# Balloon Flying Handbook

# 2008

U.S. Department of Transportation
**FEDERAL AVIATION ADMINISTRATION**
Flight Standards Service

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Although plotting can be continued as long as the pibal remains in sight, only the three points marked will be used for this exercise. *Figure 3-9* illustrates the results of the above sequence.

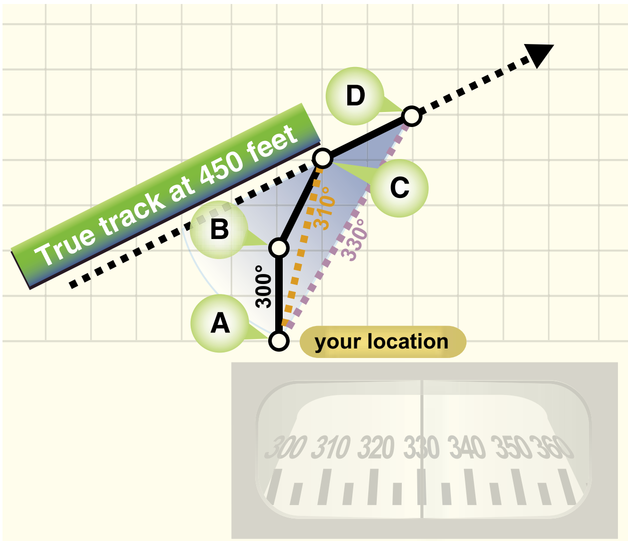


**Figure 3-9.** *A line drawn through the last two plots provides a basis to measure the angle and determine the wind at that altitude. In this case, it is 450 feet.*

To determine the wind directions at different altitudes, extend lines between the plotted points as shown in *Figure 3-9* back through the initial azimuth. Using the plotter, measure the angle between the lines (the angle between the A-B line and the C-D line). That angle, added to the original azimuth heading, gives a good approximation of the winds at that altitude. For the example shown in this sequence, the true track at 450 feet AGL is 005°. A grid appropriate for this computation is located in Appendix B.

This exercise demonstrates a practical method for determining approximate wind directions using items readily available to most pilots. It does not require expensive handheld calculators, laptop computers, or a theodolite that costs thousands of dollars. There is some error inherent in this process that can be lessened with experience and practice, but the readings obtained by this method can offer real time, on site weather data no forecast or briefer can provide. *[Figures 3-10* and *3-11]*

The information on basic surface winds and winds aloft readings gathered by this method can be used by a pilot to project a flight path and anticipated landing sites with a sectional or topographic map. This plot will form a "V," with the cone beginning at the launch site. The two legs will represent the extremes of the plotted measurements. The difference between these two extremes is called steerage. Flying higher will track the flight path closer to the winds aloft reading, while contour flying will put the balloon closer to the ground track leg. Varying altitude will allow the pilot to fly down the middle of the "v." Accuracy will depend on the consistency of the conditions, but flight paths and landing sites may be predicted, after practice, with a high degree of reliability.

Assume for exercises one and two that winds are at 5 miles per hour.

**Exercise 1:** The morning of the flight, the following pibal plots are taken:

| | |
|---|---|
| 30 seconds: | 117° |
| 1 minute: | 122° |
| 1:30 minutes: | 135° |
| 2 minutes: | 140° |
| 2:30 minutes: | 144° |
| 3 minutes: | 150° |

What is the wind direction at 600 feet above ground level (AGL)? At 900 feet AGL?

**Exercise 2:** On an afternoon flight, the following readings are taken:

| | |
|---|---|
| 30 seconds: | 290° |
| 1 minute: | 273° |
| 1:30 minutes: | 277° |
| 2 minutes: | 279° |
| 2:30 minutes: | 282° |
| 3 minutes: | 284° |

What is the wind direction at 600 feet?

**Figure 3-10.** *Practice pibal plots. These exercises are designed to assist the student pilot in devleoping proficiency in using the pibal plotting method. (answers on next page)*

The balloon pilot, more than pilots who fly other types of aircraft, must have the capability of visualizing the winds aloft in three dimensions. Continued spatial awareness (how the balloon is moving through the air), is important for maintaining control of the balloon and navigating to the desired point on the ground. Every other safety measure taken is compromised by inflating a balloon and taking off without proper planning and an understanding of the winds and terrain to be navigated. *[Figure 3-12]*

**Exercise 1:** The pibal is climbing at approximately 300 fpm. The winds between the third and fourth reading are for 600 feet AGL, and the winds between the fifth and sixth reading are for 900 feet AGL.

For the first computation, draw a line between the third and fourth plots, extending back through the original azimuth line of 117°. Measure the angle created between the original azimuth and the new line. That angle is 36°. Add 36° to the original azimuth of 117°. The resulting 153° should be the wind direction at approximately 600 feet AGL.

For the second computation, follow the same procedure. Draw a line from the fifth plot to the sixth plot, extending back through the original azimuth line. Measure the angle created between the original azimuth and the new line. Add the result of 68° to the original azimuth of 117°. The resulting 185° equals the wind direction at approximately 900 feet AGL.

**Exercise 2:** This exercise is a little more difficult, due to two factors: (1) the winds are starting out bearing to the left instead of to the right, which occurs during some weather and wind patterns; and (2) after the first reading, it is impossible to draw the lines back through the original azimuth line; therefore,another method must be used.

Draw a line through the first and second plots, the 300 feet AGL wind line. Measure the angle between that line and the original azimuth. That angle is 35°. Subtact 35° from the original azimuth of 290°, and the result is 255°. This line become a new baseline azimuth.

Draw a line between the fourth and fifth plots back through the new azimuth line. Measure the angle. Add the resulting 30° to the new azimuth line. The result of 285° is the apprximate wind direction at 600 feet.

**Figure 3-11.** *Additional practice pibal plots.*

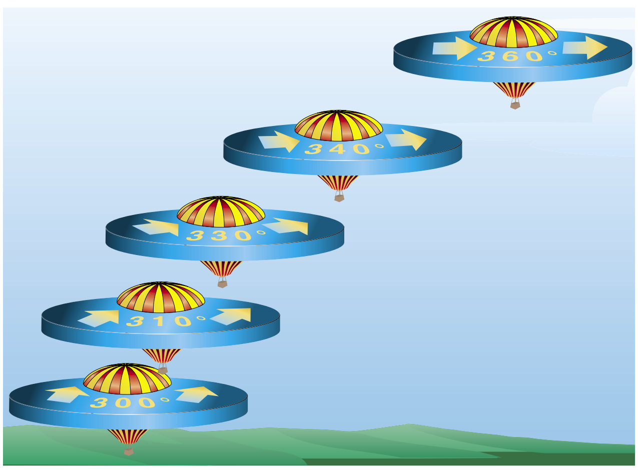


**Figure 3-12.** *As the balloon ascends, the flightpath inclines to the right. Correlate this visualization to a map to determine the ground track of the balloon during flight.*

## Performance Planning

Prior to a discussion of performance planning, a number of terms must be defined.

Maximum Allowable Gross Weight is that maximum amount of weight that the balloon may lift, under standard conditions. This figure is usually stipulated in design criteria, and addressed in the Type Certificate Data Sheet pertaining to that balloon. It can also be found on the weight and balance page of the flight manual for that particular balloon. An average of 1,000 cubic feet of air, when heated, will lift 20 pounds.

Useful lift (load) in aviation is the potential weight of the pilot, passengers, equipment, and fuel. It is the basic empty weight of the aircraft (found in the flight manual for each balloon) subtracted from the maximum allowable gross weight. This term is frequently confused with payload, which in aviation is defined as the weight of occupants, cargo, and baggage.

Density altitude is defined in the Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25) as "pressure altitude corrected for nonstandard temperature." Density altitude is determined by first finding pressure altitude, and then correcting this altitude for nonstandard temperature variations. For example, when set at 29.92, the altimeter may indicate a pressure altitude of 5,000 feet. Under standard temperature conditions (59 °F), this may allow for a useful load of 1,050 pounds. However, if the temperature is 20° above standard, the expansion of the air raises the density altitude level (the air is less dense, thereby mimicking the density of the air at a higher altitude). Using temperature correction data from tables or graphs, it may be found that the density level is above 8,000 feet, and the useful load is then reduced to 755 pounds. This definition, however, has a tendency to confuse many new (and some not-so-new) pilots, so a more thorough explanation is justified.

The AIM explains density altitude as being nothing more than a way to comparatively measure aircraft performance. Paragraph 7-5-6 states, in part, "Density altitude is a measure of air density. It is not to be confused with pressure altitude, true altitude or absolute altitude. It is not to be used as a height reference, but as a determining criteria [sic] in the performance capability of an aircraft." With respect to ballooning, this is a more useful definition of the term.

How does density altitude affect balloon performance? Density altitude affects balloon performance in two ways. First and more important, as a balloon gains altitude, it loses capacity, insofar as its lifting capability is concerned. This means a balloon capable of lifting 1,400 pounds at sea level may only be able to lift 1,150 pounds or less at 4,000 feet. For a pilot who seldom leaves the local area, this rarely causes a problem. For the pilot who travels from the low area of the Southeast to fly in the mile-high altitudes of Albuquerque, New Mexico, the changes in balloon capability and decrease in burner performance are important considerations while planning for the flight.

Second, heater performance is degraded at a rate of 4 percent per 1,000 feet of altitude. This means on a standard reference day, a particular heater will have lost 12 percent of its efficiency at 3,000 feet, or be performing at 88 percent of its capability. This is due to the loss of the partial pressure of oxygen, a necessary component of combustion.

Preflight planning requires consideration of balloon loading and performance with respect to altitude and expected temperatures. Balloon manufacturers have provided the information necessary to determine these factors in the form of a performance chart in the flight manual. Referred to as nomographs or nomograms, performance charts are simple to use and provide excellent planning information. *[Figure 3-13]*

If three of the above factors are known, a fourth may be determined. The performance charts may be used in many ways to determine performance of the balloon on a given day. This process does not have to be computed at the beginning of each flight. Many pilots develop a listing of possible weights, temperatures, and altitudes, depending on the average flying conditions for their home area. This is an acceptable practice

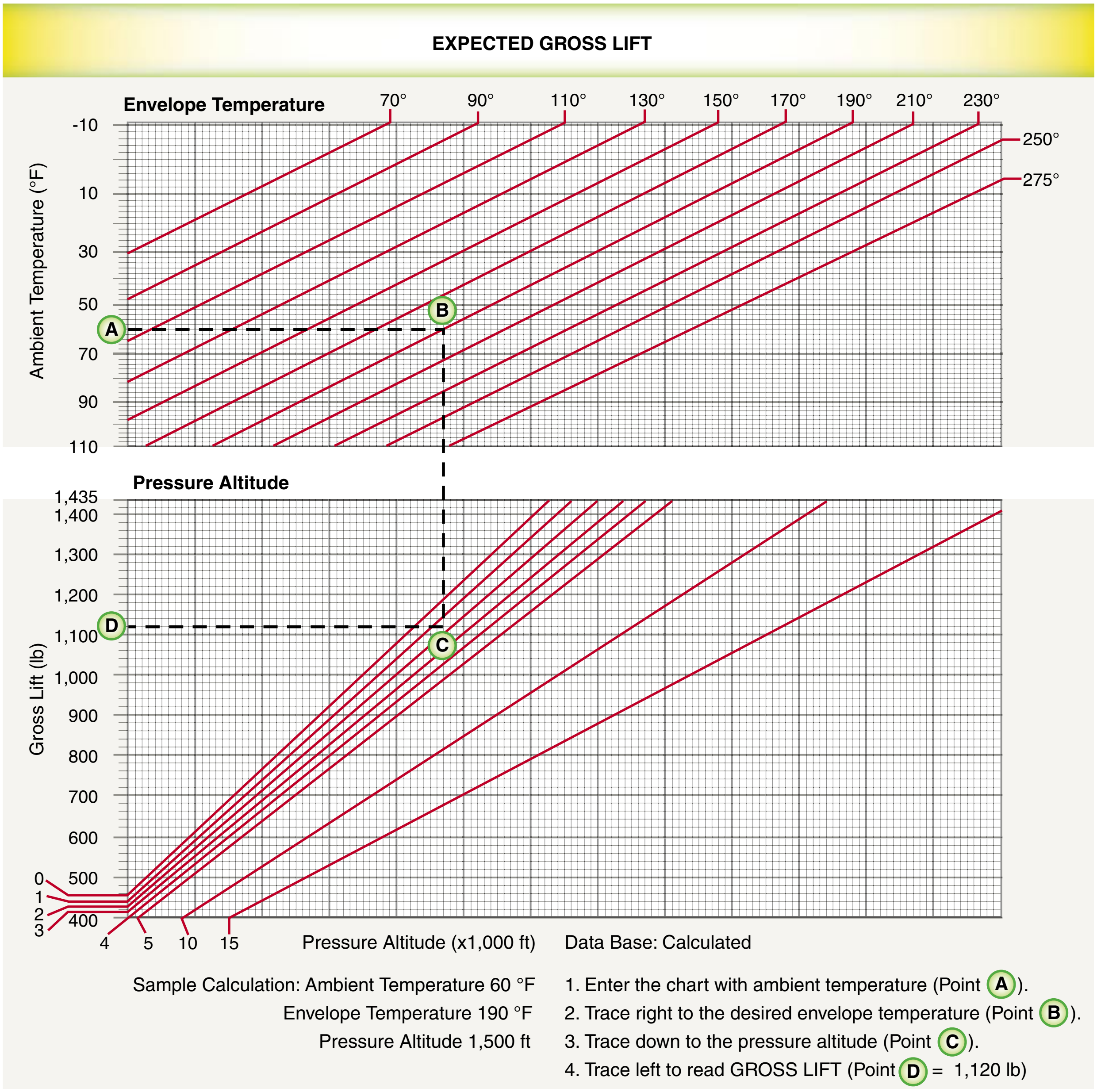


**Figure 3-13.** *Typical performance chart for a 77,000 cubic foot balloon.*

as long as the information is available and consulted when appropriate.

Using the chart in *Figure 3-13*, determine the maximum gross lift that may be expected on a 60 °F day, with decisions not to exceed 190 °F envelope temperature and 1,500 feet pressure altitude. In this example, the established parameters equate what many pilots consider when doing performance planning. They decide they do not want to exceed a given altitude or envelope temperature.) To determine the maximum gross lift available, the nomograph should be entered at point A, at the ambient temperature of 60 °F. Move right, to the line indicating an envelope temperature of 190 °F (point B). Then, move down vertically to a point equidistant between the lines denoting altitude of 1,000 and 2,000 feet (point C). Then, move horizontally to the left to the gross lift axis of the chart and read the result (point D). In the illustrated example, this computation results in a maximum gross lift of 1,120 pounds.

Using the chart again in *Figure 3-13*, determine the maximum altitude to which the balloon may climb, given the same maximum gross lift figure of 1,150 pounds. In this example, it is simply a matter of extending the lines appropriately. The A-B line would be extended to the diagonal line indicating a maximum temperature of 250 °F (which is the maximum continuous operating temperature for most balloons). Then, a perpendicular line would be drawn from that intersection point. After that line is drawn, extend the C-D line to the right, and the intersection of those two lines will indicate the maximum altitude. In this example, this computation results in a maximum altitude of 10,000 feet.

## Special Conditions

Most balloon flying is done in non-hostile terrain and benign weather. There are, some instances in which the terrain may be more difficult, both for the pilot and the chase crew, and the weather may become a significant factor. With proper preflight planning, the problems inherent in mountain flying and cold weather flying can be resolved. While somewhat riskier than normal flying, this type of flying can be safely conducted.

### Cold Weather Flying

Some pilots prefer flying in cold weather, which offers the advantages of more stable air and less fuel consumption to maintain flight. This means long, gentle flights for the pilot. There are two main disadvantages to cold weather flying: the need to maintain adequate pressure in the balloon's fuel system and the difficulty of keeping the pilot, crew, and passengers warm.

As propane gets colder, it has less vapor pressure. (See chart of propane and butane partial pressures, Appendix C). To ensure adequate pressure in cold weather, follow the manufacturer's recommended method, which will be described in the flight manual. Many manufacturers recommend the use of nitrogen, an inert gas that may be added to the fuel tanks by means of a regulator. This is perhaps the easiest way to pressurize tanks, as it may be done on site, and with little or no prior planning. It does require the use of a nitrogen tank and a two-stage regulator. These items must be available to the pilot before the flight. If the flight is cancelled after pressurization, and the anticipated rise in temperature is expected to be more than 30°, the pressure will need to be bled off by using the fixed liquid level gauge.

Balloon systems using a vapor feed pilot system may not be able to use nitrogen as it can result in an unreliable pilot light. Those systems commonly use heat tapes or heated tank covers in order to warm the propane. Heat tapes, similar to those used to prevent water pipes from freezing, are reliable. They do require frequent inspection, as normal wear and tear may cause an electrical short, with potential danger of damage to the fuel tanks. Among the aftermarket types of heat tapes, the ones with an internal thermostat will cycle once a particular temperature is reached, reducing the possibility of overheating the tanks.

Use tank heaters and heat tapes with extra caution. Tanks must not be heated in an area within 50 feet of an open flame, near an appliance with a pilot light, or in a closed area without natural ventilation.

Pilots, as well as crew, should be dressed appropriately for the environment. Layered clothing that entraps warm air is standard cold weather gear. Note that cold weather environments commonly promote static electricity. It is important that clothing of natural fibers be used, rather than synthetics. A hat is important, as significant body heat escapes from the head. Warm gloves and footwear are a must. Remember that certain types of hypoxia, or lack of oxygen to the brain (discussed in Chapter 9, Aeromedical Factors), may be aggravated by exposure to continued cold. Pilots and crew should be aware of the symptoms of hypothermia and frostbite, guard against them, and have a plan in place to deal with potential medical emergencies.

From an equipment standpoint, the balloon requires no special preparation, other than insuring proper pressure in the fuel system. Pilots should be aware that seals and O-rings may shrink somewhat or become brittle in cold weather. This may cause a propane leak, and special caution should be taken during the equipment preflight process to ensure that this will not be an issue. The pilot and chase crew should also be careful not to pack snow in the envelope, particularly if the balloon will be stored for a long period of time before the next flight. With respect to the chase vehicle, remember to have antifreeze in the cooling system. It is advisable to carry chains, a shovel, and a windshield wiper/scraper if there is a possibility of snow.

### Mountain Flying

Flying in mountainous terrain can provide one of the most exhilarating flights imaginable, but there are numerous planning factors that must be considered. *[Figure 3-14]*

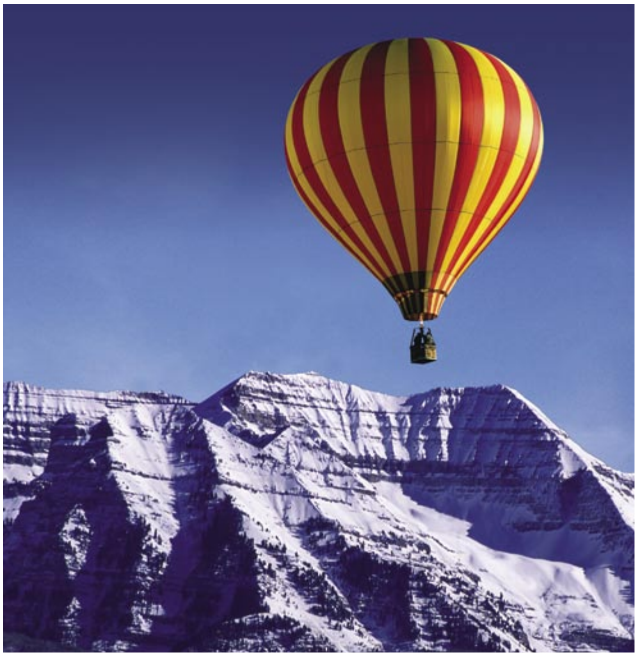

**Figure 3-14.** *Mountain flying.*

Weather, with its associated phenomena, is perhaps the most important to understand of the many factors involved in mountain flying. When inflating a balloon, drainage winds (a form of orographic wind) may cause the envelope to move from its planned position, and may even roll back over the basket, pilot, and crew. As most weather forecasts do not address this issue, consult with local pilots regarding these wind's formation, strength, and onset. In flight, winds flowing across mountain terrain set up features, such as rotors and standing waves (discussed in Chapter 4, Weather) which may cause a complete loss of control of the balloon. Other less violent winds may cause the balloon to proceed in unplanned directions, and require adjustments to landing and retrieval plans. It is important that any pilot contemplating flight in mountainous terrain be aware of these potential conditions, and plan to minimize their effects.

Communications in mountainous terrain can be a significant factor because most radios used by balloonists are line of sight, and will not work well, if at all, in particularly hilly or mountainous terrain. Cell phones may be used after landing, but again may be limited by the lack of cell towers and general reception problems. A good communications plan between pilot and ground crew includes a "lost balloon" contact with a common phone number that both parties call in order to find where the other is. This could possibly be a person at home, willing to relay the information as necessary, or perhaps an answering machine from which both the pilot and crew may retrieve messages.

Mountain flying that involves long distances requires appropriate clothing. Refer to the earlier paragraph on dressing for cold weather flying, which also applies to mountain flying. Good preflight planning will ensure that the pilot and passengers are prepared for a cold weather flight. It also prepares for the possibility of remaining out in the cold while the ground crew locates the balloon, since following a balloon can be difficult in mountainous terrain. Some pilots carry additional equipment in the balloon that they do not carry on flatland flights. Suggested provisions and equipment are water, additional warm clothing or a sleeping bag, a strobe, a radio, a compass, a lightweight shelter (a Mylar® sheet can be made into a simple tent, for example), and a good map or maps of the area.

## The Ground Crew

As ground crew have no legal status or authority within 14 CFR, it is easy to overlook or downplay their role in the preflight process, as well as flight safety. Ground crew knowledge and skill bring both the brains and brawn necessary at every stage of a flight—from equipment set-up and flight path plotting to taking inflight wind readings and assisting challenging landings. Without sufficient crew, a pilot becomes rushed, distracted, uninformed, or in the midst of hazardous conditions. Ground crews serve not only as physical help and assistance, but also serve as a form of redundancy for a pilot's eyes, muscles, and mind. *[Figure 3-15]*

While crew requirements may vary from flight to flight, consider the following during the preflight process:

- Two crew members to assist is a good starting point. During the chase phase, one may drive while the other navigates; two may handle emergencies better than one. Words of caution: more is not always better. In some cases, passengers on board the balloon may be able and willing to help pack and unpack equipment. Another factor may be the capacity of the chase vehicle.