Stan/Eval Newsletter
CIVIL AIR PATROL
UNITED STATES AIR FORCE AUXILIARY
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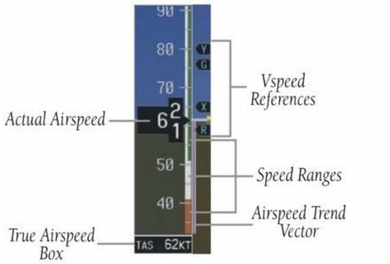
Back to Basics: The Airspeed Indicator

When flying we constantly reference the air speed indicator (ASI) but probably don't think much about some of its subtleties. So, let's take a closer look. ASI's are simple devices that do only one thing. They measure the difference in air pressure between the pitot tube and the static port. The idea is that as we go faster, the difference between dynamic pressure and static pressure will increase proportionally with airspeed. That's a good assumption with some caveats that we sometimes forget. We'll get back to that.

ASI's have certain fixed indicators on the dial that we can reference. The ASI has a redline that defines the "Never Exceed Speed" (VNE) that hopefully we never exceed. It also has a yellow arc, a green arc, and a white arc (if the airplane has flaps). The yellow arc extends from VNE down to the top of the green arc. The yellow arc represents a "smooth" air only range of airspeeds. If you are in rough air (how rough?), stay below the yellow arc. Contrary to what some pilots think, the yellow arc has nothing to do with maneuvering speed (Va). The bottom of the yellow arc ends where the green arc begins. The green arc is the "normal operating range" whatever that means (many aircraft operate "normally" in the yellow). Where the yellow stops and the green begins is Vno. The yellow arc and the green arc never overlap. The lower end of the green arc is the stall speed of the aircraft with flaps up. The white arc begins below the green arc and extends and ends somewhere in the green arc. The lower end of the white arc represents the stall speed with full flaps. The upper end of the white arc is sort of a never exceed speed for full flaps. Exceeding this speed with full flaps overstresses the flaps. Note the white arc is for full, not partial flaps. Thus, the top of the white arc in a C182 might be 100 knots, but you can have one notch of flaps up to 140 KIAS.



On approach to landing, we normally fly somewhere in the white arc. Being in the yellow arc for landing might mean a very long float. Trying to land above Vne could cause other problems. Not recommended.

There are a lot of important airspeeds that are not normally displayed on the ASI. You won't see maneuvering speed, best glide, minimum sink rate, approach speed, and so forth. Some glass ASI's will display additional air speeds (like the G1000) but this is not a standard.

One observation is that the difference in air speed between the bottom of the green arc and the bottom of the white arc is a measure of how much additional lift flaps provide. The greater the difference, the greater the amount of lift the flaps produce. In a C182T, the difference between the bottom of the green arc (VS1) and the bottom of the white arc (VS0) is 10 knots. This means the flaps on a C182 are a pretty effective lift device. The difference in an AA5B Tiger is only 2 knots. The flaps are only a drag device. Not much increase in lift. In your B787, the difference between flaps and no flaps can be around 50 knots. Lots of lift there! Pay attention to this difference if you fly multiple types of aircraft.

The ASI doesn't measure speed directly. It only measure pressure differences. The ASI assumes a fixed relationship between pressure differences and airspeed. That assumption, as it turns out, is only correct in very special circumstances, namely at sea level on a standard day. The further you get from those conditions, the more inaccurate the speed indication is. But before we go there, we need to introduce one other problem.

UNITED 787 29 APR 22 **7.110.13 Performance Non-Normal App & Land (787-9 74/75)**

HOLDING ***(787-9 74/75)***

Condition(s):

Flaps UP, set thrust for level flight.

Pressure Altitude (feet)		Weight (1000 lb)							
		280	320	360	400	440	480	520	560
10,000	Pitch Att.	3.5	4.0	4.0	4.5	4.5	4.5	4.5	5.0
	%N1	51.1	53.9	56.4	58.6	60.9	63.2	65.4	67.3
	KIAS	205	213	221	229	239	250	258	258
5000	Pitch Att.	3.5	4.0	4.0	4.5	4.5	4.5	4.5	5.0
	%N1	47.6	50.1	52.7	55.0	57.2	59.5	61.5	63.2
	KIAS	205	212	220	228	239	249	258	258

TERMINAL AREA (5000 FEET) ***(787-9 74/75)***

Condition(s):

Set thrust for level flight.

Flap/Gear Position		Weight (1000 lb)							
		280	320	360	400	440	480	520	560
Flaps UP Gear Up	Pitch Att.	3.5	4.0	4.0	4.5	4.5	4.5	4.5	5.0
	%N1	48.7	51.3	54.1	56.7	59.2	61.6	63.6	65.5
	KIAS	205	212	221	228	239	249	258	258
Flaps 1 Gear Up	Pitch Att.	5.0	5.5	6.0	6.0	6.0	6.0	6.0	6.0
	%N1	49.0	52.0	54.9	57.7	60.3	62.7	65.0	67.0
	KIAS	180	187	197	207	218	227	237	238
Flaps 5 Gear Up	Pitch Att.	2.5	3.0	3.0	3.0	3.5	3.5	3.5	4.5
	%N1	49.4	52.5	55.4	58.2	60.7	63.1	65.3	67.6
	KIAS	165	172	181	188	196	203	208	208
Flaps 15 Gear Up	Pitch Att.	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.5
	%N1	50.9	54.2	57.4	60.1	62.8	65.3	67.7	69.9
	KIAS	145	152	160	168	176	183	190	193
Flaps 20 Gear Down	Pitch Att.	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4.0
	%N1	60.0	63.1	65.9	69.4	72.2	74.9	77.4	79.2
	KIAS	140	147	155	163	171	178	185	188

2201 **FLIGHT MANUAL**

What we see on our ASI is termed Indicated Airspeed (IAS) which is a fancy term for what you read on the dial. Even though we said that the ASI measures the difference between dynamic and static pressure, it turns out, the dynamic pressure and static pressure measured at the pitot tube and static port may introduce errors in the sensed pressure. This usually gets worse at high angle of attack where the pitot tube is no longer oriented directly into the relative wind and will sense a lower dynamic pressure, that is what the wing "feels". Manufacturers will often provide a table that will tell you what the actual airspeed (at sea level on a standard day) is, versus, what you see on the ASI. This "corrected" airspeed we call Calibrated Airspeed (CAS). As an example, the no flap stall speed for a C182T is 55 KIAS which is 61 KCAS. With full flaps it is 40 KIAS and 51 KCAS (again, this is only accurate at sea level on a standard day). As we go faster, IAS and CAS tend to merge.

SECTION 5 PERFORMANCE — CESSNA MODEL 182Q

AIRSPEED CALIBRATION

NORMAL STATIC SOURCE

FLAPS UP													
KIAS	50	60	70	80	90	100	110	120	130	140	150	160	---
KCAS	60	64	71	80	89	99	108	117	127	136	145	155	---
FLAPS 20°													
KIAS	40	50	60	70	80	90	95	---	---	---	---	---	---
KCAS	52	57	64	72	81	90	95	---	---	---	---	---	---
FLAPS 40°													
KIAS	40	50	60	70	80	90	95	---	---	---	---	---	---
KCAS	51	56	63	72	81	91	95	---	---	---	---	---	---

The bigger problem with the ASI is that it doesn't measure our actual airspeed or True Airspeed (TAS). One definition of TAS is the groundspeed of the aircraft in a no wind condition. Put another way, TAS is the speed of the aircraft through the air. The engineers have calibrated the ASI so that the CAS at sea level on a standard day is equal to TAS. After that, all bets are off. Because of this, we are often concerned about how long a flight will be, TAS is very important to us. The errors creep in when the air density is different from what it is at sea level on a standard day. If the air density is less which it always is as we climb, the IAS and CAS will be less than TAS because the dynamic pressure is less. If you fly in Death Valley or near the Dead Sea, your IAS and CAS will be greater than TAS.

Your E6B can calculate TAS if you know your pressure altitude and temperature, but for most of us our handy dandy G1000 calculates it automagically and displays it with IAS. For those of us still flying Piper Cubs and such, a rule of thumb that works pretty well up to 10,000 feet is to add 2 knots for every 1,000 feet of altitude to IAS to get TAS.

One last observation is that TAS is meaningless when doing stalls, slow flight, or flying Va. Here IAS is what counts because that represents what the airplane "feels". TAS has nothing to do with aerodynamics (other than VNE). It has everything to do with "getting there".

Adjusting airspeeds for actual weight:

Many airspeeds such as stall speed, maneuvering speed and best glide are dependent on the weight of the aircraft. The POH will have these speeds for the maximum gross weight but not always for weights less than maximum. For example, if your checklist has an approach speed of 65 knots, it is probably only valid at gross weight or maximum landing weight. Using that speed when you are under gross (and most of the time you will be) results in excessive float and a longer landing distance than necessary. These airspeeds can be adjusted for the actual weight by multiplying the speed by the square root of the quantity actual weight divided by gross weight, affectionately known as alpha. (If you are computing landing speeds, replace gross weight with max landing weight.) This multiplication must be done using calibrated airspeed (CAS) and not indicated airspeed (IAS). The procedure would be to take the particular airspeed of interest and convert it from IAS to CAS. Then multiply by alpha and convert the resulting airspeed back to IAS.

This procedure only applies to airspeeds that are weight dependent. Airspeeds like Vne are not weight dependent (but you knew that, right?). A similar consideration should be given to performance envelopes (VG diagrams). VG diagrams are only valid for a particular weight. Again, these are usually computed for maximum gross weight. If the weight is less, you need to redraw the diagram based on the actual weight.

JOG Charts (LtCol S. Lipson/LtCol M. Eberle TXWG)

Joint Operations Graphic (JOG) charts are 1:250,000 scale charts available to CAP ForeFlight users. These charts are the same scale as the FAA Terminal Area Charts but cover the entire country (and much of the world) instead of just the major metropolitan areas covered by TACs. As with the TACs, JOGs provide much greater detail than the 1:500,000 scale sectionals, which is particularly helpful in mountainous areas.

To download JOG charts, select the DOD section of the ForeFlight Download menu and then select the JOG menu. You will then be able to select your areas of interest on the JOG catalog map. After selecting the charts, go back to the main Download page and begin downloading the charts.

Using the JOG charts is easy: Just select JOG Charts in the left column of the Map Layers menu.

If you use the Aviation layer that Foreflight provides on top of the JOG charts, you get incredibly detailed topographical / aviation data charts at the Terminal level across the entire nation.

UND electrical Simulator (LtCol S. Lipson TXWG)

Thank you to Carl Keil who provided a link to the following electrical simulator. It is awesome and I've used it to teach some folks about what would happen if certain circuit breakers / switches are activated or moved. On this simulator, you can click on every switch and button as well as circuit breaker and see the flow of electricity to see what happens.

See what happens if you turn off Avionics 2 but leave Avionics 1 on. Observe what the Battery powers vs. the Alternator. You should know this stuff by what is labeled on the panel, but this simulator gave me a new appreciation for what is happening behind the scenes:

C172S Electrical System (und.edu)

More on Mag Checks (LtCol G. Stinson KYWG)

I have found that the IO-540 engines in the G1000 aircraft may exceed the 175 RPM drop, especially in hot, humid weather, (even though they run smoothly and the EGTs/CHTs) show that all cylinders are operating properly. By following the procedure specified in E(1)(d) of Lycoming Service Bulletin 1132B, the engine almost always passes the mag drop test. Of course, if the temperature indications are not proper or the engine sounds rough, the plane should not be flown until cleared by an A&P.

You can view the Service Bulletin here.

Contact Approaches

A contact approach can be a very useful technique when flying IFR as it can greatly simplify getting on the ground. Pilots operating under an IFR flight plan (provided they are clear of clouds and have at least one mile flight visibility and can reasonably expect to continue to the destination airport in those conditions) may request a contact approach. ATC cannot suggest or assign you a contact approach independently, the pilot must request it.

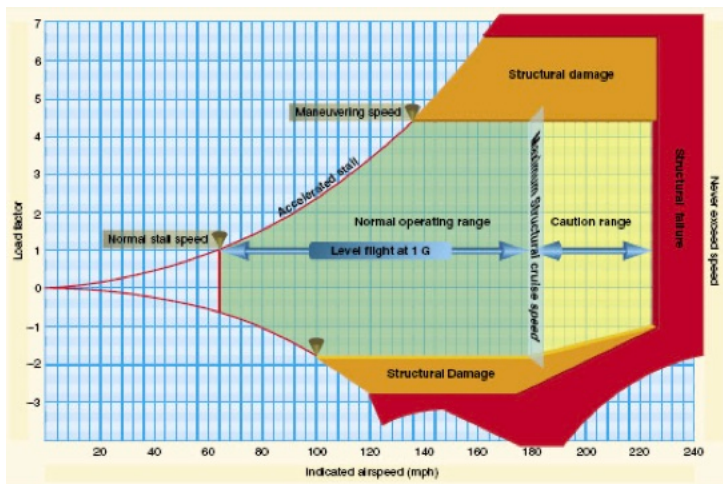
The advantage of a contact approach is that the pilot can navigate to the airport without regard to published procedures. This is particularly useful when you have the airport in sight on your way to a published approach fix. Just request a contact approach. It is not required for you to have the airport in sight to request a contact approach. For example, if you are over a road that leads to the airport or some other navigable terrain, it may make sense to request a contact approach vice flying a cumbersome instrument procedure when you know perfectly well how to get to the airport. There is no missed approach procedure for a contact approach, so be sure you can really make it to the airport safely. Nor can you fly on instruments while on a contact approach. You must fly visually on a contact approach remaining clear of clouds. Radar services are automatically terminated on a contact approach so don't expect any. It would also be foolish for a pilot to request a contact approach to an unfamiliar airport. The pilot will be flying in marginal conditions by pilotage, so must know the terrain and the airport well to safely execute a contact approach. You must cancel your IFR clearance once on the ground.

ATC is unlikely to assign a contact approach if it's a busy airport with multiple IFR arrivals. Once you are on a contact approach, they must hold everything till you get on the ground. Since you are navigating on your own, they have no control of your course or altitude. It only works at small airports with no other traffic around. However, when it works it is a wonderful way to go and can reduce the time required to get on the ground.

Contact approaches are described in the Aeronautical Information Manual (AIM) Section 5-4-25.

What do G limits really mean?

We all understand that we cannot exceed the G limits in the aircraft we fly but it's of interest to look a little deeper to better understand what this really means. Our CAP aircraft are certified for the normal category which can be found in the POH as 3.8 G's positive and 1.5 G's negative (flaps down can reduce these numbers). These G limits are good up to maximum gross weight so let's do a little math. A C182T gross weight is set at 3100 lbs. If we now go fly and do a very steep turn so that we are pulling right at 3.8 G's, we are within the envelope. 1 G for a C182T means the wing must support 3100 lbs. (gross weight) while at 3.8 G's it's 3.8 times the gross weight or 11,780 lbs. That means the spar and the wing structure must be able to carry 11,780 lbs. That's a lot of weight!



What you won't find in the POH is that our aircraft are built with a margin in them so they will actually carry more (don't try this at home). The 3.8 G's is the design limit which means that metal starts deforming (bending) beyond this but won't break (hopefully). They don't publish this for our aircraft, but most design limits have a 50% margin, e.g., the wings won't break off until you reach 1.5 X 3.8 G's or 5.7 G's or at gross weight the wing breaks around 17,670 lbs. Between 3.8 G's and 5.7 G's, you will suffer structural damage (e.g., the wing bends) but won't break till 5.7 G's (the plane may be uncontrollable with a bent wing). I don't want to test this, and neither should you. Bending a wing is not a good thing and you don't get your money back if the wing fails at 5.0 G's instead of 5.7 G's. Of course, some of our aircraft are old and metal fatigue takes its toll, so it isn't as strong as it was when it was new. If you want to pull Gs like that, then go buy an Extra 300 or a Decathlon.

We know that at 3.8 Gs at full gross our C182 wing must be designed to be strong enough to carry 11,780 lbs. What happens if I'm not at gross? Can I pull more Gs? Let's say the C182T is only carrying partial fuel, just a pilot and weighs a mere 2500 lbs. Since I know that the wing can carry 11,760 pounds then I should be able to pull 11,760/2500 G's or 4.7 G's? Well, you have just enough knowledge to be dangerous. It is true that the wing should safely carry 11,760 and so the WING can go to 4.7 Gs at 2500 lbs. However, that's not what the POH says and there are very good reasons why G limits published in the POH's are not a function of gross weight. Since the aircraft is certificated in the normal category you cannot safely pull more than 3.8 G's, no matter how lightly loaded you are. Why not?

The answer is that the G limit applies to more than just the wing. The G limit applies to the entire aircraft. Consider the engine mounts, whether you are at gross or at 2500 lbs., the engine weighs the same. The 3.8 G limit tells you how strong the engine mounts must be. So, even if you are "light", the engine still weighs the same and if you go past 3.8 G's the wings might be ok, but the engine mounts are not, and the engine falls off. As you go out of control, without the engine up front, it will be of little solace that the wings are still on. The same logic applies to the empennage, the seats you are sitting on and lots of other stuff you haven't thought of. G limits apply to every structural element of the airplane and so reducing the weight of the airplane may reduce the stress on the wing, but it does nothing for other structural limits. When the POH says 3.8 G's, believe it. A little knowledge will kill you. You need to know the whole story.

Articles for the National Stan Eval Newsletter:

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