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Double Vision

Seminole and Duchess--Tales of two twins

By MARC E. COOK

Beech Model 76 Duchess

Training airplanes aren't supposed to be glamorous, being as they are destined to illustrate the nuances of flight to the as-yet-unwashed masses. They have to be rugged, cheap, and easy to build. They must have handling qualities docile enough to keep a novice from constantly submerging eyebrow-deep but also sharp enough to teach the lesson at hand. They must make a profit for the owner and operator and have no fondness for the inside of the maintenance hangar. All of which might seem to suggest a taxi-driver mentality: direct, no-frills, and don't ask for any favors, bub.

These requirements are often at odds with such obviously emotional needs as beauty, speed, and ego gratification — really, when was the last time you got all fired up about a Cherokee Flite Liner?

That the Beech Duchess manages to combine all the qualities of a trainer without necessarily wearing that role like a badge of dishonor is an impressive feat. No question, Beech intended the Duchess, or Model 76, to be a multiengine trainer first and foremost. But the 76's jaunty T-tail, rakish nose, sleek engine cowlings, and stands-tall stance help pull your eyes away from the homely constant-chord wing and somewhat inelegant Musketeer-based fuselage. It is an airplane that manages to look more substantial than its weight and horsepower would suggest and, with the right paint scheme, altogether more graceful than it has any right.

The Duchess wasn't Beech's first light-light twin. That honor goes to the Travel Air, basically an outgrowth of the Bonanza, sharing with the Model 35 its fuselage and wing. Like the Duchess, the Travel Air carried 180- horsepower Lycomings on each wing; the earlier twin was somewhat more fleet on the same power. But the Travel Air, like the Bonanzas before and since, was relatively expensive to build, a characteristic that forced it up-market to become the genesis of the Baron line. The Travel Air went out of production in 1968, against stiff competition from the Twin Comanche and Aztec on one side and the Barons on the other.

After a decade's hiatus, Beech returned to the light-light twin fray with the Duchess. At the time, there were no new light trainers, with the Twin Comanche (an airplane that some felt wasn't a good trainer anyway) out of production since 1972, and the fleet of Apaches was growing ever older. Larger twins like the Barons, Cessna 310s, and Aztecs were deemed too thirsty and expensive to operate as multi trainers. In all, 437 Duchesses were built from 1978 to 1982, the majority of them in 1979. That was the same year the Piper Seminole and Grumman Cougar debuted, and while the Piper soldiered on into the 1990s, the light-light-twin market quickly saturated, production of these models fell to a trickle or stopped completely by 1982.

Beech might be criticized for taking the parts-bin approach in designing the Duchess, but few could argue with the results. The Model 76's Musketeer/Sundowner/Sierra fuselage and straight wing were far cheaper to build than the labor-intensive Bonanza construction and would benefit from an existing pool of spare parts. The bonded-aluminum construction promised to be both strong and light, ideal qualities for a trainer.

But Beech did far more than hang a couple of engines on the Sierra's wing, slap it on the tail, and send it out the door. A large, King Air-style T-tail with separate horizontal stabilizer and elevator grew where the Sierra had a low-mounted stabilator, rudder size shot up, and the entire aft fuselage strengthened for twin duty. What's more, the landing gear was completely redesigned from the Sierra; the mains, which swung outward during retraction on the single, now folded conventionally inward. And the single's nosewheel, which did a 90-degree turn to fit more or less (usually less) flush with the belly, was traded for a forward-folding wheel hidden behind long doors. Also, the Sierra's Mooney-style rubber

doughnut suspension gave way to soft oleo shocks and strut — which, combined with the trailing linkage on the mains, help give smooth touchdowns from all but the most grossly miscalculated landings — and don't ask me how I know the exception. The gear are activated by an electrically driven hydraulic pump.

An intelligent choice was to retain the Sierra's multiplicity of doors — one each for pilot and copilot, plus a large baggage door on the left. Spend some time with the Duchess, and you'll soon love to hate the usual contortions required with typical twins and low-wing airplanes. It's amazing what not having to shuffle over seats or stuffing luggage through mail-slot doors can do for one's opinion of an airplane. If only the side windows had been cut higher into the roofline, the Duchess would have superlative visibility; as is, the 76 is good but not great.

Cabin comfort is also good, with the four seats providing plenty of space to move around. Baggage capacity is generous, too, and the lack of a nose compartment is not serious. All four seats get inertial-reel shoulder harnesses.

One of the best features of the Duchess is the instrument panel. Logically arranged and clearly marked, the instruments and switches are a pleasant change from the Baron's seemingly archaic arrangement. Pilots moving from other singles or twins (Barons excepted, of course) will have no trouble finding the right switch or lever. One curious glitch occurs in the early airplane only: At first, standard equipment included separate tachometers for the left and right engines, stacked one over the other. Though clearly marked, the tachs were not as easy to read or interpret as the standard two-needle tach on the later models. And though the subpanels look smart and businesslike, the unprotected metal cutouts for the fuel levers can slice a careless finger faster than you can say "crossfeed, please." The cowl flap and carb heat levers also have a tendency to pop out of the selected position, which is more annoying than anything else but out of character for Beech nonetheless.

No matter how comfortable the cabin or how glitzy the panel, if the Duchess had not posted good performance, it would have been shot in the back by the Seminole and eaten alive by the Cougar. If you care to flog the poor little Lycomings all day at 2,700 rpm (the maximum and takeoff setting), you can achieve cruise speeds of 166 knots true at 6,000 feet, burning 22.6 gallons per hour total. More reasonable souls will probably pull back to 2,500 rpm, where at 6,000 feet, the Duchess will pull her royal carriage along at 162 knots true, using a total of 21 gph. Even thriftier types might also consider letting the O-360s loaf at 2,300 rpm and thrum along at 157 knots true at 6,000 feet on 19.6 gph.

Curiously, the Duchess operating handbook does not issue percent-of- power cruise charts, preferring to state the figures in terms of propeller rpm, a maximum of 24 inches of manifold pressure (or full throttle), and the nebulous phrases "Maximum Cruise Power," "Recommended Cruise Power," and "Economy Cruise Power." Savvy owners should obtain the engine operators manual from Lycoming to get the whole story.

As you might imagine, an airplane with 360 total horsepower and a maximum takeoff weight of 3,900 pounds turns in good climb numbers. In the typical training environment, with two aboard and three-quarters fuel (75 gallons of the 100 usable in the tanks), the Duchess charges upward at 1,500 feet per minute or better at full power, and still better than 1,000 fpm with the props pulled back to 2,500 rpm to keep the airport neighbors from grousing. The manual lists a maximum-weight, two-engine, sea-level climb of 1,300 fpm.

Twins by their nature have sprightly two-engine climb rates because they need something left over when one engine up and dies. Like virtually all light twins, the Duchess does well in single-engine climb at low altitude and light weights; in the above-mentioned training role, the airplane will climb through 5,000 feet at 200 fpm with an engine feathered. Its single-engine service ceiling is listed as just over 6,000 feet.

But if your intent is to always have an out, to always be able to climb from the runway with an engine failure at the critical moment — right after rotation — you will be seriously limited in runway length and/or payload. For example, at maximum-gross weight, the 76's accelerate-stop length for sea- level, standard-day conditions is 2,500 feet, but the accelerate-go distance might as well be infinity because it will not climb at that weight, according to the handbook. In order to have some assurance of climb after engine failure, you will need to be no heavier than 3,390 pounds (510 pounds under gross), and even then, expect to use more than 5,000 feet to get past the 50- foot obstacle. Takeoff from a 4,000-foot-elevation airport would limit you to just 3,100 pounds gross weight if you expected the airplane to climb — a figure good for two FAA-standard souls and all of 19 gallons of fuel in a typically equipped airplane. As usual, the your-mileage-may-vary caveat applies because handbook numbers often represent the absolute best-case situation.

In many respects, though, the way the airplane handles engine-out scenarios is more important than the total performance available. Here, the Duchess positively shines. It is as docile as you could want, thanks in part to counterrotating props and generous control authority. In fact, multi pilots coming from Barons or Twin Comanches will probably find the Duchess a snooze on one engine. Because takeoffs are made with the flaps up, a failure shortly after rotation requires you to pull up the gear, fly the airplane at the 85- knot blueline (best single-engine climb speed and also the best two-engine climb speed, incidentally), and work through the usual "identify, verify, feather" routine.

Because it is modestly powered, the Duchess will teach an aspiring multiengine pilot the necessity of proper configuration for best single-engine performance. At 5,000 feet and light weight, you can change a 400-fpm climb into a 700-fpm descent by dropping flaps and gear. Likewise, the Duchess will demonstrate the importance of proper airspeed during single-engine maneuvers; let the airspeed drop to 75 knots, and you'll experience firsthand the drag rise provided by that thick, straight wing.

During normal maneuvers, the Duchess is equally docile and honest. You know immediately that engines and fuel are distributed span-wise; even during taxi, the Duchess tends to list. Otherwise, the 76 carries on the Beech reputation for smooth controls, immediate response, and plentiful authority. One might wish for a bit more aileron effectiveness for crosswind landings and takeoffs, but the authoritative tail (and differential thrust available) make that a point of preference rather than necessity.

Good, honest manners are important for training, sure, but ever more so for the pilot using the airplane as a traveling machine. A lack of sharp-edged handling helps maintaining currency easier and should ultimately make the airplane safer. A listing of Duchess accidents for the period of 1982 to 1988 shows just 11, with a total of four fatalities. (About the same number of 76s are flying as Piper Seminoles, but the PA-44 had 23 accidents in the same period.) Two accidents involved a door opening on takeoff — one airplane crashed after losing control during the takeoff roll, the other landed gear up. (The obvious moral here is to fly the airplane first and worry about the door after you've landed.) Two other takeoff accidents involved loss of control after an engine was cut at rotation; another Duchess crashed after the pilot attempted to take off with full flaps.

Of the fatalities, one loss of control during a single-engine go- around claimed two lives; another fatality occurred when the airplane hit terrain during a VFR approach; and the last was the classic "continued VFR under overcast into mountainous terrain." The final three accidents uncovered involved two hard landings and one "[a]ttempted landing on unsuitable terrain/strip/runway."

In addition to its good safety record, the Duchess appears to do well on the maintenance front. A listing of service difficulty reports disclosed a handful of gear problems, including broken retraction arms and cracked actuator brackets, failed brakes, and broken brake discs. These failures point to the Duchess's role as a trainer and the subsequent abuse of the endeavor. Also, several reports noted cracked engine mounts and failures of a spring on the prop control that guards the feathering detent.

Airworthiness directives have been issued relating to many of the failures noted above. Among them: AD 78-20-08 covers replacement of rudder and elevator trim tab push rods; 79-17-06, which called for inspection of main landing gear hardware; 79-23-06, inspection and/or replacement of certain aileron-bellcrank and rudder stop bolts; 80-07-06, requiring an inspection for water trapped by the rudder and trim tab; 80-19-12, calling for inspection of engine mount tubes; 82-02-03, mandating an inspection of elevator control cable routing; and 91-14-04, calling for another inspection of the main landing gear A-frame assembly.

By all accounts, the Duchess's 180-hp Lycomings are fully deserving of their reputation as bulletproof. Several operators we surveyed reported engine lives well exceeding the engines' recommended TBO of 2,000 hours.

Perhaps the only serious shortcoming of the Duchess is its rarity. With just 281 still registered in the United States, finding one that hasn't spent its best years as a trainer might be difficult, and when you do find one, expect to pay a premium. Although the _Aircraft Bluebook-Price Digest_ says the average retail price of a Duchess ranges from $56,000 for a 1978 model to $81,000 for one built in 1982, one broker we spoke with says the airplanes are fetching more than that, especially, as mentioned, when they haven't been trainers. Also, aircraft with Bendix/King avionics are prized over Duchesses with the more common Collins stack. A handful have been fitted with radar as well.

If your hunt for a Duchess bags one that's been someone's personal transport, consider yourself lucky. And enjoy the Duchess's combination of trainer-made docility and durability and the happy coincidence that it is a handsome, appealing airplane — certainly one more glamorous than any trainer's got a right to be.

BEECH MODEL 76 DUCHESS
AVERAGE EQUIPPED PRICE, NEW (1978-1982): $105,000-$174,000
CURRENT MARKET VALUE: $65,000-$90,000

SPECIFICATIONS

Powerplants	Lycoming O-360-A1G6D (LO-360-A1G6D), 180 hp @ 2,700 rpm
Recommended TBO	2,000 hr
Propellers	Harztell constant-speed, full-feathering, 76-in diameter
Seats	4
Cabin length	7 ft 11 in

Cabin width	3 ft 8 in
Cabin height	4 ft 0 in
Empty weight, as tested	2,641 lb
Maximum gross weight	3,900 lb
Useful load, as tested	1,259 lb
Payload w/full fuel, as tested	659 lb
Fuel capacity, std	103 gal (100 gal usable) 618 lb (600 lb usable)
Baggage capacity	200 lb, 19.5 cu ft
PERFORMANCE	
Takeoff distance, ground roll	1,000 ft
Accelerate-stop distance	2,400 ft
Rate of climb, sea level	1,300 fpm
Single-engine ROC, sea level	220 fpm
Cruise speed/endurance w/45-min rsv, std fuel (fuel consumption, ea engine)	
@ approximately 75% power, best economy, 5,000 ft	160 kt/4 hr (10.5 gph)
Service ceiling	19,650 ft
Single-engine service ceiling	6,170 ft
Landing distance, ground roll	1,000 ft
LIMITING AND RECOMMENDED AIRSPEEDS	
VMC (min control w/one engine inoperative)	65 KIAS
VSSE (min intentional one-engine operation)	71 KIAS
VS1 (stall, clean)	68 KIAS
VSO (stall, in landing configuration)	58 KIAS
All specifications are based on manufacturer's calculations. All performance figures are based on standard day, standard atmosphere, sea level, gross weight conditions unless otherwise noted.	

Piper PA-44 Seminole

A comfortable conveyance for student or sage

BY THOMAS B. HAINES

1978. A banner year. Airline deregulation drives the demand for pilots to the flight levels. Flight schools scurry to fill the void with new multiengine pilots.

General aviation deliveries reached an all-time high that year. Topping the list of light twins by far was the Piper Seneca, with 534 deliveries. The Seneca, Aztec, Apache, Twin Comanche, and Beech Travel Air, among others, had dominated the twin training market for years, but schools, anxious to turn a buck as well as to turn out a plethora of students, wanted something cheaper to buy and operate than the older twins. Beech answered the call with the Duchess, Grumman with the Cougar, and Piper with the Seminole. Only the Cougar was a clean-sheet airplane. Beech and Piper dusted off the plans from existing models to fill the demand.

For Piper, in particular, the deal must have been a good one. The then-17-year-old PA-28 tooling and engineering surely had been amortized. Hanging a pair of 180-horsepower Lycoming engines on the short, tapered wing took some new engineering and design work, for sure, but after tens of thousands of copies and dozens of iterations, the airframe was as proven as they come.

Perhaps what the folks in Vero Beach, Florida, didn't anticipate, though, was the way in which their twin trainer would be embraced by the business flier. The number of Seminoles sold to individuals was not huge, but the market turned out to be big enough that Piper soon began offering it amenities such as turbocharging, radar, and deicing equipment. The private owners found the Seminole to be a comfortable airplane with plenty of payload and reasonable speed and economy. Most of all, it offered what they couldn't get in high-performance singles that cost and performed about the same: the comforting sound of two engines working in sync — well, almost in sync. With the soothing *wah wah wah* of two engines came two alternators, two vacuum pumps, and the knowledge that if one engine quit, at least you had some options. And, unlike in the Aztec, for example, the Seminole with its counterrotating propellers requires less action and dexterity on the part of the pilot when one engine goes quiet.

These were many of the factors Pittsburgh engineering contractor Donald Beckman took into account when he bought N8187H, a 1981 turbocharged Seminole. He could as quickly dash around the East and more economically make his regular trips to Phoenix in a high-performance single than in his turbo Seminole, but he prefers the engines' comforting tete-a-tete as he flies in all types of weather, at night, and over mountains and water.

As a nuclear engineer, Beckman frequently makes the 40-minute flight from his home base at Rostraver Airport near Pittsburgh to Washington National to do contract work for the Department of Energy. In the Seminole, he easily beats the airlines, even without including waiting and parking time at each end when flying commercially. The airlines might make more sense when the destination is Phoenix, but the Seminole allows him to make side trips enroute for other clients — side trips that could add days if he were to rely on the commercial carriers. The Seminole also allows him to conveniently carry enough luggage and equipment to stay on the job for several weeks at a time. His computer equipment and files often fill the airplane, meaning he regularly departs solo at near the turbo Seminole's maximum takeoff weight of 3,925 pounds.

Beckman typically flies the Pittsburgh-to-Phoenix trips at about 65- percent power on 19 to 20 gallons per hour and sees speeds from 160 to 172 knots, depending on altitude. He usually flies at 10,000 feet or less westbound to avoid the strongest headwinds and 11,000 to 15,000 feet eastbound. He conservatively plans IFR legs of 3.5 hours, giving him 1- to 1.5-hour reserves.

Unlike the PA-28 singles from which it sprang, the Seminole doesn't carry its fuel in the inboard section of the wings. The engine nacelles on the twin occupy that space in the structure, so the Seminole carries 55 gallons of fuel in bladder tanks in the aft section of each of the nacelles. The two fuel drains are conveniently located just aft of the right wing, near the step; it beats climbing under a wing or the belly. While the outboard portions of the wing are identical to those on the 1977-and-later Arrows, and the empennage and fuselage are nearly identical, there are differences — most obviously in the nose, which, in the Seminole, carries a Janitrol heater and avionics equipment instead of an engine. Unfastening four screws allows the twin's nose to tilt down for ease of access but only to the equipment. There is no nose baggage compartment.

In 1981, three years after introducing the Seminole, Piper, eying the owner-flown market, redesigned the nose to permit the installation of weather radar. The turbo model was introduced in mid-1980, but the airplanes were considered 1981 airplanes. The first 26 turbocharged Seminoles still used the old-style nose, which housed the landing light. To accommodate the radar antenna, the light was moved to just above the nose gear.

In 1982, the last year of production until 1989, buyers could opt for heated props and wing deice boots, but few did. Built-in oxygen systems and three-blade props were more popular on the turbos.

Aside from the additional gauges and levers you'd expect in a twin, the panel is very similar to the Arrows of the era and full of the same human-factors oversights. For example, the manifold pressure gauge and tachometer are located above the pilot's right knee, blocked from convenient view by the yoke. Engine gauges are scattered across the bottom of the panel, again hidden by the yoke. The left side-wall panel is a confusing array of rocker-style light, fuel pump, and magneto switches. The letters silkscreened onto the switches eventually wear off, leaving the uninitiated pilot to guess just what it is he might be turning off or on.

Piper fixed many of the problems when it reintroduced the Seminole in 1989. Production of the original rendition ceased in 1982, after five years

had passed and 467 aircraft had been delivered, including 87 turbocharged airplanes.

Sensing a need for new twin trainers and urged on in particular by the University of North Dakota, Piper in 1989 began spooling up production of the normally aspirated Seminole. Piper planned to build at least 100 aircraft, but the company's cash-flow problems soon caught up with it, and it managed to deliver only about a dozen, nine of them to UND.

In reintroducing the Seminole, Piper kept the Lycoming O-360 engines and the counterrotating Hartzell propellers and, for the most part, left the exterior alone. One UND-driven change was the addition of unfeathering accumulators. Accumulators ease airborne engine starts by using stored oil pressure in the hubs to windmill a propeller once the prop control is moved out of the feather position.

Inside, the earlier version's Royalite panel was replaced with a flat black metal panel. The mags and starter switches were moved to the lower left panel. The engine gauges were stacked just to the right of the yoke, and the tach and manifold pressure gauges were moved up for easier viewing. The light switches were moved to the right panel, but all the rocker switches still carry the silkscreening. Piper also added several new annunciators and made other small changes. The new panel appears much cleaner and is designed to reduce pilot work load.

Don't expect to find one of the newer airplanes on the market. UND still has all it purchased, and according to Federal Aviation Administration records, only one of the airplanes is in the hands of a private owner.

To turbocharge or not to turbocharge is the question any prospective buyer of a used Seminole must ask. Many times, the question can be answered by one's wallet. The _Aircraft Bluebook-Price Digest_ shows average retail prices of $77,000 for a 1981 turbo Seminole and $63,000 for a normally aspirated airplane of the same year. The turbo Seminole does offer a significant speed and payload increase over its normally aspirated brother, along with a single- engine service ceiling increase from 3,200 feet to 12,500 feet. Though the two will fly about side-by-side down low, at altitude the turbochargers add some 15 knots to the 75-percent cruise speed at optimum altitude (183 knots at 20,000 feet versus 168 knots at 8,000 feet; fuel burns are 24.2 and 22.4 gph, respectively), according to Piper. The turbochargers allow maximum takeoff weight to be increased 125 pounds, to 3,925 pounds. Empty weight increases by only 17 pounds with the turbochargers, to 2,435. With full fuel, that leaves 842 pounds for people and baggage: four of the FAA's 170-pounders and 153 pounds of baggage. Usually, though, empty weights will be higher. Beckman's airplane, which has an oxygen system and is typically equipped for IFR, including a fuel totalizer, IFR loran, and WX-8 Stormscope, weighs in at 2,675 pounds, leaving a payload with full fuel of 590 pounds.

The turbo Seminole, like the turbo Arrow, uses a fussy turbo system that requires careful attention on takeoff and in go-arounds to prevent overboosting. Overall, the Seminole handles much like an overweight T-tail Arrow. Like T-tail singles, the Seminole doesn't seem to want to leave the runway. A purposeful tug on the yoke finally brings the nose off and usually promises an overrotation as the tail comes alive. While the T-tail arrangement leads to rather graceless low-speed handling, it does make for fewer trim changes during power and configuration changes. Extending or retracting gear or flaps, for instance, requires almost no trim change.

You can land a Seminole like an Arrow, using only slightly higher speeds because of the greater gross weight, but it really does much better when landed like a twin ought to be, with a bit of power and a flat approach.

When shopping for a Seminole of your own, remember where it may have been used. The list of airworthiness directives and service difficulty reports reflects the Seminole's primary role as a trainer. Cracked engine mounts and plenty of reports of cracked and broken landing-gear components lead the list of SDRs. The most significant ADs affect the ailerons, requiring various inspections, modifications, and reinforcements of the aileron push rods and surfaces.

There are no surprises when examining the airplane's accident record statistics, as compiled by the AOPA Air Safety Foundation. From 1982 through 1989, there were 28 Seminole crashes, three of them fatal. As might be expected of training aircraft in particular, half of all the accidents occurred during the landing phase, usually as a result of landing hard or not extending the landing gear. Fuel exhaustion led to two accidents.

The accident types show that the airplane itself has few bad habits. As in many cases, it's the pilot, not the aircraft, who makes the mistakes. For the traveler who can learn from those mistakes, the Seminole offers a lot of utility packed into a fuselage design with 30 years of experience. Any pilot with a multiengine rating and time in a PA-28, particularly an Arrow, will quickly feel at home in the cockpit, and if you have no multiengine rating, the Seminole is a great airplane in which to get one.

PIPER PA-44-180 SEMINOLE
AVERAGE EQUIPPED PRICE, NEW (1979-1982): $105,200-$169,640
CURRENT MARKET VALUE: $60,000-$88,500

SPECIFICATIONS

Powerplants	Two counterrotating Lycoming O(L)-360-E1A6D, 180 hp @ 2,700 rpm
Recommended TBO	2,000 hr
Propellers	Hartzell, two-blade, 76-in diameter
Seats	4
Cabin length	8 ft 6 in
Cabin width	3 ft 5.5 in
Cabin height	4 ft 1 in
Empty weight	2,418 lb
Max takeoff weight	3,800 lb
Useful load	1,382 lb
Payload w/full fuel	734 lb
Fuel capacity	110 gal (108 gal usable)
Baggage capacity	200 lb, 24 cu ft

PERFORMANCE

Takeoff distance, ground roll	1,185 ft
Accelerate-stop distance	2,780 ft
Rate of climb, sea level	1,220 fpm
Single-engine ROC, sea level	217 fpm
Max level speed, sea level	167 kt
Cruise speed/endurance w/45-min rsv, std fuel (fuel consumption, ea engine)	
@ 75% power, best power, 8,000 ft	168 kt/3.9 hr (11.2 gph)
Service ceiling	16,000 ft
Single-engine service ceiling	3,200 ft
Landing distance, ground roll	830 ft

LIMITING AND RECOMMENDED AIRSPEEDS

VMC (min control w/one engine inoperative	56 KIAS
VSSE (min intentional one-engine operation)	82 KIAS
VS1 (stall, clean)	57 KIAS
VSO (stall, in landing configuration)	55 KIAS

All specifications are based on manufacturer's calculations. All performance figures are based on standard day, standard atmosphere, sea level, gross weight conditions unless otherwise noted.