Arizona Type Ratings

Most Citations are certificated under FAR Part 25. However, a few hundred are certificated under FAR Part 23 for the purpose of allowing them to be flown single pilot. However, takeoff and landing performance and other special condition certification requirements are equivalent to 14 CFR Part 25 on the Normal Category Citation ISP and IISP, just as is the case on all Transport Category Citations. In order for the 501 and 551 to be flown “single pilot”, FAR Part 23 was followed during certification. However, in the interest of safety and liability mitigation, the more stringent FAR Part 25 performance standards were adhered to when documenting the aircraft’s takeoff, climb and landing capability. There will be no takeoff or landing data published for any of the Citation family whether Transport or Normal category unless Part 25 takeoff, landing and climb performance requirements are all met.

PERFORMANCE: FAR PART 25

Civil airplanes are certificated under Part 23 or Part 25 of the Federal Aviation Regulations. Normal, Utility, and Aerobatic category aircraft are certified under FAR Part 23. These aircraft have a maximum gross takeoff weight of 12,500 lbs, and are normally propeller driven. FAR Part 23 airplanes require only one pilot. Transport Category airplanes are certificated under FAR Part 25. They usually have a maximum gross takeoff weight of more than 12,500 lbs, require two pilots, and in some cases, a Flight Engineer. The Certificate of Airworthiness will tell us under which category a specific airplane has been certified. Just look in the upper right hand corner for the word NORMAL, TRANSPORT or COMMUTER.

FAR Parts 23 and 25 specify criteria that airplanes must meet to obtain certification. These regulations contain many standards relating to materials, construction, performance, flight characteristics, and more.

In a Normal category airplane such as a light twin, the regulations do not require that the aircraft be able to climb, or even maintain, altitude if an engine failure occurs during the departure. In fact, if the failure occurs between rotation and Vyse, you may find yourself unable to stop on the runway, AND unable to continue. The result will likely be a controlled crash.

Transport Category aircraft, if operated within their limitations, never depart at a takeoff weight such that the failure on one engine will leave the pilot without the performance capability to either stop on the remaining runway, or continue the takeoff with the remaining engine(s). Similar weight limitations exist for landing. If operated at legal weights, Part 25 aircraft can always execute a go around or missed approach with an inoperative powerplant.

Transport Category aircraft have two sets of limitations. "Certificate Limitations" such as Maximum Takeoff or Landing Weight, and "Performance Limitations" such as Maximum Takeoff Weight permitted by climb requirements, or Runway Limited Takeoff Weight. Compliance with BOTH limits is mandatory. The certificate limits remain constant, but the performance limits vary as the altitude, temperature, runway and wind change. A hot day, high elevation or short runway can limit your Max Takeoff Weight to a figure well below the Max Certificated Takeoff Weight. Remember, in FAR Part 25 (Transport Category), performance limits are OPERATING LIMITATIONS, not just "Good Information".

A Type Rating is required to act as pilot-in-command on aircraft over 12,500 pounds and turbojet powered transport in the NORMAL category, regardless of weight.

There are some terms and definitions one must know if the FAR Part 25 performance data presented in most Flight Manuals is to be understood. We will define them now.

DEFINITIONS

Accelerate - Stop Distance

Distance required to accelerate the airplane from a standing start to V1 with all engines operating and come to a full stop.

Balanced Field length or Published Takeoff Distance: The longest of:

The distance required to accelerate to V1, and stop: or

Accelerate to V1, lose an engine, continue the takeoff and reach a speed of V2 at an altitude of 35 ft AGL, or

115% of the distance required to reach V2 at 35 ft AGL with all engines operating. If the accelerate stop distance and accelerate go distances differ, the longest distance will be used. The term Takeoff Field Length would be used to describe the required takeoff distance in this case.

Climb - General

Compliance must be shown at each weight, altitude, and ambient temperature within the operational limits established for the airplane and with the most unfavorable center of gravity for each configuration.

Climb Gradient

The ratio between a horizontal distance and a vertical distance. Example: a 2% Climb Gradient means for every 100 feet traveled horizontally, 2 feet altitude gain is achieved.

Landing Distance

The horizontal distance necessary to land and to come to a complete stop from a point 50 feet above the runway surface.

Reference Zero

The point in the takeoff path when the airplane is 35 feet above the takeoff surface and at the end of the takeoff distance required.

V1

Decision speed. (Formerly, critical engine failure speed.) If an engine fails before V1 is reached, the takeoff is aborted in any case. Aborted takeoffs at or after V1 are only advisable in the case of catastrophic failure. An engine failure or systems malfunction does not constitute a catastrophic failure on a Part 25 Aircraft. There is no performance data available nor is there performance criteria established for any takeoff aborted after V1 is reached.
As an aircraft approaches V1, its ground traction has diminished to the point that controllability is not guaranteed. The aircraft has shifted from being a ground vehicle to an air vehicle. You are statistically much safer continuing the takeoff than attempting an abort after V1. The pilot's hand is removed from the thrust levers at this speed.

V2

Demonstrated climb speed at 35 AGL with one engine inoperative. V2 is to be reached by 35 ft AGL and maintained to 400 ft AGL so that the second segment climb performance criteria will be met. V2 is never less than 1.1 x Vmca, or 1.2 x stall speed in the configuration used for takeoff. V2 will assure that the aircraft performs as stated in the flight manual. V2 varies with weight and flap setting. Less flaps means better climb performance, but usually will require a longer runway.

Vbe

Maximum brake energy speed. The maximum speed (IAS) from which the aircraft may be stopped with the brakes without exceeding the brakes' capacity to dissipate the heat generated. Exceeding the brake energy limit usually results in flat tires due to melted fuse plugs in the wheels, and/or brake fires. Refer to the “Maximum Brake Energy Speed” and/or “Minimum Turnaround Time” charts in the AFM.

Vef

The speed at which the critical engine is assumed to fail.

Venr / Vyse / Vse

The speed used for climb during the 4th or final segment of a departure with one powerplant failed. This speed will be close to best rate of climb speed with one engine failed and the wing flaps and leading edge devices retracted.

Vle

Maximum landing gear extended speed. The maximum speed at which the airplane can be flown with the landing gear extended.

Vlo

Maximum landing gear operating speed. The maximum speed at which the landing gear can be safely extended or retracted. In some cases, the landing gear may be extended at a different speed (usually higher) than it can be retracted. In this case, there will be two landing gear operating speeds published.

Vlof

The airspeed at which the airplane first becomes airborne. Heavy jets may roll down the runway several hundred feet or even a few thousand feet between the beginning of rotation and actually lifting off.

Vmca

The minimum airspeed at which directional control can be maintained in the air with the critical engine windmilling and the remaining engine(s) at takeoff thrust.

Vmcg

The minimum speed at which directional control can be maintained on the ground with the critical engine windmilling and the remaining engine(s) at takeoff thrust.

Vmo

Maximum certificated operating speed in knots indicated airspeed. This number can be thought of as a measure of the structural strength of the airframe.

Mmo

Maximum certificated operating speed in relation to the speed of sound, or MACH. This number can be thought of as a measure the high speed aerodynamic quality of the airframe.

Vr

Rotation speed. The speed at which rotation to takeoff attitude is initiated. Gross weight and takeoff flap setting are the variables used to determine Vr. Some aircraft charts also consider altitude, but the changes in Vr due to change in altitude are usually small.

Vref

Vref is the minimum safe approach speed in the landing configuration. It is equal to 1.3 times the power off stall speed in landing configuration. This is the desired speed crossing the runway threshold.

Vsb

Maximum operating speed with speed brakes extended.

CLIMB SEGMENTS

First Segment:

This segment begins at reference zero (end of takeoff distance, typically at 35 ft) and ends when gear retraction is complete.

Airspeed: V2
Gear: Retracting
Flaps: Takeoff
Climb Gradient:Positive

Second Segment:

This segment begins at the end of the first segment (gear retraction) and ends at a <u>minimum</u> height of 400' above the runway. This is the most restrictive climb segment.

Airspeed: V2
Gear: Retracted
Flaps: Takeoff

Climb Gradient:2.4%

Third Segment:

This segment extends from the end of the second segment to the completion of flap retraction and acceleration to Venr.

Airspeed: Accelerating to Venr
Flaps: Retracted at V2 + 10 kias
Climb Gradient:Not negative

Fourth Segment

This segment begins at the end of the third segment and ends at a height of 1500 feet AGL. This segment completes the takeoff path.

Airspeed: Venr
Flaps: Retracted
Climb Gradient:1.2%

Balked landing Climb:

This segment begins when an all engine go around is initiated at 50' AGL and the engines have reached go around thrust.

Airspeed: Vref
Flaps: Landing position
Climb Gradient:3.2%

Approach Climb:

This segment begins when the gear is retracted, flaps are in the approach position, one engine windmilling and the remaining engine(s) at go around thrust.

Airspeed: Vref + 10
Flaps: Approach position
Climb Gradient:2.1%

Climb limit

The climb limit is the maximum weight at a particular altitude and temperature, at which the aircraft can meet the FAR part 25 climb gradient requirements for takeoff (First, second, third and fourth) or for landing (Approach and Balked Landing Climb). Climb limited weights are lower if engine anti-ice is used because of the reduction in available engine power. Climb limits do not consider runway length, gradient or surface condition. Only atmosphere, configuration, and use of systems requiring bleed air are considered (Engine or airframe anti-ice and pressurization.) The Approach Climb

and the Landing Climb limits are established to insure that the aircraft has the capability to successfully execute a "Go Around" from as low as 50 ft AGL with all engines operating, and/or a missed approach with an inoperative engine if initiated soon enough.
In other words, if you can't go around safely, you are not allowed to go there.

Runway Limit

The runway limit is the maximum weight at which the aircraft may take off from, in the case of the takeoff weight limit, or land on, in the case of the landing weight limit, a given runway at a specified temperature, altitude, and runway condition. Runway limits consider any factor that will influence the ability of the aircraft to accelerate, and/or stop. Altitude, temperature, configuration, wind, runway gradient, runway clutter, and inoperative aircraft systems are all considered. Runway limit is expressed in terms of weight, because unless you are building your own airport, your concern is not "How much runway do I need?", but "How heavy can I operate using the runway available?"

Certificate Limit

The maximum weight at which an aircraft may be operated with respect to a specific situation, (Takeoff, landing, zero fuel weight). These weights may NEVER be exceeded, even if all performance requirements are met or exceeded.

BRAKE ENERGY LIMITS

The maximum speed from which the aircraft may be stopped in the case of a rejected takeoff, (expressed in KIAS), or the maximum weight at which the aircraft may be landed and stopped with brakes without exceeding the capability of the brakes to dissipate the resulting heat without damage. Reverse thrust may NOT be considered when computing ANY Part 25 takeoff or landing data. Brake energy may limit the maximum landing weight of the aircraft, or limit the maximum value of V1, thereby limiting the maximum takeoff weight for a given runway in some cases. On most aircraft, brake energy will only be limiting when high V speeds and minimum flap settings are used to meet climb segment requirements. Brake energy limits which apply to landing usually occur only at high density altitude and high landing weight.

BRAKE ENERGY

If the least understood airplane subject areas were listed, brake energy would surely be among them. This need not be so, as brake energy is not complicated. It merely involves some simple physics.

As we learned in our old high school science classes, **"Energy can not be created or destroyed, only changed".** Mankind has built many machines that "change" energy from one form to another to suit our needs. Take for instance the automobile. Chemical energy within the gasoline is changed to heat, causing expansion of gases within the engine. The energy in these expanding gases is converted to mechanical energy used to turn the engine's crankshaft. Through the use of gears, this energy is finally used to make the car go. When the car is in motion it has what is called "kinetic energy". When you need to stop the car, you must convert this kinetic energy into another type of energy so the car will stop. We use devices called "brakes" to do this. The brakes convert the kinetic energy stored in a vehicle in motion into heat. This heat will be absorbed by the atmosphere as the brakes cool.

The brakes can only handle a certain amount of heat. If they are forced to exceed this limit they may be damaged, and the intense heat generated may damage other nearby equipment.

If the brakes convert too much kinetic energy into heat in the process of stopping the airplane, they will heat the wheels and tires. If the wheel and tire assembly get too hot, they could catch fire, or the tire could explode in the wheel well after retraction. The tires used by large aircraft are usually inflated to pressures in the 100 - 200 PSI range. This can make for a bang large enough to seriously damage an airplane.

In order to avoid this, "fuse plugs" are installed in the main wheels. The cores in these fuse plugs will melt and release the pressure within the tires prior to the tire failing or catching fire due to the heat. It is far better to have a flat tire during taxi or parking than to risk an explosion. The best way to deal with all this is to check the Aircraft Flight Manual for brake energy limitations and do not exceed them in the first place.

Brake energy and its limitations may be expressed in a number of ways. Maximum takeoff or landing weight may be restricted as a result of brake energy. In this case, the brake energy limit is expressed in pounds. You might also see brake energy expressed in knots indicated airspeed. This addresses the question: How fast can I be going at a given weight, altitude and temperature and still stop without exceeding the brake energy limit? (V1 can NEVER be higher than this figure, as you must be able to stop from V1). Or brake energy may be addressed in terms of time, specifically “Minimum Turnaround Time” as is the case in certain Citations.

TAXI PROCEDURES

Avoid riding the brakes during taxi. Apply brakes to slow the airplane and then release the brakes. When the airplane is traveling too fast, apply the brakes again. By riding the brakes, you may heat them up enough to melt the fuse plugs. DO NOT pump the brakes.

TAKEOFF PROCEDURES

As indicated in the Checklist, the Captain will give a Crew Briefing prior to taking the runway. There are many ways to accomplish this, but thoroughness, accuracy, efficiency are to be considered. Of the utmost importance is that both crewmembers are on the same page should something go wrong. The following is an example of a typical captains briefing.

> I will be making this takeoff. It will be a rolling (or static) takeoff with a flap setting of 15°.
>
> I will advance the throttles to the TO detent.
>
> On the Takeoff roll, please call “AIRSPEED ALIVE, 70 KNOTS CROSSCHECK, V1 & ROTATE”
>
> On Climbout, please call POSITIVE RATE and V2 + 10. I will command “GEAR UP and FLAPS UP” as appropriate.
>
> After departure, we will turn to a heading of ??? and climb to ??? feet.
>
> If there is a problem prior to V1, I will abort the takeoff.
>
> Any problem after V1 will be treated as an in flight emergency. This runway will be our emergency return runway.
>
> Any questions or concerns?

This briefing is merely an example. Try to make your briefings specific to the conditions that exist. In other words, there really is no single briefing that covers all situations. A briefing on a long dry runway may differ from a briefing on a much shorter wet runway.

After taking the runway, the pilot flying will advance the thrust levers to the upright position first, and then to a fan setting near the computed takeoff thrust. If operating as a crew, the pilot flying will then instruct the pilot not flying to "Set Takeoff Power". The pilot’s right hand will remain on the thrust levers until V1. It is important that the pilot flying does not unknowingly drag a brake on takeoff. To prevent this potential problem, make certain that your feet are low on the pedals with heels on the floor. The pilot flying will remove his hand (usually right) from the thrust levers at V1, indicating a commitment to continue the takeoff. Since we are continuing the takeoff, we remove our hand from the thrust levers to eliminate the tendency to retard the thrust levers should a problem occur after V1. In addition, we already have applied takeoff thrust and have no more legal thrust available should an engine problem occur. Assuming both engines are operating, it is usually best to remove your feet from the rudder pedals shortly after liftoff and select or ask for the Yaw Dampner. Any rudder input at this point is unnecessary and frequently undesirable.

Gear is to be commanded up after the positive rate call and flaps are commanded up after V2+10 knots and (usually) after 400 feet AGL.

On climbout, takeoff thrust is typically available for at least 5 minutes. However, in many cases, airspeed limits may dictate reducing thrust significantly well before 5 minutes. When appropriate, climb power should be set.

Within reason, the “After Takeoff Checklist” should be performed shortly after takeoff to confirm the crew did not miss anything. Generally speaking, the after takeoff items have already been accomplished by memory and the checklist is used to confirm this. Do not request the “After Takeoff Checklist” so quickly that either crewmember’s attention is diverted from flying the airplane and watching for traffic while very close to the ground on climbout. There is no urgency to most of these items.