering each of these periods.

The warmup and taxi period includes all operation before the start of the takeoff run. It is impossible to predict the bhp to be used during this period of operation since it includes starting the engines, warming up the engines, taxiing to the end of the runway, checking out the engines before takeoff, and standing by awaiting clearance from the tower for takeoff. Absolute accuracy could be achieved only by performing this operation in a normal manner, then stopping the engines before takeoff and determining, by sight gages, dipsticks, and servicing, how much fuel had been used for the warmup and taxi period. Obviously, a better procedure for determining the fuel required for warmup and taxi is to make an allowance of a specified amount determined by practical experience. Also, the time for warmup and taxi is not included in flight time, for flight is considered to start at the end of the warmup and taxi period; that is, at the start of the takeoff run.

Takeoff is the period of operation from the time the throttles are pushed forward to maximum power for the takeoff run until the power is reduced for climb. The time required for this operation is usually 2 to 5 minutes and an allowance of a specified amount of fuel for this operation is determined from practical experience.

At the end of the takeoff period, when the aircraft speed, direction, and trim have been stabilized, the power to be used for the initial climb is established and maintained until the cruising altitude is attained. During the initial climb, the power and airspeed should be maintained at the desired values, allowing the rate of climb to vary. To obtain greatest range from the aircraft, all climbs should be accomplished at rated power and at the recommended airspeed for climb. In predicting the elapsed time, fuel used, and distance covered in a climb, use the rate of climb curve, based on the predicted power and airspeed to be used.

The cruising portion of a mission is defined as all level-flight operation. While most missions are long range, parts of the cruise may be constant power, constant airspeed, long range, maximum range, emergency, three-engine, cruise to alternate airport, cruise to destination in minimum time on fuel available, or other types of operation.

Secondary climbs are intermediate climbs made between two cruising altitudes. They are usually incorporated as a delay in reaching the final cruising altitude if the weather conditions are such as to make it advisable to climb to a cruising altitude on top of an overcast. The climb data for secondary climbs is obtained from the climb control curves in the same manner as for initial climbs.

The descent portion of a mission is, as the name implies, that portion in which the aircraft descends from a higher to a lower altitude. There are numerous ways in which descents may be flown, and the procedure for predicting the data depends upon the prevailing conditions. The major factor which determines the type of descent to be flown is the weather condition at the various altitudes. Tests and experience have proved that every little range difference is obtainable regardless of the rate of descent flown. In general, the energy from descent provides 2.2 nautical miles additional free range for each 1000 feet descended.

The landing and taxi portion of the mission includes all operation from the end of the final cruise or descent, as the case may be, until the engines are stopped on the ramp. The power requirements for these operations, like the power requirements for warmup and taxi, are unpredictable. The fuel required for the landing and taxi operation is usually expressed as a specified amount based on previous experience.

THE ENGINEER'S PREDICTED FLIGHT PLAN

The engineer's predicted flight plan is, in general, a summary of the predicted altitudes, airspeeds, and fuel required for a mission that is to be flown. A flight plan may be made up as much as a week in advance of the planned mission. In some instances you may be able to use a flight plan from a previous mission from your squadron or group completed-mission file. Usually the flight plan is computed the day before the mission.

The entries and calculations on the flight plan are based on planning data provided by base operations, the aircraft commander's flimsy, the aircraft navigator, and the base weather station.

Since the Aircraft Performance Log/Plan (AF Form 796), the front side of which is shown in figure 10-18, serves a two-fold purpose as indicated by its title, it may be used at this stage of the mission planning to record the flight plan data. For practical purposes of discussion, the form is divided into three sections. These sections accommodate the entries for each phase of the mission; before flight, during flight, and after flight. The after flight entries, however, depend on variables which occur during flight and are not made until completion of the mission.

The heading is self-explanatory. Applicable blocks of the form may be filled out as your predicted flight plan. The front side, figure 10-18, is shown with typical entries. The back side is shown later in figure 10-36. These numbered block headings are also self-explanatory, but the entries for each will be discussed in terms of flight planning. This form, completed before flight along with the TOLD card, constitutes all data needed to complete the mission. The flight plan with required entries is shown in figure 10-18. Although the Log/Plan is sufficiently comprehensive for the average mission, a supplemental maintenance form may be used if it is required for a particular type of mission.

Takeoff Planning (TOLD Card)

Since takeoff planning is a most critical phase of flight planning, an outlined procedure should be followed to lessen the possibility of overlooking a point necessary for safety. Also, the planning should include data for a safe return to the field for landing in case trouble is experienced immediately after takeoff. Careful consideration of the essential factors and proper entry of the data in the Log/Plan will promote safety of the mission.

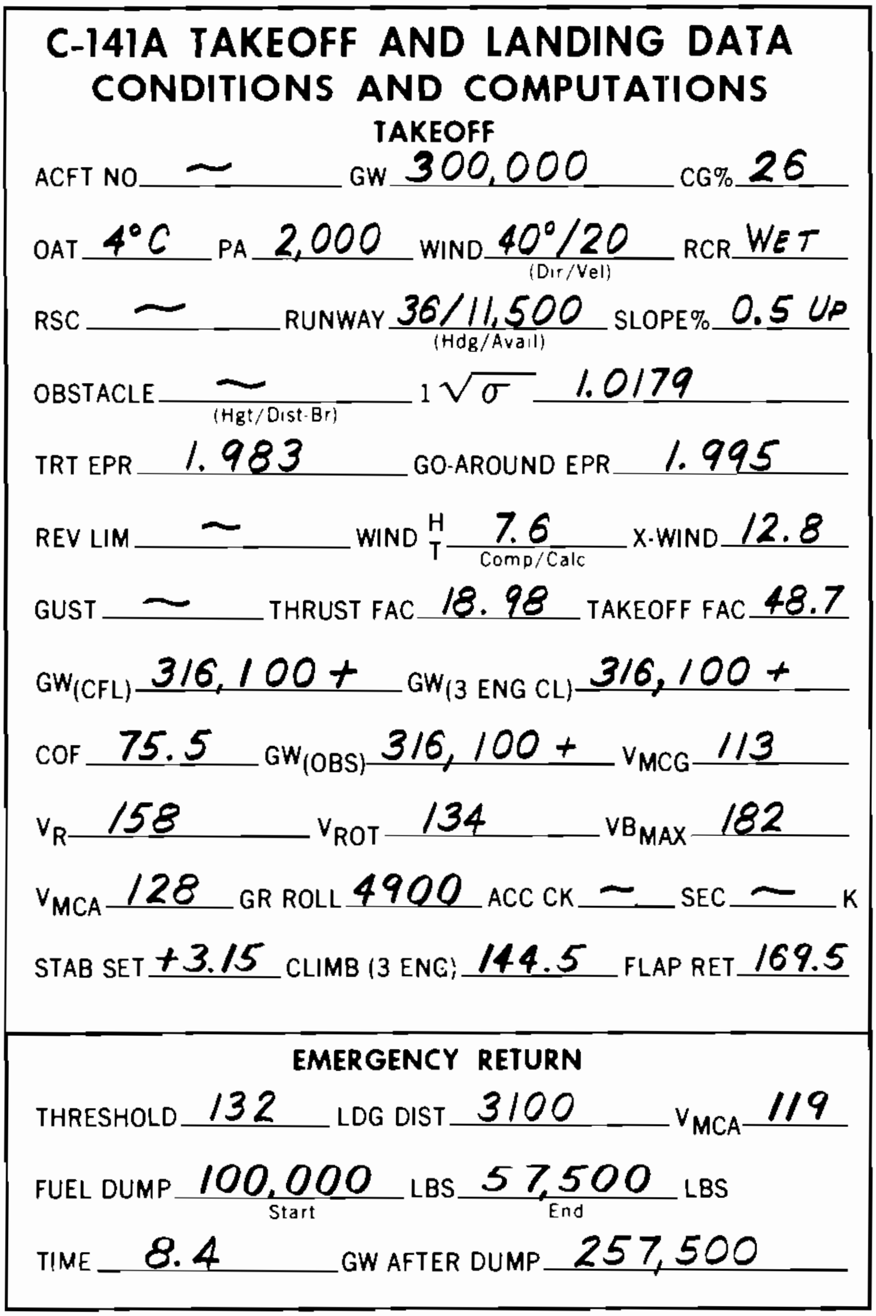
Normally, takeoff planning involves a determination of: (1) takeoff gross weight of the aircraft, (2) thrust factor and takeoff factor, (3) runway available, (4) stabilizer trim setting, (5) critical field length and critical engine failure speed, (6) rotation speed, (7) takeoff ground run, (8) takeoff speed, and (9) climbout and flap retraction speeds. Careful computations for the exact value for each of the above must be accomplished from the performance charts and entered on a takeoff and landing data card such as the one shown in figure 10-1. This procedure affords a logical sequence for your takeoff planning and eliminates the possibility of omitting a step necessary for safety.

For our takeoff problem for a typical turbine engine powered aircraft, the known data are as follows:

Gross weight	300,000 lbs
OAT	4° C
Pressure altitude	2,000 feet
Wind (direct velocity)	40° / 20K
Runway condition	Wet
Runway heading	36°/11,500 feet
Runway slope	0.5% uphill

From these known data, compute (1) thrust factor and takeoff factor, (2) stabilizer trim setting, (3) critical field length and critical engine failure speed, (4) takeoff ground run, (5) rotation speed, (6) takeoff speed, and (7) climbout and flap retraction speeds. Notice the entries on the TOLD card in figure 10-1 as we proceed with the solution. The computed values do not appear consecutively on the TOLD card as we proceed through the problem, but rather in the order of logical sequence.

The first value that we need to determine is the expected thrust, expressed as EPR. For this value, enter the thrust chart shown in figure 10-2 at the bottom with the runway ambient temperature of 4° C, then proceed vertically to the pressure altitude line. Notice in this case it is necessary, with this temperature, to intersect the curved altitude line before we reach the 2,000 feet altitude



C-141A TAKEOFF AND LANDING DATA
CONDITIONS AND COMPUTATIONS

TAKEOFF

ACFT NO ~ GW 300,000 CG% 26

OAT 4°C PA 2,000 WIND 40°/20 (Dir/Vel) RCR WET

RSC ~ RUNWAY 36/11,500 (Hdg/Avail) SLOPE% 0.5 UP

OBSTACLE ~ (Hgt/Dist-Br) $1\sqrt{\sigma}$ 1.0179

TRT EPR 1.983 GO-AROUND EPR 1.995

REV LIM ~ WIND H/T 7.6 Comp/Calc X-WIND 12.8

GUST ~ THRUST FAC 18.98 TAKEOFF FAC 48.7

$GW_{(CFL)}$ 316,100+ $GW_{(3 ENG CL)}$ 316,100+

COF 75.5 $GW_{(OBS)}$ 316,100+ V_{MCG} 113

V_R 158 V_{ROT} 134 VB_{MAX} 182

V_{MCA} 128 GR ROLL 4900 ACC CK ~ SEC ~ K

STAB SET +3.15 CLIMB (3 ENG) 144.5 FLAP RET 169.5

EMERGENCY RETURN

THRESHOLD 132 LDG DIST 3100 V_{MCA} 119

FUEL DUMP 100,000 (Start) LBS 57,500 (End) LBS

TIME 8.4 GW AFTER DUMP 257,500

Figure 10-1. TOLD Card

line. Then read the engine pressure ratio, EPR, in the left margin as 1.983. Enter this value in the appropriate block of the TOLD card, labeled Takeoff Rated Thrust (TRT EPR).

In addition to the takeoff rated thrust value, compute a go-around EPR for emergency power. This is necessary in the event a go-around becomes necessary, if you have to return for an immediate landing after takeoff. Enter the chart shown in figure 10-3, at the bottom with the runway temperature (4° C). Move vertically to the curving pressure altitude line and read the go-around EPR in the left margin as 1.995. Enter this value in the appropriate block of the TOLD card. These computations account for the power. Now consider the effective wind for takeoff.

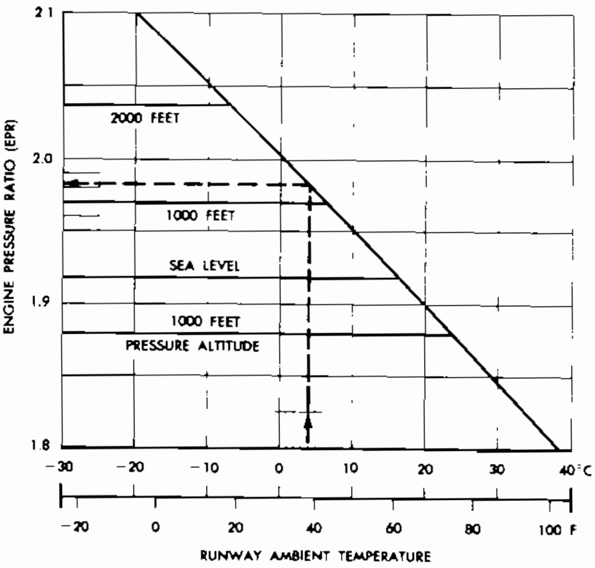


Figure 10-2. Thrust—EPR

Notice that we show the wind as 40°/20K in our problem known data, and the runway direction as 36°. Refere to the crosswind component chart in Chapter 9 (figure 9-14) and determine the crosswind component as 12.8 knots. Enter this value in the TOLD card in the X-wind block.

Now we are ready to determine the thrust factor and the takeoff factor. Enter the thrust factor chart in figure 10-4 with the obtained engine pressure ratio 1.983. Move down to the pressure altitude line (2000 feet) and then directly to the left to a thrust factor of 18.98. Take this thrust factor number into the bottom of the takeoff fatcor chart, figure 10-5. Move up to the temperature line (4° C) and to the right to a reference number of 7.6. Enter the right-hand portion with this reference number, then continue to the right and intersect the 2000 feet pressure altitude line. The takeoff factor appears directly beneath this point as 48.7. Enter the thrust factor (18.98) and the takeoff factor (48.7) in the appropriate blocks of the TOLD card.

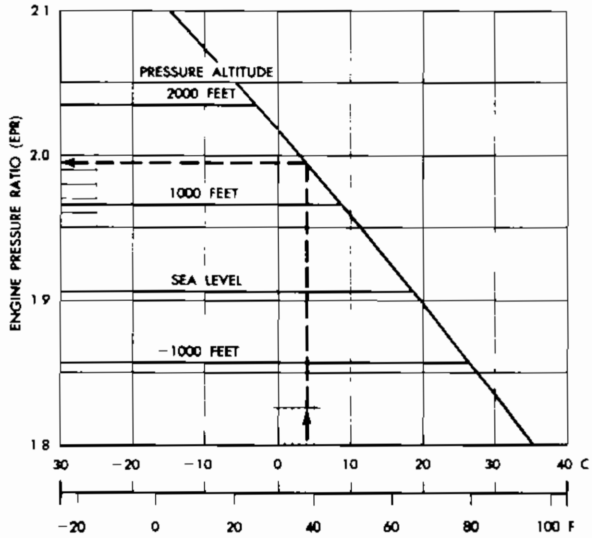


Figure 10-3. Go-Around EPR

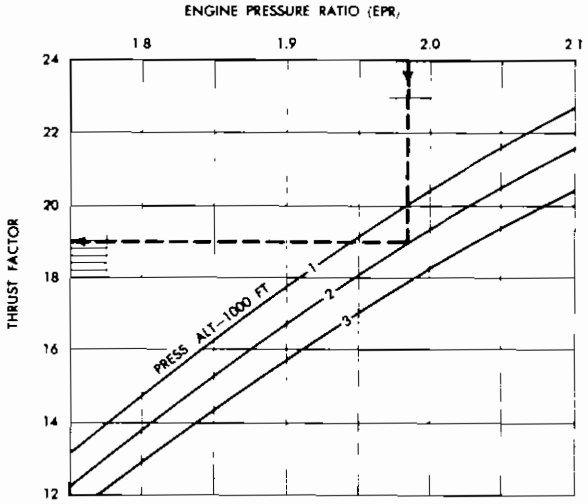


Figure 10-4. Thrust Factor

For safety purposes, check the charts applicable to the critical field length for the runway available and gross weight for our given problem. In this case, we find that the runway available is sufficient for the gross weight.

Next we need to compute the climbout factor. For safety, we use the three engine performance chart to obtain a climbout factor, as illustrated in figure 10-6. Enter at the bottom with the thrust factor (18.98), move vertically to the gross weight line (300,000 lbs) and read the climbout factor as 75.5 in the right-hand margin. Enter this value in the TOLD card in the block labeled COF.

After you consult the charts and find that our gross weight will allow ample clearance of any obstacle after takeoff, compute the ground minimum control speed. This, as you know, is the minimum speed at which an engine failure can be

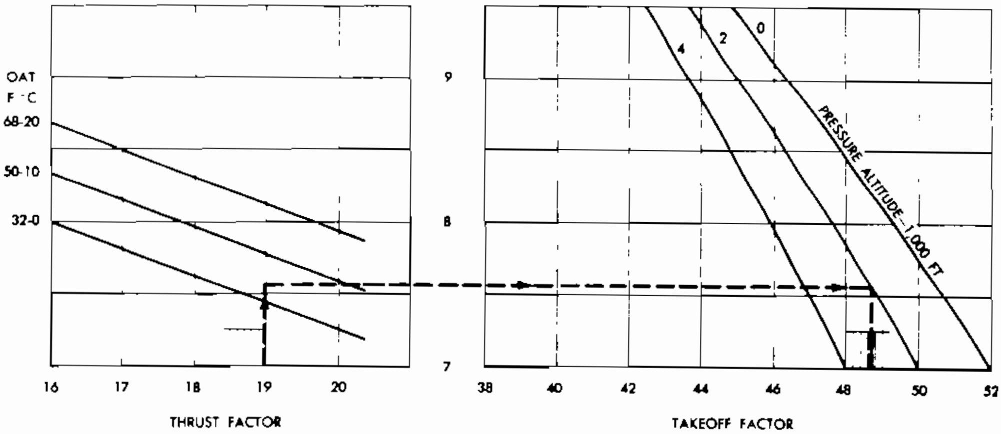


Figure 10-5. Take-off Factor

experienced during the takeoff run and allow the pilot to maintain directional control of the aircraft by use of the rudder control.

Notice carefully, from figure 10-7, the adverse effect of a wet or icy runway on the minimum ground control speed in contrast to a dry runway. You find this computed value to be 113 knots for entry into the TOLD card in the block labeled V_{mcg}.

Next in the sequence of computations for takeoff, determine a refusal speed. As you compute this value, notice that the runway available for takeoff is sufficient to allow acceleration to takeoff speed and then to permit the aircraft to stop in the remaining distance in the event trouble should develop which would necessitate an abort. For reasons of safety, however, check the refusal speed regardless of runway length. Figure 10-8 reveals a refusal speed of 158 knots after accounting for gross weight, runway length, runway slope, effective wind, and runway condition. Enter 158

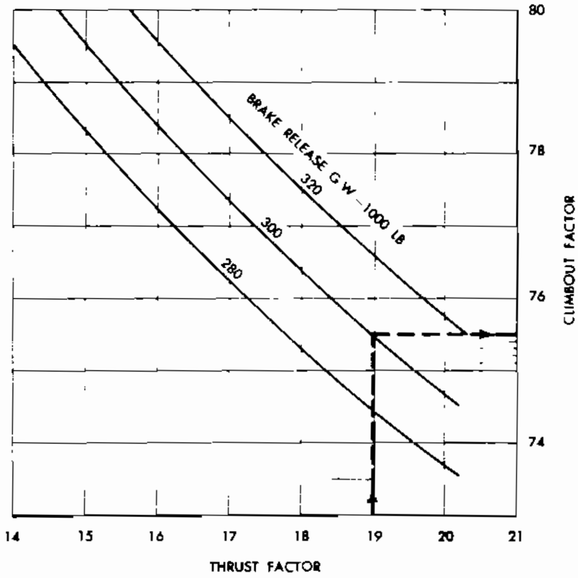


Figure 10-6. Climbout Factor

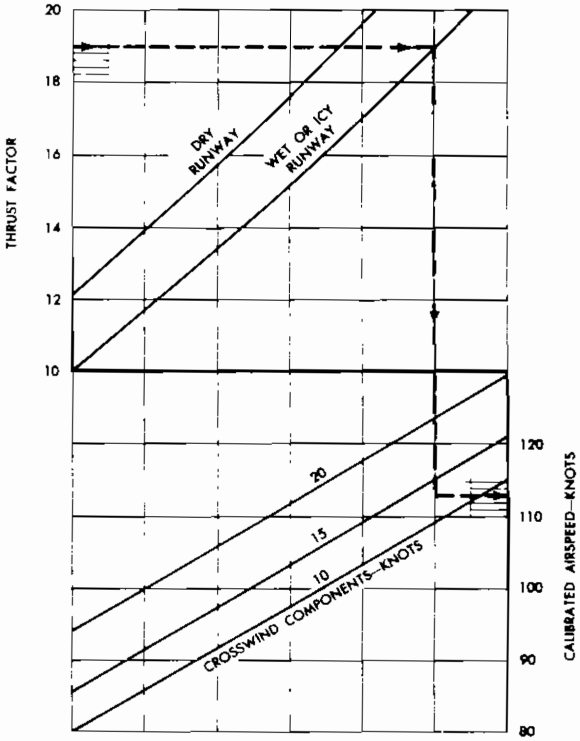


Figure 10-7. Minimum Ground Control Speed

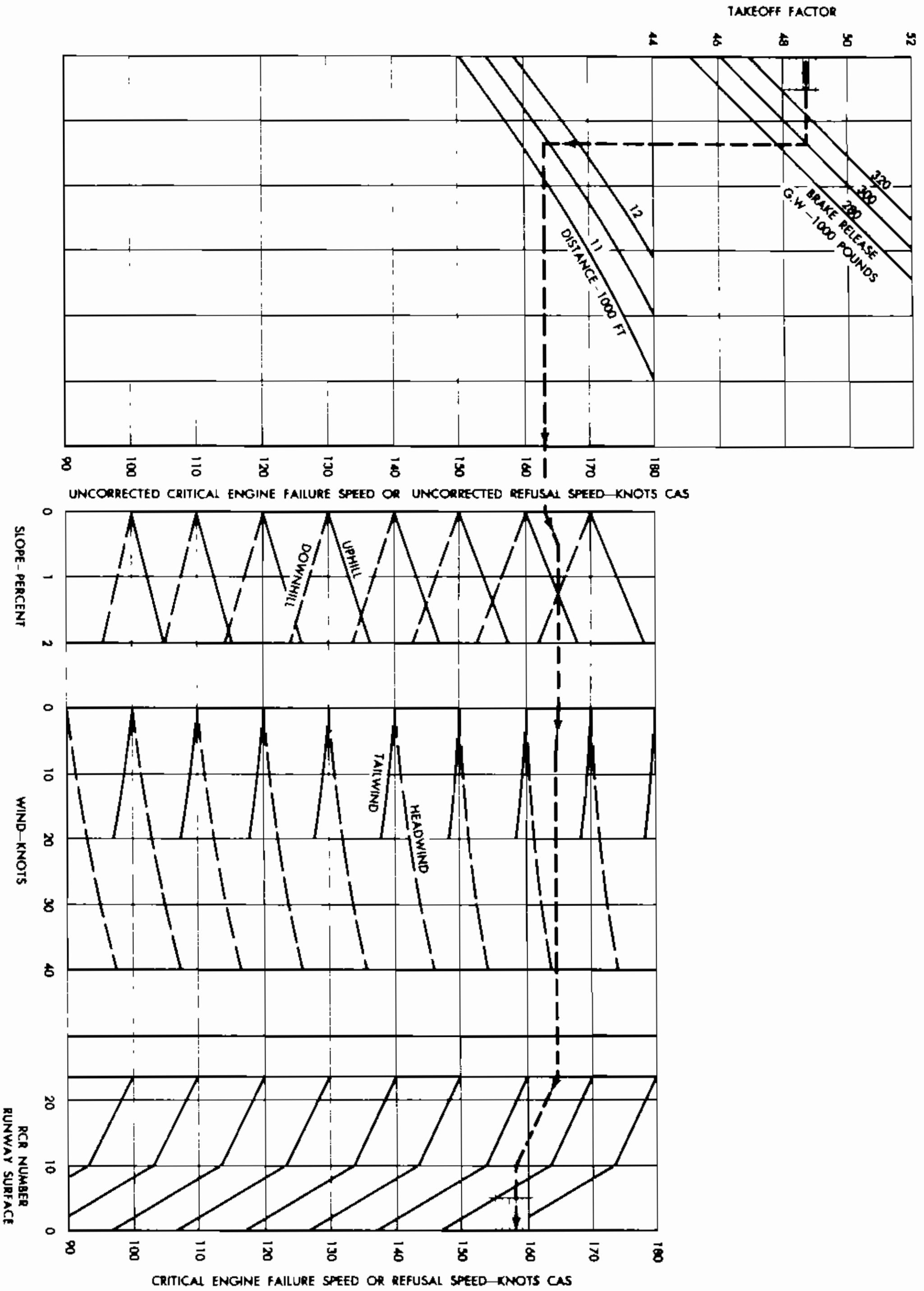


Figure 10-8. Refusal Speed

knots in the V_R block of the TOLD card, even though the refusal speed exceeds the takeoff speed.

Compute the rotation speed from the chart shown in figure 10-9. For some aircraft, the rotation speed occurs shortly before takeoff speed (approximately 3 seconds). But for the turbine engine powered aircraft selected for our illustrative problem, takeoff occurs at the same time as the completion of rotation. Consequently, rotation speed and takeoff speed are the same. So

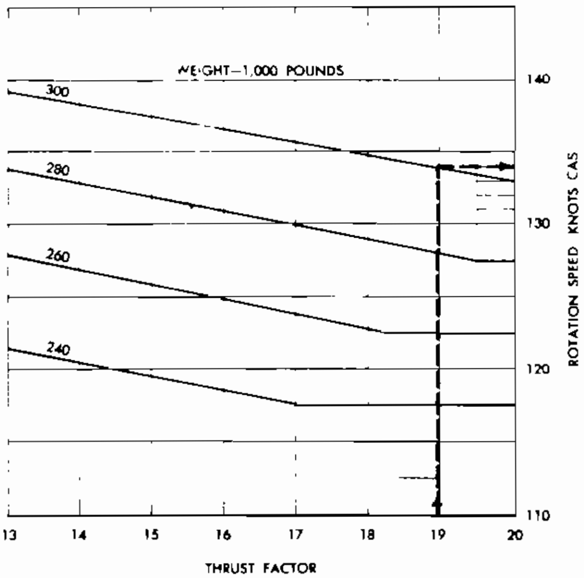


Figure 10-9. Rotation Speed

enter 134 knots in the V_{rot} block of the TOLD card, as the computed value from the chart in figure 10-9.

As you compute the safety factors for each takeoff, consider the maximum braking speed for the type of aircraft that you are operating. This is advisable in the event trouble develops for which an abort becomes necessary, and you need to brake to a stop. Maximum braking speed is always less than refusal speed. Enter the chart in figure 10-10 with the gross weight (300,000 lbs). Move in to the pressure altitude line (2,000 feet), and descend to the OAT° scale and interpolate the existing temperature (4° C). From there, move to the right to the slope % scale and account for 0.5% uphill gradient. Then after you account for the effective wind as shown, read the maximum braking speed as 182 knots in the right-hand margin. Enter this figure in the TOLD card block labeled VB_{max}.

After you determine the maximum braking speed, you need to know the takeoff ground run distance. For this value, enter the chart in figure 10-11 with the takeoff factor (48.7) and ascend to the gross weight line (300,000 lbs). Move directly to the right from the gross weight line to read the uncorrected ground run of 4,600 feet. Then move directly into the right-hand section of the chart and account for the runway slope (0.5%). Chart the effective wind as illustrated and then plot the effect of the runway condition (wet). Let's assume that the water level on the wet runway is 0.4 inches as illustrated by the chart in figure 10-11. Then move directly from that point to the right margin to read the corrected ground run as 4,900 feet. Enter this figure in the GR ROLL block of the TOLD card.

Notice that no values are computed for the acceleration check time and speed blocks of the TOLD card. These computations are not required for our present problem since the refusal speed exceeds the rotation (takeoff) speed by twenty-four knots. For this aircraft, when V_{rot} exceeds V_r by twenty knots or more, an acceleration check time or speed is not required.

After the aircraft is airborne, we need to determine the minimum speed at which the pilot can maintain directional control by use of the rudder in the event of engine failure. This is called the air minimum control speed (V_{mca}), based on the use of full rudder control to maintain directional stability. Later in this chapter, we present a problem of this type for which entries are shown in figure 10-12. Disregard the specific problem for the present. We illustrate the card here to familiarize you with its content.

For the aircraft selected for this problem, the horizontal stabilizer trim must be set before takeoff. This setting is calculated from the gross weight and center of gravity percent as shown in figure 10-13. For this problem assume the center of gravity is to be 26% of the MAC. Enter the chart at the bottom with the gross weight (300,000 lbs). Follow that weight grid line up to the CG line (26%). Then directly to the left-hand margin, you read the stabilizer setting as 3.15 for entry into your TOLD card.

Finally, determine the climbout and wing flap retraction speeds, and the information required for the normal takeoff portion of the TOLD card is complete. Plot the climbout speed first by entering the chart in figure 10-14 with the thrust factor (18.98). Notice again that the 3-engine chart is used for safety. Proceed horizontally to the gross weight line (300,000 lbs) and read the climbout speed directly below as 144.5 knots. For the aircraft used in our illustrative problem, add 25 knots to the climbout speed (144.5) to establish a minimum wing flap retraction speed. Determine this speed as 169.5 knots, and enter it along with the climbout speed in the appropriate blocks of the TOLD card.

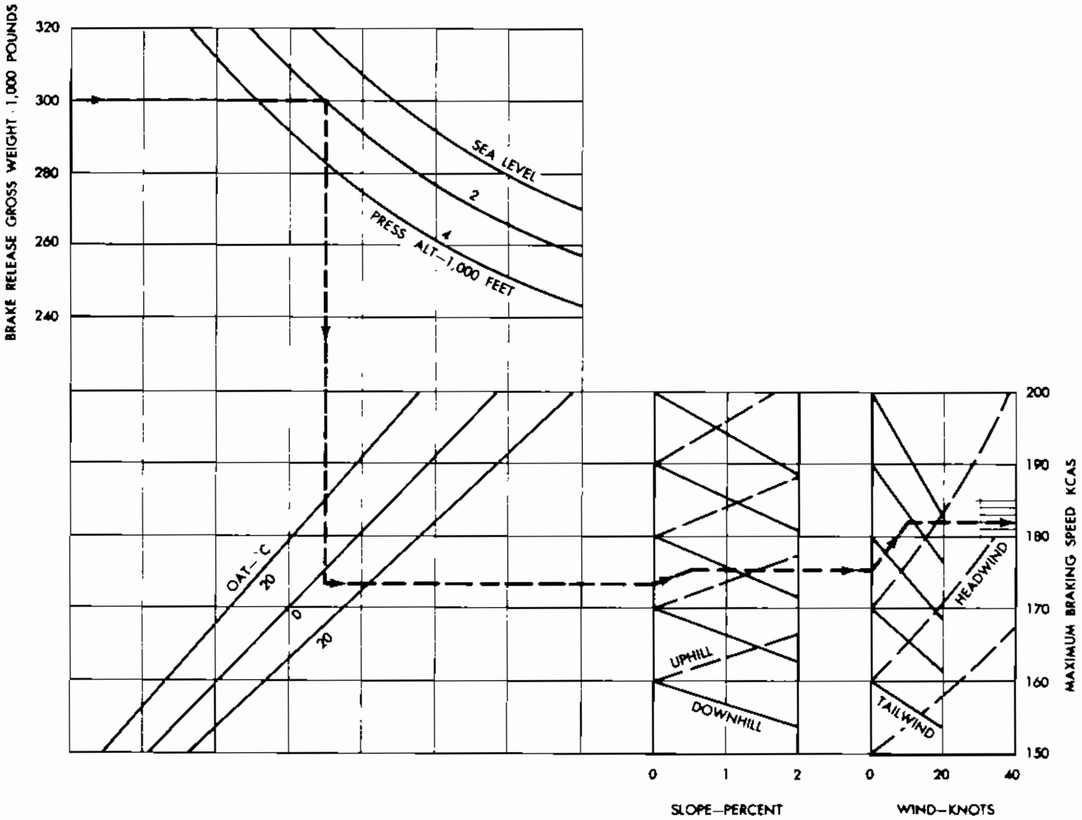


Figure 10-10. Maximum Braking Speed

Now, in addition to the recorded information required for a safe takeoff, compute the data for ready reference to the pilot in the event of an emergency return to the landing field after the aircraft is airborne. As you can see, the emergency return portion consists of the six blocks at the bottom of the TOLD card. The first reference needed is the threshold speed. But before we can accurately compute this speed, we must know the landing gross weight of the aircraft. Let's assume

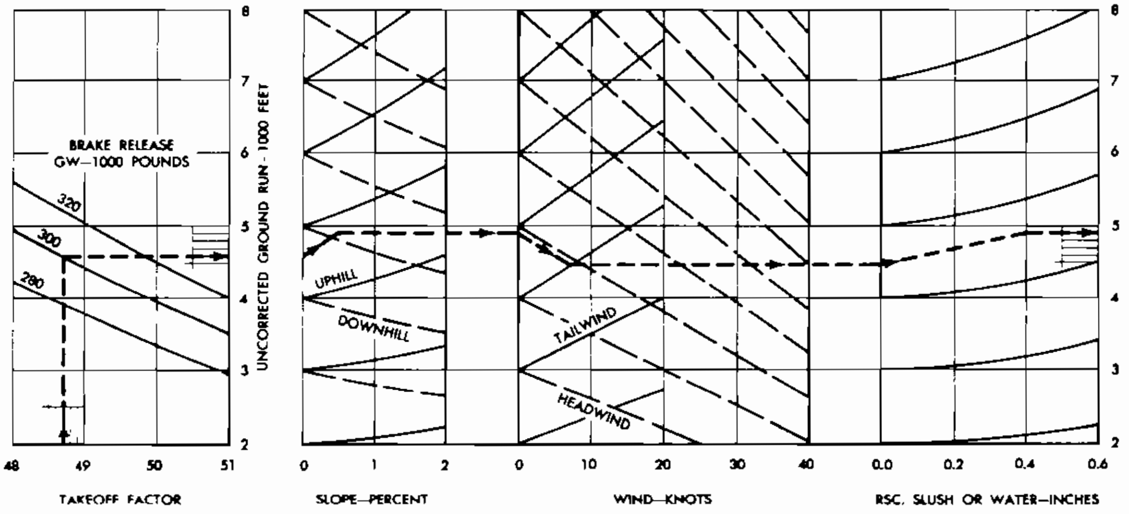


Figure 10-11. Take-off Ground Run

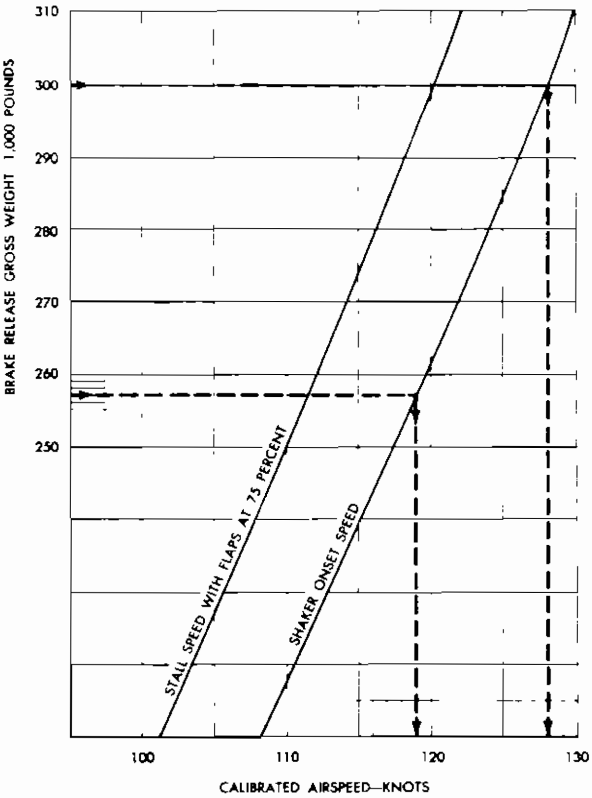


Figure 10-12. Air Minimum Control Speed

that we have a total fuel load of 100,000 pounds on board, and that we would need to dump 42,500 pounds of the total fuel to reduce the aircraft gross weight to a recommended weight limit for landing. This leaves 57,500 pounds of fuel remaining with an aircraft gross weight of 257,500 pounds for the landing. Enter these known figures in the emergency return section of the TOLD card as follows: Fuel dump start weight 100,000 pounds; fuel dump end weight 57,500 pounds. Then enter 257,500 pounds for the aircraft gross weight after fuel dump. Now we have accurate weight figures from which to compute the remaining data for an emergency return.

Enter the fuel jettison time chart, figure 10-15, with the total fuel weight (100,000 lbs), and follow that weight line horizontally into the FUEL ABROAD line as illustrated. Read that time directly below on the time scale as 8.6 minutes. Now continue on down the fuel aboard line until you intersect the horizontal grid line which represents the END dump fuel weight (57,500 lbs). Directly below that point, read that time as 17.0 minutes. Then subtract the first obtained figure (8.6 minutes) from the second (17.0 minutes) and arrive at 8.4 minutes to jettison 42,500 pounds of fuel. Enter this figure in the TIME block of the emergency return section.

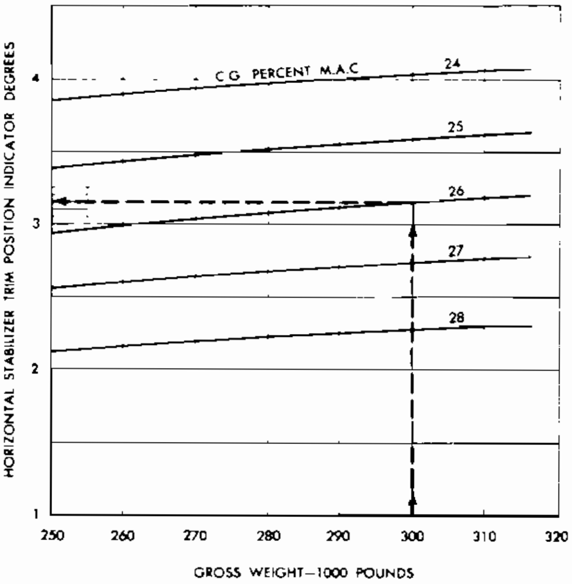


Figure 10-13. Stabilizer Setting

Determine a threshold speed for an emergency return and landing using 257,500 pounds for the aircraft gross weight, which represents the weight after fuel dump. The chart shown in figure 10-16 reveals the threshold speed, with landing flaps, as 132 knots. Enter this value in the emergency return portion of the TOLD card.

Plot the landing ground roll for an emergency return from the chart shown in figure 10-17. The

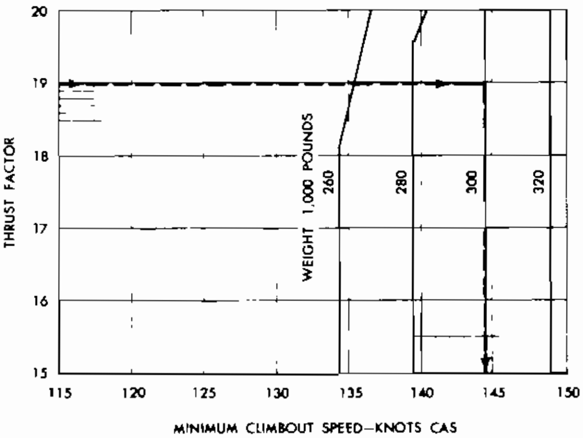


Figure 10-14. Climbout Speed

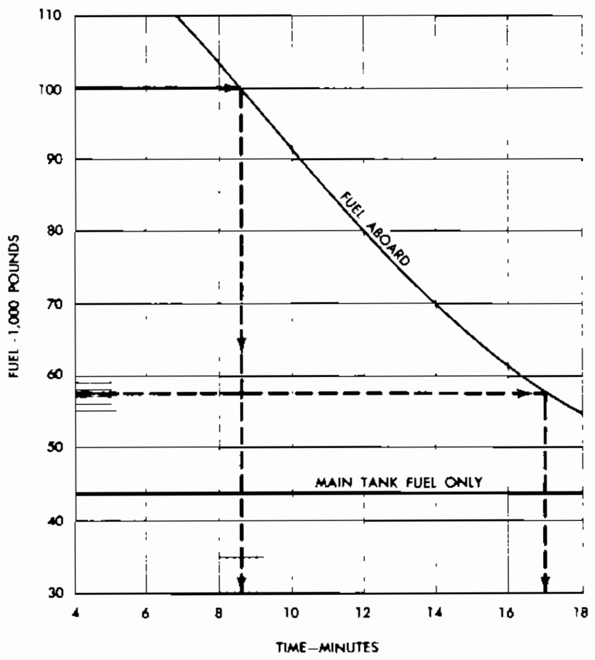


Figure 10-15. Fuel Jettison Time

values derived from this chart presupposes the use of landing flaps, spoilers, and anti-skid brakes after touchdown. Landing ground roll charts are also available in the flight handbook for aircraft which are not equipped with antiskid brakes. Select the chart applicable to your aircraft when you compute the landing ground roll. Enter the chart shown with the OAT C (4°) and move into the pressure altitude line (2,000 ft). Then descend to the gross weight line and interpolate 257,500 pounds and read the UNCORRECTED landing ground roll in the right-hand margin as 2,300 feet. Continue directly into the adjoining portion of the chart and account for the runway condition (wet). Then plot the runway slope percent, the effective headwind, and read the CORRECTED landing ground roll in the extreme right-hand margin as 3,100 feet. Enter this figure in the LDG DIST block for your emergency return data.

Now for the final item of needed information for the emergency return section of your TOLD card, return to the chart in figure 10-12 and compute the air minimum control speed for the emergency condition. As you recall from the earlier illustration for our takeoff problem, we used the *one engine out* chart for safety planning when we computed the V_{mca}. Reenter the chart with the emergency landing weight of 257,500 pounds, and compute the air minimum control speed of 119 knots. Enter the figure in the V_{mca} block of the emergency return section, and your TOLD card entries for takeoff are complete.

Inflight Computations

The inflight condition of any mission begins when takeoff power is set on the engines at the beginning of the takeoff run, and ends when the engines are shut down after the landing. The entire flight consists of the takeoff, climb, cruise, descent, landing and taxi. Each of these conditions must be accurately recorded on the aircraft performance log/plan in the planning stage of your flight.

Since we begin at this point to make the flight plan entries for the mission, let's first discuss the peculiarity of some of the blocks of the performance log/plan.

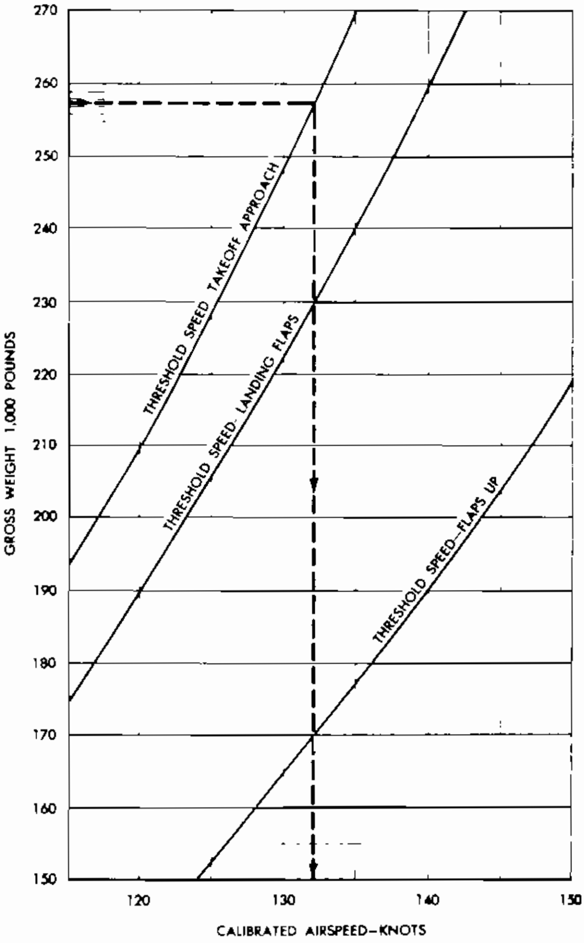


Figure 10-16. Threshold Speed

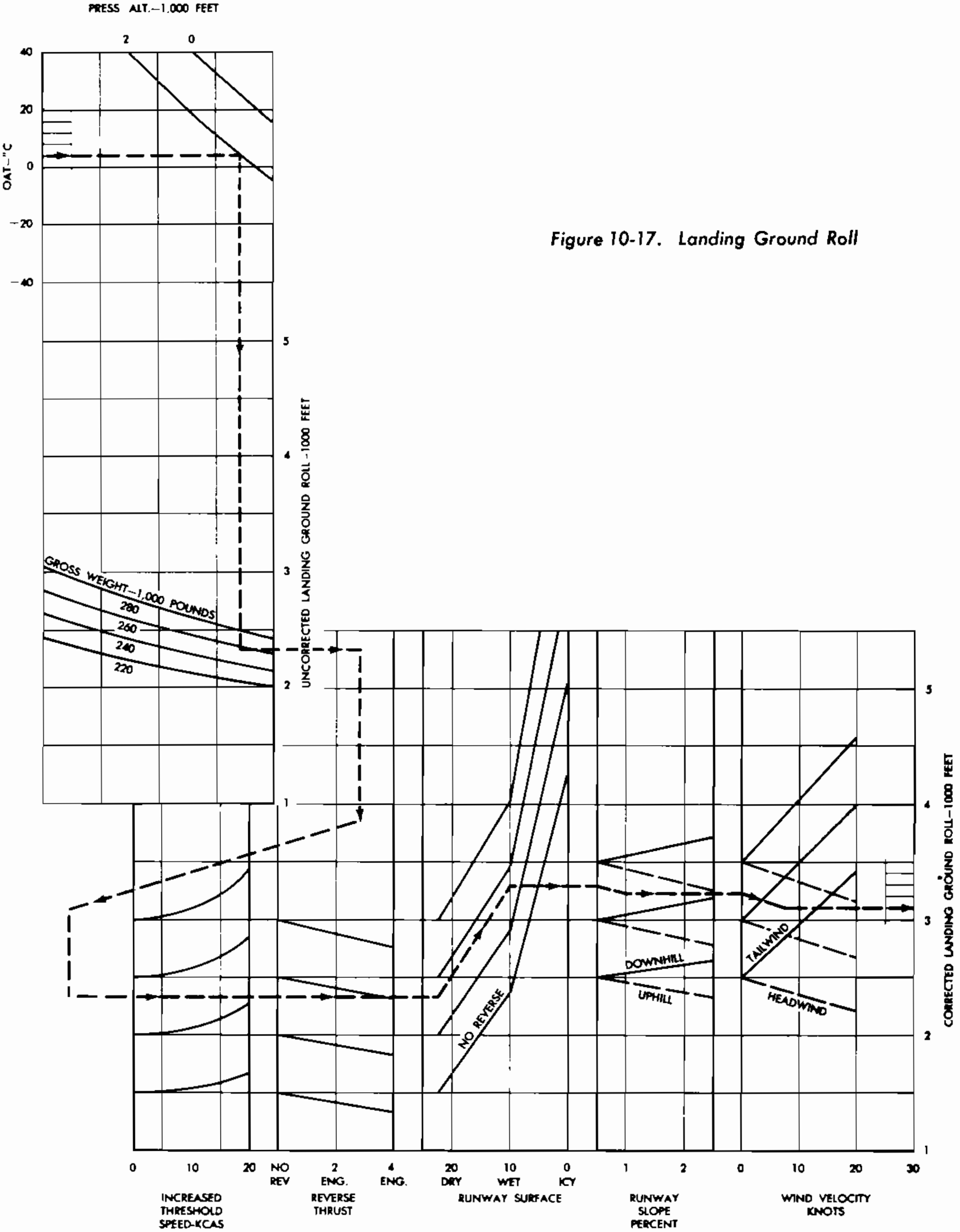


Figure 10-17. Landing Ground Roll

The aircraft performance log/plan, AF Form 796, shown in figure 10-18, is sufficiently comprehensive to accommodate the entries required for flight of reciprocating or turbine engine aircraft in use by the Air Force. However, when additional information is required to identify trends in engine failure or for special test programs, the directing headquarters usually furnishes necessary supplemental forms.

Blocks of the performance log are identified by

AIRCRAFT PERFORMANCE LOG/PLAN

AIRCRAFT NUMBER	AIRCRAFT T M S	AIRCRAFT COMMANDER	FLIGHT ENGINEER	FLIGHT ENGINEER
DATE	TO	FROM	MISSION NUMBER	WING / SQUADRON

1 FUEL DATA LBS	2 FUEL GAUGE LBS				3 WEIGHT COMPUTATIONS	
FUEL REQUIRED 81548	TANK		BEFORE	AFTER	A ACFT BASIC WEIGHT	130000
	1	1	ENTER AMOUNT OF FUEL TOTAL DISTRIBUTED IN EACH TANK.		B OIL ENGINE LBS	138
		2			C CREW	800
	2	3			D OPERATING WEIGHT	130938
		4				
FUEL RESERVE 18452	3	5			E CARGO	69062
		6			F	
	4	7			G	
		8				
OFF LOAD (For tanker use)	CW	9			H	
		10			I	
	EXT	11			J TOTAL FUEL (INTERNAL)	100000
		12				
	TOTAL		100000		K STATIC GROSS WEIGHT	300000

4 ENGINE START 0800Z	5 CREW NR	6 R STATIC MAP T OIL QTY 1	2	3	4	26 ENGINE INST F/F LBS HR	FUEL USED	FUEL REMAINING CALC	GAGE	36 FUEL USED 37 △ GR WT 38 END GR WT

7 COND 8 END	9 SET 10 TOTAL	11 OATI 12 OATC/VAR	13 HP 14 HD/HO 15 $\frac{1}{\sqrt{\sigma}}$	16 RPM 17 MAP 18 TOP 19 BHP, EPR	20 IAS/EAS 21 NMPP	22 TAS/IMACH 23 DIST 24 TOTAL AIR DIST	25 OIL QUAN EGT/TIT	1 2 3 4 TOTAL	27 PERIOD 28 EXTRA 29 TOTAL	30 PERIOD 31 TOTAL 32 100,000	33 PERIOD 34 TOTAL 35 100,000	39 — 40 — 41 300,000
WU/TAX TO 0815Z	⑬ :02	 +4	2000 1200 1.0180	— — — 1.983			↓		 3000	3000 97000	3000 97000	3000 — 297000
1 ↗ 0835	:20 :22	−30 −5	20000 34900 —	— — — 2.160	280 —	376 124 124	↓	— — — — —	8200 — 11200	8200 88800	8200 88800	8200 288800
1 → 0935	1:00 1:22	−55 —	34900 34900 —	— — — 1.800	— —	421.5 421.5 545.5	↓	3200 3200 3200 3200 12800	12800 24000 24000	12800 76000	12800 76000	12800 — 276000
2 → 1035	1:00 2:22	−55 −1	34900 34900 —	— — — 1.750	— —	421.5 421.5 967.0	↓	3000 3000 3000 3000 12000	12000 — 36000	12000 64000	12000 64000	12000 — 264000
3 → 1135	1:00 3:22	−55 —	34900 34900 —	— — — 1.725	— —	421.5 421.5 1388.5	↓	2850 2850 2850 2850 11400	11400 — 47400	11400 52600	11400 52600	11400 — 252600
4 → 1235	1:00 4:22	−55 —	34900 34900 —	— — — 1.690	— —	421.5 421.5 1810.0	↓	2810 2810 2810 2810 11240	11240 — 58640	11240 41360	11240 41360	11240 — 241360
5 → 1335	1:00 5:22	−55 —	34900 34900 —	— — — 1.650	— —	421.5 421.5 2231.5	↓	2700 2700 2700 2700 10800	10800 — 69440	10800 30560	10800 30560	10800 — 230560
6 → 1435	1:00 6:22	−55 —	34900 34900 —	— — — 1.635	— —	421.5 421.5 2653.0	↓	2600 2600 2600 2600 10400	10400 — 79840	10400 20160	10400 20160	10400 — 220160

Figure 10-18. Performance Log/Plan

number. Some of the multi-purpose blocks are indicated either by a letter, or by a slash (/) mark. Block number 6, for instance, may be used to record the static manifold pressure for a reciprocating engine aircraft as indicated by the (R), or to record the oil quantity of a turbine engine powered aircraft as indicated by the (T). You may enter the OAT C in block 12, or the temperature variation from standard required for some aircraft as indicated by the slash (/) mark. Block 14 may reflect the density altitude or the optimum altitude for the condition (HD/HO). The indicated airspeed or the equivalent airspeed may be entered at your discretion in block 20 (IAS/EAS). Then too, block 25 may show the oil quantity, the exhaust gas temperature, or the turbine inlet temperature (EGT/TIT).

Before we make the flight plan entries, let's discuss the blocks as they are numbered on the aircraft performance log/plan.

The form heading is self-explanatory. This, as you can see, reflects general information concerning the aircraft serial number, type, model, and series. The mission information disclosed in the general mission briefing is entered in the heading blocks.

Block 1 reflects the mission fuel data. This is a record of the fuel required (1) for fuel reserve, (2) for transfer to the receiver aircraft, and (3) for tanker aircraft operation.

Block 2 is a record of the aircraft internal fuel as indicated by the fuel tank quantity indicators. Notice that provisions are included to accommodate aircraft which have 12 internal fuel tanks; or for those aircraft which have 4 main tanks, center wing tanks, and external tanks.

Block 3 shows the weight computations for the mission. This block reflects the figures from your DD Form 365F, Weight and Balance Clearance, for the flight. The columns of the weight computations block which are lettered F through I, are for use at your discretion to record the weight of passengers, of emergency equipment, or of any item which is not accounted for in columns A through E. You should record the total aircraft internal fuel weight in column J and the ramp static gross weight of the aircraft in column K.

Enter the time in block 4 in GMT that the last engine is started, and the crew number in block 5.

Block 6 may show either the static manifold pressure for a reciprocating engine aircraft or the oil quantity for a turboprop engine aircraft.

Block 7—Condition: The flight symbols are as follows: a. WU/TAX/TO indicates warmup, taxi, and takeoff. b. Initial climb is indicated by the symbol ($^{1}\nearrow$) whereas secondary climb is shown as ($^{2}\nearrow$). c. Cruise conditions are indicated throughout the mission by the number in the cruise sequence and an arrow. ($^{1}\rightarrow$, $^{2}\rightarrow$, $^{3}\rightarrow$, etc.). Descents are shown by a number and an arrow ($^{1}\searrow$, $^{2}\searrow$, etc.) Do not confuse descents with the *final letdown*. This loss in altitude is indicated in the landing and taxi sequence (LT). Landing and taxi includes the time from the end of the last entry in the sequence of descent to engine shutdown after the flight. Holding time, however, must be accounted for as an additional cruise condition after descent when necessary before the landing. Enter the above symbols (a through e) in the CONDITION block 7 to show each condition of the flight throughout the mission.

Block 8— End: The ending time for each condition will be shown in GMT. Cruise time ($\rightarrow$) normally will be of not more than one-hour duration. However, the cruise immediately before en route climb, or secondary climb, or the last cruise before descent may be extended to a maximum of 1 hour and 30 minutes.

Block 9— Set: Enter the increment time duration for each flight condition. Enter all warmup and taxi time in the circle of the SET block. This differentiates the ground operational time from the actual flight time which begins when the takeoff run is started.

Block 10— Total: Enter accumulative total of time from the SET block. This time begins with the takeoff time, which is usually 2 minutes or less, and is entered accumulatively with each condition throughout the flight.

Block 11— OATI: Enter the outside indicated air temperature.

Block 12— OATC/VAR: This is a dual purpose block for entry of (1) the corrected outside air temperature, or (2) the degree of temperature variation from standard for the flight condition.

Block 13— H_p: Enter the pressure altitude for the condition.

Block 14— H_d/H_o: Enter either the density altitude or the optimum altitude to meet the requirements of the aircraft being flown.

Block 15— $\frac{1}{\sqrt{\sigma}}$: Enter the smoe factor as determined from the appropriate flight manual density altitude chart.

Block 16— rpm: Enter the average engine rpm for all reciprocating engines commensurate with the required brake horsepower for the flight condition.

Block 17— MAP: Enter the manifold pressure average for all engines which, with the rpm involved, is required to produce the brake horsepower desired for the flight condition.

Block 18— TOP: Enter the maximum torque oil pressure reading indicated for the rpm and MAP combination to obtain the desired brake horsepower.

Block 19— bhp: Enter the resultant brake horsepower from the rpm, MAP, and TOP, set for the desired brake horsepower or engine pressure ratio.

Block 20— IAS/EAS: Enter the average indicated airspeed, or the average equivalent airspeed for the flight condition.

Block 21— NMPP: Enter the charted nautical miles per pound of fuel for the average brake horsepower set for the flight condition.

Block 22— TASK/IMACH: Enter the true airspeed or the indicated MACH number.

Block 23— DIST: Enter the air distance flown during the set condition. This block reflects the time set in block 9 multiplied by the true airspeed.

Block 24— TOTAL AIR DIST: Enter the accumulative air distance flown during the successive conditions.

Block 25— OIL QUANTITY-EGT/TIT: Enter the oil quantity for reciprocating engine aircraft, the exhaust gas temperature, or turbine inlet temperature as applicable to the aircraft flown.

Block 26— ENGINE INST F/F LBS/HR: Enter the fuel flow instrument readings for individual engines.

Block 27— Period (fuel used): Enter the fuel used for the condition period, using the total for all engines as computed from the total of block 26.

Block 28— EXTRA: Enter the extra fuel required for the condition period for heaters, defueling, GTU, APU, etc. as determined from appropriate performance charts of the flight manual.

Block 29— Total: Enter accumulative total of fuel used.

Block 30— Period (Calculated): Enter the total fuel amount for this block in the same manner as you did for block 27.

Block 31— TOTAL (Calculated fuel remaining): Enter the total calculated fuel remaining, determined by subtracting the amount shown in block 30.

Block 32— RAMP CALCULATED FUEL: Enter the ramp calculated fuel aboard obtained by dipstick procedure or by total fuel quantity gage reading and applying any known correction factor.

Block 33— Period (Gage fuel remaining): Enter the increment of fuel used for the condition period, determined by the difference in the total fuel quantity gage reading for the preceding period.

Block 34— TOTAL (Gage fuel remaining): Enter the total fuel aboard as indicated by the fuel quantity gages.

Block 35— Ramp fuel aboard: Enter the total of all fuel quantity gage readings.

Block 36— Fuel used: Same as block 29.

Block 37— Δ Gross Weight: Enter any weight correction factor (change) determined by comparing the calculated gross weight of the aircraft with the actual performance weight.

Block 38— End gross weight: Enter the aircraft gross weight at the end of the condition period, determined by subtracting the fuel used for the period from the gross weight at the end of the previous period.

Block 39: Enter the total ramp aircraft gross weight.

Block 40: Enter the fuel used for WU/TAX/TO.

Block 41: Enter the aircraft gross weight determined by subtracting the amount shown in block 40 from the gross weight figure of block 39. (The resultant figure for entry into block 41 represents the aircraft gross weight immediately after takeoff.)

Block 42— Remarks: Enter any remark pertinent to the flight which you feel noteworthy.

Block 43—AIR REFUELING DECK TANKS: Enter the total fuel quantity of the forward and aft deck tanks, before and after the refueling process. Record the amount off-loaded in the appropriate columns.

Block 44— OIL GAGE (Gallons): Enter the oil quantity of each engine oil tank and the central oil tank, before and after the flight. Enter the amount transferred in flight from the central oil tank to the individual engine oil tanks.

With the foregoing discussion of the aircraft performance log/plan in mind, let's proceed to make the required entries for a predicted flight plan.

As you recall, the known data were stated earlier in this chapter for computations of the TOLD and takeoff flight plan entries. The parts of those data which apply to the computations for takeoff entries for the flight plan are as follows: Gross weight 300,000 pounds, OAT C+4°, and pressure altitude 2,000 feet. Further, let's assume that our total fuel aboard is 100,000 pounds. Now, from these data, we can complete the takeoff portion of the flight plan.

Block 1 through 6 of the performance log may be completed as the *known* data. Let's assume that the engine start time for our illustrative problem is 0800 Z. Enter this time in block 4 of the flight plan. Further, let's assume that the planned takeoff time is 0815 Z. Enter this time in block 8. This gives us an elapsed time of 15 minutes from engine start to takeoff. Break this total elapsed time down as previously discussed, and enter :13 minutes in the circle in block 9 (set), and :02 minutes in block 10 (total). This designates :13 minutes for engine start and taxi, and :02 minutes for takeoff.

Enter the OAT +4°, in block 12 OAT C. Notice that block 11 is blanked out for the takeoff condition since we use only calibrated temperature for this period.

Enter the field pressure altitude (2000 feet) in block 13. To determine the correct density altitude for the pressure altitude of 2000 feet, refer to the density altitude chart in figure 10-19. Enter the bottom of the chart with the existing temperature (4° C). Move vertically to the 2000 foot pressure altitude line, and read the density altitude in the left hand margin as 1200 feet. Then stay on the 1200 foot density altitude grid line and move to the right hand margin and read the smoe factor as 1.0180. Enter the density altitude in block 14, and the smoe factor in block 15.

We do not use blocks 16, 17, and 18 in this problem since these blocks are used for reciprocating engine aircraft only.

In chapter 2, you learned that the slide rule or computer can be used to determine density altitude and smoe. At this stage of the mission. however, the density altitude chart of the flight handbook is more expedient.

Block 19 reflects the engine pressure ratio. EPR. As you recall, the EPR was previously computed and recorded on the TOLD card. Merely enter the computed figure here as it appears on the TOLD card as 1.983.

Notice that blocks 20 and 21 are blanked out, since the airspeed and the fuel consumption are precomputed for the takeoff condition period. Likewise. no values are entered in blocks 22, 23, and 24 for the takeoff condition.

Enter the maximum exhaust gas temperature (EGT) in block 25. The turbine engine aircraft selected for our problem has a limit of 555 degrees for the EGT.

Block 26 is blanked out for the takeoff condition since the weight of fuel used for this period is of a pre-computed value. For the same reason, blocks 27 and 28 are left blank.

Block 29 shows the total fuel used for the warm-up, taxi, and takeoff (WU/TAX/TO) period. For practical reasons, each command has individual regulations which specify a definite amount of fuel as standard for the WU/TAX/TO period. For instance. the aircraft used for our illustrative problem has a standard amount of fuel of 1,500 pounds, plus 100 pounds per minute, from engine start until takeoff. Consequently, the amount of fuel used for WU/TAX/TO is 3,000 pounds; 1.500 pounds basic amount. plus 100 pounds per minute for a period of 15 minutes since we start engine at 0800 Z and takeoff at 0815 Z. Enter 3.000 pounds in block 29 for calculated total fuel used. Assume the fuel quantity gages to be accurate, and enter 3.000 pounds in block 34 for total fuel used as indicated by the fuel gages.

Enter 3,000 pounds in block 36 for fuel used, in the gross weight column.

Subtract 3.000 pounds from the total fuel shown in block 32, and arrive at 97,000 pounds of calculated fuel remaining after takeoff. Also, subtract 3,000 pounds from the total amount shown in block 35, and determine the gage fuel remaining after takeoff as 97,000 pounds.

To determine the aircraft gross weight after takeoff, subtract 3,000 pounds of fuel from the ramp gross weight figure (300,000) and arrive at 297,000 pounds.

Figure 10-20 shows the aircraft preformance log/plan with entries completed through the WU/TAX/TO condition period for the mission.

Now, with takeoff computations completed and the data properly entered on the flight plan, we are ready to compute the data for the climb. The climb speed for our aircraft is 280 knots. Three

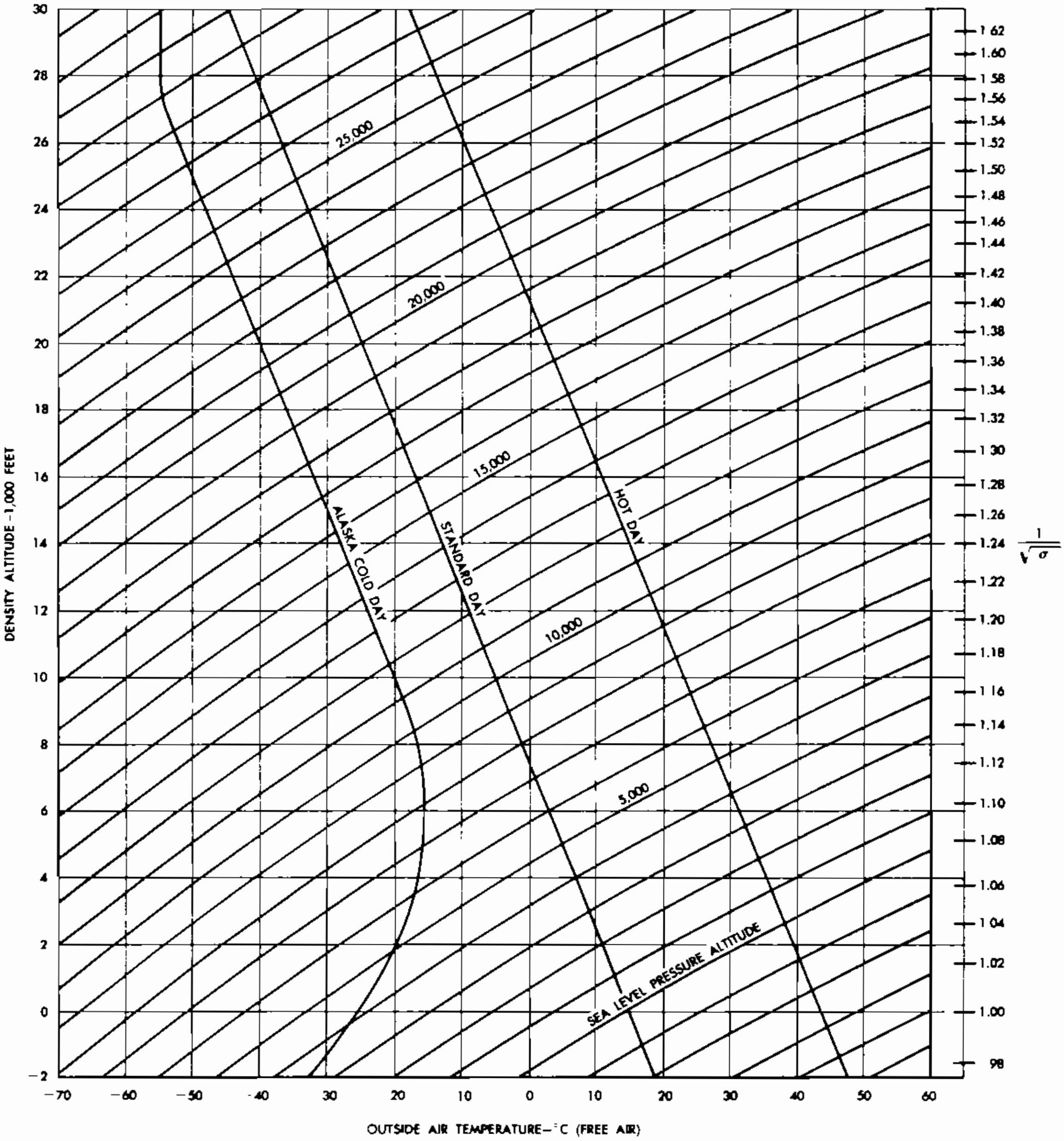
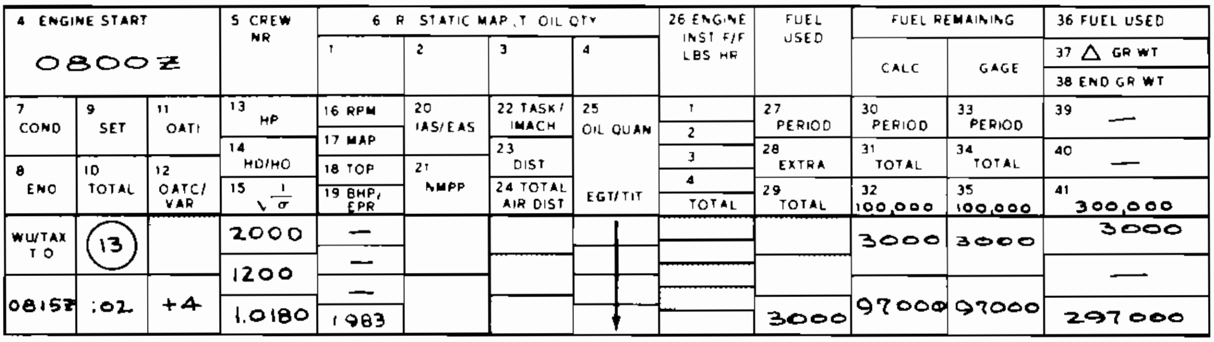


Figure 10-19. Density Altitude

factors must be considered for proper climb computations: (1) time, (2) fuel, and (3) temperature variation from standard. Compute the climb time first.

For this problem, notice from the chart, figure 10-21, that the optimum cruise climb altitude for our gross weight is 34,900 feet and that we plan to reach this altitude in two climb steps. The first step is a climb from the field to 20,000 feet and the second step, from 20,000 feet to the optimum cruise climb altitude. Determine the climb time from the chart shown in figure 10-21 as follows. Enter the chart at the bottom with the aircraft gross weight computed for the end condition of the takeoff (297,000 pounds). Move vertically to the pressure altitude line of 20,000 feet, and follow that grid line horizontally to the right to the zero line of the temperature section of the chart. Assume the existing temperature at 20,000 feet to be minus 30 degrees. The standard temperature



4 ENGINE START 0800Z			5 CREW NR	6 R STATIC MAP/T OIL QTY				26 ENGINE INST F/F LBS HR	FUEL USED	FUEL REMAINING		36 FUEL USED
				1	2	3	4			CALC	GAGE	37 △ GR WT 38 END GR WT
7 COND	9 SET	11 OATI	13 HP	16 RPM 17 MAP	20 IAS/EAS	22 TASK/IMACH	25 OIL QUAN	1 2	27 PERIOD	30 PERIOD	33 PERIOD	39 —
8 ENO	10 TOTAL	12 OATC/VAR	14 HD/HO 15 $\frac{1}{\sqrt{\sigma}}$	18 TOP 19 BHP/EPR	21 NMPP	23 DIST 24 TOTAL AIR DIST	EGT/TIT	3 4 TOTAL	28 EXTRA 29 TOTAL	31 TOTAL 32 100,000	34 TOTAL 35 100,000	40 — 41 300,000
WU/TAX TO	⑬		2000 1200	— —			↓			3000	3000	3000 —
0815Z	:02	+4	1.0180	— 1983					3000	97000	97000	297 000

Figure 10-20. Flight Plan—Wv/TAX/TO Condition

for 20,000 feet is minus 25 degrees, so we have a minus 5 degrees variation from standard to account for in our climb time. The standard temperature may be determined from your computer in the following manner: Set 20,000 feet under the pointer in the *density altitude* window. Now read minus 25 degrees directly over the 20,000 feet figure in the *standard atmosphere altitude* window. As you know from your study of the computer in Chapter 2, any problem pertaining to standard altitude and density altitude may be solved in the same manner as presented above.

From the zero line of the temperature variation section of the chart in figure 10-22, parallel the

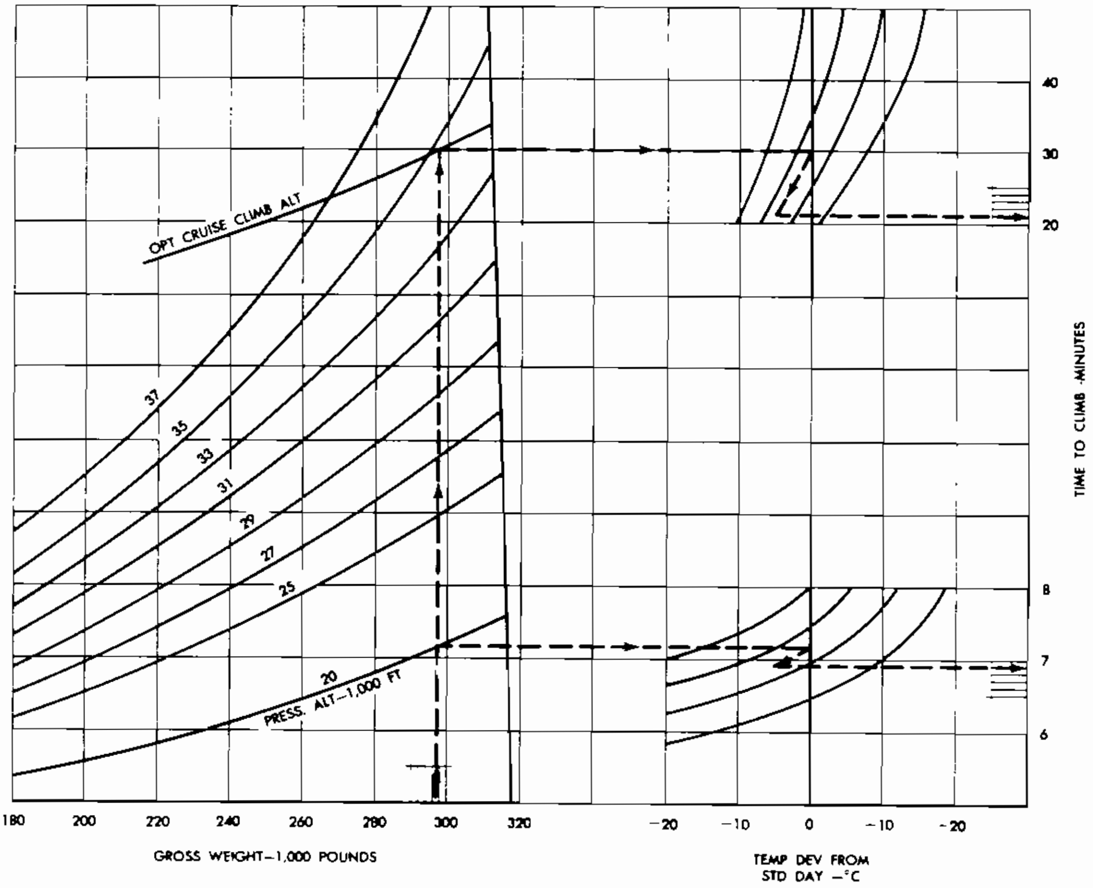


Figure 10-21. Climb Time

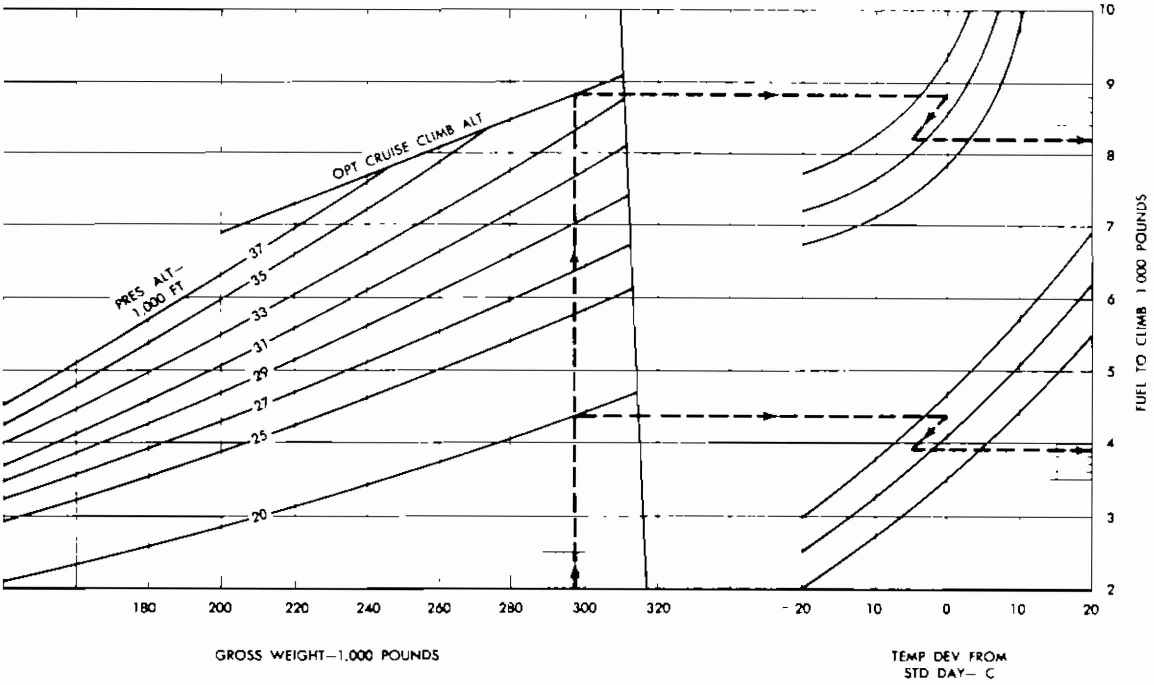


Figure 10-22. Climb Fuel

curving line down to the minus 5 degrees variation line, then read 3,900 pounds of fuel required for the climb to 20,000 feet in the right-hand margin.

Now, if it were necessary to hold at 20,000 feet before completing the climb to optimum altitude, you would enter the figures obtained for the climb time and for the fuel in the flight plan. But since our newly computed gross weight (297,000 pounds minus 3,900 pounds of climb fuel) equals 293,100 pounds, we may climb on to optimum altitude.

Re-enter the climb time chart shown in figure 10-21 and carry your plotted problem for 20,000 feet on up to the optimum cruise climb altitude line of 34,900 feet. Then account for the temperature deviation from standard as illustrated, and determine the climb time as 21.1 minutes. Round the time off to the nearest tenth of a minute and enter 20 minutes for the climb in the SET block 9 of the flight plan which we shall introduce later. Add this time to the :02 minutes reflected for the takeoff time, and record :22 minutes total flight time in block 10.

The END time for the climb condition is 0835 Z.

Enter the indicated air temperature (OATI)—30° in block 11, and the temperature variation (—5 degrees) in block 12.

Enter the pressure altitude (H_p), 20,000 feet, in block 13, and the optimum altitude (H_o) 34,900 feet in block 14.

Compute the engine pressure ratio (EPR) for the climb from the chart shown in figure 10-23. Enter the bottom of the chart with the temperature (—30°) and ascend to the pressure altitude line (20,000 feet). Read the EPR in the left-hand margin as 2.160, and enter this figure in block 19.

The indicated climb speed for our aircraft as you recall, is 280 knots. Enter this speed in block 20, and the true air speed, 376 knots, in block 22.

For the distance block 23, compute the nautical miles traveled in the climb from the range chart, figure 10-24. Enter at the bottom with the gross weight as illustrated. Follow that grid line up to the optimum altitude line, move from there to the right, account for the temperature deviation and read the climb range in the right-hand margin as 124 nautical miles. Enter this figure in block 23 for the DISTANCE traveled in this condition period, and also in the TOTAL AIR DISTANCE block 24.

Enter the exhaust gas temperature (EGT) for each engine in block 25.

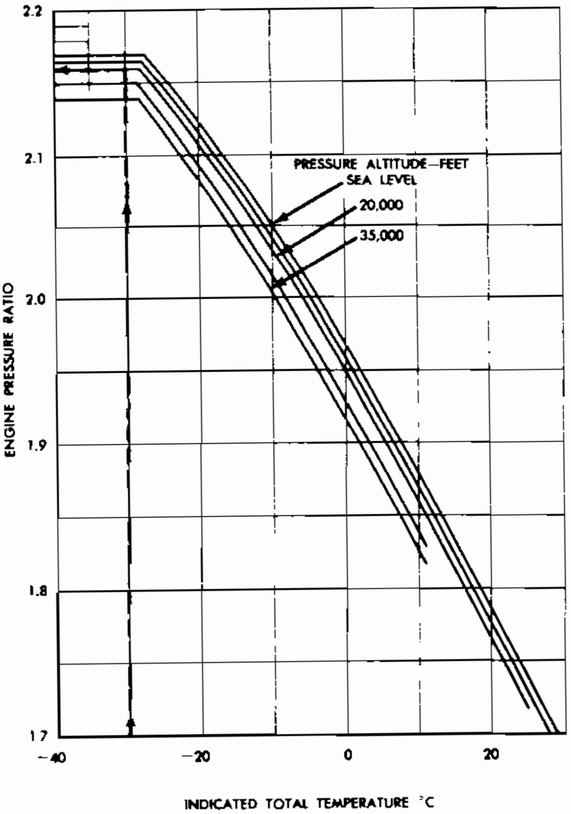


Figure 10-23. Climb EPR

Now re-enter the climb fuel chart shown in figure 10-22, and compute the fuel consumed for the entire climb, as 8,200 pounds. This figure represents the fuel consumption for four engines. Divide that figure by four (8200 ÷ 4 = 2050) to arrive at a fuel consumption figure per engine. Since we are here concerned with flight plan fuel, however, we need only the total charted figure for the climb fuel. So enter the total climb fuel weight of 8,200 pounds in blocks 27, 30, 33, and 36. Add the values of block 27 to obtain the total fuel used, 11,200 pounds. Subtract 8,200 pounds from 97,000 pounds in blocks 30 and 33 to determine the fuel remaining at the end of the climb condition period.

Determine the aircraft gross weight at the end of the climb condition period by subtracting 8,200 pounds of fuel from the end of takeoff gross weight of 297,000 pounds. Thus you have a gross weight of 288,800 pounds for the end of the climb condition period.

A strip of the flight plan depicting the climb condition is illustrated in figure 10-25.

Now with the end of climb gross weight, fuel consumption, and fuel remaining properly computed, you are ready to establish the condition for the first cruise period.

The first consideration for the cruise period will be time. Normally this is based on one-hour increments. The horizontal arrow in block 7 of the flight plan indicates the first cruise period, and the END block 8 will reflect the condition ending time of 0930 Z hours.

Block 9, SET time will show one hour, and the TOTAL block 10 will indicate the total elapsed time of the mission which is 1 hour and 22 minutes (1:22).

The standard temperature for the cruising altitude is minus 55 degrees. Let's assume the temperature to be standard and enter this temperature in block 11, which results in no temperature variation.

The pressure altitude (H_p) is 34,900 feet for entry into block 13. Since the temperature is standard for this altitude, the density altitude (H_d) is the same as the pressure altitude (H_p). So enter 34,900 feet in block 14.

Now we are ready to establish a cruise engine pressure ratio (EPR), and a cruising speed. Enter the thrust EPR setting chart in figure 10-26 with the level-off gross weight, 288,800 pounds. Move inward on that gross weight grid line and interpolate the 34,900 foot pressure altitude line. The normal cruising speed is 0.74 True MACH. Descend directly on the chart from the 34,900 foot pressure altitude line to the curving line which depicts MACH 0.74, as illustrated. Then read the EPR of 1.80 directly in the left-hand margin, and enter that number in block 19.

Now we must convert the MACH number to a true airspeed in knots to properly determine the distance traveled. To do this, enter the chart shown in figure 10-27 at the left-hand margin with MACH number 0.74. Move horizontally to the right and interpolate the temperature of −55 degrees. From that point, move directly downward to read the true airspeed (421.5) at the bottom of the chart. Enter the speed of 421.5 in block 23 as the distance traveled in that condition. Add the figure in block 23 to the total air distance block of the preceding climb condition, and enter the resultant 545.5 miles in block 24. This figure represents the total air distance flown in the mission at the end of the first hour of cruise.

Now determine the fuel used in one hour of

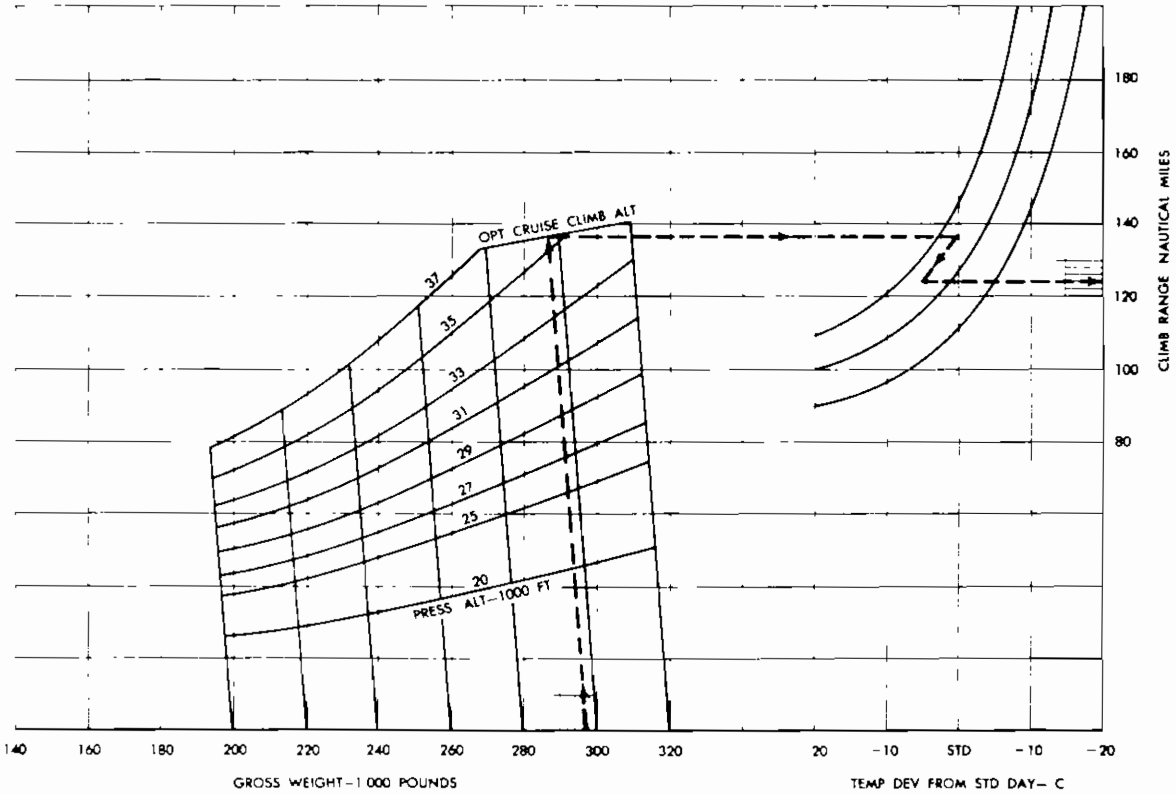


Figure 10-24. Climb Range

cruise at the present condition. Enter the first part of the fuel flow chart illustrated in figure 10-28 at the bottom with the EPR, 1.80. Move vertically to 0.74 MACH then directly to the reference number (12) indicated in the left-hand margin of the illustration to the right. With this reference number move inward to the temperature line (—55 degrees C) and vertically to the pressure altitude line (34,900 feet). Then directly to the left, read the fuel flow of 3,200 pounds per hour for one engine. Enter this amount in the appropriate spaces provided for each individual engine fuel flow in block 26. Total the amount entered as 12.800 pounds for all engines. and enter this figure in blocks 27. 30. 33 and 36. Add the figure thus obtained to the previous climb condition figure and arrive at 24.000 pounds of fuel used after the first hour of cruise in the mission. Enter the total amount in block 32. Subtract the fuel flow pounds for the hour cruise (12.800 pounds) from the previous climb condition fuel figures in blocks 30 and 31 to determine the fuel remaining as 76.000 pounds. Subtract the fuel flow pounds for one hour cruise from the previous gross weight figure. 288.800 pounds, to determine a new gross weight of 276,000 pounds. Enter this figure for the cruise 1 ending gross weight.

A strip of the flight plan depicting the condition period for cruise 1 is illustrated in figure 10-29.

For cruise 2. the condition period time blocks (8 and 9) will be the same as the time for cruise 1, of one hour duration. The total flight time

1 ↗	:20	−30	20000	— —	280	376			— —	8200	8200	8200	8200
			34900	—		124			—	—			
0835	:22	−5	—	2.160	—	124	↓		— —	11200	88800	88800	288800

Figure 10-25. Flight Plan—Climb Condition

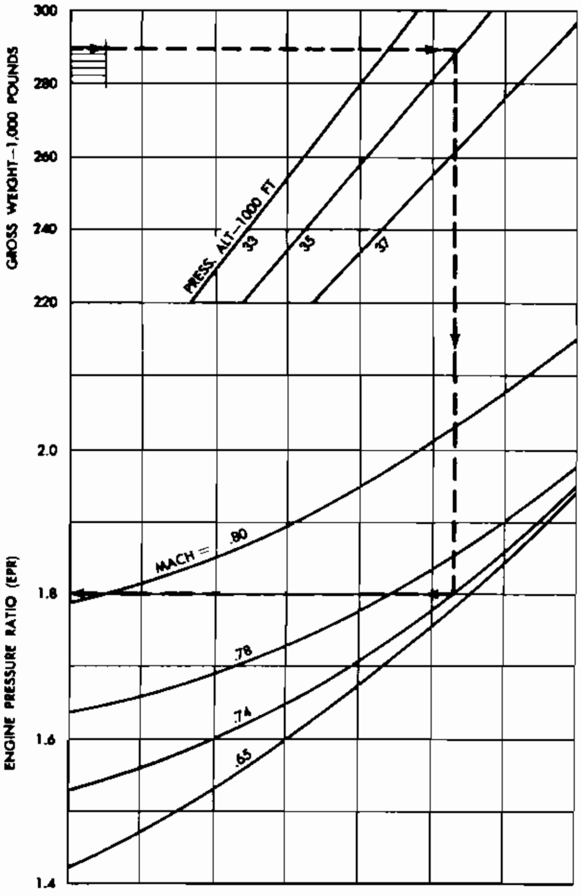


Figure 10-26. Thrust EPR

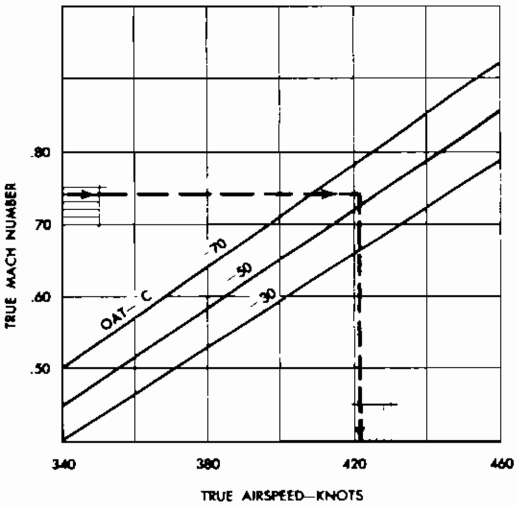


Figure 10-27. Conversion—(Mach—True Airspeed)

shown in block 10, however, will increase by one hour, making a total of 2 hours and 22 minutes (2:22) into the mission. Blocks 11, 13, and 14 remain the same since the temperature, pressure altitude, and density altitude do not change for cruise 2. However, a new EPR for cruise 2 must be computed.

To compute the new EPR for cruise 2, re-enter the thrust chart in figure 10-26. Use the ending gross weight from cruise 1 (276,000 pounds) for

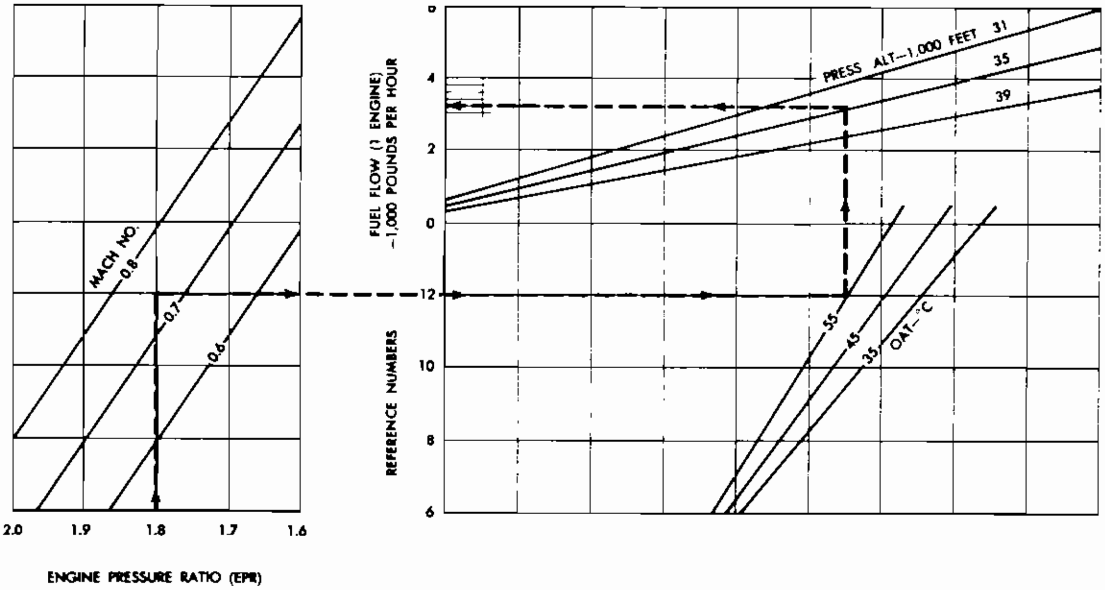


Figure 10-28. Cruise Fuel Flow

1 →	1:00	-55	34900	—	—	421.5		↓	3200	12800	12800	12800	12800
				—					3200				
0935	1:22	—	34900	—	—	421.5			3200	24000	76000	76000	—
			—						3200				
				1.800		545.5			12800	24000			276000

Figure 10-29. Flight Plan—Cruise 1

entry into the chart. Parallel the original problem, using the new gross weight figure, 34,900 feet pressure altitude, MACH number 0.74 and determine the new EPR as 1.75 for cruise 2. Enter that number in block 19. See figure 10-30.

Blocks 22 and 23 remain the same for cruise 2 (421.5 knots) since the MACH number, pressure altitude, and temperature have not changed from those entered for cruise 1. Add the condition period distance (421.5 nautical miles) shown in block 23 for cruise 2 to the total air distance shown in block 24 for cruise 1. This results in a total air distance of 967.0 nautical miles flown at the end of cruise 2 in the mission. Enter that figure in block 24.

The entries for block 25, EGT, remain the same for cruise 2 as those entered for cruise 1.

A fuel flow for cruise 2 must be computed. Reenter the fuel flow chart shown in figure 10-28 and determine the fuel flow per engine. Enter the chart at the bottom with the EPR newly determined (1.75) for cruise 2. Parallel the fuel flow problem illustrated for cruise 1, and determine the fuel flow for cruise 2 as 3,000 pounds of fuel per engine. Enter this figure in each individual engine space of block 26, and total the amount for all engines as 12,000 pounds for cruise 2. Enter this total figure in blocks 27, 30, 33, and 36.

Add the figure in block 27 for cruise 2 to the total figure shown in block 29 for cruise 1. Enter the sum of 36,000 pounds in block 29 for cruise 2. This figure represents the total amount of fuel used on the mission at the end of cruise 2.

Subtract the figures shown in blocks 30 and 33 for cruise 2 from those figures shown in blocks 31 and 34 respectively for cruise 1. This shows a calculated and a gage amount of fuel remaining after cruise 2 as 64,000 pounds. Subtract the fuel weight for cruise 2 entered in block 36 from the ending gross weight block 38 for cruise 1, and enter the result in block 38. This shows the ending gross weight of 264,000 pounds for cruise 2. A strip of the flight plan showing the entries for cruise 2 is illustrated in figure 10-30.

For each successive cruise leg as the flight progresses through the mission, re-enter the charts as illustrated for cruise 1 and 2 and compute current data. This means that for each cruise period, not to exceed 1-hour duration, a current EPR, condition distance, total air distance, and total fuel flow must be determined. Also, compute an accurate figure for the fuel used, fuel remaining, and gross weight for each cruise condition of the flight. Figure 10-31 shows the cruise conditions for the succeeding four periods, (cruises 3, 4, 5, 6) which gives us a total of six cruise periods for the mission.

After the cruise legs of the mission are complete, determine the data for the descent and landing at the destination. There are, of course, different types of descents which are best suited to the type of aircraft flown, the nature of the mission, or surface topography. Local policy, however, will in most cases dictate the type of descent procedure employed.

For the turbine engine powered aircraft selected for our problem, an en route type descent is best suited for reasons of both economy and penetration. To properly determine the data for this type of descent, four factors must be considered: (1) descent speed, (2) descent time, (3) descent range, and (4) descent fuel.

DESCENT SPEED. Enter the descent chart shown

2 →	1:00	-55	34900	—	—	421.5		↓	3000	12000	12000	12000	12000
				—					3000				
1035	2:22	-1	34900	—	—	421.5			3000	—	64000	64000	—
			—						3000				
				1.750		967.0			12000	36000			264000

Figure 10-30. Flight Plan—Cruise 2

3 →	1:00	−55	34900 34900	— —	—	421.5 421.5			2850 2850 2850	11400 —	11400	11400	11400 —
1135	3:22	—	—	— 1.725	—	1388.5	↓		2850 11400	47400	52600	52600	252600
4 →	1:00	−55	34900 34900	— —	—	421.5 421.5			2810 2810 2810	11240 —	11240	11240	11240 —
1235	4:22	—	—	— 1.690	—	1810.0	↓		2810 11240	58640	41360	41360	241360
5 →	1:00	−55	34900 34900	— —	—	421.5 421.5			2700 2700 2700	10800 —	10800	10800	10800 —
1335	5:22	—	—	— 1.650	—	2231.5	↓		2700 10800	69440	30560	30560	230560
6 →	1:00	−55	34900 34900	— —	—	421.5 421.5			2600 2600 2600	10400 —	10400	10400	10400 —
1435	6:22	—	—	— 1.635	—	2653.0	↓		2600 10400	79840	20160	20160	220160

Figure 10-31. Flight Plan—Cruise 3, 4, 5, 6

in figure 10-32 with the en route cruising altitude (34,900 feet). Move inward to the weight line which depicts the ending gross weight for the last cruise, condition 6 (220,160 pounds). From that point, descend vertically to the bottom of the chart to determine the rate of descent as 2,350 feet per minute. Then return to the intersection of the gross weight and cruising altitude lines, and follow that grid line horizontally to the MACH 0.74 line. Directly above this intersecting point, at the top of the chart, read the descent speed as 252 knots. Enter this figure in block 22, for the chart descent speed.

Descent Time. Determine the descent time from the chart shown in figure 10-33. First, enter with cruising altitude, then move inward to the gross weight line, and read the descent time at the bottom of the chart as 15.8 minutes. Round off this value to 16 minutes, and enter this descent

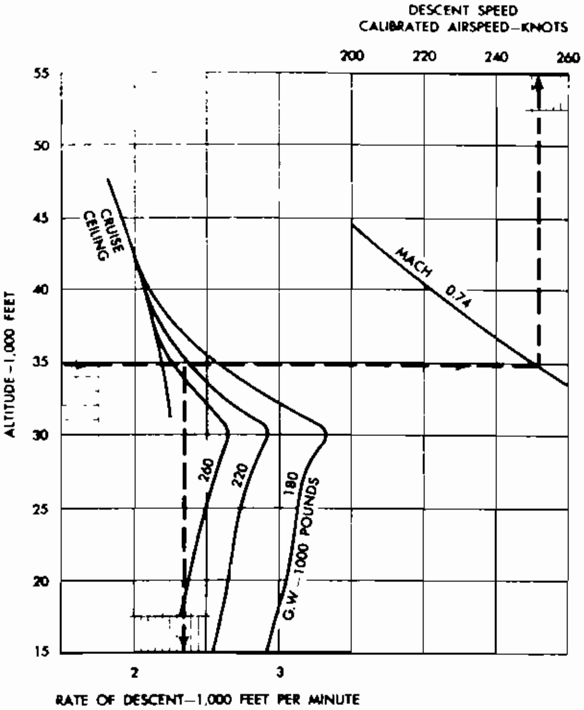


Figure 10-32. Descent Chart—Speed

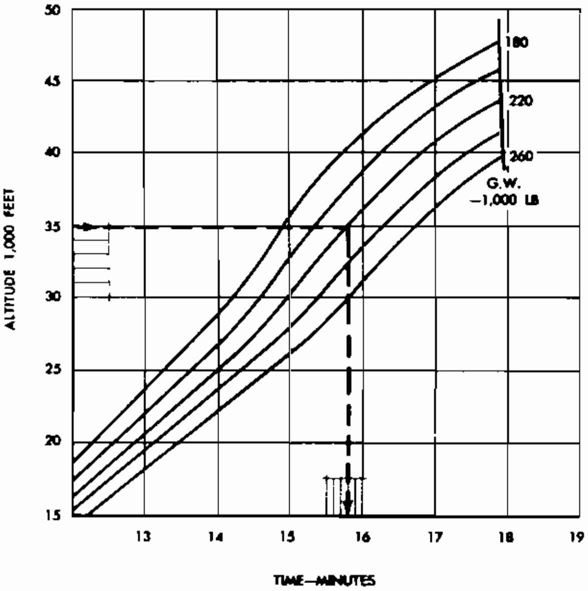


Figure 10-33. Descent Chart—Time

time in block 9. Add the descent set time (16 minutes) to the total elapsed flight time shown in block 10 to determine the elapsed time to the end of descent (6:38). Enter the total elapsed flight time of 6 hours and 38 minutes in block 10.

Now that we have determined the time required for descent, we can enter the END condition time for the descent period. Add the descent time (:16) to clock END time for cruise 6 (1435), and enter 1451 hours in block 8 as the END clock time for the descent condition period.

The OATI, block 11 and OATC block 12, are not relevant to the chart values for the descent data, so you may leave these blocks blanks for descent, unless local policy requires an entry to record the temperature.

DESCENT RANGE. Determine the descent range from the chart in figure 10-34. Enter the chart with the cruise altitude, move horizontally to the gross weight line, and descend vertically to the range distance of 94 nautical miles. Add this distance to the total air distance flown at the end of cruise 6, and enter the figure (2747 miles) in block 24. This figure represents the total air miles flown in the mission at the end of the descent.

DESCENT FUEL. Determine the fuel used in the descent from the descent fuel chart, figure 10-35. Enter with the cruising altitude, account for the gross weight, and plot the fuel used for descent as 708 pounds. Since this is a charted flight plan and you are interested at this point in total descent fuel, write in the word *descent* for the individual engine amounts for block 26. Enter the obtained chart fuel amount (708 pounds) for descent in blocks 27, 30, 33, and 36. Add the figure in block 27, and subtract the figures in blocks 30, 33, and 36. Thus you have 80,548 pounds of fuel used, and 19,452 pounds of fuel remaining at the end of the descent condition.

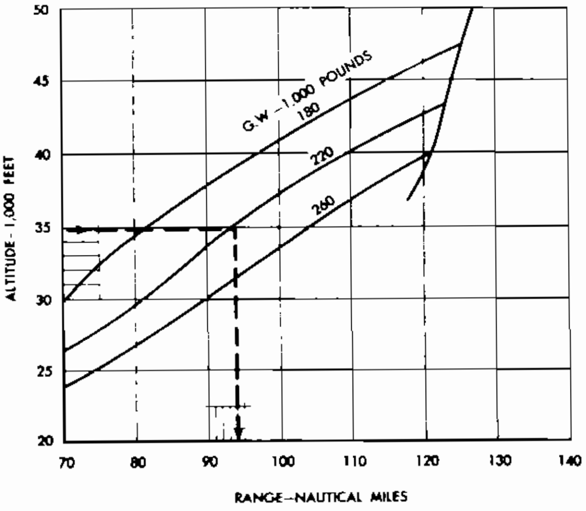


Figure 10-34. Descent Chart—Range

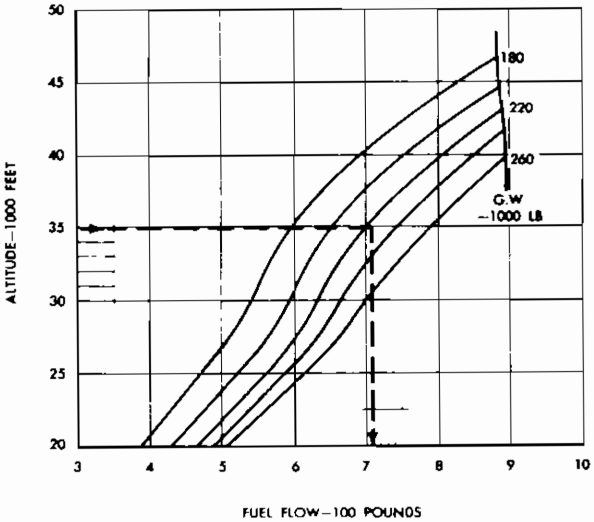


Figure 10-35. Descent Chart—Fuel

LANDING AND TAXI FUEL. The landing and taxi operation begins at the end of the descent, at traffic altitude over the destination. The time for landing and taxi may vary, depending on the traffic conditions and weather; however, 20 minutes is considered as the average landing and taxi time.

The power setting and thrust during landing and taxi varies considerably, so no EPR is recorded on the predicted flight plan. A standard fuel flow in pounds is calculated for use in landing and taxi. For the turbine engine aircraft for our problem, a standard fuel consumption of 1,000 pounds is used. No airspeed is recorded on the predicted flight plan for the landing and taxi operation. Since this operation usually takes place as the aircraft circles the destination in the traffic pattern, no distance along the course is recorded. The significant flight plan entries for the landing and taxi operation are those relating to time elapsed and fuel consumed.

Block 7 reflects the flight condition as L&T, and block 9 shows the SET time as 20 minutes (:20). Add the 20 minutes to the ending clock time of the descent condition period (1451), and enter 1511 in block 8 as the END clock time for landing and taxi. This represents the end-of-mission time.

Enter the standard landing and taxi fuel weight of 1,000 pounds in block 27. Add that figure to the total fuel used figure (80,548 pounds) reflected in block 29 for the descent condition. Enter the sum of the added figures 81.548 pounds in block 29 for the total fuel used at the end of the landing and taxi operation. This figure represents the total fuel used during the entire mission.

Enter the 1,000 pounds of fuel for landing and taxi in blocks 30, 33, and 36. Then, subtract that amount from the fuel remaining totals and the ending gross weight for the descent condition period. Thus you have the calculated and gage reading for fuel remaining at 18,452 pounds. Enter this figure in blocks 31 and 34. This figure represents the total fuel remaining at the end of the mission.

Finally, subtract the landing and taxi fuel weight (1000 pounds), entered in block 36, from the ending gross weight for the descent condition period. The result shows the mission termination gross weight of 218,452 pounds, at the end of the landing and taxi operation condition period.

A strip of the flight plan entries for the descent, and the landing and taxi condition periods is shown in figure 10-36.

Thus you have the operational data for the flight plan completed. From the computed data, you may now determine the mission fuel required and the fuel reserve. As you recall, computations of fuel reserve requirements were previously discussed in chapter 9. If you find a review of the subject necessary at this time, reread the section of chapter 9 entitled FUEL RESERVES.

The discussion previously presented is of a general nature to include the procedure used for reserve fuel computations for aircraft of all types. However, the provisions of Air Force Manual 60-16, General Flight Rules, individual command regulations, and local policies must be adhered to when computing reserve fuel requirements. At any rate, the total of the wind reserve, three-engine reserve, and the endurance reserve, will be entered in the fuel reserve section of block 1 of the flight plan. For illustrative purposes, the computed total fuel reserves for our flight plan problem is 18,452 pounds. The fuel required for the mission, based on chart computations is 81,548 pounds. The total of the *required* fuel and *reserve* fuel equals 100,000 pounds, as reflected in the total internal fuel aboard.

Enter the required fuel and the reserve fuel in the fuel data block 1 of the flight plan as previously illustrated in figure 10-20.

FLYING THE MISSION

The successful accomplishment of the mission is the end result of applying all the knowledge gained through previous study, through training and experience, and through the application of judgment. Regardless of the type of aircraft flown, the essential demands of the mission are the same—to obtain safe, economical operation within the performance capability of the specific aircraft. Once an aircraft is designed and built around a given powerplant, little can be done to change its performance characteristics. However, much can be done within these design limitations to obtain operational economy and reliability. It is the duty of the flight engineer to study these performance characteristics, and to develop methods, techniques, and procedures that result in efficient, economical operation of the aircraft-powerplant combination.

During flight, it is the flight engineer's responsibility to advise and assist the aircraft commander in accomplishing the assigned mission. The flight engineer should be aware of the forces acting on the aircraft, and he should understand what means are at his disposal for controlling these forces.

Aircraft performance is not a hit or miss proposition; it is predictable and controllable through the correct use of the proper relationship of altitude, airspeed, and horsepower or thrust. The Predicted Flight Plan (AF Form 796), as studied previously, is an example of how performance is predictable at al stages of the flight. When it comes to flying the actual mission, however, the predicted and actual flying conditions seldom coincide because of the presence of unpredictable variables. Therefore, as flight engineer, it is your duty to determine the exact performance characteristics of the aircraft early in the mission and to use this information in replanning subsequent phases of the mission. You accomplish this by making inflight entries on the performance log. Then, as the mission progresses through the condition periods of the flight, you compare the actual flight entries with those which you had made on the predicted flight plan. Thus, you have readily available the predicted data and the actual flight data on which to base your analyses of the aircraft and engine performance.

								26 ENGINE INST F/F LBS HR	FUEL USED	FUEL REMAINING CALC	FUEL REMAINING GAGE	
7 COND 8 END 1435	9 SET 10 6:22	11 OATI 12 OATC/VAR	13 HP 14 HD/HO 15 $\frac{1}{\sqrt{\sigma}}$	16 RPM 17 MAP 18 TOP 19 BHP/EPR	20 IAS/EAS 21 NMPP	22 TASK/MACH 23 DIST 24 TOTAL AIR DIST	25 OIL QUAN EGT/TIT	1 2 3 4 TOTAL	27 PERIOD 28 EXTRA 29 79840	30 PERIOD 31 TOTAL 32 20160	33 PERIOD 34 TOTAL 35 20160	36 FUEL USED 37 Δ GR WT 38 220160
↘ |	:16	—	— —	— —	—	252 94	↓	DESCEND	708 —	708	708	39 708 40 —
1451	6:38	—	—	— —	—	27470			80548	19452	19452	41 219452
LET	:20	—	— —	— —	—		↓		1000 —	1000	1000	1000 —
1511	6:58	—	—	— —	—				81548	18452	18452	218452

42 REMARKS

43 AIR REFUELING DECK TANKS

	BEFORE	AFTER	OFF LOADED
FWD			
AFT			
TOTAL			

44 OIL GAUGE GALLONS)

TANK	BEFORE	AFTER	OIL TRANSFERED
1			
2			
3			
4			
C			

Figure 10-36. Flight Plan—Descent, L & T

Final Station

At a time established during the detailed briefing for the mission, the final station procedures are completed. Final station time is usually 2 hours before the scheduled takeoff time. The procedures vary somewhat with local SOPs, but with slight variations, the following routine prevails:

- Crew inspection
- Final crew briefing and TOLD card presentation
- Boarding the aircraft
- Initiating the flight log

CREW INSPECTION. The aircraft commander conducts an inspection of the crew members and their equipment required for the mission. The crew inspection assures the aircraft commander that all crew members are present with the proper equipment to sustain the mission through normal and possible emergency conditions dictated by the mission plan. In order that these inspection procedures may be standardized, individuals and their personal equipment are usually aligned in appropriate rows, and the rollcall and inspection proceeds in a military manner.

FINAL CREW BRIEFING. This final meeting is generally used for the following purposes:

- To make a final check on crew members and passengers.
- To obtain results of the preflight inspection.
- To complete any final entries in the DD Form 781 and Form F.
- To review pertinent emergency signals, routine scanner reporting, emergency positions and exits, oxygen positions, and "abort takeoff" procedures.
- To cover any changes in route, altitude, or duration of flight dictated by weather or the clearing authority.
- To answer any questions the crew might have.

At this time, the flight engineer presents the TOLD card to the aircraft commander and answers any questions that may arise from the computations on the card.

BOARDING THE AIRCRAFT. As indicated during the preflight operational equipment check, a good mission starts from the individual crew stations aboard the aircraft. Go aboard, stow your equipment properly, and proceed directly to your station with proper equipment and check lists. A station check establishes the conditions that must be set up prior to a good preflight, such as electrical power ON, ignition power switches OFF, and the like; it also places individuals in communication so that items requiring coordination may be checked. The priority of checks should determine the order in which crew members enter the aircraft, consistent with the physical aircraft arrangement. This, roughly, would be the reverse of a bailout order, with the pilot substituting for the aircraft commander. The commander likes to "bring up the rear" whenever possible.

The pilots and engineers have several duties to perform between the time they board the aircraft and start the engines. Approximately 15 minutes should be allowed for this period to make sure the remaining schedule is not interrupted. Normally, a good time schedule would be to board the aircraft 45 minutes before takeoff, and to start engines 15 minutes before takeoff. Since the pilot and engineer have the most duties to perform before engine start, they should be the first to enter the aircraft after their dismissal from the final briefing.

INITIATING THE FLIGHT LOG. To keep a record of actual operating conditions, you record various data in the aircraft performance log. The log must, however, be initiated before starting the engines. The heading of this log provides spaces for general information such as aircraft number, aircraft commander, squadron, and so forth. The general procedure is to complete the log with the information available up to and including the climb condition. Then, at the top of the climb, the actual time in the climb is computed and entered on the log.

Starting Engines

After completing the before-starting-engines check list, the engineer, on command from the aircraft commander, starts the engines. This procedure varies somewhat for turbine engine aircraft. For the sake of economy and engine life, an effort should be made to start the engines as close to takeoff time as the situation and the experience of the crew will permit (usually 15 minutes). The start-engines time is entered in the flight log at the time that the last engine is started.

Engine Warmup

All engines require a certain warmup and stabilization period (excluding jets). Reciprocating engines may require from 3 to 10 minutes, depending on the weather. The time required for engine warmup must be used intelligently to insure completion of as many checks as possible. Use this time (1) to establish normal electrical power output, (2) to note whether instrument readings are consistent with normal operating conditions, and (3) to clear wheel chocks and ground handling equipment prior to taxiing.

Taxiing

Taxiing is begun as soon after engine start as practicable, consistent with the attainment of proper engine temperatures and the completion of the before-taxi check list requirements. During taxi, proper rpm must be maintained for controlled taxi speed. Also during taxi, the engineer must monitor instruments and complete specific checks pertaining to the taxi check list.

Engine Runup

After taxiing to a suitable runup area, complete all the required power checks in accordance with the standard check list while you await clearance for lining up on the takeoff runway. You should know the engineer's amplified check list so that you will understand the exact runup procedure and sequence. The recognition of acceptable instrument readings during power checks should be "second nature." Power checks should be made as rapidly as engine operating limitations will permit.

Engineers and pilots should indicate by proper signals or interphone communications what they are doing at all times to allow appropriate crew members or ground observers to anticipate their activities where coordination is required. Under a single runup preflight system, the required checks are held to a minimum consistent with safety and with essential rechecks of maintenance corrections. Each pound of fuel saved during ground operation prior to takeoff means more distance, if needed, during inflight operations.

Before Takeoff

Panel-equipped aircraft require close coordination among the aircraft commander, the pilot, and the flight engineer, as well as with other crew members observing and reporting on various phases of the operation. The *aircraft commander,* the *pilot,* and the *flight engineer* are the "key three" during takeoff, and must be prepared to perform with precision and perfect coordination. To set this up, takeoff procedures are standardized as reflected on the standard check lists. Takeoff performance is predicted on the TOLD card, and this information is checked by the aircraft commander. Takeoff performance should be fixed in the aircraft commander's mind so that he may arrive at logical decisions more rapidly during the busy takeoff period.

It is the responsibility of the flight engineer to have this information computed completely and accurately for the safety of the flight. With the takeoff performance data firmly in mind, continue takeoff preparations by completing the before takeoff section of the standard check list. Use your check list and follow it carefully. No matter how proficient you are or how well you know your procedures, you are inviting trouble when you fail to use the check list. It is not just a list of items to be read from a piece of paper; nor is it a reflection on the ability of the flight engineer. The intent is to provide a positive recheck of each item which could have any bearing on the safety of the aircraft during takeoff. The flight engineer's takeoff procedure usually includes appropriate interphone communication to assure the aircraft commander and himself that his panels are properly set up for takeoff. Stand by to set takeoff power at the aircraft commander's request.

This completes the preparation phase of the mission. If your planning is complete and accurate and if the aircraft is in good condition, the mission should be a successful one.

INFLIGHT LOGGING PROCEDURES

During the takeoff, the flight engineer should continuously monitor the engine and systems instruments. He should not attempt to make log entries during takeoff since this activity would divert his attention from the instruments. Therefore, to assure an accurate, useful flight log, this log should be initiated properly before starting the engines, and the start engines time should be entered after the last engine has been started as we mentioned earlier. Then, while monitoring instruments, the flight engineer should note and remember certain instrument readings during the takeoff. By having a properly initiated flight log, and by remembering certain definite instrument readings, the flight engineer can enter this accurate information in his log after the initial climb has been established.

To initiate a log properly, all information that is known up to and including the initial power setting of climb number 1 must be entered.

Time cannot be determined at this point. There are no speeds nor distances involved in warmup, taxi and takeoff. Total fuel used for warmup, taxi, and takeoff is an average figure, used to arrive at an ending weight for the condition. Remember that this figure is correct for one type of engine. Other types of engines require the use of other figures.

Only the power setup can be entered when initiating the flight log. For cruise 1, the power setup as entered on the predicted flight plan is entered here and should be set up on reaching cruise altitude.

When the mission is started and the log is initiated, there are certain readings that the engineer must note and enter on the flight log to keep it current. The readings are:

Start Engine Time—This is the clock time at which the last engine was started.

Warmup and Taxi—This time is entered and circled but is not counted in total time. For this entry, the flight engineer need only note the ending time of this period which is the time the takeoff roll begins. Some SOPs may require that a clock time be recorded when the chocks are pulled.

Takeoff—For this condition the engineer should closely monitor the engine power, electrical system, and all related systems for proper reading at about the time life-off speed is reached. Enter the takeoff time after climb power is set and stable.

Climb—The time for climb power is established at the ending time for the takeoff condition. During the climb, the engineer should obtain average settings for power, fuel flow, and temperatures, as well as the average IAS used throughout the climb. Climb entries are made on the log at $\frac{2}{3}$ climb altitude.

Initial Cruise—In most cases, the aircraft is leveled out at the cruising altitude on the pilot's altimeter. This reading is almost always different from the reading on the flight engineer's altimeter because the pilot's altimeter is set on local altimeter setting while the flight engineer's altimeter should be set on 29.92 to read true pressure altitude. The difference in altitude may require a different bhp or EPR for cruise 1 than that computed before takeoff. The engineer should not attempt to make a power correction at this time. He should establish the power setting as determined on the predicted flight plan and enter it in the flight log for cruise 1, regardless of the altitude variation.

Different pilots use different techniques to establish the cruise condition and to bring the aircraft into a stabilized condition. Changing the power frequently to make airspeed or altitude compensations lengthens the time required to stabilize the aircraft. The easiest method to attain effective coordination between the flight engineer and the pilot is for the engineer to establish his predicted power and for the pilot to manually fly the aircraft until the altitude, airspeed, and cooling flap requirements are stable. In most cases this should require from 5 to 10 minutes.

As soon as the engineer is reasonably certain the aircraft is stable, he should record the instrument readings for power, airspeed, temperature, and altitude. Then, by means of the readings and notes he had jotted down during takeoff, climb, etc., he should bring the log up to date by entering the fuel used and thus determine the new values for the fuel and weight columns.

Climb entries are completed as follows:

- Enter the end clock time (time condition ends), time in condition, and total time.
- Enter OAT (I) and OAT (c) or temperature variation as observed and calculated at the end of the climb.
- Compute and enter the density altitude at end of the climb.
- Compute and record the two-thirds H_d and $\frac{1}{\sqrt{\sigma}}$ (smoe) for the climb.
- Correct the IASK to BASK, then to CASK, then to EASK, and multiply the EASK by the two-thirds $\frac{1}{\sqrt{\sigma}}$ to obtain a climb TASK and record these values.
- With the TASK and the time in the climb, compute and record the air distance covered.
- Compute and enter fuel used in the climb by using time and fuel flow. Compute and enter the new fuel remaining and gross weight values.

At this time, your log will be current. The aircraft will have been stabilized and engine readings for cruise 1 may be entered. By now you will be approximately one-half hour into cruise 1. All entries on cruise 1 should now be entered except time, speed, distance, fuel used, and ending weight.

These are all *ending* values and hence cannot be determined at this time.

With the information now available on the log, the engineer is able to analyze the performance of his aircraft.

AIRCRAFT PERFORMANCE ANALYSES

Let us consider an analysis which applies principally to reciprocating engine aircraft operation. However, you should apply the principles to turbine engine aircraft as applicable. The many variables affecting aircraft and engine performance make it necessary for the flight engineer to compare the actual performance of his aircraft to the charted (standard) performance of the aircraft. Therefore, as soon as the aircraft has stabilized in cruise, the engineer should analyze the aircraft's performance in relation to charted values.

Analyzing the various cruise conditions during flight enables the flight engineer to determine how much the aircraft and engine performances vary from their charted values. Comparing and analyzing the results usually discloses the cause of this variation.

A very effective method of evaluating aircraft performance is to compare logged air and ground NMPP with charted NMPP (block 19 of the log).

Charted NMPP

Since we know what the actual NMPP is for cruise 1, $\frac{\text{log TASK}}{\text{log fuel flow}}$, we can evaluate aircraft engine and crew performance by comparing this performance with charted NMPP. If the charted NMPP value *exceeds* the actual value, performance is not as good as charted. On the other hand, if charted performance is *lower* than the actual value, performance is better than charted.

To find the charted NMPP, it is first necessary to establish the bhp_{req} with the following formula:

$$\text{bhp}_{\text{req}} = \frac{\text{logged bhp for condition}}{\text{smoe for Cr H}_p} \times \text{Std smoe at Cr H}_p$$

Next establish the Δ F bhp as follows:

$$\Delta\text{F bhp} = \text{Logged }\Delta\text{F Corr} \times \text{EASK}^2 \times \text{Std smoe at Cr H}_p$$

Next, the average gross weight for the condition is determined. The beginning gross weight for cruise 1 is as determined from the log. The fuel flow for cruise 1 is determined and we will remain in cruise 1 for one hour. Therefore, use ½ of the average gross weight, and fuel *used* weight is the computation. Compare the actual engine power and the airspeed with those values entered for this condition on your flight plan. The difference, plus or minus, between the charted and actual computations is the amount of correction required for subsequent performance throughout the flight. Enter the required correction in the REMARKS block 39 of the log.

Air NMPP

Air NMPP represents the performance of the aircraft and engines compared to air miles covered. Air NMPP is computed by dividing the logged TASK by the logged fuel flow in pounds per hour for the cruise being analyzed.

Ground NMPP

Ground NMPP value represents the performance of the aircraft and engines, including the effects of winds, compared to ground miles covered. Ground NMPP is the ground speed (TASK ± wind) divided by the logged fuel flow. The effect of wind on the aircraft is obtained from the navigator. If, for instance, in cruise 1 you encounter a 12k headwind, your ground speed would be the indicated speed of the aircraft minus the velocity of the headwind.

Analyzing NMPP Values

Comparison of these NMPP values indicates the variations in performance, which in most cases can be attributed to changes in drag, improper crew techniques, instrument errors, or unfavorable weather conditions.

A comparison of the *charted* NMPP with the *air* NMPP indicates a loss or gain in NMPP value resulting from aircraft and engine performance.

A comparison of the air NMPP with the ground NMPP indicates the loss or gain in NMPP caused by winds.

A net loss or gain in NMPP can be determined by algebraically adding the losses or gains brought about by variations in aircraft and engine performance and by winds.

Upon completion of this analysis, if the comparison of charted NMPP and air NMPP indicates a loss due to aircraft or engine performance, the engineer should make a thorough check of all the controllable items affecting the drag of the aircraft to see if this loss can be decreased. The engine operating temperature should be checked for the possibility of further closing the cowl flaps. Wing flaps, wheel well doors, and the like, should be checked for creeping. Check the CG to see that it is within limits and ask the pilot to retrim the aircraft. If performance in terms of NMPP does *not* increase after these checks, the engineer can be sure that the difficulty is due either to drag-creating factors that cannot be controlled in flight or to improper powerplant management, which causes excessive fuel consumption. After all corrections have been made to reduce drag within the margins of safety and to improve powerplant management, the flight engineer must adjust the bhp to maintain the EASK which produces the most efficient L/D for the weight of the aircraft.

Analyzing Weights and Delta F Corrections

Further analysis of the cruise is made by computing a weight correction factor, which is indicated by the weight change symbol (Δ) shown in block 37 of the performance log. This weight correction factor is like an additional amount of weight equal to the *excessive* drag affecting the speed of the aircraft for any given power and gross weight. To determine the amount of weight correction affecting the aircraft, the following procedure is used.

To determine the weight correction factor, a comparison of charted and actual EASK is necessary. Compute charted EASK in the same manner as before for a charted NMPP value. Smoe the logged bhp to the charted altitude and subtract the Δ F bhp to obtain a charted bhp_{std}. To obtain the charted EASK, enter the appropriate NMPP chart with this bhp and the average gross weight for the condition being analyzed.

The charted EASK represents the speed the aircraft should fly for that particular bhp and gross weight. Compare the actual (logged) EASK for the cruise being analyzed with the charted EASK. If the logged EASK is lower than the charted EASK, the aircraft has a plus (+) correction factor because it is flying more slowly as if it weighs more. If the logged EASK is greater than the charted EASK, the correction factor is minus (−) meaning that the aircraft is performing as though it weighs less.

Computing Weight Correction Factor

The total weight correction factor used in the flight log for cruise 2 is computed from the difference between the actual *average gross weight* of cruise 1 and the *average performance weight* for cruise 1. The performance weight is one of the indications as to how the aircraft is flying. Therefore, actual conditions are used to find performance weight. Two facts from the log are used to obtain this performance weight: logged bhp and logged EASK. To use the NMPP chart. convert the logged bhp to a bhp_{req}. When the conversion is made, interpolate an average performance gross weight (lbs) at the intersection of bhp_{req} and the logged EASK line on the appropriate NMPP chart. Then subtract the charted bhp from the actual required bhp for that weight.

Actual average gross weight for cruise 1 is computed in the *charted NMPP* chart. In other words, the aircraft flies as if it weighs more than it actually does, when a plus (+) correction factor is indicated. Remember that *speed* is determined from the *actual weight,* and *power* is determined from *performance weight.*

Inasmuch as a weight correction factor is valid for only narrow speed ranges such as long range airspeed, it is recommended that Δ F correction factors be used in inflight replanning. By using Δ F bhp you simplify the planning process. These Δ F bhp factors are valid for all speed, power, and weight ranges. Remember, however, that the Δ F factor itself changes during flight because of such factors as oil leaks, engine exhaust deposits on the aircraft, changes in CG position, or changes in an engine's condition that may bring about changes in cooling requirements. For these reasons, the flight engineer should recompute the Δ F factor frequently to keep his planning effective.

INFLIGHT REPLANNING

As soon as possible after the analysis has been completed, make the necessary bhp corrections to fly the succeeding cruise condition at the proper airspeed. How the aircraft performs after the planned bhp is established demonstrates the degree for either weight correction or Δ F correction in each condition. The weight or Δ F correction factor enables the engineer to determine the bhp from the NMPP fuel chart for a specific airspeed, even though the performance of the aircraft and engines is not the same as that which is charted.

Use of Weight Correction Factor

To find the bhp for cruise 2 by using weight correction, you must determine what the approximate average gross weight is for cruise 2. This is determined by using the ending weight of cruise 1, minus one-half of the fuel in cruise 1.

Enter this weight into the appropriate NMPP chart to find an airspeed that gives the desired angle of attack. Then to apply the weight correction factor, add a plus (+) correction or subtract a minus (—) correction from the average gross weight to obtain a performance weight.

Use of Delta F Correction Factor

You have seen how the weight correction factor can be used to determine the power for cruise 2; now let us use the more simplified Δ F bhp correction for the same cruise. In applying the Δ F factor for replanning, you must first determine the average gross weight for the condition just as you did when you used weight correction.

At the time selected to terminate the cruise being analyzed, set up the cruise power that was computed with the Δ F correction, but do not enter this new bhp or its settings on the flight log at this time. Allow the aircraft to stabilize with the new power to see if the aircraft is flying at its proper airspeed. If it doesn't fly at the proper speed, further adjustment is needed.

FINAL ANALYSIS

On the reverse of the flight log a section is devoted to REMARKS, where you may record the analysis of the mission. This analysis is a comparison of the flight engineer's log with the predicted flight plan. The results indicate both the degree of engine and aircraft efficiency and the proficiency of the crew. Average NMPP values for the entire mission are used in this comparison in much the same manner as was done in cruise analysis. The NMPP values used in this comparison are *average charted*, *actual average air*, and *actual average ground NMPP*.

Average Charted NMPP

Average charted NMPP indicates how the aircraft and engines should perform during the mission according to the charts used to complete the predicted flight plan. Obtain the average charted NMPP by dividing the predicted ground distance to be flown by the predicted fuel to be used to cover the distance (total fuel used less fuel used for warmup, taxi, takeoff, and landing and taxi).

$$\text{Av charted NMPP} = \frac{\text{Predicted ground distance}}{\text{Predicted fuel}}$$

Actual Average Air NMPP

Actual average air NMPP indicates how the aircraft and engines actually performed according to data recorded on the flight log. Obtain the actual average air NMPP by dividing the air miles flown by the actual amount of fuel used to cover the distance (total fuel used less fuel used for warmup, taxi, and takeoff, and for landing and taxi).

$$\text{Average air NMPP} = \frac{\text{Air miles flown}}{\text{Actual fuel used}}$$

Average Ground NMPP

Actual ground NMPP is computed from data recorded on the flight log and indicates how the aircraft and engines actually performed in the winds encountered in flight. Obtain the actual ground NMPP by dividing the ground NM flown by the fuel used to cover the distance (total fuel used less fuel used for warmup, taxi, and takeoff, and for landing and taxi).

$$\text{Average ground NMPP} = \frac{\text{Ground miles flown}}{\text{Actual fuel used}}$$

Comparison of NMPP Values

The comparison of these NMPP values indicates variations in performance for the entire mission. A comparison of the actual average air NMPP value to the average charted NMPP indicates the loss or gain in NMPP caused by various characteristics of aircraft and engine performance. When the actual air NMPP is less than that which had been charted, there is a performance loss. When the air NMPP is greater than that which had been charted, there is a gain in performance.

A comparison of the actual average ground NMPP to the actual average air NMPP indicates the loss or gain in NMPP caused by winds. When ground NMPP is less than air NMPP, a performance loss is indicated. When ground NMPP is greater than air NMPP, a performance gain is indicated. A net loss or gain in NMPP can be determined either by comparing the actual average ground NMPP to the average charted NMPP, or by adding algebraically the loss or gain caused by aircraft and engine performance and by winds.

A properly computed flight log, when accurately filled out, is an asset to any organization. When filed, it becomes a running history of that particular aircraft's performance for use by both aircrew and maintenance personnel. For aircrew personnel, it serves as a guide for planning future missions; for maintenance personnel, it provides background information for effective troubleshooting.

PILOT-ENGINEER TEAM

There are many aerodynamic factors that affect aircraft performance which are controllable only by close coordination between the pilot and the flight engineer. If coordination between these two men is lost or ineffective, economy of operation is lost and performance is low. This can be illustrated in a cruise condition where bhp, pressure altitude, and EAS are constant. For instance, let us assume that the engineer has planned and established a bhp and EAS for this particular gross weight. As fuel is burned off in the cruise, gross weight decreases, causing the aircraft to climb. Because the pilot is interested in maintaining a constant pressure altitude, he (improperly) changes the angle of attack with the trim tab control to hold straight and level flight at cruising altitude. This is where the pilot and the engineer start "pulling in opposite directions." The engineer is expecting an increase in EAS which would normally permit him to reduce power and increase his average NMPP and still maintain the recommended cruising EAS. But, because the angle of attack was changed with the trim tabs, lift was reduced but only at the expense of increased drag. As a result, the normal bhp gain was used to overcome the drag induced by the trim tabs.

The proper method to establish cruise with a constant altitude and EAS is to make frequent small power reductions when the aircraft tends to climb. The reduction in power causes the airspeed to decrease slightly. To control airspeed, the pilot should then reduce the angle of attack by use of the elevator control. The reduced angle of attack reduces drag, which allows the airspeed to increase to its original value. At the same time, the Coefficient of Lift (C_L) has decreased to create just enough lift to equal the new gross weight so that altitude remains constant.

If this procedure is followed closely, the altitude and airspeed changes are so slight that they appear to be constant. However, from a fatigue standpoint, you cannot ask the pilot to fly the aircraft manually throughout the entire mission. For this reason most cruises are flown by the atuomatic pilot. Since the autopilot uses trim instead of elevator control to maintain constant altitude you are not able to control altitude by making power reductions. Therefore, to obtain a fair NMPP value for the mission, you must periodically ask the pilot to release the autopilot and remove all trim induced (thereby removing drag) so you can make your power reductions.

A flight engineer's success in obtaining the maximum economy for any type of cruise depends on a harmonious crew relationship, on an understanding of the aerodynamic forces acting on an aircraft, and on a knowledge as to how they are created and controlled.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

J. P. McCONNELL, *General USAF*
Chief of Staff

R. J. PUGH, *Colonel, USAF*
Director of Administrative Services

Summary of Revised and Added Material

Adds the performance of turbine engine aircraft to that of reciprocating and turboprop aircraft and develops fully the use of the Aircraft Performance Log/Plan (AF Form 796) which was developed specifically for this revision. Changes in Chapters 1 through 8 reflect performance data for aircraft currently in the Air Force inventory. Chapters 9 and 10 update the training to include problems relating specifically to the C-141A aircraft and generally to other turbine engine cargo aircraft.