ALC_Content

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Course Name: **ALC-629: Gliding – For the Airplane Pilot.**
Status: Previewing (Enroll)
Presented by: **FAASTeam**

Before you will be permitted to take the course exam, you must log in, view the intro chapter, all numbered chapters and the review chapter.
Legend: = Chapter Completed; = Current Chapter; = Chapter Not Completed; Review and/or Exam = Previous Chapters Not Completed

⇦ Intro 1 Review Exam ⇨

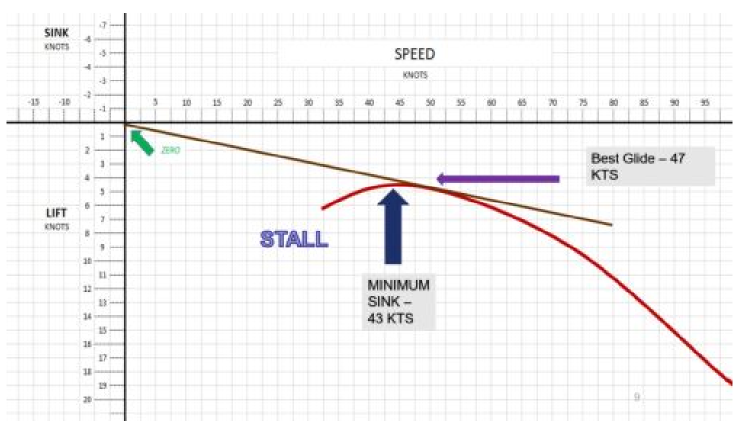
Review

Basic information on glide speeds

- Best Glide – is what is usually taught to airplane pilots, and is normally portrayed or published as a “single” airspeed in the Approved Flight Manual.
  - Many pilots know this speed as $\mathbf{V_{BG}}$
  - This glide speed will provide the greatest distance for altitude lost – in still air, appropriate configuration, weight and etc.
  - In most general aviation aircraft, this speed is half-way between V_X and V_Y.
- L/D Max – is what is usually taught to glider pilots, and is portrayed as a speed that will vary based upon numerous factors. It is usually listed in the Approved Flight Manual for a glider, or shown on a diagram.
  - It is basically V_{BG} in a given set of conditions, such as weight, still air etc. However, it does vary based upon various conditions, which we will look at in this course.
  - It is the greatest ratio of Coefficient of Lift (C_L) to Coefficient of Drag (C_D).
  - In an aircraft you are also going to achieve the following:
    - Maximum range in still air (Propeller driven)
    - Maximum glide distance in still air.
    - Maximum Endurance (Jet/Thrust producing aircraft)
- Minimum Sink (Min Sink) – is usually taught to glider pilots. It is rarely taught to airplane pilots. It is the Minimum Sink speed. It is usually listed in the Approved Flight Manual for a glider, or shown on a diagram.
  - This speed is the lowest rate of descent, i.e. the most time in the air for altitude lost.
  - It is slightly lower than maximum range speed (L/D Max)
  - In small single engine airplanes certificated under CAR Part 3 or FAR Part 23, by happenstance it is just about the glide (power idle) speed clean with the elevator trim to the full nose-up position.
    - You might want to try this with your flight instructor to find out. (You may even find out if your airplane is rigged properly).

A “Glide Polar” that shows these speeds in still air.

- A glide polar shows the rate of descent of an aircraft, in a specified configuration and weight (usually clean and maximum weight) versus air speed. It shows the ratio of speed to descent at any airspeed. This is the Lift to Drag Ratio (L/D) at any given point.
- There are three points easily recognizable on a glide polar.
  - Stall Speed – at 1g and a slow deceleration. The far end left side of the curve is the stall speed.
  - Minimum sink – the highest point (or lowest as shown later) on the curve. The point closest to the X axis, regardless of how the curve is shown.
  - L/D Max – Also (V_{BG} in still air etc.) – The tangent from the zero point (X-Y Axis) to the curve. This will normally be a higher airspeed than Min Sink in almost all circumstances, but the amount of difference will vary upon aircraft design.
  - NOTE: these graphs will vary on the display of their end point on the right end of the curve. It could be a limitation, such as Never Exceed Speed or Maximum Dive Speed, the maximum speed the aircraft can obtain in a vertical dive (worst L/D) or other structural or operating limitation. It may even be carried beyond any of these to some theoretical point, or even simply just the edge of the paper or diagram. So don’t try to read into the far right end of the polar unless you are aware of how it is determined.
  - Here is an example, with other examples including “flipped” versions available on the video.



- It is important to recognize that a glide polar needs to have “like” units on both the X & Y axis of a glide polar graph and when determining the glide ratio. As a result, most glider pilots knots in determining climb or descent rates, versus feet per minute (FPM) like you might see on a traditional vertical speed indicator (VSI).
  - Basically 1 knot of climb or descent is equal to 100 FPM
    - 1 Knot = 6076 feet per hour
      - Divide by 60 Minutes
        - Equals101.2 Feet per minute
  - Described another way….. “*Knot—one nautical mile per hour (NMPH). A nautical mile is 6,076.115 feet as opposed to 5,280 feet in a statute mile. Rounded that is 6,000 feet, which divided by 60 minutes equals 100 feet per minute (fpm). Hence, this gives 1 on a variometer, which means one knot per hour or approximately 100 fpm. A 4-knot thermal lifts the glider at 400 fpm.*”

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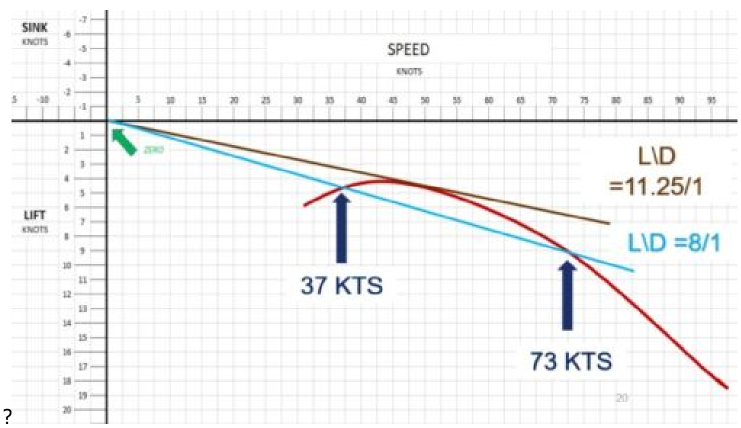
- This is one of the most important points to remember.
- The glide ratio (absolute value) is the ratio of speed divided by descent rate.
- It is the slope of a line (tangent) drawn to the polar curve.
- L/D Max is the optimum, but there are variation that can occur, both at higher and lower airspeeds.
- Look at the following polar and notice that the optimum is a ratio of about 11.25/1, as indicated by the brown line. However, flying either slower (37 kts) or faster (73 kts) is shown by the light blue line and shows a ratio of about 8/1.
  - Flying anywhere in between these speeds we get a "better" glide performance – L\D and at the low end at 37 kts (going slightly faster) we improve our sink rate (less).
    - So rarely will we want to fly at less than minimum sink (peak of the polar) in a glide, other than training and learning how it flies at very low slow speeds.



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- An example of this can be determined by looking at the classic airplane trainer, a Cessna 152.
  - At 60 knots, the published V_{BG}, you find the descent rate about 6.5 to 7 kts, yielding a glide ratio of about 9:1.
  - At 47 kts, close to, if not the minimum sink speed, you find a sink rate of about 6.1+ kts, yielding a glide ratio of about 7.5:1, worse than the best glide speed.
  - Typical small single engine general aviation airplanes usually have glide ratio that vary from about 7:1 up to about 12:1, with most common trainers being close to 9:1.
    - Paragliders on the low end are 4 or 5:1 ratios and modern day gliders can easily exceed 45:1.

Aircraft factors on glide speeds

- Weight – as weight increases...
  - Min Sink – Higher airspeed and higher sink rate
  - Best Glide & L/D Max – The airspeed and sink rate is higher, however, the ratio (L/D) is the same. There is no change in glide performance, just it happens at a higher airspeed.
  - You will also see the stall speed increase.
- Configuration – typically this is viewed concerning changes in flaps, landing gear or similar. As an example, if we look at adding flaps we will see.
  - Lower stall speed
  - Lower Minimum sink speed, with a greater sink rate.
  - Lower Best Glide speed, with a higher sink rate and lower glide ratio.
- Other enhancements that will typically improve the glide ratio or L/D, along with Best Glide and Min Sink include winglets, extended wing tips and active wingtips such as the Tamarack Company.
- Enhancements that usually are a detriment to improving glide ratios, but may improve other flight characteristics to include, but are not limited to:
  - Oversize tires
  - Cargo Pods
  - External Cameras
  - Antennas
  - Much more.

Rising and sinking air and associated factors

- Sinking air – It will not change minimum sink, but it increases L/D max speed. The ratio, glide range, will be worse, but the speed at which the optimum ratio occurs will be greater.
  - To determine the new L/D speed, instead of drawing the tangent from the zero point, draw the tangent from the amount of sink on the Y Axis of the plot. You will find the tangent to the polar curve touches at a point of higher airspeed.
  - A way to think about it is to think that if you are in sinking air, you want to minimize your time in it, so speed up.

- Rising air - It will not change minimum sink, but it decreases the speed for L/D max. The ratio, glide range, will be better and the speed at which the optimum ratio occurs will be less.
  - To determine the new L/D speed, instead of drawing the tangent from the zero point, draw the tangent from the amount of lift on the Y Axis of the plot. You will find the tangent to the polar curve touches at a point of lower airspeed.
  - Note – you only want to decrease the speed down to a minimum of the Min Sink speed.

Headwinds and tailwinds and associated factors

- Flying in a headwind – It will not change minimum sink, but it increases L/D max speed. The ratio, glide range, will be worse, but the speed at which the optimum ratio occurs will be greater.
  - To determine the new L/D speed, instead of drawing the tangent from the zero point, draw the tangent from the amount of headwind on the X Axis of the plot. You will find the tangent to the polar curve touches at a point of higher airspeed.
  - A way to think about it is to think that if you are in a headwind, you want to minimize your time in it, so speed up. An extreme example would be flying into a 50kt headwind at 50 kts, you go nowhere. You would need to fly faster in order to get any glide ratio.
- Flying in a tailwind - It will not change minimum sink, but it decreases the speed for L/D max. The ratio, glide range, will be better and the speed at which the optimum ratio occurs will be less.
  - To determine the new L/D speed, instead of drawing the tangent from the zero point, draw the tangent from the amount of tailwind on the X Axis (left side) of the plot. You will find the tangent to the polar curve touches at a point of lower airspeed.
  - Note – you only want to decrease the speed down to a minimum of the Min Sink speed.
- It is also possible to plot the tangent from a new point on the X & Y axis dependent upon headwind/tailwind and lift/sink.
- Also – remember, there is usually no reason to fly below minimum sink considering these factors.
- Rules of thumb for flying in a tailwind/headwind.
  - In a headwind, add 50% of the headwind component to your Best Glide speed (to achieve L/D Max)
  - In a tailwind, subtract 20% of the tailwind down to, but not below minimum sink speed.

Descent Angles

- It is good to know what your "best" glide ratio is, such as most single engine training airplanes are in the 9:1 glide ratio.
- An ILS approach, with a 3 degree glideslope requires an 18:1 glide ratio
  - This is more than twice most trainers
- Glider certification requires a 7:1 glide ratio, which is close to an 8 degree glideslope.
- <u>Bank Angle</u>
  - These speeds will all increase with an increase in bank angle.
  - It is similar to flying an airplane with a "smaller wing", i.e. higher wing loading.
    - A general way to determine the increase in the speed is to multiply the speed by the square root of load factor. As an example, 60 degrees of bank has a load factor of 2, and the square root is 1.414, so a little over a 40% increase
      - Note – as bank angle increases minimum sink speed and stall speed get exceptionally close.
- <u>Airplane Factors to consider</u>
  - Airplanes may publish speeds for an emergency approach and landing that is different from Best Glide (L/D Max) for various reasons. These may different in order to account for elevator control and flare with a high descent rate, system airspeed requirements such as landing gear or back-up electricity generators or specified configurations. There are even some that the lack of prop wash over the elevator has an impact.
  - It is also extremely important to understand the configuration of your airplane for the published best glide speed.
    - Example, the PA28R published a best glide for the propeller at "Full Decrease" (full aft/low RPM), yet most people fly it in a glide with the propeller full forward (High RPM), which makes a significant difference.
  - Other airplanes, not certificated in the standard airworthiness category may also have different design criteria. For example:
    - It is not unusual to have Light Sport Aircraft (SLSA or ELSA) fly at a speed that is higher due to limitations associated with the light weight restrictions and control effectiveness.
    - Open aircraft, with struts, braces and pilots out in the open may require steep angles and high airspeeds without the use of power, and that there will be little differences between cruise speeds and best glide speeds.

Wrap Up

- Although in your training you were tested on it time and time again, it is unlikely you will really ever meet your published glide ratio unless you have a tailwind.
- Glider training – Pilots are taught for planning purposes in the initial stages of glider cross-country flying to only use ½ of the glide published glide ratio, and then adjust of for wind etc.
  - So a 40:1 glider, a ratio of 20:1 would be used in planning.
- Know your glide speeds, Min Sink, V_{BG}, and Max L/D and what the glide ratio is of each. Know the differences between them.
- Know how to adjust for headwinds and tailwinds, along with rising and sinking air.
- In a given circumstances, know what is more important, time or distance and adjust.
  - Know and think about circumstances where neither is, but maybe getting down is (High Altitude/Fire or?) and that another glide speed is important.
- Emergency landing, know the correct approach speed and that it is important to touchdown as slow as possible.

Related Media for this Section

FAASTeam Handout on "Best Glide"
Best Glide Handout.pdf(1.03 MB)

A template to use to "Hand Draw" glide polars.
Graph Template.pdf(95.46 KB)

A small excel spreadsheet you can use to create a glide polar for your aircraft.
Polar Template.xlsx(23.89 KB)

A CAFE Foundation article about testing a Cessna 152 in glides
Propless in CA - CE152.pdf(1.43 MB)