CHAPTER 3. AIRPLANE PERFORMANCE AND AIRPORT DATA

SECTION 1. AIRPLANE PERFORMANCE COMPUTATION RULES

901. GENERAL. This chapter contains direction and guidance to be used by inspectors for reviewing and approving performance data sections of company flight manuals (CFM's). The chapter also contains guidance for accepting or approving an operator's system for acquiring airport data. A separate chapter of this handbook (TBD) is devoted to rotorcraft performance.

A. *Chapter Contents.* Section 1 of this chapter is intended as background and reference material. It contains basic explanations of the terms and concepts used in airplane performance computations. Section 2 contains detailed information on the rules applicable to specific airplanes. Section 3 contains specific direction and guidance for the review and approval of performance data sections of company flight manuals. Section 4 contains specific direction and guidance for the review and approval of airport data acquisition systems. Section 5 (TBD) contains direction and guidance concerning specific related topics.

B. *How to Use this Chapter.* Inspectors should first determine the specific make and model of aircraft involved. In many cases, inspectors must know which modifications have been performed by supplemental type certification (STC). Next, inspectors must determine the specific paragraphs which apply to the airplane from figure 4.3.1.1. in this section. An inspector who is generally familiar with the terms and concepts involved may then consult the specific paragraph in section 2. Inspectors who are not familiar with the terms and concepts involved will find it useful to review the background material contained in section 1 before proceeding to section 2.

903. OVERVIEW OF AIRPLANE PERFORMANCE RULES. Aircraft performance requirements are contained in Part 91 and in Part 121 or Part 135, as applicable.

A. *Certification Limitations.* FAR 91.31 requires that all flight operations (both air transportation operations and others) be conducted within the limitations approved for that aircraft. These limitations are determined by the Aircraft Certification Service. Since March 1, 1979 these limitations must be published in an approved airplane flightmanual (AFM) or an approved rotorcraft flight manual (RFM). Before March 1, 1979, the limits could also be presented as placards or by other means. Specific limitations are presented as maximum and minimum values, such as the maximum certified takeoff weight (MTOW).

B. *Performance Limits.* Subparts I of Part 121 and of Part 135 require operators conducting air transportation operations to conduct those operations within specified performance limits. Operators must used FAA-approved data to show this compliance. The aircraft certification rules require the manufacturer to determine the aircraft's performance at capabilities at "each weight, altitude, and ambient temperature within the operational limits." The performance section of the AFM or RFM presents variable data in tabular or graphic format. Operators must use data extracted from the performance data section of the AFM or RFM to show compliance with the operating rules of Part 121 or Part 135. For those aircraft certified without an approved flight manual, the FAA-approved data may be placed on placards or placed in an approved company flight manual (CFM.)

C. *Advisory Information.* Aircraft manufacturers occasionally publish advisory information in flight handbooks that is not required for certification and which has not, therefore, been placed in the limitations section of the AFM or RFM. For example, manufacturers of light, multiengine aircraft certified under Part 23 frequently publish accelerate-stop distances as advisory information. When such information is not placed in the limitations section, it is not a limitation. Inspectors are advised that operators who do not observe such advice are not exhibiting good judgment and may be in violation of FAR 91.9, but are not in violation of FAR 91.31. POI's should ensure that operators enforce such limitations by placing approprate policy statements in a section of the general operations manual (GOM).

D. *Date of Aircraft Certification.* As aircraft performance and complexity have increased, more stringent operating limitations have become necessary for operators to maintain an acceptable level of safety. Certification and operating rules have also become correspondingly more complex. Once an airplane is certified, however, it normally remains in production and in service under the original rules even though those rules have been superseded. Subparts I of Part 121 and of Part 135 contain a number of sets of rules to account for the progressive enhancement of safety standards. These rules frequently refer to superseded airplane certification rules. and effective certification dates. When determining which performance rules apply to a specific airplane, inspectors must determine the airplane certification category, the aircraft size, and whether the aircraft has been modified by STC. This information can be found on the type certification data sheet. Figure 4.3.1.1 contains a summary of the categories into which airplanes have been divided for purposes of performance computations under Part 121 and Part 135.

FIGURE 4.3.1.1

AIRPLANE GROUPING	CHARACTERISTICS
LARGE TRANSPORT CATEGORY	• More than 12,500 lbs. MTOW. • Certified under CAR 4, 4A, 4B, SR 422, SR 422A, SR 422B, or FAR 25
LARGE NONTRANSPORT CATEGORY	• More than 12,500 lbs. MTOW. • Certified prior to July 1, 1942 under Aero Bulletin 7A.
SMALL TRANSPORT CATEGORY	• Not more than 12,500 MTOW. • Certified under CAR 4, 4A, 4B, SR 422, SR 422A, SR 422B, or FAR 25
COMMUTER CATEGORY	• Up to 19,000 lbs. MTOW, 19 pax. seats • Reciprocating or turbopropeller • Certified under Part 23 • Refined as small for performance computation purposes and large for purposes of pilot certification
NORMAL CATEGORY, Over 12,500 lbs.	• Certified under FAR 23 and 10 to 19 Pax SFAR 41.1(b). • 19 Pax. Seats and 19,000 MTOW • Defined as a small airplanes for performance computation purposes and large airplanes for pilot certification by SFAR 41
NORMAL CATEGORY, 12,500 lbs. or less	• 12,500 pounds or less MTOW 10 to 19 Pax take off weight (MTOW) • Certified under CAR 3 or FAR 23 and one of the following (including STC's): • Special conditions of the Administrator, SFAR 23, & SFAR 41, Paragraph 1(a)
NORMAL CATEGORY, 9 or less Pax. Seats	• 12,500 pounds or less MTOWW • Certified CAR 3 or FAR 23

905. LARGE AIRPLANE CERTIFICATION. On July 1, 1942, Civil Air Regulation (CAR) 4 became effective establishing the transport category for the certification of large airplanes. Large airplanes were first defined in this rule as airplanes of more than 12,500 pounds MTOW.

A. *Large, Nontransport Category Airplanes.* Large airplanes certified under Aero Bulletin 7A (before the establishment of the transport category) and not modified and recertified in the transport category are now referred to as "large nontransport airplanes" in the performance rules. Only three of these airplanes are still in active service which inspectors are likely to encounter. They are the Lockheed 18, the Curtis C-46, and the Douglas DC-3. Many of these airplanes have been modified by supplemental type certificates (STC's) and been recertified in the transport category. These airplanes may only be operated in passenger-carrying service if they have been recertified in the transport category or if operated in accordance with the performance rules applicable to the transport category. In the latter case, the performance data required to comply with these rules must be approved by the POI and carried in the aircraft during passenger operations. Operators of C-46 aircraft must use Part 121, Appendix C to comply with the large nontransport performance requirements.

B. *Reciprocating-Powered Transport Category Airplanes.* By November of 1945, CAR 4 was amended by CAR 4A and CAR 4B. Most large, reciprocating-powered transport category airplanes which remain in operation, such as the DC-6, were certified under these rules. While subsequent rules contain provisions for the certification of reciprocating-powered transport category airplanes, very few of these airplanes have been certified since CAR 4 has been superseded.

C. *Turbine-Powered Transport Category Airplanes.* Effective August 27, 1957, Special Regulation (SR) 422 was the basis for certification of the first turbine-powered transport airplanes, such as the Boeing 707, the Lockheed Electra, and the Fairchild 27. SR 422A became effective July 2, 1958 and was superseded by SR 422B effective August 29, 1959. Only a few airplanes were certified under SR 422A, such as the Gulfstream I and the CL44. The majority of the turbine-powered transport category airplanes now in service, such as the DC-8, DC-9, and B-727, were originally certified under SR 422B. SR 422B was recodified with minor changes to Part 25, which became effective in February 1965.

907. DETERMINING APPLICABLE OPERATING RULES. Until the publication of Part 119, SFAR 38-2, as amended, governs the use of aircraft in air transport operations. Inspectors should use the guidance that follows when determining rules that apply to specific operations.

A. *Part 121 Operations.* SFAR 38-2 requires that airplanes of more than 7,500 pounds payload or more than 30 passenger seats be operated in air transport service under the provisions of Part 121. This requirement applies to both transport and nontransport category aircraft. Transport category airplanes of less capacity may, but are not required to, be operated under Part 121.

B. *Part 135 Operations.* Airplanes with less than 7,500 pounds payload or more than 30 passenger seating capacity (except transport category airplanes) must be operated in air transport service under the provisions of Part 135. Helicopters must be operated under Part 135.

C. *Congruence of Part 121 and Part 135.* Since the adoption of SFAR 38-2, large transport and nontransport category airplanes are operated under both Parts 121 and 135. Subparts I of Part 121 and of Part 135 have identical aircraft performance provisions.

909. SMALL AIRPLANE CERTIFICATION. FAR Part 1 defines a small airplane as one of not more than 12,500 pounds MTOW. Under CAR 3 and Part 23 an airplane could only be certified as a small airplane in the normal category with a MTOW of not more than 12,500 pounds and 9 passenger seats. The "special conditions of the administrator" (FAR 21.16), SFAR 23, and SFAR 41, modified this definition to the extent that airplanes were modified by STC and certified as small airplanes with up to 19 passenger seats. SFAR 41 further modified the definition to the extent that airplanes meeting the requirements of SFAR 41, paragraph 1(b) and having up to 19,000 pounds MTOW were defined as small airplanes. Amendment 34 to Part 23 established the commuter category and defined airplanes of up to 19,000 pounds certified in that category as small airplanes.

A. *Small Transport Category Airplanes.* A small transport category airplane is an airplane 12,500 pounds or less MTOW certified in the transport category. While Part 25 permits certification of small airplanes in the transport category, manufacturers have rarely chosen this option. For example, the Cessna Citation 501 and the Learjet 23 are certified in the normal category under Part 23. Other models of Citations and Learjets of over 12,500 pounds MTOW (large airplanes as defined in Part 1) are certified in the transport category under Part 25. Small turbojet airplanes certified in the normal category are operated as small, turbine-powered transport category airplanes for the purposes of Part 135.

B. *Normal Category Airplanes with 10 or More Passenger Seats.* Since deregulation, small-reciprocating and turbopropeller, executive transport airplanes have been “stretched” and passenger seats have been added. These airplanes were primarily redesigned versions of existing designs. These aircraft were originally certified under Part 23 because it was considered impractical to redesign them to Part 25 standards. The “special conditions of the administrator,” SFAR 23, SFAR 41, and Appendix A to Part 135 were additional airworthiness standards developed to allow for the certification of a Part 23 airplane with more than nine passenger seats. All of these rules except Appendix A of Part 135 have been superseded. Production of airplanes certified under these rules will end in 1991. Currently, airplanes certified under any of these provisions (except SFAR 41.1(b) airplanes) are limited to an MTOW of 12,500 pounds and must meet the additional performance rules of Part 135, Appendix A. SFAR 41.1(b) provided for certification of airplanes with up to 19,000 pounds MTOW and 19 passenger seats in the normal category. These airplanes must meet the provisions of Part 23 and the additional airworthiness standards specified by the SFAR. They are defined as small airplanes by SFAR 41.1(b) for the purposes of Parts 22, 23, 36, 121, 135 and 139. They are defined as large airplanes for the purposes of Parts 61 and 91. These airplanes are not required to comply with the provisions of Appendix A of Part 135, since SFAR 41.1(b) provides additional standards for operations over 12,500 pounds MTOW.

C. *Commuter Category.* In January of 1987, Amendment 34 to Part 23 became effective and established the commuter category. Reciprocating and turbopropeller-powered airplanes with up to 19 passenger seats and 19,000 pounds MTOW may be certified in the commuter category. Commuter category airplanes of over 12,500 pounds MTOW are defined as small airplanes by Part 23 for the purposes of Parts 21, 23, 36, 121, 135, and 139. They are defined as large airplanes for the purposes of Parts 61 and 91.

D. *Determining Allowable Takeoff Weight.* Depending on the specific rule under which an airplane was certified, the calculations that must be performed to determine allowable takeoff weight can include any of the following:

(1) AFM Maximum Weight Limitations (Structural)

- Takeoff
- Zero Fuel
- Landing

(2) Airport Elevation and Temperature

- Departure point
- Destination
- Alternate

(3) Runway Limit Weight

- Accelerate-stop distance
- Accelerate-go (one-engine inoperative)
- All-engines takeoff distance

(3) Takeoff Climb Limit Weight

- First segment
- Second segment
- Transition segment (divided into 3rd and 4th segments under some rules)

(4) Takeoff Obstacle Limit Weight

(5) En Route Climb Limit and Terrain Clearance Weights

- All-engines operative
- One-engine inoperative
- Two-engines inoperative

(6) Approach Climb Limit Weight

(7) Landing Climb Limit Weight

(8) Destination Landing Distance Weight

(9) Alternate Landing Distance Weight

E. *Application of Flight Handbook Performance Limits.* Many of the requirements of Subparts I of Part 121 and Part 135 apply only until the aircraft takes off from the departure point. Other requirements from these Subparts apply at all times as do the AFM limitations. For example, FAR 121.195 and FAR 135.385 prohibit a large, turbine airplane from takeoff unless, allowing for en route fuel burn, the airplane will be capable of landing on 60% of the available runway at the planned destination. The regulations do not, however, prohibit the airplane from landing at the destination when, upon arrival, conditions have changed and more than 60% of the runway is required. In this case, the airplane must only be able to land on the effective runway length as shown in the flight manual performance data.

911. V SPEED DEFINITIONS. Inspectors should be knowledgable in the terminology and definitions that apply to V speeds. The following definitions apply to speeds used in airplane performance computations.

A. *Vmc Speed.* V*mc* is defined in Part 1 as the minimum speed at which the airplane is directionally controllable with the critical engine inoperative.

(1) *Vmcg* is the minimum speed at which the airplane can be demonstrated to be controlled on the ground using only the primary flight controls when the most critical engine is suddenly made inoperative. Throttling an opposite engine is not allowed in this demonstration. Forward pressure from the elevators is allowed to hold the nosewheel on the runway, however, nosewheel steering is not allowed.

(2) *Vmca* is the minimum speed at which directional control can be demonstrated when airborne with the critical engine inoperative. Full opposite rudder and not more than 5 degrees of bank away from the inoperative engine are permitted when establishing this speed. V*mca* may not exceed 1.2 V*s*.

B. *Vef Speed.* V*ef* is the airspeed at which the critical engine is assumed to fail. V*ef* is selected by the aircraft manufacture for purposes of certification testing, primarily to establish the range of speed from which V*1* may be selected. V*ef* may not be less than V*mcg*.

C. *Vmu Speed.* V*mu* is defined as minimum unstick speed. V*mu* is the minimum speed demonstrated for each combination of weight, thrust, and configuration at which a safe takeoff has been demonstrated.

D. *Vr Speed.* V*r* is defined as rotation speed and is applicable to transport category airplanes certified under SR 422A and later rules and commuter category airplanes. V*r* is determined so that V2 speed is reached before the aircraft reaches35 feet above the runway surface. V*r* may not be less than V*mu* or 1.05 V*mca*.

E. *V1 Speed.* V*1* speed is defined in Part 1 as "takeoff decision speed" (formerly the critical engine failure speed). V*1* may be selected from a range of speeds. V*1* may be selected as low as Vef but cannot exceed any of the following speeds:

- V*r*
- Refusal speed (the maximum speed the aircraft can be brought to a stop at the selected weight and flap setting on the remaining runway)
- V*mbe* (brake energy limit speed)
- Limiting tire speed (if one has been established)

F. *Vlof Speed.* V*lof* is the speed at which the aircraft becomes airborne.

G. *Vs, Vso, and Vs1 Speeds.* V*s* is power-off stalling speed or the minimum steady speed at which the aircraft is controllable. V*so* is stalling speed in the landing configuration. V*s1* is the stalling speed or minimum controllable speed in a specified configuration.

H. *V2.* V*2* is defined in Part 1 as "takeoff safety speed." V2 is used in multiengine transport, commuter category, and large nontransport category airplanes. V2 is the speed at which the airplane climbs through the first and second takeoff segments. V2 must be greater than V*mu* and 1.1 V*mca*. V2 must also be greater than the following:

- 1.2 V*s1* for two-engine and three-engine reciprocating and turbopropeller-powered airplanes
- 1.2 V*s1* for turbojet airplanes without the capability of significantly reducing the one-engine inoperative stall speed (no flaps or leading edge devices)
- 1.5 V*s1* for turbojet airplanes with more than three engines
- 1.5 V*s1* for turbojet airplanes with the

capability for significantly reducing the one-engine inoperative stall speed

I. *Vref Speed.* V*ref* is 1.3 V*so*. V*ref* is the speed used on approach down to 50 feet above the runway when computing landing distances.

NOTE: All V speeds are measured and expressed as calibrated airspeeds, but may be considered as indicated airspeeds for purposes of general discussion.

913. RUNWAY LENGTH. The usable runway length may be shorter or longer than the actual runway length due to stopways, clearways, and obstacle clearance planes.

A. *Takeoff Runway Length - Nontransport Category Airplanes.* The effective takeoff runway length for non-transport category airplanes is defined by obstacle clearance planes. When a 20:1 obstacle clearance plane does not intersect the runway, the effective runway length is defined as the distance from the start of the takeoff roll to the far end of the runway. When the obstacle clearance plane does intersect the runway, the effective runway length is defined as the distance from the start of the takeoff roll to the point at which the obstacle clearance plane intersects the far end of the runway.

Figure 4.3.1.2
Effective Runway Length

B. *Transport Category Airplanes.* For transport category airplanes the usable runway is not determined by the obstacle clearance plane. An obstacle clearance analysis must be made for each runway. For transport category airplanes certified under SR 422A and subsequent rules, the actual runway length may be extended by clearways and stopways. Clearways and stopways are discussed in paragraph 937 in this section.

C. *Obstructions.* An obstruction is a man-made or natural object which must be cleared during takeoff and landing operations. While fixed towers and buildings can be readily identified as possible obstructions, obstruction heights over roadways, railroads, waterways, and other traverse ways are not so apparent. Unless the airport authority or the operator determines with certainty that no movable objects will project into the airspace over the following passageways when an airplane flies over, obstructions are considered to exist on them to the following heights:

- Over interstate highways - 17 feet
- Over other roadways - 15 feet
- Over railroads - 25 feet
- Over waterways and other traverse ways - the height of the tallest vehicle that is authorized to use the waterway or traverse way

D. *Line-Up Distance.* Takeoff distance is measured from the position of the main landing gear on the runway to the same point as it passes the runway crossing height (RCH). The distance required to place the airplane in position for takeoff is not available for the takeoff run. A significant error may be introduced if this distance in not subtracted from the available runway distance when takeoff performance is computed. Large airplanes can use several hundred feet of runway when turning into position on the runway. Also, rolling starts from a taxiway can reduce effective runway by an additional increment because of slow acceleration while takeoff thrust is being set. The allowance may be included in the published data or published as a correction in the AFM. POI's should ensure operators have appropriate guidance for flightcrews.

915. RUNWAY LIMIT WEIGHT - TRANSPORT AND COMMUTER CATEGORIES. The required takeoff distance is the longest of three takeoff distances: accelerate-stop, accelerate-go, and all-engines. Since the available runway length is a fixed value, allowable takeoff weight for any given runway is determined by the most restrictive of the applicable distances.

A. *Accelerate-Stop Takeoff Distance.* The accelerate-stop distance is the total distance required to perform the following actions:

- Accelerating, with all engines operating at takeoff thrust, from a standing start to V*ef* speed at which the critical engine is assumed to fail
- Making a transition from takeoff thrust to idle thrust, extending the spoilers or other drag devices, and applying wheelbrakes (no credit may be taken for reverse thrust)
- Decelerating, and bringing the airplane to a full stop

B. *Accelerate-Go Takeoff Distance.* The accelerate-go (with one-engine inoperative) takeoff distance is the total distance required to perform the following actions:

- Accelerating with all engines operating to V*ef* speed with recognition of the failure by the flightcrew at V*1*
- Continuing acceleration with one engine inoperative to V*r* speed at which time the nosegear is raised off the ground (V*r* is V*2* for all airplanes certified prior to SR 422A)
- Climbing to the specified RCH, crossing the RCH at V*2* speed

C. *All-Engines Takeoff Distance.* All-engines takeoff distance is the total distance required to accelerate, with all engines at takeoff thrust, to V*r* or V*2* speed (appropriate to the airplane type), and to rotate and climb to a specified RCH. For airplanes certified under SR 422A and subsequent regulations, this distance is 1.15 the measured distance.

917. TAKEOFF CONDITIONS. Takeoff performance data published in the AFM is based on takeoff results attainable on a smooth, dry, hard runway with a specified flap setting and a specific weight. The FAR's do not require that data for compensating takeoff performance for the effects of wet or contaminated runways be published in an AFM. These factors, however, must be accounted for during revenue operations (see paragraph 921 for more information on wet or contaminated runways).

A. *Airport Elevation.* Airport elevation is accounted for in takeoff computations because the true airspeed (groundspeed in no-wind conditions) for a given takeoff increases as air density decreases. As airport elevation increases, the takeoff run required before the airplane reaches V*1*, V*lof*, and V*2* speeds increases; the stopping distance from V*1* increases; and a greater air distance is traversed from lift-off to the specified RCH because of the increased true airspeed at the indicated V*2* speed.

B. *Temperature.* As air temperature increases, airplane performance is adversely affected because of a reduction in air density which causes a reduction in attainable takeoff thrust and aerodynamic performance.

C. *Density Altitude.* Takeoff performance is usually depicted in an AFM for various elevations and temperatures. The effect of variations in barometric pressure, however, is not usually computed or required by the FAR's. Some airplanes with specific engine installations, however, must have corrections in allowable weight for lower-than-standard barometric pressure.

D. *Weight.* Increasing takeoff weight increases the following:

- V*l* of and the ground-run distance required to reach the lift-off point
- The air distance required to travel from the lift-off point to the specified RCH
- The distance required to bring the

aircraft to a stop from V*1* speed and the energy absorbed by the brakes during the stop

E. *Flap Selection.* Many airplanes have been certified for takeoff with variable flap settings. The effect of selecting more flap (within the allowable range) reduces V*r,* V*lof,* and the required ground-run distance to reach lift-off. All of these increase the accelerate-stop distance limit weight, the accelerate-go distance limit weight, and the all-engines operating limit weight. The additional flap extension increases aerodynamic drag and also decreases the climb gradient the airplane can maintain past the end of the runway. In the case of a short runway, it may not be possible to take off without the flaps set at the greatest extension allowed for take-off. In the opposite case, at a high elevation and a high ambient temperature, it may only be possible to climb at the required gradient with the minimum allowable takeoff flap extension. See table 4.3.1.1. for an example of the effect of flaps on required runway length and climb gradient.

TABLE 4.3.1.1.

Wing Flaps Inoperative Position	Runaway Length Required for Takeoff	One-Engine Climb Gradient
25°	6350 feet	2.9%
15°	7000 feet	4.5%
5°	7950 feet	5.3%

NOTE: This is an example only.

F. The effect of runway slope on the acceleration, stopping distance, and climb-out to the end of runway crossing height (RCH) must be accounted for. Uphill grades increase the ground run required to reach the points at which V*1*, V*r,* and V*lof* are attained, but they also improve stopping distance. An airplane climbing over an uphill grade runway will require more distance to reach the specified RCH. The reverse is true of downhill grades. Gradient corrections are computed for both runway length and takeoff speeds and the average runway gradient is normally used. The average gradient is determined by dividing the difference in elevation of the two ends of the runway by the runway length. For large variations in runway height (+5 feet), the retarding effect on the uphill segment is proportionally greater than the acceleration gained on the downhill portion. In such a case, the slope used for computations should be proportionately greater than the average slope.

919. WIND CONDITIONS DURING TAKEOFFS AND LANDINGS. Runway performance computations for both takeoffs and landings must always account for the effect of wind conditions in a conservative manner.

A. *Headwinds.* Although it is not required, the beneficial effect of a headwind on takeoff and climb distances may be used to compute performance. Only one half of the reported steady-state wind component (parallel to the runway) may be used.

B. *Tailwinds.* For a downwind takeoff or landing, at least 150% of the reported steady-state tailwind component must be used to compute the performance effect. While most airplanes are certified for takeoff with not more than 10 knots of tailwind component, some airplanes have been certified with higher limits. To use these higher limits, the operator must not be limited by the AFM and must be authorized by the operations specifications.

C. *Crosswinds.* The maximum-gust velocity must be used in the most unfavorable direction for computing the effective crosswind component. Inspectors should be aware of the following guidance.

(1) Crosswind values in most AFM's are stated as "demonstrated values" rather than as limits.

(2) While a crosswind may not directly limit an operation from a specific runway, crosswinds and runway

conditions affect V*mcg*. Under some runway conditions, an increase of 1 knot of crosswind component may raise V*mcg* by as much as 4 knots. Inspectors should be aware that the flight manual may contain different V*mcg* values for wet and dry conditions and crosswind components.

NOTE: V*1* may not be less than V*mcg*.

921. WATER AND CONTAMINATION OF RUNWAYS. AFM performance data is based on a dry runway. When a runway is contaminated by water, snow, or ice, charted AFM performance values will not be obtained. Manufacturers typically provide guidance material to operators so that appropriate corrections for these conditions may be applied to performance calculations. Inspectors should be aware of the following guidance concerning these conditions.

A. Any runway which is not dry is considered to be wet. Standing water, puddles, or continuous rain are not necessary for a runway to be considered wet. Runway braking friction can change when there is a light drizzle. In some cases, even dew or frost which changes the color of a runway will result in a significant change in runway friction. The wet-to-dry stopping distance ratio on a well-maintained, grooved, wet runway is usually around 1.15 to 1. On a runway where the grooves are not maintained and rubber deposits are heavy, the stopping distance ratio could be as high as 1.9 to 1. On ungrooved runways, the stopping distance ratio is usually about 2 to 1. In the case of a runway with new pavement or where rubber deposits are present, the ratio could be as high as 4 to 1. Some newly-surfaced asphalt runway surfaces can be extremely slippery when only slightly wet.

B. Inspectors should consult AC 91-6, "Water, Snow, and Slush on the Runway" for operations on runways which have snow, slush, ice, and standing water. Such conditions typically require corrections for takeoff calculations because of two factors. The first factor is the reduction of runway friction which may increase stopping distance in the case of a rejected takeoff. The second factor is the impingement drag of water or slush on the landing gear or flaps which could cause a retarding force and deceleration force during takeoff.

923. TIRE SPEED AND BRAKE LIMITS. Inspectors should be aware that allowable takeoff weight may be limited by either tire speed limits or the ability of the brakes to absorb the heat energy generated during the stop. The energy the brakes must absorb during a stop increases by the square of the speed at which the brakes are applied. Accelerate-stop distances are determined with cold breaks. When the brakes are hot, they may not be able to absorb the energy generated, and the charted AFM stopping distances may not be achieved. The heat generated by the stop may cause the wheels or tires to fail. The peak temperature is usually not reached until 15 to 20 minutes after the stop, which can result in the wheels catching on fire. The wheels of most large airplanes are protected by frangible plugs which melt and allow air to escape from the tires before they explode. Short turn-around times and rejected takeoffs present a potential hazard in terms of heat build-up in tires and in brake assemblies. Most manufacturers publish short turn-around charts to provide a minimum cooling period for subsequent takeoffs. POI's should ensure that operators include these charts and procedures in the operator's GOM's or CFM's.

925. TAKEOFF CLIMB LIMIT WEIGHT. The climb limit is the weight at which the airplane can climb at a specified minimum climb gradient or specified minimum climb rate in still air through the segments of the takeoff flightpath.

A. *Turbine-Powered Transport Category and Commuter Category Airplanes.* Climb performance for airplanes in these categories is measured in terms of a gradient (height gained divided by distance traveled - expressed as a percent) in specified climb segments. The gradients for each group of airplanes are provided in section 2 of this chapter.

B. *Other Airplanes.* All airplanes other than turbine-powered, transport category and commuter category airplanes must be able to maintain a specified rate of climb throughout the takeoff climb segments. Rates of climb are expressed as multiples of V*s*. The required rates of climb for various categories of airplanes are given in section 2 of this chapter.

927. TAKEOFF WEIGHTS LIMITED BY OBSTACLES. To obtain obstacle clearance throughout the takeoff flightpath, operators of transport category and commuter category airplanes must identify obstacles and limit takeoff weight. Obstacles in the takeoff path that are not cleared horizontally must be cleared vertically by at least the amount specified in the certification rule.

A. *Definition of Obstacle.* Any object inside the airport boundary which is within a horizontal distance of 200 feet of the flightpath or outside the airport boundary within 300 feet of the flightpath, must be considered an obstacle for takeoff computations.

B. *Net Flightpath.* A "net" flightpath for takeoff is derived by subtracting a specified percentage from the actual demonstrated climb gradient. This has the effect of adding a progressively larger clearance margin as the airplane travels away from the runway. Specified percentages for airplanes certified under different rules are listed in section 2 of this chapter.

C. *Conditions for Computing Net Flightpath.* The takeoff weight limited by obstacle clearance is computed in a manner similar to the runway takeoff weight limit as follows:

(1) One engine is assumed to fail at V*ef*. The remaining engines are at takeoff thrust.

(2) Landing gear retraction is assumed to begin immediately after lift-off. The airplane should climb out at a speed as close as practical to, but not less than, V*2* speed until the selected acceleration height is reached. The acceleration height is chosen by the operator but may not be less than 400 feet.

(3) After the airplane reaches the acceleration height, the final segment begins with the transition to en route climb configuration (which is to accelerate to climb speed, retract wing flaps, and reduce to maximum continuous thrust (MCT)). The operator has considerable latitude in choosing the transition method. The operator may choose the flightpath for any runway that gives the best results for the particular height and distance of the obstacles. One extreme is to climb directly over the obstacle at V*2*, with takeoff flaps and takeoff thrust. The opposite extreme is to level off at the selected acceleration height, accelerate in level flight (negative slope not allowed) to the flaps-up climb speed, and then to continue climbing and reducing thrust to MCT. An infinite variety of flightpaths between these two extremes may be used. In any event, the flightpath chosen to show obstacle clearance must extend to the end of the takeoff flightpath. The takeoff flightpath ends not lower than 1,000 feet for SR 422 airplanes and not lower than 1,500 feet for SR 422A, SR 422B, Part 25, and commuter category airplanes.

D. *Turns.* For analysis purposes, it may be assumed that the airplane turns to avoid obstacles, but not before reaching 50 feet above the runway and by not more than a 15-degree bank. When a turn is used, the rate of climb or gradient must be reduced by the increment of climb performance lost.

E. *Takeoff Minimums.* TERPS criteria is based on the assumption that the airplane can climb at 200 feet per nautical mile (approximately 30:1) to the minimum en route altitude through the takeoff flightpath.

(1) When obstacles penetrate the obstacle clearance plane, the airplane must be able to climb at a steeper gradient or to use higher than standard takeoff minimums to allow the obstructions to be seen and avoided under visual conditions. Authorizations for lower-than-standard takeoff minimums are based on the operator adjusting airplane takeoff weight to avoid obstacles in the takeoff flightpath if an engine fails on takeoff. POI's shall not authorize operators who do not prepare an airport analysis and perform obstacle climb computations to use lower-than-standard takeoff minimums. POI's may approve a system in which the operator makes obstacle clearance computations and performs lower-than-standard visibility takeoffs on specified runways, as opposed to all runways.

(2) The criteria for TERPS does not take into account whether or not the aircraft is operating on all engines. Operators must either show compliance with TERPS criteria with an engine out or have an alternate routing available for use in case of an engine failure. Specific guidance for approval of these procedures is in development and will be included in this handbook at a later date.

929. EN ROUTE PERFORMANCE LIMITS. There are a number of en route performance rules which may limit the weight at which an airplane can be dispatched or released.

A. *Part 121 En Route Obstacle Clearance.* Subpart I of Part 121 contains en route obstacle limitations for all airplanes operated under Part 121. The details of these limitations differ for reciprocating-powered, transport category airplanes; turbine-powered, transport category airplanes; and large, nontransport category airplanes. In general, all airplanes must be operated at a weight at which single-engine failure (two-engine airplanes) or multiple engine failures (3- and 4-engine airplanes) can be experienced and the airplane continued on to destination or diverted to an alternate airport. After the engine failure, the airplane must be capable of clearing all obstructions by a specified margin. Driftdown or fuel dumping may be used to comply with these requirements (see subparagraph E that follows for a discussion of driftdown).

B. *Part 135 En Route Obstacle Clearance.* FAR 135.181 places en route performance limitations on all IFR passenger-carrying operations.

(1) FAR 135.181(a)(1) effectively prohibits the release of passenger-carrying flights under IFR conditions in single-engine airplanes. The rule does permit over-the-top operations under limited circumstances. The flight must be able to reach VFR conditions within 15 minutes after takeoff. At the point the airplane has flown 15 minutes, the weather below any overcast must be VFR. These conditions must exist at all points on the route, including overhead the destination.

(2) FAR 135.181(a)(2) prohibits the release of multiengine airplanes in passenger-carrying IFR operations or VFR over-the-top operations unless specific conditions are met. The airplane must be able to sustain a failure of the critical engine and climb at a rate of 50 feet per minute at the MEA or 5,000 MSL, whichever is higher. The other circumstance in which a multiengine airplane can be released in IFR conditions or VFR over-the-top conditions is when, after an engine failure, a descent can be made to VFR conditions at or above the MEA.

NOTE: Inspectors must be aware that small airplanes of 6,000 pounds or less MTOW are not required to have the capacity to climb or maintain altitude with an engine failed at any altitude for certification.

C. *Part 121 Extended Overwater Operations.*

(1) FAR 121.161 prohibits the release of 2- and 3-engine airplanes (except 3-engine turbojet airplanes) for operations more than 1-hour distance from an acceptable alternate airport, measured at one-engine inoperative cruise speed. The only exception is that extended overwater operations of two-engine turbojet airplanes (ETOPS) may be approved by the POI with prior concurrence of AFS-400. When such approval is granted to an operator, these authorizations are contained in paragraph B42 of the operations specifications.

(2) FAR 121.183 and FAR 121.193 limit the release of 4-engine, transport category airplanes. The limitations of these rules vary with the rule under which the aircraft was certified. In general, the airplanes must be dispatched at a weight which will allow the loss of two engines simultaneously at the most critical point of the flight, while still allowing the airplane to maintain a specified altitude and reach an alternate airport. The two means by which operators may choose to show compliance are by limiting the takeoff weight or by fuel dumping (see subparagraph E). Two points on a route that are frequently critical are the point at which the airplane reaches the top of climb and the point at which the airplane is furthest from an alternate airport.

D. *Part 135 Overwater Operations.* FAR 135.183 prohibits operators from operating a land airplane overwater (except for takeoff and landing) at a weight at which a positive rate of climb of 50 feet per minute cannot be maintained at 1,000 feet above the surface. There are no provisions in Part 135 for the use of fuel dumping to comply with this requirement. A number of Part 135 operators have, however, obtained exemptions to allow the use of fuel dumping (see subparagraph E).

E. *Fuel Dumping and Driftdown.* Part 121 operators may use driftdown or fuel dumping procedures to comply with certain en route performance rules. Part 135 operators may apply for a grant of exemption to use driftdown or fuel dumping as an alternate means of complying with FAR 135.181 or FAR 135.183 in accordance with Part 11 (see volume 1, chapter 4, section 4 of this handbook for information on exemptions).

(1) Driftdown can be defined as a procedure by which an airplane with one or more engines inoperative, the remaining engines at maximum continuous thrust (MCT), and while maintaining a specified speed (usually best L/D X 1.01%), descends to the altitude at which the airplane can maintain altitude and begin to climb (this altitude is defined as driftdown height).

(2) Many modern airplanes can be dispatched or released at takeoff weights which place the driftdown height below the minimum altitude that the airplane is required to maintain by Part 121 or Part 135. In this case, the takeoff weight must be limited or fuel dumping must be used to comply with the en route limit. Compliance must be demonstrated at all points in the en route segment of the flight.

(3) Before approving driftdown or fuel dumping procedures for Part 121 operators (or 135 operators who hold exemptions authorizing the use of these procedures) POI's shall carefully evaluate the operator's proposed data, procedures, and training program. The data must either come from the AFM or from the manufacturer. Unapproved data must be reviewed by the applicable aircraft evaluation group (AEG) either in the exemption process or prior to the POI's approval. The company flight manual (CFM) must contain specific flightcrew procedures. The operator's training program must provide adequate initial and recurrent training in these procedures. Operators must provide for the POI's evaluation for each route, route segment, or area, an analysis of the reliability of wind and

"weather forecasting, the means and accuracy of navigation, prevailing weather conditions - particularly turbulence, terrain features, air traffic control facilities, and the availability of suitable alternate airports. The operator must provide flightcrews with adequate weather briefings.

931. APPROACH AND LANDING CLIMB LIMITS. Approach and landing climb limit weights limit the allowable takeoff weight. To compute the maximum allowable takeoff weight, the predicted weight of the airplane after arrival at the intended destination and alternate airports must be computed by subtracting the estimated en route fuel burn. The resulting weight must allow the airplane to climb at a minimum specified gradient (rate of climb) in both the approach and landing configurations.

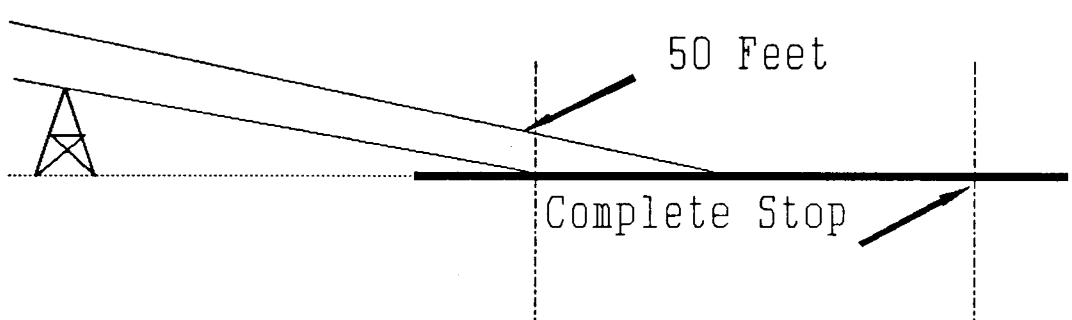
A. *Approach Climb.* This requirement is intended to guarantee adequate performance in the go-around configuration after an approach with an inoperative engine (gear up, flaps at the specified approach setting, the critical engine inoperative, and remaining engines at go-around thrust).

B. *Landing Climb.* This requirement is intended to guarantee adequate performance to arrest the descent and allow a go-around from the final stage of a landing (gear down, landing flaps, and go-around thrust).

933. LANDING DISTANCE. The maximum weight for an airplane landing on any runway must be limited so that the landing distance required by the performance rules will be less than the effective landing length available.

A. *Effective Landing Runway Length.* Effective landing runway length for all categories of airplanes is the distance from the point on the approach end of the runway at which the obstruction plane intersects the runway to the roll-out end of the runway. The obstruction plane is a plane that is tangent to the controlling obstruction in the obstruction clearance area that slopes down toward the runway at a 1:20 slope from the horizontal. The area in which the obstruction clearance plane must clear all obstacles is 200 feet on each side of the runway centerline at the touchdown point, which expands to a width of 500 feet on each side at a point 1,500 feet from the touchdown end and beyond. The centerline of the obstruction clearance area may curve at a radius of not less than 4,000 feet, but the last 1,500 feet to the touchdown point must be straight in. Stopways are not usually considered, and clearways may not be considered, as available landing areas.

Figure 4.3.1.4
Landing Distance



B. *Required Landing Distance.* The required landing distance is the distance needed to completely stop from 50 feet above the point at which the obstacle clearance plane intersects the runway. In establishing landing performance data, the airplane must approach in a steady glide (or rate of descent) down to 50 feet at a speed not less than 1.3 times the landing stall speed. After touchdown, the stopping distance is based on the drag from the landing flaps, fully extended speedbrakes.

934. - 946. RESERVED.

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