CHAPTER 15

WEIGHT & BALANCE/PERFORMANCE

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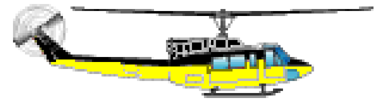
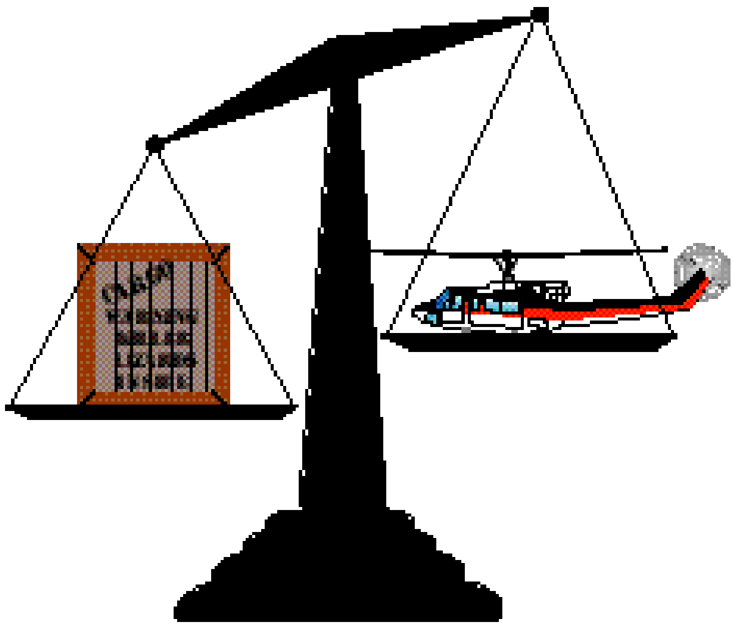


CHAPTER 15
WEIGHT AND BALANCE/PERFORMANCE



INTRODUCTION

This chapter combines several of the chapters of the Rotorcraft Flight Manual in order to establish a correlation between Weight and Balance, Limitations and Helicopter Performance. In addition to basis weight and balance calculations, this chapter will discuss the proper use of several of the various performance charts and graphs. Please keep in mind that these graphs are included for training purposes only.

General

It is helpful to remember that the performance data provided by the *RFM (Rotorcraft Flight Manual)* is informational data while the limitations in Section 1 of the *RFM* require mandatory compliance. The weight of the loaded helicopter and the resulting center of gravity is the variable that the pilot can control most effectively in order to achieve the performance required for a specific operation. The weight and balance of the 212 is a primary factor in many of the requirements of the Limitations section of the *RFM.*

Helicopter performance charts are provided in Section 5 of the *RFM.* Weight and balance loading data is in Section 6 of the RFM.

Data supplied in these sections reflects information needed to obtain optimum helicopter performance while, at the same time, minimizing wear and tear on individual parts to ensure maximum component life and safety.

Performance charts provide the pilot with information on how the helicopter performs, provided applicable limitations are followed and the engines are providing proper power. Since engine performance is somewhat variable, helicopter performance charts are based on the engine manufacturer's specification engine power.

The following text covers limitations, performance charts, and weight and balance separately. Sample performance charts are provided for reference. The pilot should refer to the latest revisions of the *RFM* for the most current information.

LIMITATIONS

General

The limitations section of the *RFM is* approved by the Federal Aviation Administration, and it is the pilot in command's responsibility to ensure compliance with all limitations in the *RFM.*

Limitations for manufacturer approved optional equipment are provided in the *Flight Manual Supplements (FMS*) found in Section 10, "Optional Equipment," of the *RFM.* If optional equipment is installed in the helicopter, the limitations of the appropriate supplement may supersede the limitations of Section 1 of the *RFM.*

The pilot should refer to Section 1 of the *RFM* during the following discussion. Chapter 23 of this manual discusses some of the limitations in more depth than presented here.

Basis Of Certification

This helicopter is certified under FAR Part 29,Category B.

Type of Operation

The helicopter is certified for flight in non-icing conditions, both day and night VFR. Campbell Helicopters does not currently have Night or IFR Operations authorized on it's Air Operator Certificate so it's aircraft are currently restricted to Day VFR only.

Required Equipment

Heated pitot-static system

Pilot windshield wiper

Force trim system

Optional Equipment

Optional equipment supplements are provided in Section 10 of the *RFM* and are listed by a different number for each piece of equipment covered. Limitations, performance data, and weight and balance information for optional equipment approved under a Supplemental Type Certificate (STC) are provided by the holder of the STC.

If optional equipment is installed, the associated limitations, procedures (both normal and malfunction), performance data, and weight and balance information, provided in the supplements, have the same FAA status as that supplied in the *RFM.*

Some optional equipment may prohibit operation of the helicopter under certain circumstances. For example, installation of the Nightsun searchlight or the Loudhailer prohibits IFR operations. The pilot should consult the appropriate *RFM* supplement for specific limitations and restrictions.

Flight Crew

The Bell VFR 212 is certified for single-pilot operation for VFR. An additional crewmember is required when internal cargo includes flammable materials.

The Bell IFR 212 is certified for single pilot operation for VFR and for two pilot operation for IFR if both pilots hold instrument ratings in helicopters. An additional crewmember is required when internal cargo includes flammable materials.

Doors Opened Or Removed

Helicopter may be flown with doors open or removed only with Bell Helicopter standard interior installed. Door configuration shall be:

Both crew doors removed.
Both sliding doors locked open or removed with both hinged panels installed or removed.
In all cases, door configuration shall be symmetrical.

NOTE

Opening or removing doors shifts helicopter center of gravity and reduces V NE· Refer to Section 5 and to Airspeed imitations.

WEIGHT/CG

General

Numerous weight and CG limitations apply; the pilot should refer to the *RFM* for additional information.

Maximum gross weight for takeoff and landing is 11,200 pounds <u>unless otherwise restricted by the weight-altitude-temperature chart</u> or other factors.

Weight Altitude Temperature Limitations Chart (WAT)

Maximum GW is 11,200 pounds (5080.3kilograms).

The weight-altitude-temperature limitations for takeoff, landing, and in-ground-effect (IGE) maneuvers chart, commonly called the WAT chart, is used to determine the maximum allowable weight for takeoffs, landings, and IGE hovering operation. The WAT chart is a limitations chart as opposed to a performance chart.

The gross weights determined from the WAT chart may exceed continuous IGE and OGE hover capability under certain ambient conditions. In addition to validating the Height-Velocity Chart, the WAT Chart is an excellent general reference chart for flight planning and can be used to determine helicopter gross weights limits for critical areas of a flight. By using the chart to determine the limiting gross weights for a critical phase of flight, the takeoff gross weight can easily be calculated.

WAT chart gross weight limitations should be computed for both initial takeoff and the hottest and highest conditions expected for IGE hovering. Conservative rather than optimistic OAT and PA values should be used to avoid less than expected performance.

If the helicopter must be hovered extensively IGE or hovered OGE to perform the flight mission, the pilot should refer to the Hover Ceiling IGE or OGE charts in the "Performance" section of the *RFM* to determine helicopter gross weight. A detailed discussion of the Hover Ceiling Charts is provided later in this chapter.

Additional Weight Limits

Minimum combined weight in the crew seats is 170 pounds.

Note: Allowable gross weight obtained from this chart may exceed continuous hover capability under certain ambient conditions. Refer to hover ceiling charts in section 4 of the RFM.

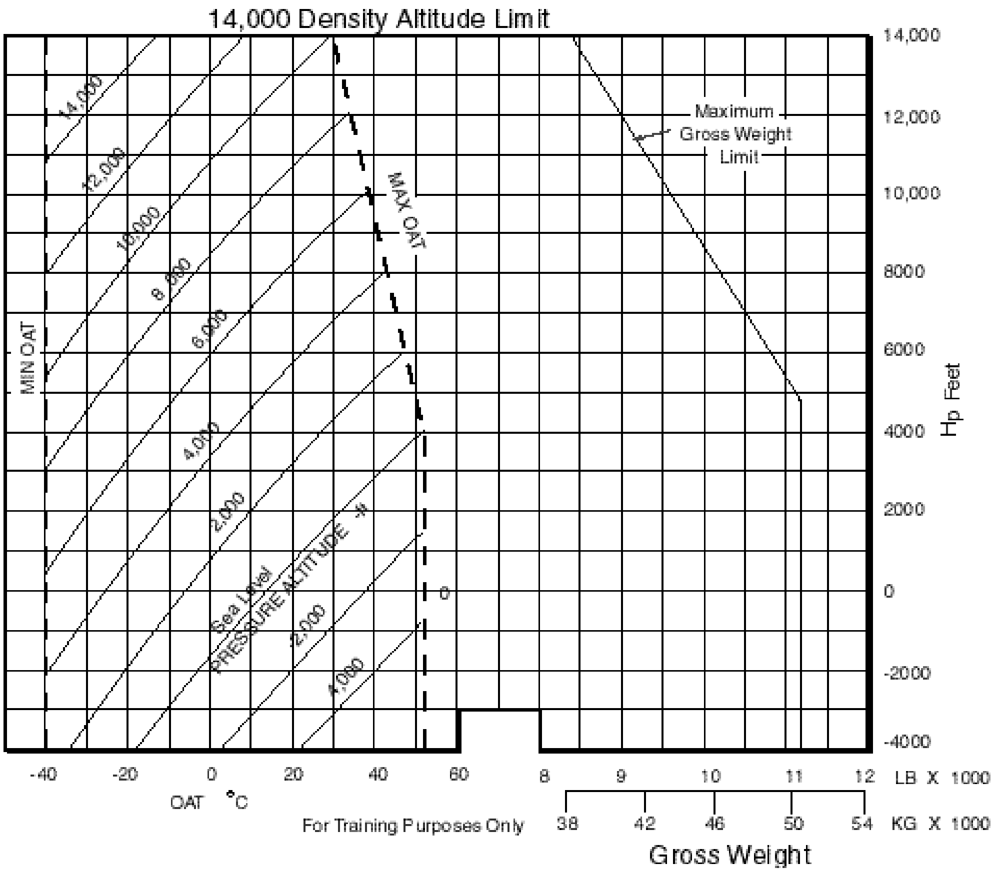


Figure 15-1 Weight-Altitude-Temperature Limitations Chart

Center of Gravity Limits

VFR *Flight Manual* CG range is from station 130 to 144, depending on gross weight (Figure 15-2).

VFR *Flight Manual* lateral CG limits are 4.7 inches left and 6.5 inches right of the fuselage centerline. Loading Limitations

Passenger loading—Outboard facing seats should not be occupied until at least four of the forward or aft facing seats are occupied.

Internal cargo loading. Maximum deck loading is 100 pounds per square foot. Cargo tiedown limitations are provided in the RFM.

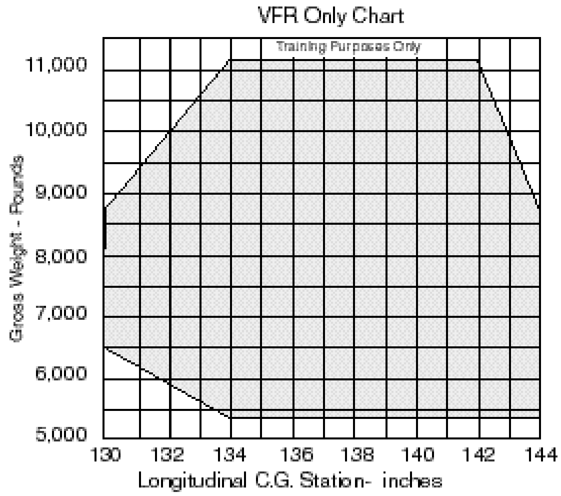


Figure 15-2 Gross Weight Center-of-Gravity Chart

Airspeed

The airspeed limitations on the Bell 212 vary with weight, temperature and altitude as with most other helicopters. The type of flight control system is also a factor in the Airspeed limitations.

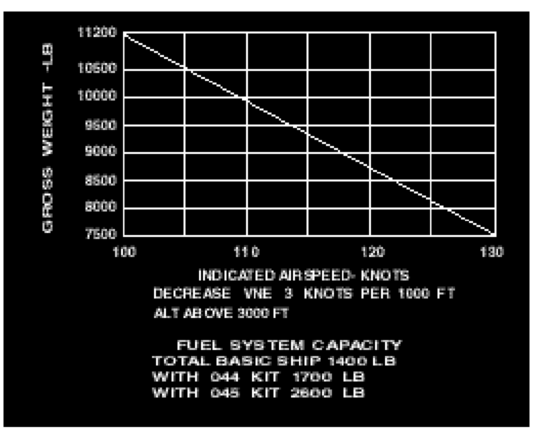


Figure 15-3 V_{ne} Placards

VNE decreases linearly from 130 KIAS (VFR *RFM)* or 120 KIAS (IFR *RFM)* to 100 KIAS with gross weight. The VNE also decreases 3 knots per 1,000 feet above 3,000 feet **density altitude** (Figure 15-3).

The full Center of Gravity envelope is limited to VFR flight only.

Maximum airspeed when above maximum continuous torque (87.5%) is 80 KIAS. The high airspeed/torque combination puts undue stress on many of the dynamic components.

VNE with only doors open or removed is 100 KIAS.

Crosswind and downwind operations have been demonstrated up to 20 knots, but this should not be considered as a limited value since the maximum operating wind velocities for these conditions have not been established.

Altitude

Maximum operating altitude is 20,000 feet pressure altitude.

Maximum DA for takeoff, landing, and IGE maneuvers is 14,000 feet.

These charts do not define conditions which permit continued flight following an engine failure.

Ambient Air Temperature

Maximum temperature is 125° F (51.7° C).
Minimum temperature is -65° F (- 54° C).

Height Velocity

Unlike the older version of the Single Engine Height -Velocity charts that required several different graphs and a rather confusing method of “building” your custom H-V curve, the newer chart is very simple to use. Prior to using the Single Engine Height Velocity chart, it is necessary to first use the WAT Chart discussed earlier. In addition to giving a general idea of expected performance, the WAT Chart validates the H-V Chart by giving the maximum weights allowable for using the

Single Engine Height Velocity chart.. Remember, if the gross weight exceeds the WAT limit, then the Single Engine Height Velocity chart is no longer usable.

You'll notice that the Single Engine Height-Velocity chart has the typical shape and contour of the standard H-V curve that we are familiar with. The difference is the additional outer shaded area which represents the WAT Limit. The inner shaded represents operations at 1,000 pounds below the WAT limit. There are no provisions for determining a precise curve at weights other than those mentioned so the conservative (i.e. safe) approach would be to use the inner curve. If the aircraft is weighing less than 1,000 pounds under the WAT Limit and the outer curve if the aircraft is weighing more than WAT Limit minus 1,000 pounds.

When takeoffs are made in accordance with the height-velocity charts, proceed as follows:

1. Determine hover torque at a four-foot skid height.

2. Perform takeoff with no more than 15% torque above hover power while accelerating to takeoff climb-out speed (VTOCS) (refer to Section S of the *RFM* for VTOCS)

NOTE: Downwind takeoffs are not recommended since the published takeoff distance performance will not be realized. When near zero wind conditions prevail, determine actual direction of the wind.

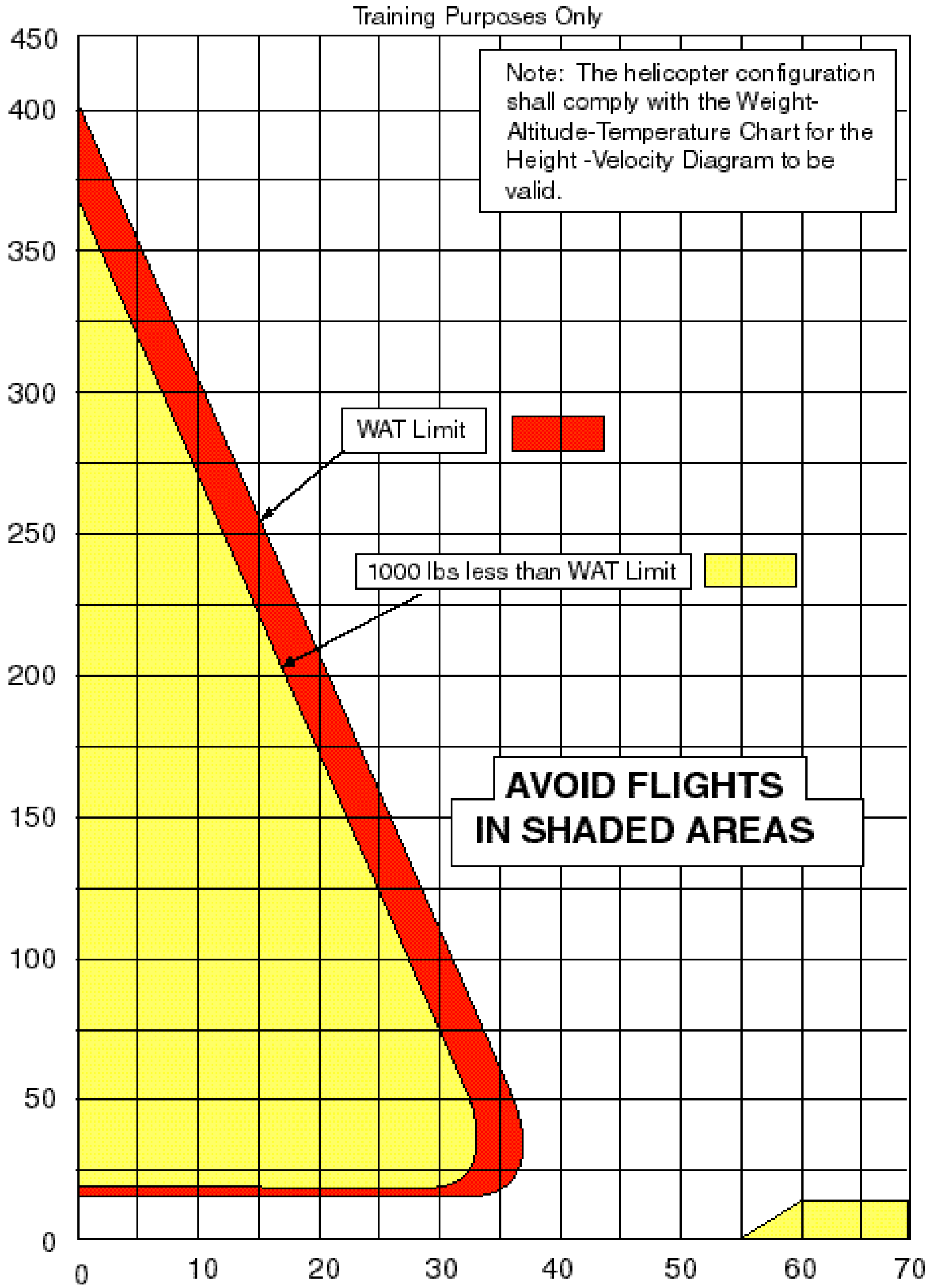


Figure 15-4 Single Engine Height Velocity Curve

Maneuvering

Aerobatic maneuvers are prohibited.

Systems

Section 1 of the *RFM* also provides limitations for operation of the electrical, powerplant, transmission, rotor fuel, oil, and hydraulic systems. The pilot should review these limitations and the instrument panel gage markings applicable to the specific system.

Performance Charts

The example performance charts on the following pages include conditions listed below each chart which provide necessary data to work the sample problem shown. We have not included all the charts as found in the RFM but rather a representative sampling of the various types of charts.

Helicopter performance, provided in the "Performance" section of the *RFM, is* based on the powerplant producing the engine manufacturer's specification power. The power assurance check chart is used to ensure that each engine is operating properly and is capable of producing minimum specification power as installed in the helicopter.

If the engines pass the power assurance check, the helicopter should be capable of meeting all performance chart capabilities.

If an engine fails to meet the power assurance check limits, the helicopter's performance can be expected to be less than performance chart capabilities.

Power Assurance Check

The power assurance check does not require the engine to produce maximum power, but rather determines that, for the power produced during the check, N_1 and ITT fall within limits of the manufacturer's specification engine. If N_1 and ITT limits are not exceeded, the engine's performance can be expected to provide the power of a specification engine.

The PT6T-3 power assurance requires a single engine target Tq based on pressure altitude be set while N_1 and IIT specificationsare based on OAT. These figure are all determined from one Table (Figure 4-2 of the RFM).

Two power assurance charts are provided for the PT6T-3B, in the performance section of the RFM. One, titled "Power Assurance Check (Hover)," may be used with the helicopter in a hover or resting lightly on the ground. The other, titled “Power Assurance Check (in-flight)," may be used during cruise flight. The hover check is generally preferred since the higher Tq used will provide better indication of engine performance. Whichever check is used, it should be performed daily and whenever unusual operating conditions or engine indications arise.

There are two different power assurance charts for the PT6T-3B engine. The one labeled “With Gas Producer P/N 212-075-037-113” is for use when FMS-29 “Increased Takeoff Horsepower” is applicable. The N1 section of this chart allows a Maximum of 101.8% N1.

Helicopter configuration and instructions to perform the check are printed on all of the charts. Both engines must be operating and the heater/ECU systems must be off to ensure proper readings. Each engine is checked separately with N2 rpm at 97%.

On the PT6T-3B charts, the engine being checked must be operating at a torque setting that results in a high enough N_I rpm to ensure that the compressor air bleed valve is closed. As a general rule 50% or higher torque on the engine being checked provides proper results.

If either engine exceeds the maximum N_I or ITT values of the charts, published performance capability may not be achieved, and corrective maintenance action should be taken as soon as practical.

Density Altitude Chart

An industry standard density altitude chart is provided to allow the pilot to convert pressure altitude (PA) and ambient/outside air temperature (OAT) to density altitude (DA). The chart also provides a true airspeed conversion factor which, when multiplied times calibrated airspeed (KIAS), gives true airspeed (KTAS) (Figure 15-8)

The pilot can determine PA from his altimeter by setting 29.92 inches Hg in the Kollsman window. Ambient temperature /OAT is available from the cockpit OAT gage. The PA lines in the body of the chart are identified by the pressure altitude numbers above the lines. The heavy black diagonal line is for standard day.

Critical Relative Wind Azimuths Chart

The hover ceiling charts, discussed below, are based on adequate control margins, both cyclic and antitorque, for 20-knot winds from any direction. Improved control margins and/or hover performance can be realized by avoiding winds from the critical azimuths shown in the chart (Figure 15-11)

While not specifically stated in the RFM, winds in excess of 20 knots from the critical wind azimuth areas should be avoided to preclude loss of tail rotor effectiveness.

During all hovering operations, every attempt should be made to hover the helicopter into the wind whenever possible.

Hover Ceiling Charts

General

The hover ceiling charts are divided into two groups, one for IGE hovering and one for OGE hovering, and provide a method for determining the maximum gross weight at which the helicopter can be safely hovered under a wide range of ambient conditions and power settings. Gross weight is figured in the same manner as with the WAT chart.

IGE Charts

Three IGE hover ceiling charts are provided. Two provide IGE hovering gross weight while using up to takeoff power (100% torque). The other chart is for using up to maximum continuous power of 87.5% torque. (Figure 15-9)

The IGE hover charts are based on both engines operating, generators loaded to 150 amperes each, heater on or off, and a 4-foot skid height.

Adequate cyclic and tail rotor pedal flight control margins exist for winds up to 20 knots from any direction. Gross weight calculated from the continuous power chart is considerably below that of the takeoff power chart.

The charts can also be worked in reverse to determine the IGE hovering altitude for a given helicopter gross weight.

Example

Find the maximum gross weight the Model 212 can hover in ground effect.

Conditions

Maximum Continuous power
Heater OFF
OAT - 0° C
Pressure altitude - 9000 feet

Solution

a. Enter the chart on the bottom left side at 0°C OAT.

b. Move vertically to the 9000 feet Hp-FT line

c. Move horizontally right to the MAXIMUM GW LIMIT line.

d. Drop vertically to the bottom of the graph and read 9,250pounds, aircraft maximum gross weight. This is the maximum gross weight for hovering IGE under the given conditions.

OGE Charts

> **CAUTION:** OGE hover operation may result in violation of height/velocity limitations.

Eight OGE hover ceiling charts are provided. Four of the OGE charts provide hovering gross weight while using takeoff power (100% torque). The other four charts are based on the use of maximum continuous power (87.5% torque). Each group of power limited charts is further divided by temperature range and if the heater is on or off (Figure 15-10). The careful observers among you may notice that the cold weather charts have what seems to be an anomaly in the temperature /performance area of the chart. In the upper right hand corner there is an actual slight decrease in the performance at extremely low temperatures. This "inversion" of performance is more of an interesting anomaly than a practical limitation, as it occurs only at extreme edges of the flight envelope and is of little consequence at any rate. The factory was consulted on this and their answer was that the "weirdness " occurred because the data gathered came out that way. This occurs in the other Bell Helicopters as well. It is apparently an aerodynamic effect and not a powerplant deficiency.

All charts are based on both engines operating, generators loaded to 150 amperes each, and a 60-foot skid height.

Calculations provide gross weights where adequate cyclic and tail rotor pedal flight control margins exist for winds up to 20 knots from any direction.

If a wind in excess of 20 knots during OGE hover is from a critical azimuth, tail rotor flight control margins may be limited and may preclude safe OGE hovering operations.

Example

Find the maximum gross weight that the Model 212 can hover out of ground effect.

Conditions

Take-off power
Heater OFF
OAT - 0° C
Pressure altitude 9000 feet

OGE under the given conditions. Solution

a. Enter the chart on the bottom left side at 0°C OAT.

b. Move vertically to the 9000 feet Hp-FT line.

c. Move horizontally right to the MAXIMUM GW LIMIT line.

d. Drop vertically to the bottom of the graph and read 9,250 pounds, aircraft maximum gross weight. This is the maximum gross weight for hovering

Takeoff Distance Chart

A takeoff distance chart is provided for takeoff over a 50 foot obstacle. This chart allows the pilot to calculate the distance required to clear a 50 foot obstacle during a takeoff flight path from a 4-foot hover using hover power plus 15 % torque. The chart is based on a zero wind condition, the takeoff climb-out speed determined from the V_{TOCS} chart, (Figure 15-13) and a flight path which avoids the critical areas of the height-velocity diagram. Takeoff distance performance cannot be achieved if the takeoff is downwind

To get the takeoff climb-out speed used in the takeoff distance chart, a twin engine takeoff climb-out speed (V_{TOCS} a Category B term), chart is provided in the *RFM* (Figure 15-13).

A single engine landing distance chart allows the pilot to calculate the distance required to clear a 5O foot obstacle during a single engine approach to a hard surfaced runway. The chart is based on the inoperative engine being secured (shut down), 500 fpm rate of descent, using power as required, a zero wind condition, 40 knot approach airspeed, and a flight path which avoids the critical areas of the height velocity diagram (Figure 15-17).

Example

Find the take-off distance over a 50 feet obstacle under the assumed conditions.

Conditions

Take-off power
4 feet skid height
Heater OFF
Pressure altitude 4000 feet
OAT + 20° C
Gross weight 10,000 pounds

Solution

a. Enter the chart on the bottom left side at +20°C OAT.

b. Move vertically to the 10000 feet Hp-FT line. Do not go to the right of the HOT DAY TEMPERATURE LIMIT line.

c. Move horizontally right to the MAXIMUM H_D TAKEOFF line.

d. Drop vertically to the bottom of the graph and read 725 feet, aircraft takeoff distance.

Twin Engine Rate Of Climb Charts

The twin engine rate of climb (ROC) charts allow the pilot to determine the helicopter's rate of climb. There are actually thirty separate charts for rate of climb. (Only one of which is included here) The charts differ by gross weight, if the heater is on or off, if takeoff power or maximum continuous power is used, or, for the IFR RFM, if the airspeed for climb-out is 55 or 80 knots. All charts are based on both engines operating at 100% N2, generators loaded to 150 amperes each, and the doors on and closed. The chart headings also include ROC adjustment for climb with the helicopter's doors open or removed (Figure 15-14).

Example

Find the rate of climb sustained during a climb with a mean altitude of 8000 feet.

Condition

Twin-Engine
Takeoff power
V_{CAL} 55 Knots
Gross weight 9,000 pounds
Doors Closed (if open subtract 200 fpm)
Heater-OFF
OAT - 15° C

Solution

a. Check the title block for the proper chart - Twin engine rate of climb and GW 9000 LB. Figure 9-14

b. Enter the chart on the left side at the mean altitude, 8000 feet.

c. Move horizontally (right) to the 15° C OAT line.

d. Drop vertically to the bottom of the graph and read 2500 FT/MIN.

Single Engine Rate Of Climb Charts

The Single Engine Rate-of-Climb (ROC) charts are divided by Engine type in Section 4 of the RFM. In general, all the charts (for each type engine) differ depending on gross weight and if 30 minute power or maximum continuous power is used. Single Engine ROC charts for both the -3 and the -3B Engine are available so be sure to choose the correct chart All charts are based on doors on and closed, one engine operating at 97 % N2, its generator loaded to 150 amperes, the other engine secured, the heater off, and 55 KIAS. The chart headings also include ROC adjustments for climb with the helicopter's doors open or removed (Figure 15-15).

Single engine performance is provided for emergency use only. Positive rates of climb are very low for the lightest gross weights and nonexistent or negative for heavier gross weights.

Since a zero rate of climb is the same as level flight, the single engine rate of climb charts can be used to determine the pressure altitude and/or maximum gross weight that can be maintained in level flight if an engine fails. This calculation can be very important if operating in high, mountainous terrain.

The calculation to determine the PA that can be maintained in level flight requires an estimate of the OAT and then working the appropriate chart in reverse. To determine the MGW that can be maintained at a given PA again requires an estimate of the OAT at that altitude and the checking of several charts.

Our operations manual states:

No person may operate a land aircraft carrying passengers over water unless one of the following are met: (135.183)

1. It is operated at an altitude that allows it to reach land in case of engine failure.

2. It is necessary only during take off or landing.

3. It is a Multiengine aircraft operated at a weight that will allow it to climb, with the critical engine inoperative at least 50 fpm at an altitude of 1000 feet above the surface. If conducted Over-The-Top, then 1500' or MEA, whichever is higher.

4. It is a helicopter equipped with helicopter flotation devices.

Example

Find the SE rate of climb sustained during a climb with a mean altitude of 8000 feet pressure altitude.

Conditions

30 minutes power
V_{CAL} 55 knots
7,000 gross weight
Doors closed (if open subtract 200 fpm)
OAT 15° C

Solution

a. Select the proper chart (sheet 9 of 10 in the FM) for the above conditions Figure 9-15

b. Enter the chart on the left hand scale at 8000 pressure altitude. Hp-FT

c. Move horizontally (right) to the 15° C OAT line.

d. Drop vertically to the bottom of the graph and read minus 75 FT/MIN.

e. Due to the minus 75 FT/MIN rate, the Model 212 would have to descent to a lower altitude to maintain a level flight altitude under the assumed conditions, 10,000 G.W., 8000 Ft PA (DA 10,000), OAT 15° C. Therefore:

f. Enter the chart at the lower edge at 0 FT/MIN rate of climb.

g. Move vertically to the 15° C OAT line.

h. Move horizontally (left) to the left hand scale and read, 7500 feet pressure altitude.

i. The helicopter would have to descent to 7500 feet PA to maintain level flight under the assumed conditions.

Airspeed Calibration Chart

There are two airspeed calibration charts in the RFM. One is for the pilots ASI and the other for the copilots. These charts allow the pilots to calculate calibrated versus indicated airspeeds for climb, level flight, and autorotation (See Figure 15-16).

Example

Find the calibrated airspeed in level flight at 90 knots indicated airspeed.

Solution

a. Enter the PILOT'S AIRSPEED SYSTEM CALIBRATION chart, Figure 15-16, on the lower scale at 90 knots, IAS.

b. Move vertically to the level flight line.

c. Move (left) to the left hand scale and read the calibrated airspeed, 93 knots.

Landing Distance Single Engine

Single engine landing distance over a 50 foot (15.2 meter) obstacle. Figure 15-17)

Single engine landing distance over a 50 foot obstacle is shown as a function of OAT, Hp, and GW.

Example

Find the landing distance required over 50 foot obstacle under the assumed conditions:

Conditions

2000 feet pressure altitude
OAT - 20° C
Gross weight 10,000

Solution

a. Enter the chart on the bottom left side at the 20° C point.

b. Move vertically to the 2000 foot line

c. Move horizontally to the right to the 10,000 pound line

d. Move straight down to find approximately 280 feet required for landing distance.

Category A Operations

Most Bell 212s are operated under FAR Part 29 Category B operations, and the majority of the RFM limitations and performance charts are based on Category B. The Category A operations section of the flight manual is located in the Flight Manual Supplements section BHT-212-FMS-7.

A Category A takeoff is defined as the operation of a helicopter in such a manner that if one engine fails at any time after start of takeoff, helicopter can: Return to, and safely stop on, the takeoff area or continue takeoff, climb out, and attain single engine forward flight.

A Category A Landing is defined as operation of the helicopter in such a manner that if one engine fails at any point during approach, the helicopter can land and stop safely on the intended landing area; or climb out from the point of failure and attain single engine forward flight.

Category A operations are covered in Parts A, B, and C. Each section specifies limitations, procedures, and performance for a given set of conditions.

Part A provides data for vertical takeoffs and landings from 72 by 150 feet heliports.

Part B provides data for standard takeoffs and landings from 550 foot runways.

Part C provides data for standard takeoffs and landings from 2300 foot runways.

Category A helicopter operation may be required if:

- The Helicopter is operating under a FAR Part 135 or 127 certificate.
- The responsible FAA principal operations inspector requires the certificate holder to follow Category A operations for certain types of helicopter flights.
- The party owning, operating, or hiring the helicopter requires that the flight should be conducted under Category A.
- International Operations

Category A operation increases margins of safety during the takeoff and landing/approach phases of flight. Category A does not increase helicopter safety itself, but rather safety in the way it is operated.

Briefly, Category A requires helicopter operation in such a manner that if an engine fails during takeoff or landing approach, either a safe landing or climbing and attaining single engine forward flight is possible. The increased safety is achieved by significantly reducing maximum gross weight and maximum altitude for takeoff and landing and by increasing takeoff and landing distances required.

For example, given an OAT of 40°C (104°F) at a pressure altitude of 4,000 feet, the Category B maximum gross weight for takeoff and landing is 10,250 pounds. Under the same conditions, the maximum gross weight for Category A operations is only 8,950 pounds. The large reduction in takeoff and landing gross weight substantially increases the margin of safety if an engine should fail (Figure 15-18c).

If the helicopter must be operated in accordance with Category A criteria, the limitations and procedures in the approved supplement of the RFM, Category A, provide special limitations, normal procedures, emergency procedures, and performance charts for Category A operations, which must be followed.

Example

Find Gross weight limit for takeoff

Conditions

Pressure altitude	Sea Level
Temperature	95°F or 35°C
Wind Speed	20 Knots
Wind Direction	130°
Takeoff heading	100°

Solution

a. Figure Headwind component using chart on figure 15-18b

a. Enter the Vertical Operations Chart (Figure 15-18a) at 35°C

b. Move vertically to Sea Level Pressure Altitude

c. Move horizontal to the left to the beginning of the Headwind component. Maintain proportional distances form the dark lines until reaching the headwind component of 17.5 Kts.

d. Then discontinue maintaining proportional distance form the dark lines and move in a horizontal flat line to the left to find the 8870 pounds Gross Weight in pounds limit for takeoff and landing.

Cat A Takeoff

For a Category A (Part B) Takeoff with Runway Length of 550 Feet there is a Performance Segments Chart in Figure 15-18d. The first chart to consider, shown in figure 15-18e is the Hover Performance Chart. This chart gives the torque required to hover as well as the torque available under various conditions of weight, temperature, and pressure altitude. Use of the chart is relatively simple and there is an example dashed line on the chart itself.

First determine the OAT, Hp, and GW. Then enter the chart at OAT, proceed vertically upward to Hp, proceed horizontally to the right to GW, then proceed vertically downward to torque meter scale and read percent torque required to hover. (Transmission Torque)

Figures 15-18f and 15-18g are intended to be used together and depict the Takeoff Flight Path charts that give you the height above the takeoff surface in feet at a horizontal distance from the end of the take distance. Prior to going to the first chart, determine the headwind component from the chart in figure 15-18b. The first chart factors weight, OAT, Hp, and headwind component in order to derive a value called the climb index which is used on the second "Obstacle Clearance" chart. It is important to note that the height above takeoff values derived from this second chart are attained **after reaching a distance of 550 feet plus the Horizontal Distance** as shown on the bottom of the chart. This clearance is predicated on crossing the end of the 550 foot "runway" at a height above takeoff of 35 feet AGL. FMS-7 also includes several single engine climb performance charts for V_{Toss} and V_Y. It is interesting to note that under identical conditions of weight, temperature and power, flying at V_y will roughly double the rate of climb compared to flying at V_{Toss}. This is, of course, at the expense of the actual V_x (angle of climb)

Operational Information

Section 3, f the *RMD* (Rotorcraft Manufacturer's Data) provides numerous helpful conversion tables for temperature, velocity, liquid measure, distance, weight, and pressure.

Weight and Balance

General

Proper weight and balance control to ensure that the helicopter CG is within prescribed limits is essential. Failure to load the helicopter so that is within CG limits and then maintain helicopter CG within allowable limits during flight may result in insufficient control capability and unsafe flight conditions.

Helicopter CG limits, both longitudinal and lateral, are provided in Section 1, "Limitations," of the *RFM.* Section 6, "Weight and Balance," of the *RFM* provides all necessary instructions and information for calculating helicopter CG.

Helicopter CG is expressed as a location, in inches relative to a reference line, where all of the helicopter's weight is centered. The Bell 212 has two reference points, one for calculating longitudinal CG and one for calculating lateral CG.

The longitudinal CG reference line is the reference datum line which is located approximately 20 inches aft of the helicopter nose. The lateral CG reference line is the centerline of the helicopter (Figure 15-19).

Longitudinal helicopter CG is stated as inches aft of the longitudinal reference datum line while lateral CG is stated as inches right or left of the centerline.

The longitudinal and lateral CG of the helicopter must fall within the allowable CG range listed in the Limitations section of the RFM for all phases of helicopter flight.

All calculations to determine helicopter CG are based on the weight of items loaded on the helicopter and the item's location in the helicopter in relation to the reference datum lines.

CG Limitations

Longitudinal and lateral CG range limits are shown in Figure 15-2. Allowable longitudinal CG range decreases as helicopter gross weight increases. Lateral CG range is constant for all gross weights.

Calculating Helicopter CG

General

The helicopter's actual CG is calculated by starting with a known helicopter empty weight and moment. The empty weight of a helicopter consists of the basic helicopter with required equipment, optional equipment kits installed, transmission and gearbox oils (not engine oil), hydraulic fluid, unusable fuel, undrainable engine oil, and fixed ballast.

The empty weight and moment are originally calculated by the manufacturer and are provided in the actual weight record supplied with the helicopter when delivered. When installed items are added or removed from the helicopter, the actual weight record must be recalculated to provide a new empty weight (Figure 15-19).

CG Formula

The CG of the helicopter, both longitudinal and lateral, is determined by mathematical calculations using one of the formulas shown below:

Moment = Weight x Arm
Center of Gravity = Total Moment divided by Total Weight

Moment is an expression of exerted force and is calculated by multiplying the weight of an object by its Arm (distance from the reference datum line). For example, a 170 pound pilot sitting in the pilot seat (right seat) has a longitudinal moment of, or exerts a force of, 7,990 inch-pounds (170 x 47) and a lateral moment of +3,740 inch pounds (170 x 22) (Figure 15-19).

By adding the weights and moments of all fuel, persons, cargo, etc., to the empty weight and moment of the helicopter, the total weight and total moment can be obtained. Then, by dividing the total moment by the total weight, the helicopter CG is easily calculated.

Normally, helicopter longitudinal CG should be calculated for takeoff, landing, and the most critical forward CG. Additionally, the Weight and Balance section of the RFM requires computation of the helicopter's longitudinal CG for all cargo/baggage configurations and whenever weight is loaded into the baggage compartment. Longitudinal CG should also be computed whenever the crew doors, hinged panel door, or passenger doors are removed or open for flight.

Lateral CG should be calculated whenever loading or the use of optional equipment, such as the rescue hoist, can affect lateral CG.

Optional Equipment And Kits

The installation of optional equipment on the helicopter affects helicopter CG in two ways.

After installation of optional equipment, the empty weight and moment must be recalculated and any adjustment made to ensure that the empty weight CG is within allowable limits of the maintenance manuals.

When certain optional equipment is installed, the helicopter's CG must be calculated using the weight and balance information in the appropriate RFM supplement. This is particularly important for the external cargo hook, auxiliary fuel, litter kit, rescue hoist, and any STC kits whose use might affect helicopter CG.

Loading The Helicopter

Once the fuel requirements for the flight have been calculated, the pilot should determine how the helicopter is loaded. A few general limitations apply: a minimum combined weight of 170 pounds is required in the pilot and copilot seats, the two outboard facing seats should not be occupied until at least four passengers have been loaded in the forward or aft facing seats, and baggage compartment loading, if required, should be from front to rear with all items tied down.

Weight And Balance Computation (Longitudinal)

Once the pilot has determined helicopter loading, the actual CG is computed using the loading tables provided in the RFM and supplements. Loading charts with weights and moments are provided for pilots and passengers, internal cargo, baggage compartment, and fuel (Tables 19, 20, 21, 22).

Each table includes a range of weights from which the exact or closest weight and the corresponding moment can be chosen. Moments for odd weights and/or locations can be found by multiplying the exact weight by the fuselage station where the weight is loaded.

The weights and moments for fuel, oil, and all persons and objects loaded on the helicopter are added to the helicopter's empty weight and moment to obtain a total weight and total moment. Dividing the total moment by the total weight results in the takeoff CG. The CG figure obtained should be checked against the gross weight center of gravity chart to ensure that the helicopter CG falls within allowable limits. The same steps should be taken to get landing and most critical forward CG.

Weight And Balance Computation (Lateral)

Lateral CG computations are figured in a similar manner; however, there are no loading tables provided. Lateral moments must be computed by multiplying the weights of items by their respective distances from the helicopter centerline. When computing lateral moments, a plus (+) is used to indicate moments right of centerline and a minus (-) is used to indicate moments left of centerline.

The weights and lateral moments for all persons and objects loaded on the helicopter are added to the helicopter's empty weight and lateral moment to obtain a total weight and total lateral moment. Dividing the total lateral moment by the total weight provides the lateral CG, having a value that must be between +6.5 and -4.7 inches for the VFR *RFM,* and between +3.5 and -3.5 inches for the IFR *RFM.*

Some lateral moments may cancel each other when added. For example, a 170 pound pilot at lateral station +22, having a moment of +3,740, and a 170 pound copilot at lateral station -22, having a lateral moment of -3,740, when added to the empty CG moment, have lateral moments which cancel out. However, their weights do not cancel and must be added to the empty weight to ensure proper lateral CG computation.

Sample Weight And Balance Computation

The Weight and Balance section of the RFM contains sample longitudinal CG computations, like the one below for review. Additional practice CG problems are available from the instructor.

SAMPLE LOADING PROBLEM (ENGLISH UNITS) FOR HELICOPTER SERIAL NUMBERS 35409 AND SUBSEQUENT

	Weight (LBS)	CG (Inches)	Moment (In-Lbs)
Basic Operating Weight			
Licensed Empty Weight	6529.4		939996
+Oil	24.5		4146
+Pilot	*170.0		7990
Payload	*		
+Passengers (5man seat)	*850.0		99450
+Passengers (4 man seat)	*680.0		59160
+Baggage	*180.0		46980
Takeoff Conditions			
Basic Operating Weight + Payload	8433.9		1157722
+Takeoff fuel (218.6 gallons Type B)	*1421.0		216829
Takeoff Weight, CG & Moment	9854.9	139.5	1374551
Most Critical FWD CG Location			
Basic Operating Weight + Payload	8433.9		1157722
+Critical Fuel (78.5 gallons Type B)	*510.0		64955
Critical Weight, CG & Moment	8943.9	136.7	122267
Landing Conditions			
Basic Operating Weight + Payload	8943.9		1157722
+Landing Fuel (60 gallons Type B)	*390.0		50661
Landing Weight, CG & Moment	8823.9	136.9	1208383
* Information obtained from loading charts			

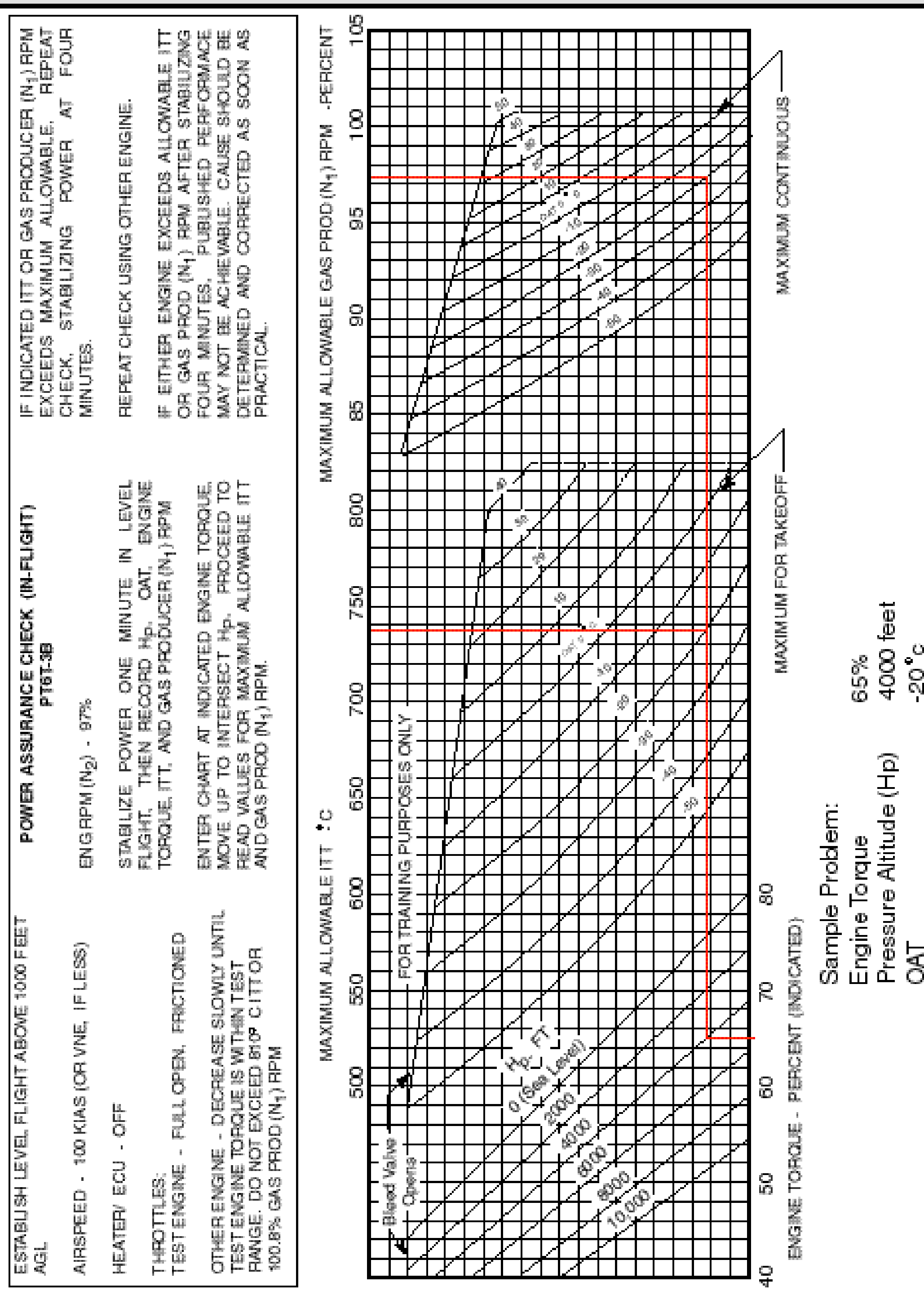


Figure 15-5 Power Assurance Check (In Flight)

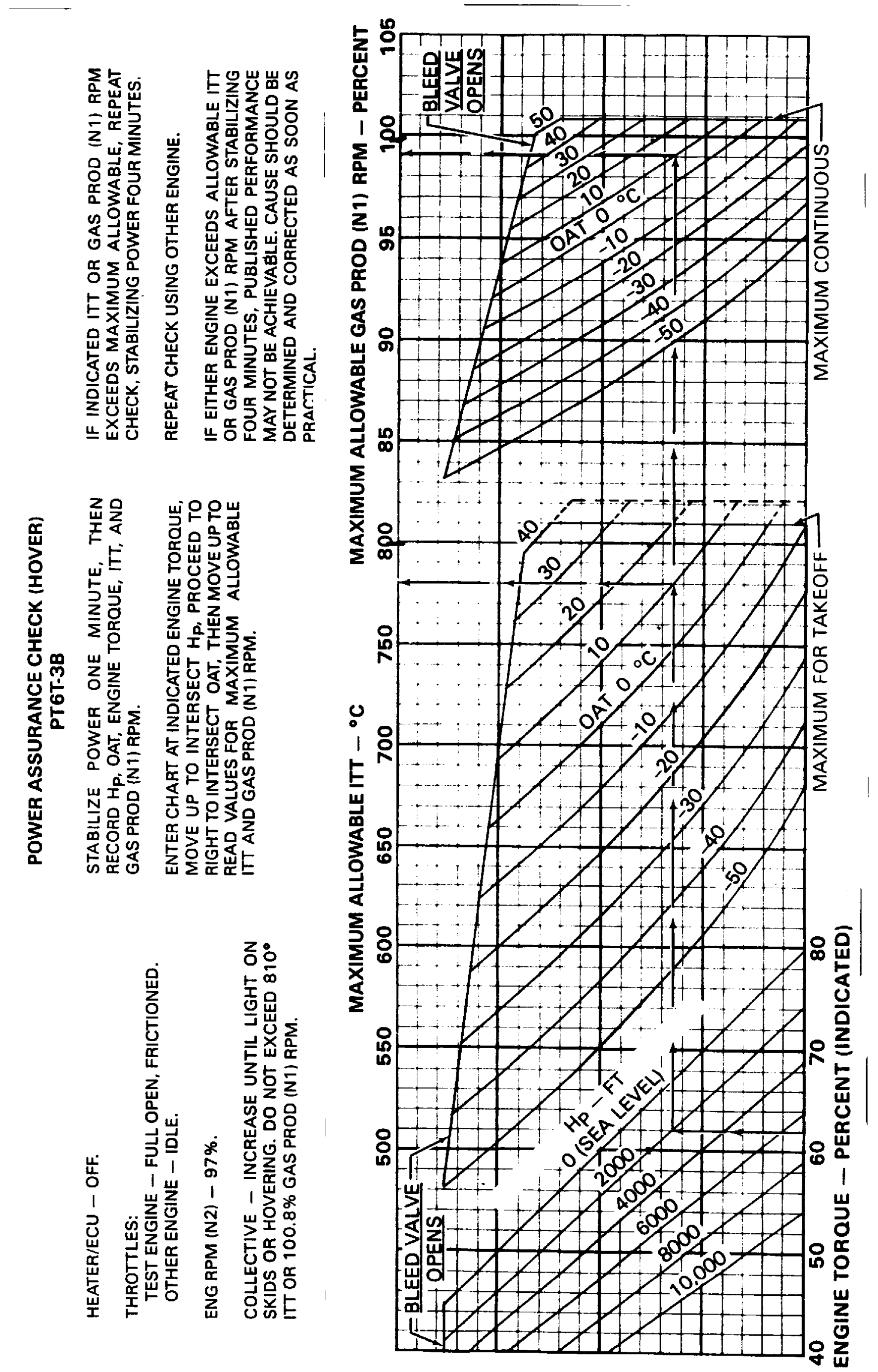


Figure 15-6 Power Assurance (Hover)

CHART A

H_P	-500	-1000	-1500
% TORQUE	50.5	51.5	52.5

H_P	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500
% TORQUE	49.5	48.5	48.0	47.0	46.0	45.0	44.0	43.5	42.5	42 0	41.0	40.5

H_P	6000	6500	7000	7500	8000	8500	9000	9500	10,000	10,500	11,000
% TORQUE	39.5	38.5	38.0	37.5	36.5	36.0	35.0	34.5	34.0	33.0	32.5

EXAMPLE

1. ALTIMETER . . . . 29.92 IN HG
2. OBSERVED H_P . . . . 1500 FT
3. OBSERVED CHART A TORQUE 47.0%
4. START BOTH ENGINES
5. TURN HEATER OFF
6. ON GROUND, ENGINE NO. 2 TO IDLE
7. STABILIZE NO. 1 ENGINE, 4 MINUTES MINIMUM, AT 97% (N2) ENG RPM AND CHART A TORQUE AND OBSERVE

   GAS PROD (N1) 95.2% RPM
   ITT 710°C
   OAT 20°C
8. OBSERVED GAS PROD (N1) RPM AND ITT MUST BE LESS THAN CHART GAS PROD (N1) RPM AND ITT FOR OBSERVED OAT.
9. REPEAT CHECK ON NO. 2 ENGINE WITH NO. 1 ENGINE AT IDLE.
10. If OBSERVED GAS PROD (N1) RPM AND/OR ITT ARE GREATER THAN CHART B GAS PROD (N1) RPM AND/OR ITT FOR OBSERVED OAT.
11. HOVER IGE AND CHECK NO. 1 AND NO. 2 ENGINE TORQUE NEEDLE SPLIT NO GREATER THAN 4%.

CHART B

OAT ~ °C	52	50	45	40	35	30	25	20	15	10	5	0
GAS PROD (N1) – % RPM	100	100	99.8	99.1	98.4	97.7	97.0	96.3	95.6	94.8	94.1	93.4
ITT ~ °C	810	810	805	795	780	765	750	735	720	705	690	675

OAT ~ °C	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-54	
GAS PROD (N1) – % RPM	92.7	92.0	91.3	90.6	89.9	89.2	88.5	87.8	87.1	86.4	85.8	
ITT ~ °C	660	645	630	615	605	590	575	560	545	530	520	

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Figure 15-7 Power Assurance PT6T-3

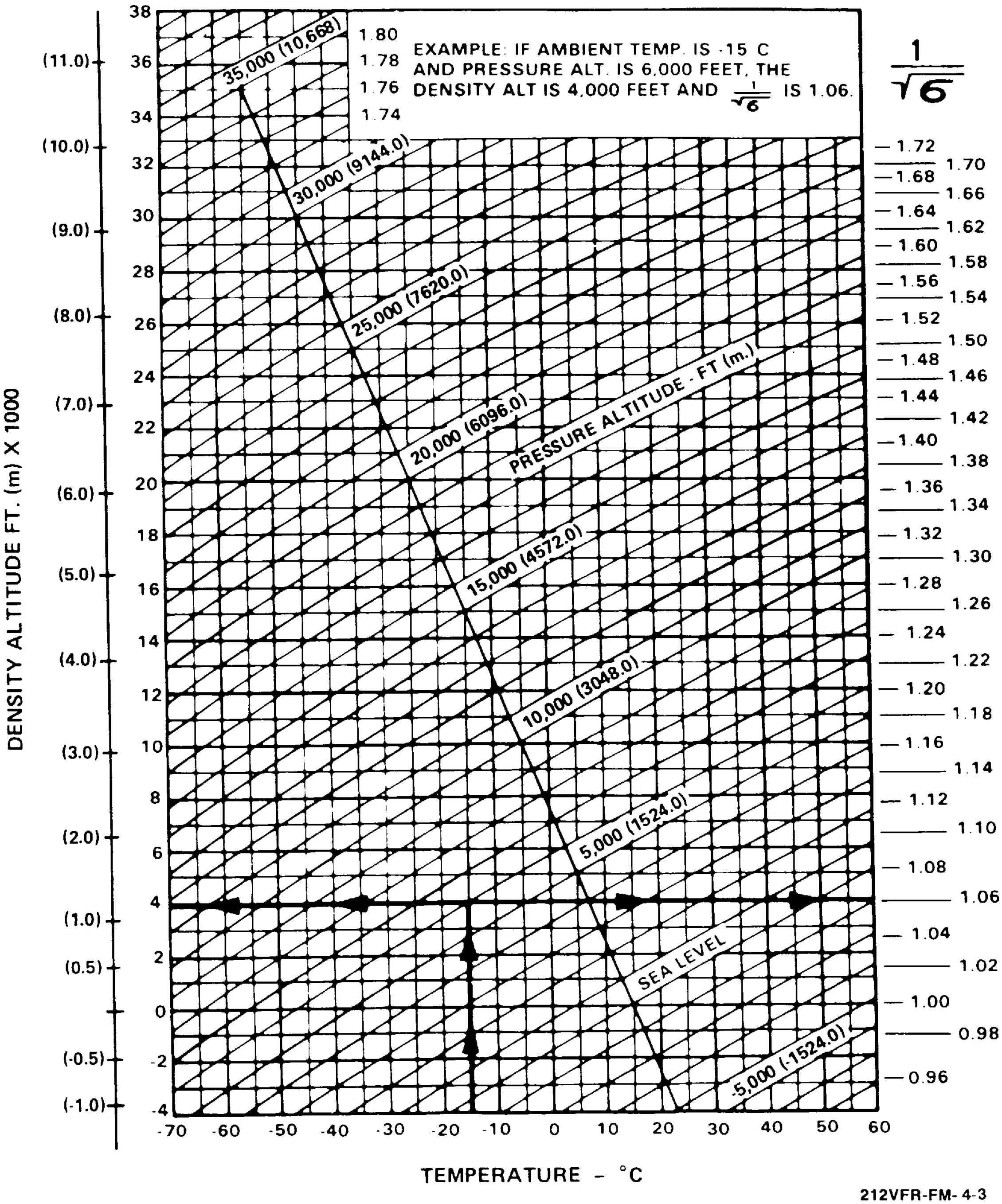

Figure 15-8 Density Altitude

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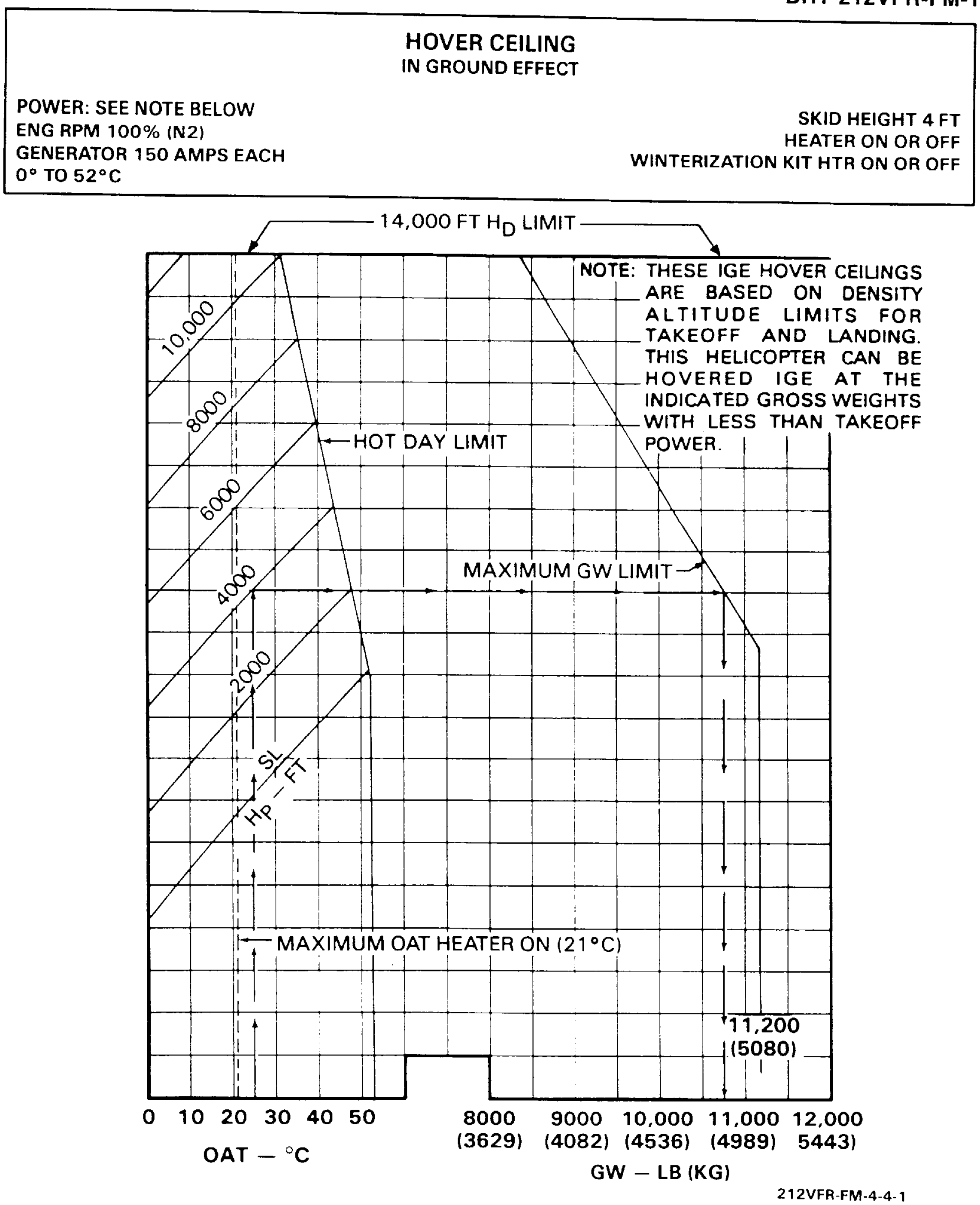

Figure 15-9 HIGE Chart

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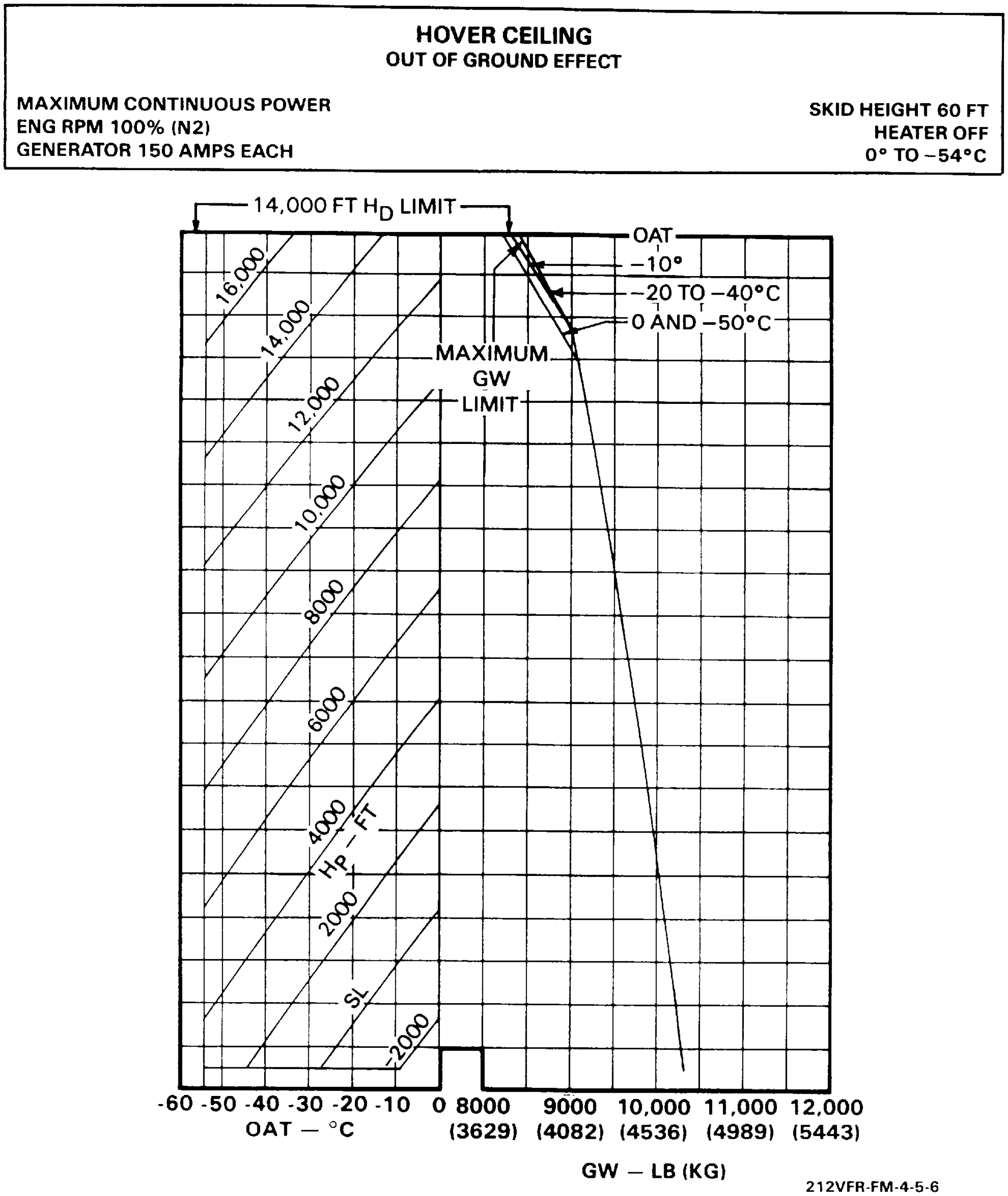


Figure 15-10 OGE Hover Chart

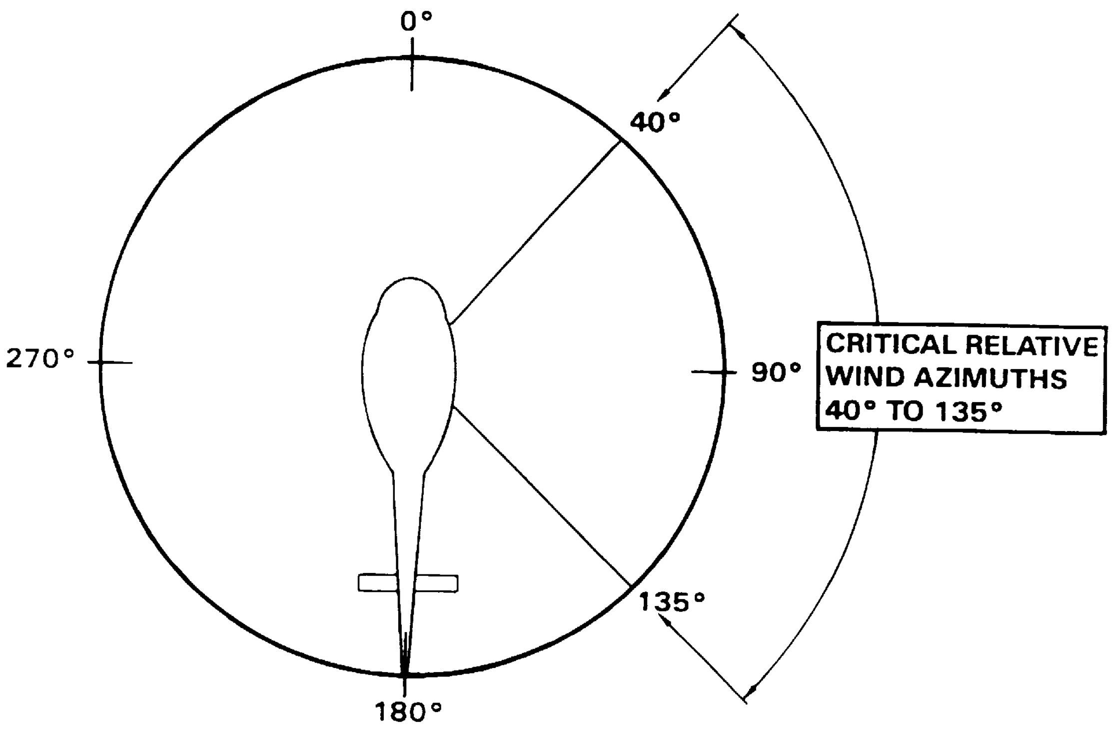


Figure 15-11   Critical Wind Azimuth

TAKEOFF DISTANCE
OVER 50 FT (15.2m) OBSTACLE

HOVER POWER +15% TORQUE
ENG RPM 100% (N2)
GENERATOR 150 AMPS

INITIATED FROM 4 FT SKID HEIGHT
HEATER ON OR OFF
WINTERIZATION KIT HTR ON OR OFF

REFER TO V_{TOCS} CHART FOR TAKEOFF SPEED

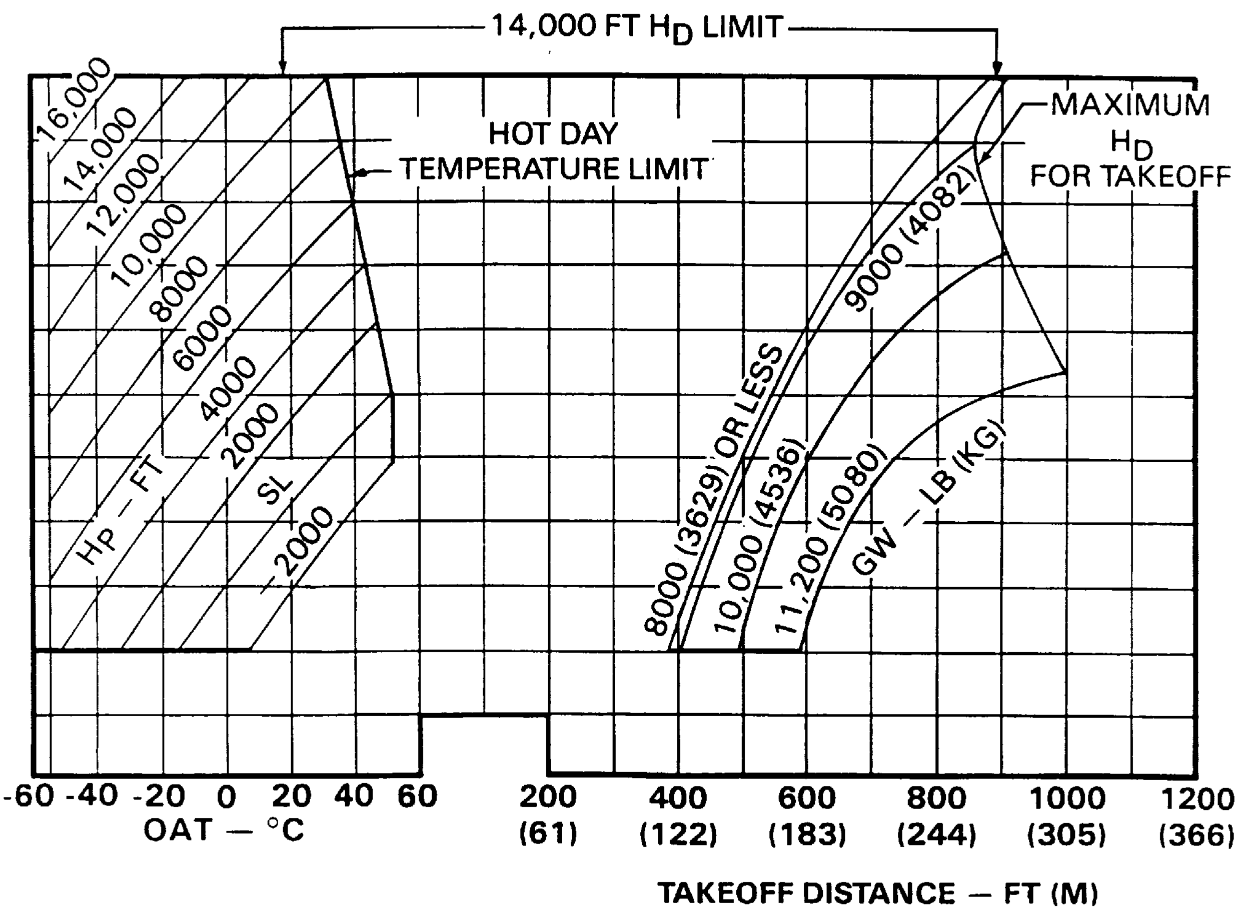


Figure 15-12 Takeoff over a 50 Foot Obstacle

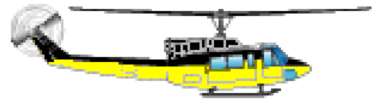
Vtocs Chart is on Figure 15-13 on the following page.

TWIN ENGINE TAKEOFF CLIMBOUT SPEED – KIAS							
H_D – FT*	GW – LB (KG)						
	7000 (3175)	8000 (3629)	9000 (4082)	10,000 (4536)	10,500 (4763)	11,000 (4989)	11,200 (5080)
0	30	30	30	35	38	40	40
1000	30	30	30	35	38	40	40
2000	30	30	30	35	38	40	40
3000	30	30	30	36	38	40	42
4000	30	30	32	36	40	42	42
5000	30	30	32	38	40	42	–
6000	30	30	34	38	42	–	–
7000	30	30	34	40	42	–	–
8000	30	30	34	40	–	–	–
9000	30	30	36	–	–	–	–
10,000	30	32	36	–	–	–	–
11,000	30	32	38	–	–	–	–
12,000	30	34	38	–	–	–	–
13,000	30	34	–	–	–	–	–
14,000	30	36	–	–	–	–	–

* Refer to Density Altitude Chart.

Vtocs is that indicated airspeed which will allow takeoff distance over a 50 foot (15.2 meter) obstacle to be realized and will comply with HV restrictions to allow a safe landing in case of an engine failure.

Figure 15-13 Twin Engine Takeoff Climb-out Speed - KIAS (V_{tocs})



TWIN ENGINE RATE OF CLIMB
GW 9000 LB (4082 KG)

TAKEOFF POWER
ENG RPM 100% (N2)
GENERATOR 150 AMPS

V_{CAL} 55 KNOTS
HEATER OFF

WITH ALL DOORS OPEN OR REMOVED, RATE OF CLIMB WILL DECREASE 200 FT/MIN

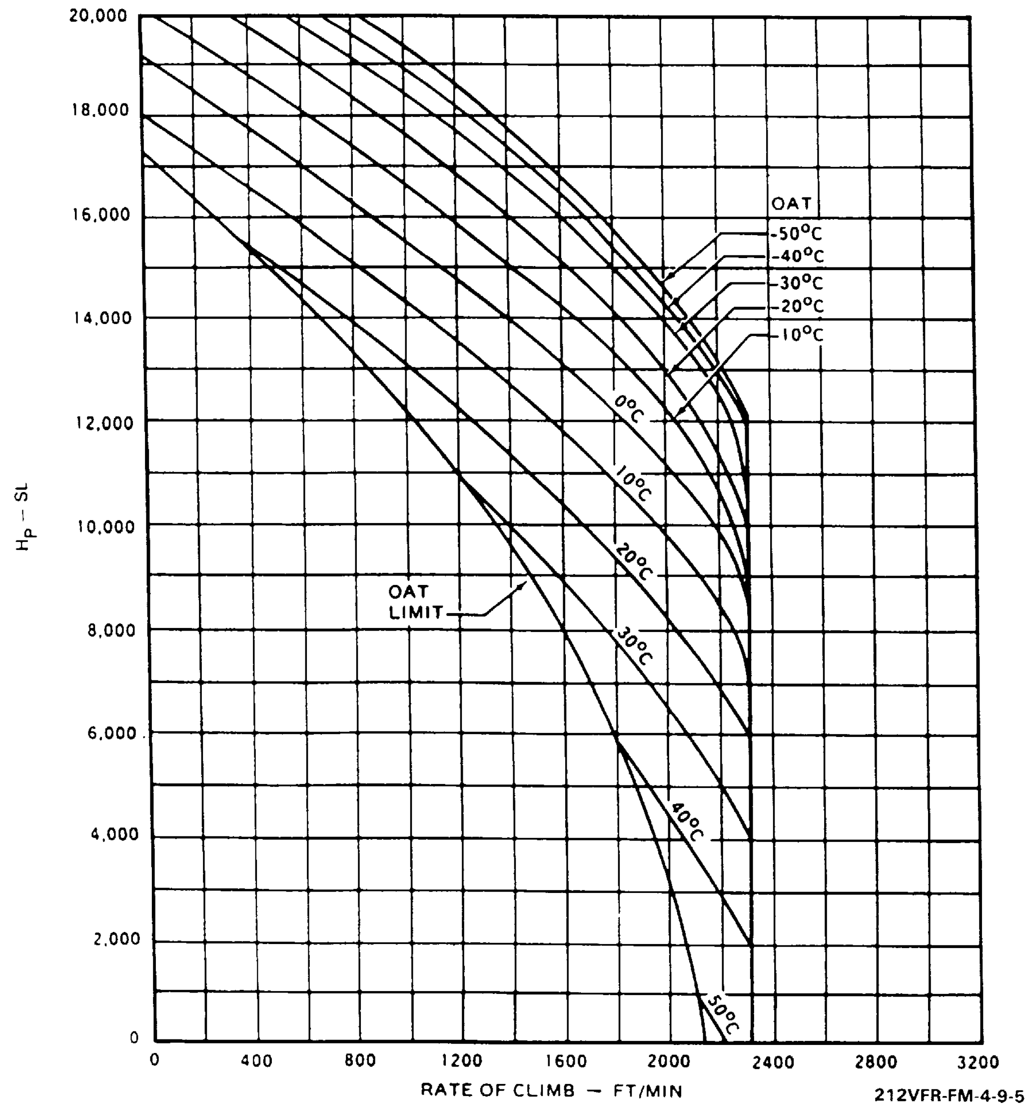


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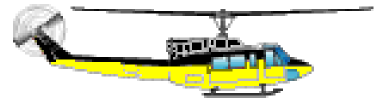
Figure 15-14 Twin Engine Rate of Climb



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SINGLE ENGINE RATE OF CLIMB — PT6T-3B
GW 10,000 LB (4536 KG)

30 MINUTE OEI POWER
ENG RPM 97% (N2)
GENERATOR 150 AMPS

55 K_{CAS}
HEATER OFF
INOPERATIVE ENGINE SECURED

WITH ALL DOORS OPEN OR REMOVED, RATE OF CLIMB WILL DECREASE 200 FT/MIN

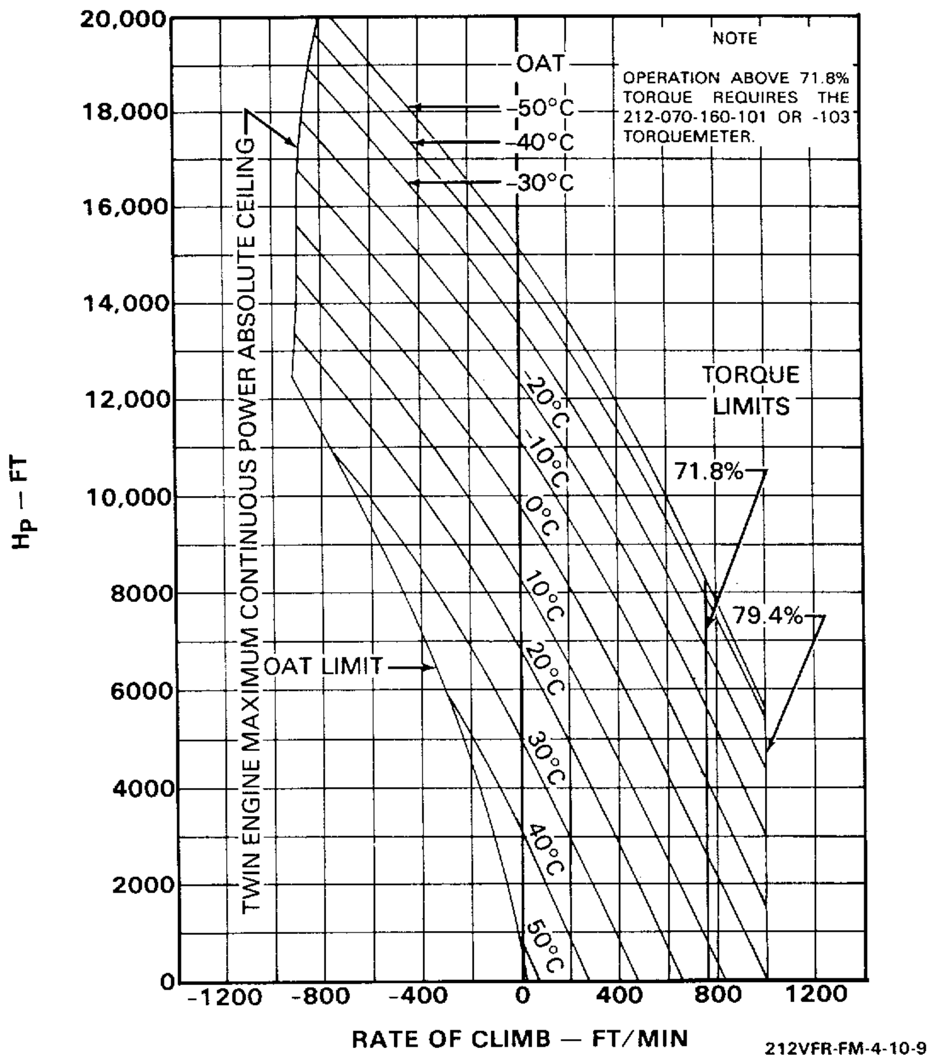

Figure 15-15 Single Engine Rate of Climb

PILOT AIRSPEED SYSTEM CALIBRATION

CLIMB
LEVEL FLIGHT
AUTOROTATION
SKID GEAR
IAS — ERROR = V^CAL

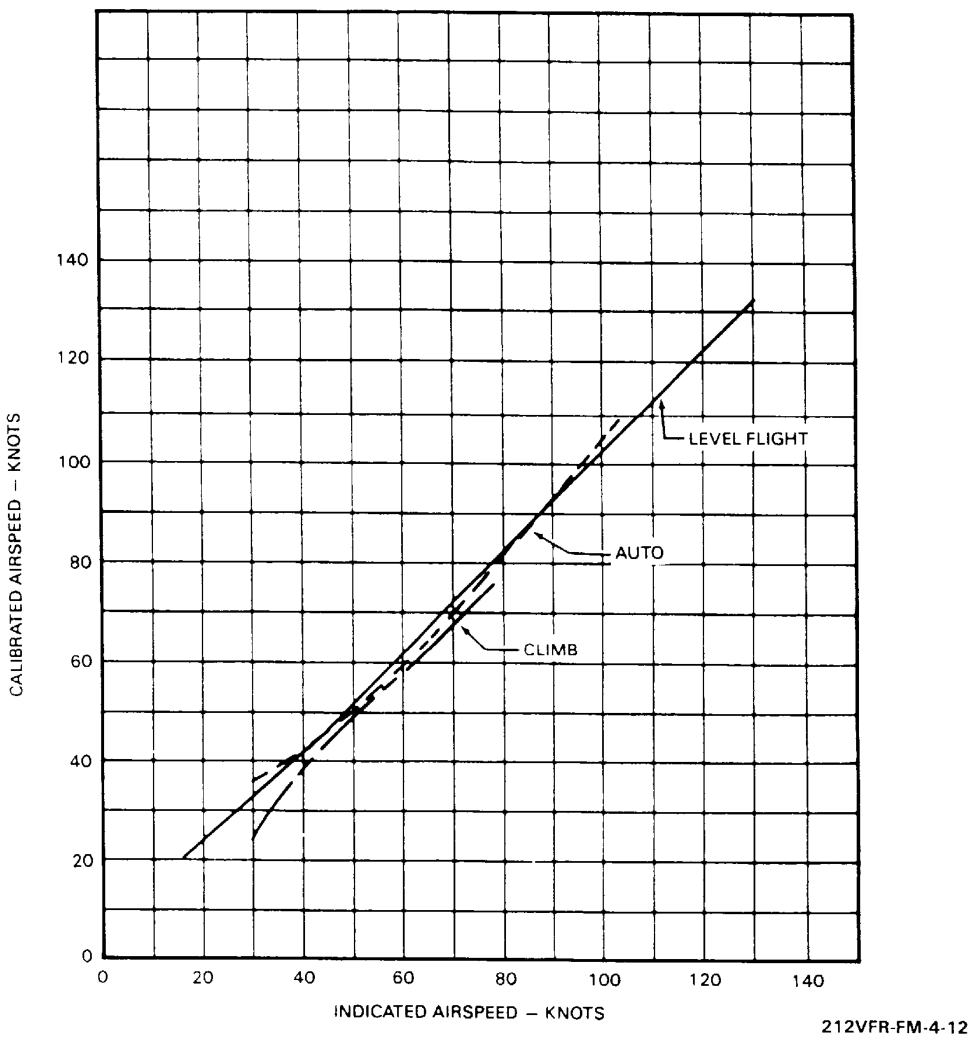

Figure 15-16 Pilot Airspeed Calibration

SINGLE ENGINE LANDING DISTANCE
OVER 50 FT (15.2 M) OBSTACLE

POWER AS REQUIRED
ENG RPM 97% (N2)
GENERATOR 150 AMPS

V_{IAS} 40 KNOTS
RATE OF DESCENT 500 FPM
HARD SURFACED RUNWAY

INOPERATIVE ENGINE SECURED

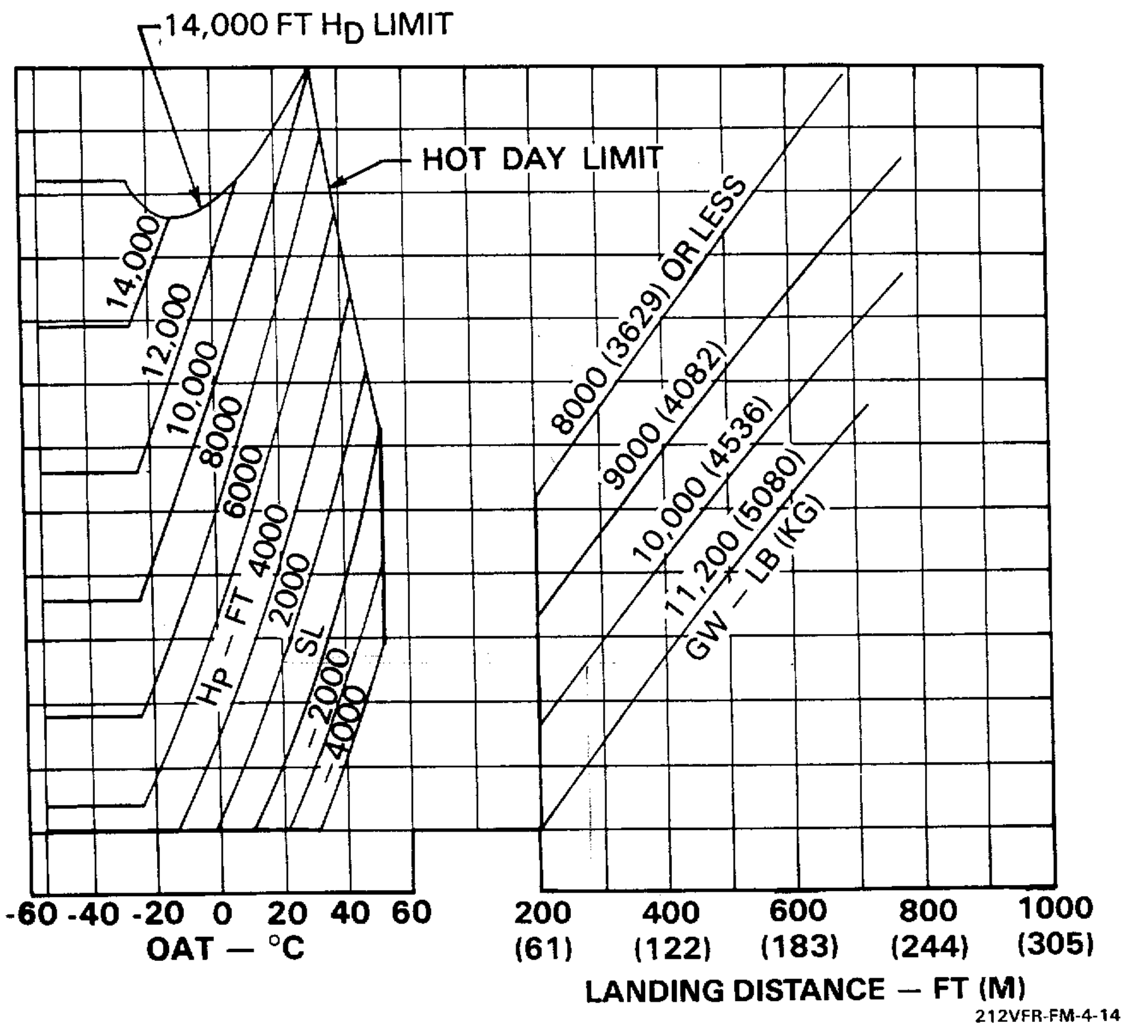

Figure 15-17 Landing over 50 Foot Obstacle (Single Engine)

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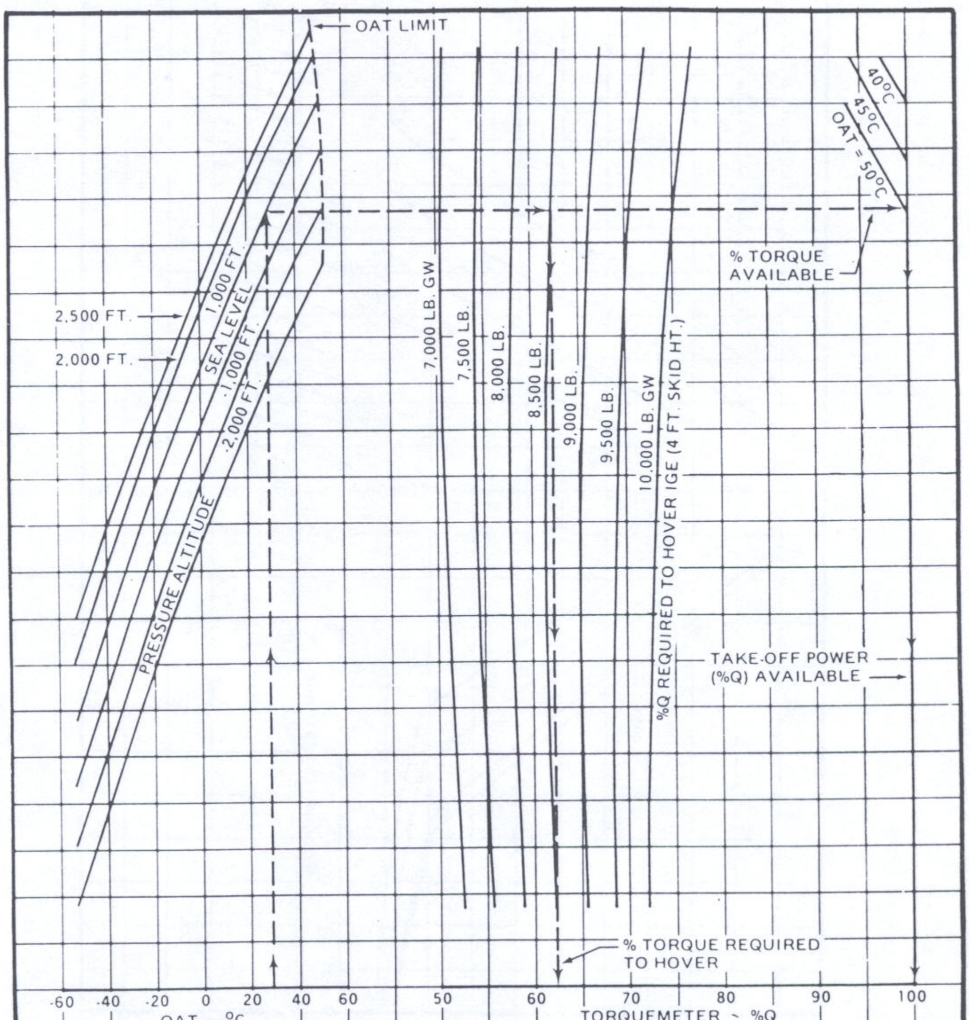
HOVER PERFORMANCE

IGE (4 FT. SKID HT.) POWER REQUIRED TO HOVER AND TAKE-OFF POWER AVAILABLE

ENGINE RPM 100% HEATER OFF
GENERATOR 150 AMPS NO WIND



212FMS7B-4-2

Figure 15-18a Hover Performance

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TAKEOFF FLIGHT PATH

CLIMB INDEX

30 MINUTE POWER	HEATER OFF
ENGINE RPM 97%	INOPERATIVE ENGINE SECURED
GENERATOR 150 AMPS	VTOSS = 30 KIAS

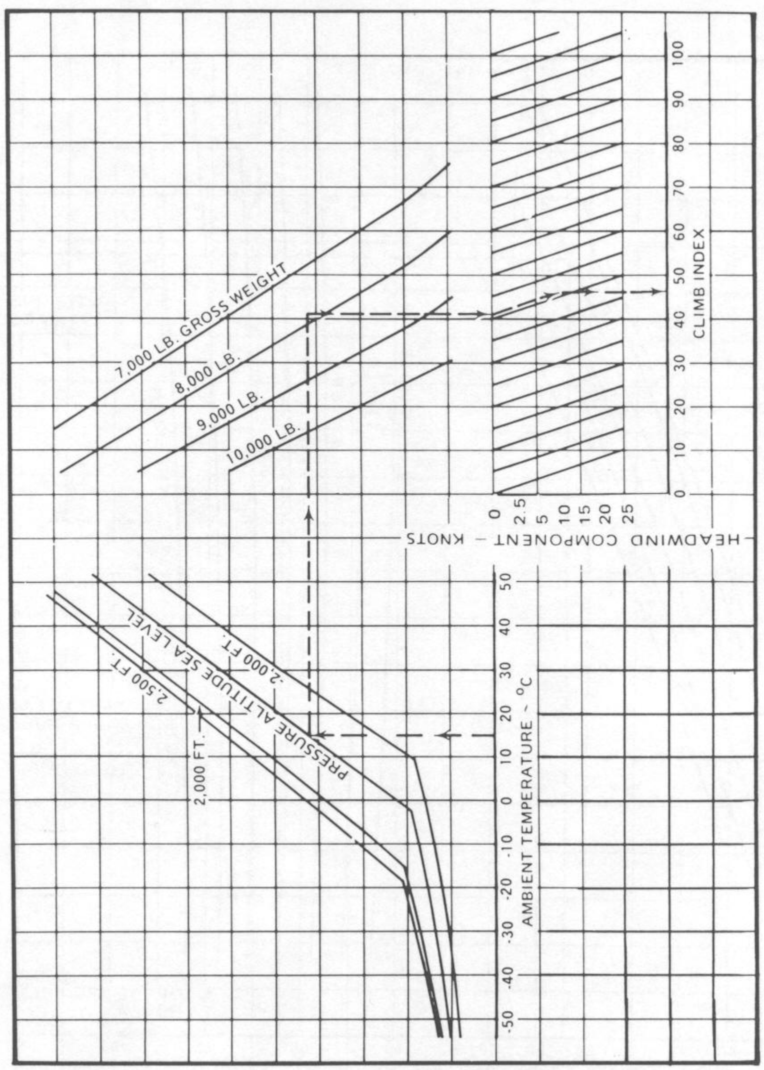

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Figure 15-18b Takeoff Flight Path Index

TAKEOFF FLIGHT PATH

OBSTACLE CLEARANCE

30 MINUTE POWER
ENGINE RPM 97%
GENERATOR 150 AMPS

HEATER OFF
INOPERATIVE ENGINE SECURED
VTOSS = 30 KIAS

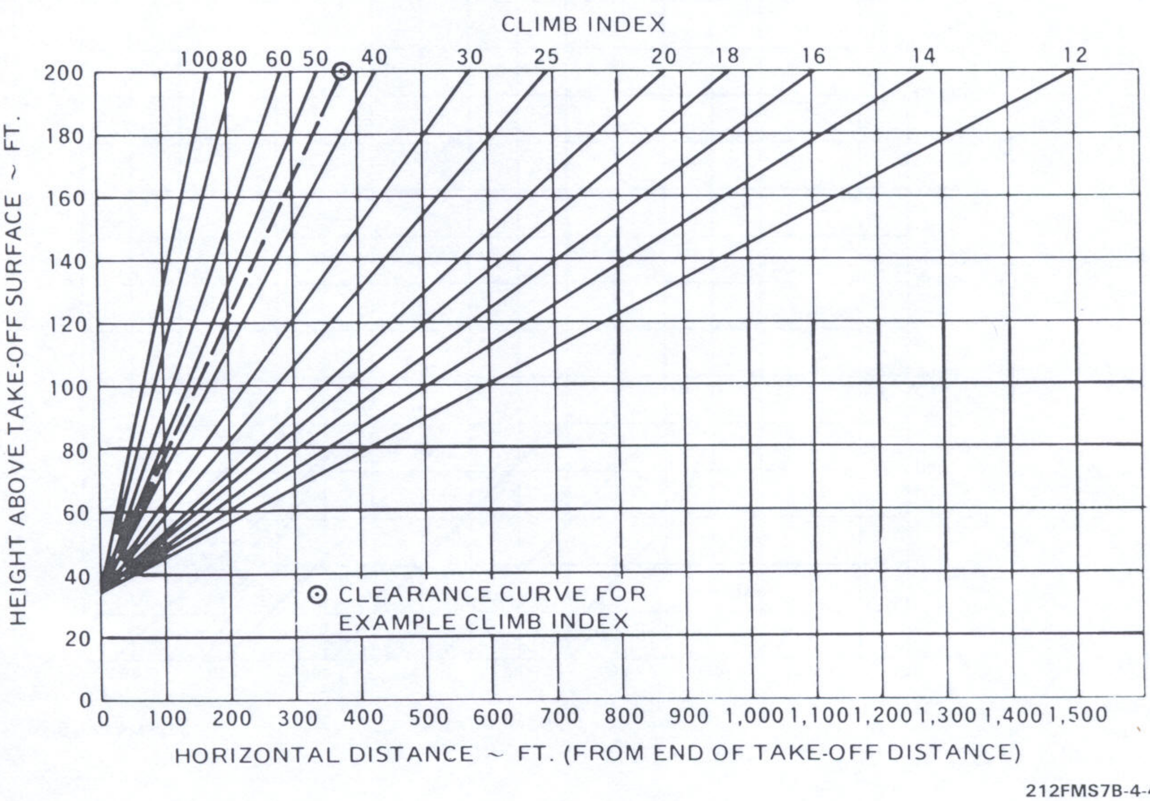

Figure 15-18c Takeoff Flight Path Clearance

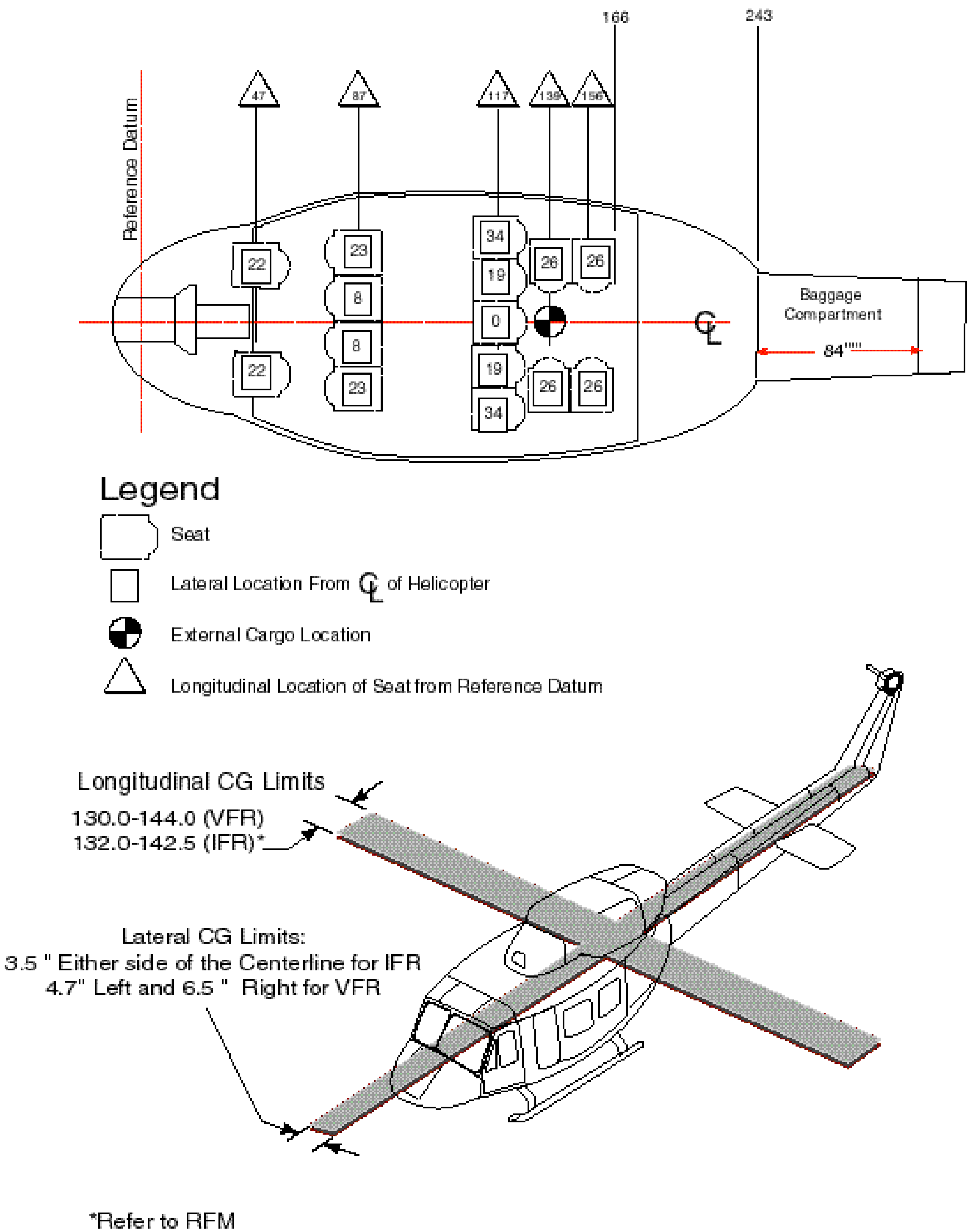

Figure 15-19 Weight and Balance

Weight (Pounds)	Pilot and Copilot* FS 47	Passenger (4-Man Seat Facing Fwd FS 117	Passenger (5-Man Seat Facing Fwd) FS 117	Passenger Facing Outboard		Litter Patient	
				Fwd Seat FS 139	Aft Seat FS 156	Lateral Loaded FS 117	Longitudinal Loaded FS 120
100	4700	8700	11700	13900	15600	11700	12000
110	5170	9570	12870	15290	17160	12870	13200
120	5640	10440	14040	16680	18720	14040	14400
130	6110	11310	15210	18070	20280	15210	15600
140	6580	12180	16380	19460	21840	16380	16800
150	7050	13050	17550	20850	23400	17550	18000
160	7520	13920	18720	22240	24960	18720	19200
170	7990	14790	19890	23630	26520	19890	20400
180	6460	15660	21060	25020	28080	21060	21600
190	8930	16530	22230	26410	29640	22230	22800
200	9400	17400	23400	27800	31200	23400	24000
210	9870	18270	24570	29190	32760	24570	25200
220	10340	19140	25740	30580	34320	25740	26400

* Left forward seat

Figure 15-20 Pilot And Passengers Table Of Moments

MANUFACTURER'S DATA **BHT-212VFR-FM-1**

Table 5-4. Baggage loading

BAGGAGE LOADING TABLE (ENGLISH)
LOAD BAGGAGE FROM FORWARD END OF COMPARTMENT
400 POUND MAXIMUM

WEIGHT (LB)	APPROX. CG (FS)	MOMENT	WEIGHT (LB)	APPROX. CG (FS)	MOMENT
20	245	4900	220	265	58300
40	247	9880	240	267	64080
60	249	14940	260	269	69940
80	251	20080	280	271	75880
100	253	25300	300	273	81900
120	255	30600	320	275	88000
140	257	35980	340	277	94180
160	259	41440	360	279	100440
180	261	46980	380	281	106780
200	263	52600	400	283	113200

Figure 15-21 Baggage Table Of Moments

BHT-212VFR-FM-1 MANUFACTURER'S DATA

Table 5-5. Fuel loading
Helicopter serial numbers prior to 35049

ENGLISH							
ASTM D-1655 TYPE A, A-1, JP-5, AND JP-8 (6.8 LBS/GAL)				ASTM D-1655 TYPE B AND JP-4 (6.5 LBS/GAL)			
QUANTITY (U.S. GAL)	WEIGHT (LB)	CG (IN)	MOMENT (IN-LB)	QUANTITY (U.S. GAL)	WEIGHT (LB)	CG (IN)	MOMENT (IN-LB)
10	68	143.6	9765	10	65	143.6	9334
20	136	143.6	19530	20	130	143.6	18668
30	204	140.2	28601	30	195	140.2	27339
40	272	134.8	36666	40	260	134.8	35048
50	340	131.6	44744	50	325	131.6	42770
60	408	129.4	52795	60	390	129.4	50466
70	476	127.9	60880	70	455	127.9	58195
*72.6	494	127.6	63034	*72.6	472	127.6	60227
80	544	128.3	69795	80	520	128.3	66716
90	612	130.6	79927	90	585	130.6	76401
100	680	134.6	91528	100	650	134.6	87490
110	748	137.8	103074	110	715	137.8	98527
120	816	140.4	114566	120	780	140.4	109512
130	884	142.6	126058	130	845	142.6	120497
140	952	144.6	137659	140	910	144.6	131586
150	1020	146.1	149022	150	975	146.1	142448
160	1088	147.6	160589	160	1040	147.6	153504
170	1156	148.8	172013	170	1105	148.8	164424
180	1224	149.9	183478	180	1170	149.9	175383
190	1292	150.9	194963	190	1235	150.9	186362
200	1360	151.9	206584	200	1300	151.9	197470
210	1428	152.7	218056	210	1365	152.7	208436
**216.8	1474	153.3	225964	**216.8	1409	153.3	216000

* Most critical fuel amount for most forward flight condition.
** Most critical fuel amount for most aft flight condition.
NOTE: All data above represents usable fuel based on nominal density at 15°C (59°F).

(TABLE I.D. 911211)

Figure 15-22 Fuel Loading Table

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