Magic Numbers…

Approach Power Settings That Work!

I like to make things as easy as possible when I fly. At the factory's Beechcraft Training Center in Wichita back in the '70s, we taught the use of what we called "Magic Numbers" that applied when operating in the instrument approach environment. Lord knows, there is enough going on during that busy and critical time that not having to spend much thought or effort on setting engine power is a useful simplifier.

The various King Air training providers of today have, often, continued to present these useful Magic Numbers. However, some King Air pilots have never heard of them! Consequently they make their approach phase of flying a bit more stressful and less accurate than it needs to be. Before I present the table with the power settings, I need to spend a little time in defining what the various instrument approach phases mean and discussing their significance. Here goes:

Initial Approach Maneuvering. The term covers a wide range of configurations and speeds that occur as an airplane transitions from the enroute to the final approach course segments of a flight. It can be as simple as slowing from a high speed descent to a visual landing pattern. It can, on the other hand, involve multiple changes of heading and altitude while following radar vectors or charted terminal routes.

One airspeed and one airplane configuration will not cover all of the possible variations that can arise during initial approach maneuvering. However, it is certainly helpful to have one speed and configuration combination in mind when we are flying a complicated procedure requiring lots of attention to detail. Likewise, even when in VMC, being able to fall back on a familiar speed and configuration frees our time and attention for the critical tasks of outside scanning and cockpit monitoring.

Let me repeat, no *one* airspeed/configuration combination will cover *all* situations. When ATC requests a certain speed, it is our goal to comply with the request as best we can. But when free to select our own speed for initial approach maneuvering, I recommend 160 knots indicated airspeed, in clean configuration, flaps and gear up.

Why 160 KIAS? Listed below are factors which favor that speed.

- It is a commonly used vectoring speed at busy terminal areas, when a variety of aircraft types are being aligned in trail.
- The speed is high enough so that lots of time is not being wasted, yet low enough so that staying ahead of the airplane is not a difficult task.
- It can be used in all sorts of weather conditions, since it is below turbulent air penetration speed (V_B) yet above 140 KIAS, the speed at which ice can readily form on the bottom, unprotected portion of the wing.
- It offers a comfortable margin above clean stall speed.
- It complies with all speed limit restrictions in Class B, C, and D airspace.
- The power settings required to hold the speed – both during level flight and descending flight – are very comfortable.

Why not extend Approach flaps at this time? Why keep the airplane clean?

- Fact: Flap extension increases drag. The longer that Approach flap selection can be delayed – within reasonable limits – the less energy will be required to overcome drag. Less energy required equals less fuel burned.

  Many pilots select Approach flaps while stepping down from one altitude to another prior to reaching the final approach course. To what advantage? **None!**

  We believe that this misguided tendency results from a reluctance to reduce power sufficiently to achieve an appropriate rate of descent while clean, a carry-over from flying piston airplanes with the need to avoid shock-cooling of cylinders. Turboprops really excel in this area. We have propellers for speed brakes and don't need flaps (yet) or spoilers.
- Flap extension decreases the allowable load factor that the wing can satisfactorily sustain. The airplane is best able to handle turbulence while flaps are up.
- Flap extension will require trim changes if a constant airspeed is to be maintained. Once trimmed for 160 KIAS clean in level flight, no change in trim will be required for descent if the configuration is not changed.
- Extension of *any* flaps in some early serial number King Airs prevents silencing of the landing gear warning horn.

In summary, 160 KIAS is an excellent target speed for use during initial approach maneuvering. Delay flap extension until you have descended to the altitude at which the final approach course begins. This altitude is usually either the glideslope intercept altitude for precision approaches or the altitude over the final approach fix, FAF, for non-precision approaches.

TWO-ENGINE INSTRUMENT APPROACHES — CONFIGURATION. The final approach course of normal, two-engine, instrument approaches should be flown with Approach flaps and landing gear extended, at an indicated airspeed of 120 knots. This happens to be very close to VYSE – actually, slightly above it at most landing weights – and, for you jet pilots, is close to VREF + 10 for the configuration now applicable.

This is the approach configuration in which the Flight Director/Autopilot system has been flight tested and certified. It allows easy handling of an engine failure during the approach as well as a simple transition to the visual landing.

More than 120 KIAS is justified in the event of gusty winds, where we recommend adding one-half of the gust velocity, not to exceed 10 knots.

PRECISION APPROACHES — TWO-ENGINE OR SINGLE-ENGINE. The final approach course of precision approaches – ones in which glide path reference is provided – may be flown in the same configuration with one engine as with two. **With an engine inoperative, your situation is changed enough already. Avoid additional changes that are unnecessary.** Go ahead and use landing gear, Approach flaps, and 120 knots on the glide path as you are used to doing.

I think it is poor technique to change the flap setting when within 500 feet vertically of the runway. It causes trim, speed, and attitude changes which prevent the approach from being stabilized and which unnecessarily increase pilot workload. Also, you never know when an asymmetrical flap deployment may occur.

If the ILS or LPV approach minimums are less than 500 feet Height Above Touchdown (HAT), then with few exceptions the runway of intended landing is sufficiently long to allow a safe landing with flaps at Approach. Therefore, if still in instrument conditions at 500 feet HAT, decide to land with Approach flaps and adjust the VREF accordingly. (Rule-of-thumb: Add 10 knots.)

The King Air *can* perform a successful go-around with one engine inoperative. However, the need for this maneuver is, we hope, exceedingly rare. Because the climb performance and margin for error are small, make every effort to avoid a situation that would require a single-engine go-around. You would not have *begun* the approach unless (A) you thought you would land successfully because the reported weather was above minimums, or (B) you were running out of fuel and options, right?! A zero-zero, controlled touchdown on a large ILS-equipped runway may be preferable to a single-engine missed approach.

TWO-ENGINE NON-PRECISION APPROACHES. Non-precision approaches – ones in which glide path reference is not provided – are usually more challenging than precision approaches. On a precision approach a glide path is directing your descent. On a non-precision approach the let-down may involve multiple steps from one altitude to another and may require lengthy periods of level flight.

One basic power setting will not suffice for these approaches as it does for an ILS. Instead, two basic powers will be needed—a lower one during the descending segments and a higher one during the level segments. Arriving at Minimum Descent Altitude (MDA) too late is a common problem. To be “continuously in a position from which a descent to a landing on the intended runway can be made at a normal rate of descent using normal maneuvers” (FAR 91.175) requires reaching MDA in a timely manner. Planning the descent so as to reach MDA right at the Missed Approach Point (MAP) will not do since you will be too high over the end of the runway.

As you descend from one altitude to the next after the Final Approach Fix (designated by the Maltese Cross symbol on the approach plate) or after the procedure turn inbound (for those ancient VOR or NDB approaches in which the navaid sits on the airport and which subsequently don’t have a designated FAF), strive for a 1,000 fpm average descent rate at 120 knots, Approach flaps, gear down. Even with variations in weight, altitude, OAT, and airframe rigging, the required torque will be surprisingly consistent. About 100 feet above either the Minimum Descent Altitude (MDA) or some intermediate step-down altitude, smoothly increase the torque to your high Magic Number. Like magic, the nose will pitch itself up and the airplane will level off. It’s not really magic, just the fact that, once properly trimmed for 120 knots, the airplane will pitch automatically in an attempt to maintain its trimmed speed. You may need to give the wheel a little help to hold altitude exactly, and keep an eye on the airspeed to see if power needs to come up or down a little, but don’t work too hard. Avoid over-use of the pitch trim. As we said, if you are trimmed for 120 there should be no appreciable change in trim setting between that required for level flight and that required for a 1,000 fpm descent.

This level-flight power setting – the same one that yields 160 KIAS when clean – is a very important one. Setting it properly allows us to concentrate on watching altitude, tracking course, and looking for the runway without having the airspeed change markedly.

If the runway comes into sight near minimums, don't leave MDA until you are on the VASI or PAPI or whatever else the runway may have, if anything. As you leave MDA, heading for the runway, now is a good time to extend flaps Down. In many cases, the minimums associated with a non-precision approach will have an HAT of around 500 feet. However, even if it is a bit lower than this, I think it makes sense to go with full flaps even though it violates our “Flaps Down by 500 Feet” suggestion. You must change from level flight into a descent anyway, so adding more drag makes some sense. Also, remember that a lot of these runways are much shorter than those served by an ILS!

SINGLE-ENGINE NON-PRECISION APPROACHES. A single-engine non-precision approach is a maneuver to be avoided! With an engine inoperative, try to find a suitable nearby airport that is VMC or else one which has an ILS with winds that will not require circling to land. Only in cases where these types of havens are beyond your safe range – or for training – should you choose to make a non-precision approach with only one engine.

Why is this type of approach so undesirable? First, because the potential for a missed approach is usually greater than that associated with an ILS or LPV due to higher minimums, more variety of altitudes, headings, etc. Second, because it will require deviations from your normal habit patterns, your normal approach configuration. That is, since level flight at 120 knots, Approach flaps, gear down requires about all the power you have available or even more, **now you should keep the gear up until you are in visual conditions,** in a position to make a normal 3° descent to the runway. If you put the gear down at the FAF, discover that you must retract it as you level-off at MDA to prevent losing airspeed, then find that the gear motor has failed, you are in a bad predicament. You cannot manually *retract* the gear, only extend it.

Remember that we are discussing ***non-precision*** single-engine approaches now***. On a single-engine ILS, LPV, or visual approach, extend the gear exactly where you would with two engines.*** Keep things as normal as possible.

Just as in a two-engine non-precision approach, strive for a 1,000 fpm average descent rate at 120 knots – but this time with gear Up – when descending on the final approach course. Use your low Magic Number. When approaching a level-off altitude, about 100 feet above it, go to your highest Magic Number to fly level with the same speed and configuration.

In summary, when forced to execute a single-engine non-precision approach, use 120 knots and Approach flaps just as you would with two engines, but do not extend the landing gear until you leave MDA for a continuous descent to landing.

So finally, let's present these Magic Numbers. The tables below are for the 200-series. Following these, I will provide the four Magic Numbers applicable to other models. For simplicity, I am going to call the numbers Low, Medium, High, and High Plus, with High Plus applicable only to single-engine work.

A few final comments. First, how accurate are these Magic Numbers? Doesn't weight, altitude, and OAT affect them? Except for weight – and even that has a minor affect – the others are negligible. I have never had an aerodynamicist explain this to me in detail, but here's my speculation: That the torque felt at the propeller shaft and the indicated airspeed observed are both relative to the actual air density being experienced. They seem to always agree quite well, whether at Aspen in July or Fairbanks in January.

I will go so far as to state this: If ever the Magic Number does not yield a speed within ten knots of the target or, vice versa, if the target airspeed requires more than 100 ft-lbs variation from the Magic Number, something else is amiss. Is your airframe badly out of rig? Have your torque gauges been correctly calibrated?

Second, the King Air has enough momentum that it takes a long while to get truly stabilized. If you have been descending at 250 KIAS and then set up the proper Magic Number for 160 as you level off, it'll take nearly forever to get there. A far better technique is to come back to the Low Magic Number, let the speed approach 160, then add power up to the High mark to stabilize at the desired speed.

Lastly, we should know that Shaft Horsepower is equal to the product of Torque and Propeller Speed. If you are using a different propeller speed than what I am specifying – perhaps due to having a Blackhawk -135A conversion on a C90 or Raisbeck propellers on a 200 – then the lower RPM you are typically using will result in slightly higher Magic Numbers.

200-Series Approximate Power Settings

(Two-Engines, 1700 RPM)

TORQUE	FLAPS	GEAR	IAS	ROC (fpm)	REMARKS
1,000	UP	UP	160	0	Maneuvering
400	UP	UP	160	–1,000	"
700	APR	UP	120	0	FAF
700	APR	DN	120	–600	ILS
400	APR	DN	120	–1,000	Non-Precision
1,000	APR	DN	120	0	"

200-Series Approximate Power Settings

(Single-Engine, 2000 RPM)

TORQUE	FLAPS	GEAR	IAS	ROC (fpm)	REMARKS
1,300	UP	UP	130	0	Maneuvering
400	UP	UP	130	–1,000	"
1,300	APR	UP	120	0	FAF
1,300	APR	DN	120	–600	ILS
400	APR	UP	120	–1,000	Non-Precision
1,300	APR	UP	120	0	"

So the Magic Numbers for the 200-series are 400 Low (L), 700 Medium (M), 1,000 High (H), and 1,300 High Plus (H+). Somewhat surprisingly, these also apply to the F90-series, but with 1,900 as the single-engine RPM.

For the 90-series at 1,900 RPM two-engine and 2,200 RPM single-engine, excluding the F90: 300 L, 500 M, 800 H, 900 H+

For the 100-series at 1,900 and 2,200 RPM: 400 L, 600 M, 900 H, 1,100 H+

For the 300 at 1,500 and 1,700 RPM: (Instead of ft-lbs, the 300-series use Percent.) 15 L, 25 M, 35 H, 45 H+

For the 350 at 1,500 and 1,700 RPM: 15 L, 30 M, 40 H, 50 H+

In closing, remember that the two-engine and single-engine ILS have exactly the same speed and configuration. So consider this: There we are, inside the Outer Marker, everything seemingly fine, and one engine shuts down for no obvious reason. Hmmmm. What does that Clements guy say to do now? Oh yeah, use your *Four Friends.* **Power**: Push both power levers forward until the responding side doubles its torque. So from the Magic Number of M on both sides we are going to 2M on the remaining side. **Props**: Push both propeller levers fully forward. As RPM goes up, torque must go down for a constant power lever position. So that is why, King Air pilots, that H+ is always just a tad less than 2M. As for **Flaps** and **Gear**, the third and fourth friends? Don't change a thing! Now it's time to observe that Autofeather has properly operated or to do the Identify/Verify/Feather steps yourself.

Try these numbers for yourself and discover how magical they really are!

- Read more of Tom Clements articles at www.kingairacademy.com