VOLUME 4 AIRCRAFT EQUIPMENT AND OPERATIONAL AUTHORIZATIONS

CHAPTER 3 AIRPLANE PERFORMANCE AND AIRPORT DATA

Section 1 Safety Assurance System: Airplane Performance Computation Rules

4-486 GENERAL. This chapter contains direction and guidance to be used by inspectors for reviewing and approving performance data sections of Company Flight Manuals (CFM). This chapter also contains guidance for accepting or approving an operator's system for acquiring airport data. This section is related to Safety Assurance System (SAS) Element 3.2.1 (OP) Aircraft Performance Operating Limitations.

A. Chapter Contents. Section 1 of this chapter, Safety Assurance System: Airplane Performance Computation Rules, is intended as background and reference material. It contains basic explanations of the terms and concepts used in airplane performance computations. Section 2, Safety Assurance System: Airplane Performance Rules, contains detailed information on the rules applicable to specific airplanes. Section 3, Safety Assurance System: Approval of Performance Data Sections of CFMs, contains specific direction and guidance for the review and approval of performance data sections of CFMs. Section 4, Safety Assurance System: Airport Data Acquisition Systems, contains specific direction and guidance for the review and approval of airport data acquisition systems. Section 5, Safety Assurance System: Selected Practices, 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 a Supplemental Type Certificate (STC). Next, inspectors must determine the specific paragraphs that apply to the airplane from Table 4-9, Airplane Categories for Performance Computation Purposes. An inspector who is generally familiar with the terms and concepts involved may then consult the specific paragraph in Volume 4, Chapter 3, Section 2. Inspectors who are not familiar with the terms and concepts involved will find it useful to review the background material contained in Volume 4, Chapter 3, Section 1 before proceeding to Volume 4, Chapter 3, Section 2.

4-487 OVERVIEW OF AIRPLANE PERFORMANCE RULES. Aircraft performance requirements are contained in Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 121, and 135, as applicable.

A. Certification Limitations. Part 91, § 91.9 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 (AIR). Since March 1, 1979, these limitations must be published in an approved Aircraft Flight Manual (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 takeoff weight (MTOW).

B. Performance Limits. Part 121 subpart I and part 135 subpart I require operators conducting air transportation operations to conduct those operations within specified performance limits. Operators must use Federal Aviation Administration (FAA)-approved data to show compliance with these regulations, supplemented as necessary with manufacturers' advisory data, for wet and contaminated operations. The aircraft certification rules require the manufacturer to determine the aircraft's performance 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 CFM.

C. Advisory Information. Aircraft manufacturers occasionally publish advisory information in flight handbooks that is not required for certification and which, therefore, has not been placed in the limitations section of the AFM or RFM. For example, manufacturers of light multiengine aircraft certified under 14 CFR 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 § 91.9. Principal operations inspectors (POI) should ensure that operators enforce such limitations by placing appropriate 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 (ALoS). 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. Part 121 subpart I and part 135 subpart I 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 date of certification, the certification category, and the aircraft size. This information can be found on the Type Certificate Data Sheet (TCDS). Modifications by the STC document the certification basis for the change only. If the modification changes the certification category of the aircraft, a new model designation is usually assigned. Table 4-9 contains a summary of the categories into which airplanes have been divided for the purpose of performance computations under parts 121 and 135.

Table 4-9. Airplane Categories for Performance Computation Purposes

AIRPLANE GROUPING	CHARACTERISTICS
LARGE TRANSPORT CATEGORY	• More than 12,500 lbs maximum takeoff weight (MTOW). • Certified under Civil Aviation Regulation (CAR) 4, CAR 4a, CAR 4b, Special Civil Air Regulation (SR)-422, SR-422A, SR-422B, or 14 CFR part 25.
LARGE NONTRANSPORT CATEGORY	• More than 12,500 lbs MTOW. • Certified prior to July 1, 1942, under Aeronautics Bulletin 7A.
SMALL TRANSPORT CATEGORY	• Not more than 12,500 lbs MTOW. • Certified under CAR 4, CAR 4a, CAR 4b, SR-422, SR-422A, SR-422B, or part 25.
COMMUTER CATEGORY	• Up to 19,000 lbs MTOW, 19 passenger seats. • Reciprocating or turbopropeller. • Certified under 14 CFR part 23. • Defined as small for performance computation purposes and large for purposes of pilot certification.
NORMAL CATEGORY—OVER 12,500 LBS	• Certified under part 23 and 10 to 19 passenger Special Federal Aviation Regulation (SFAR) 41, subparagraph 1(b). • 19 passenger seats and 19,000 lbs MTOW. • Defined as a small airplane for performance computation purposes and as a large airplane for pilot certification by SFAR 41.

NORMAL CATEGORY—12,500 LBS OR LESS	• 12,500 lbs or less MTOW, 10 to 19 passenger MTOW.
	• Certified under CAR 3 or part 23 and one of the following, including:
	  • Supplemental Type Certificates (STC);
	  • Special conditions (SC) of the Administrator;
	  • SFAR 23; and
	  • SFAR 41, subparagraph 1(a).

NORMAL CATEGORY—9 OR LESS PASSENGER SEATS	• 12,500 lbs or less MTOW. • Certified under CAR 3 or part 23.

4-488 LARGE AIRPLANE CERTIFICATION. On July 1, 1942, Civil Aviation Regulation (CAR) 4, Airplane Airworthiness, 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 Aeronautics Bulletin 7A, Airworthiness Requirements for Aircraft (before the establishment of 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 that inspectors are likely to encounter. They are the Lockheed 18, the Curtiss-Wright C-46, and the Douglas DC-3. Many of these airplanes have been modified by STCs 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. This section does not apply to airplanes operating under 14 CFR part 125.

B. Reciprocating-Powered Transport Category Airplanes. By November 1945, CAR 4 was amended by CAR 4a and CAR 4b. Most large reciprocating-powered transport category airplanes that 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 Civil Air 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 CL-44. The majority of the turbine-powered transport category airplanes now in service, such as the DC-8, DC-9, and B727, were originally certified under SR-422B. SR-422B was recodified with minor changes to 14 CFR part 25, which became effective February 1965.

4-489 DETERMINING APPLICABLE OPERATING RULES. Until the publication of 14 CFR part 119, Special Federal Aviation Regulation (SFAR) 38-2 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 Parts 121 and 135. Since the adoption of SFAR 38-2, large transport and nontransport category airplanes are operated under both parts 121 and 135. Part 121 subpart I and part 135 subpart I have identical aircraft performance provisions.

4-490 SMALL AIRPLANE CERTIFICATION. Title 14 CFR part 1 defines a small airplane as one of not more than 12,500 pounds MTOW. Under CAR 3, Airplane Airworthiness–Normal, Utility, and Acrobatic Categories, 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 nine passenger seats. The special conditions (SC) of the Administrator (14 CFR part 21, § 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, subparagraph 1(b), and having up to 19,000 pounds MTOW were defined as small airplanes. Part 23, amendment 23-34, 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 of 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 SCs of the Administrator, SFAR 23, SFAR 41, and part 135 appendix A were additional airworthiness standards developed to allow for the certification of a part 23 airplane with more than 9 passenger seats. All of these rules, except part 135 appendix A, have been superseded. Production of airplanes certified under these rules ended in 1991. Currently, airplanes certified under any of these provisions (except SFAR 41 subparagraph 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 subparagraph 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 subparagraph 1(b) for the purposes of 14 CFR parts 21, 23, 36, 121, 135, and 139. They are defined as large airplanes for the purposes of 14 CFR parts 61 and 91. These airplanes are not required to comply with the provisions of part 135 appendix A, since SFAR 41 subparagraph 1(b) provides additional standards for operations over 12,500 pounds MTOW.

C. Commuter Category. In January 1987, part 23, amendment 23-34, 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, and
- Landing.

2) Airport elevation and temperature:

- Departure point,
- Destination, and
- Alternate.

3) Runway limit weight:

- Accelerate-stop distance,
- Accelerate-go (one-engine-inoperative (OEI)), and
- All-engines takeoff distance.

4) Takeoff climb limit weight:

- First segment,
- Second segment, and
- Transition segment (divided into third and fourth segments under some rules).

5) Takeoff obstacle limit weight.

6) En route climb limit and terrain clearance weights:

- All engines operative,
- OEI, and
- Two engines inoperative.

7) Approach climb limit weight.

8) Landing climb limit weight.

9) Destination landing distance weight.

10) Alternate landing distance weight.

E. Application of Flight Handbook Performance Limits. Many of the requirements of part 121 subpart I and part 135 subpart I 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, part 121, § 121.195 and part 135, § 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 percent 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 percent 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.

4-491 "V" SPEED DEFINITIONS. Inspectors should be knowledgeable in the terminology and definitions that apply to V speeds. The following definitions apply to speeds used in airplane performance computations.

A. V_{MC}. Defined in part 1 as the minimum speed at which the airplane is directionally controllable with the critical engine inoperative.

1) V_{MCG} 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) V_{MCA} 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. V_{EF}. Defined as the airspeed at which the critical engine is assumed to fail. V_{EF} is selected by the aircraft manufacturer 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. V_{MU}. 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. V_R. Defined as rotation speed and applicable to transport category airplanes certified under SR-422A and later rules and commuter category airplanes. V_R is determined so that V_2 is reached before the aircraft reaches 35 feet above the runway surface. V_R may not be less than V_{MU} or 1.05 V_{MCA}.

E. V_1. 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 V_{EF} 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); or
- Limiting tire speed (if one has been established).

F. V_{LOF}. Defined as the speed at which the aircraft becomes airborne.

G. V_S, V_{SO}, and V_{S1}. 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. V_2. Defined as takeoff safety speed. V_2 is used in multiengine transport commuter category and large nontransport category airplanes. V_2 is the speed at which the airplane climbs through the first and second takeoff segments. V_2 must be greater than V_{MU} and 1.1 V_{MCA}. V_2 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 OEI stall speed (no flaps or leading edge devices);
- 1.5 V_{S1} for turbojet airplanes with more than three engines; or
- 1.5 V_{S1} for turbojet airplanes with the capability for significantly reducing the OEI stall speed.

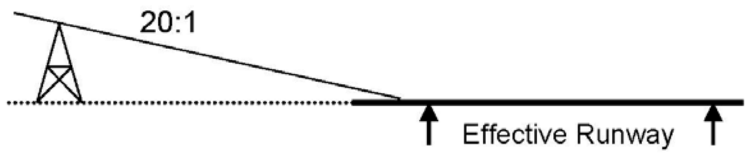
I. V_{REF}. V_{REF} is 1.3 V_{SO}. V_{REF} is the speed used on approach down to 50 feet above the runway when computing landing distances.

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

4-492 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 nontransport 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. (See Figure 4-26, Effective Runway Length.)

Figure 4-26. 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 4-502.

C. Obstructions. An obstruction is a manmade or natural object that 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; and
- Over waterways and other traverse ways: the height of the tallest vehicle that is authorized to use the waterway or traverse way.

D. Lineup 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 is 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. POIs should ensure that operators have appropriate guidance for flightcrews.

4-493 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 wheel brakes (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 OEI) 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 OEI to V_R speed, at which time the nose gear is raised off the ground (V_R is V_2 for all airplanes certified prior to SR-422A).
- Climbing to the specified RCH and 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.

4-494 TAKEOFF CONDITIONS. Takeoff performance data published in the AFM is based on takeoff results attainable on a smooth (dry or wet*), hard runway with a specified flap setting and a specific weight. The 14 CFR parts do not require that data for compensating takeoff performance for the effects of runways contaminated by frost, ice, snow, slush, or water be published in an AFM. These factors, however, must be accounted for during revenue operations (see paragraph 4-496 for more information on wet or contaminated runways).

NOTE: *Wet runway accountability was included in part 25, amendment 25-92.

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 14 CFR. 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_1 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; and
- 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 takeoff. 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 4-10, Example of the Effect of Flaps on Required Runway Length and Climb Gradient, for an example of the effect of flaps on required runway length and climb gradient.

Table 4-10. Example of the Effect of Flaps on Required Runway Length and Climb Gradient

Wing Flaps Position	Runway Length Required for Takeoff	One-Engine-Inoperative Climb Gradient
25 degrees	6,350 feet	2.9 percent
15 degrees	7,000 feet	4.5 percent
5 degrees	7,950 feet	5.3 percent
NOTE: This is only an example.		

F. Accounting for Effects. The effect of runway slope on the acceleration, stopping distance, and climbout to the end of 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.

4-495 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 percent 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 (OpSpecs).

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 AFMs 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}.

4-496 TAKEOFF FROM A RUNWAY WHICH IS WET OR CONTAMINATED. AFM performance data is based on a dry or wet* 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 regarding these conditions.

NOTE: *Wet runway accountability was included in part 25, amendment 25-92.

A. Definitions of Wet and Contaminated. A runway is dry when it is neither wet nor contaminated. A runway is wet when it is neither dry nor contaminated. A runway can be considered wet when more than 25 percent of the runway surface area is covered by any visible dampness or water that is ⅛ inch or less in depth. A damp runway that meets this definition is considered wet, regardless of whether or not the surface appears reflective. For the purpose of takeoff performance, a runway is considered contaminated when more than 25 percent of the runway surface area is covered by a reportable contaminant listed in the current edition of Advisory Circular (AC) 91-79, Mitigating the Risks of a Runway Overrun Upon Landing, Table 1-1, Pilot/Aircraft Operator Operational Runway Condition Assessment Matrix (RCAM) Braking Action Codes and Definitions, “Runway Condition Description” column. Contaminated runway data provided by the aircraft manufacturers usually includes data for wet runway conditions (which is also appropriate for use on runways contaminated by frost and reportable contaminant depths of ⅛ inch or less), as well as data for icy and contaminant depths of ¼ inch or greater as appropriate. The manufacturer may provide additional guidance on selecting the appropriate contaminated takeoff performance data.

NOTE: Wetness is a condition, not a contaminant.

B. Runway Friction. Runway braking friction can change when there is a light drizzle. In some cases, even dew or frost that 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, well-textured wet runway is usually around 1.15 to 1. On a runway where the grooves are not maintained and the runway has poor texture, polishing, or heavy rubber deposits, the stopping distance ratio could be as high as 1.9 to 1. On ungrooved, well-maintained, well-textured, wet runways, the stopping distance ratio is usually about 2 to 1. In the case of a runway with new pavement, poor texturing, 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.

C. Takeoff Data Which Accounts for Runway Contamination. Typically the manufacturer makes available takeoff data which accounts for runway contamination such as slush, snow, standing water, and ice. This data is often created using assumptions that were accepted by European certification agencies and are consistent with the recommendations in the current edition of AC 25-31, Takeoff Performance Data for Operations on Contaminated Runways. Usually, this data takes into account an engine failure at the critical point and the performance effect of the contaminant on the following:

1) The first factor is the reduction of runway friction which may increase stopping distance in the case of a rejected takeoff.

2) 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.

4-497 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 brakes. 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 turnaround times and rejected takeoffs present a potential hazard in terms of heat buildup in tires and in brake assemblies. Most manufacturers publish short turnaround charts to provide a minimum cooling period for subsequent takeoffs. POIs should ensure that operators include these charts and procedures in the operator’s GOMs or CFMs.

4-498 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 percentage) in specified climb segments. The gradients for each group of airplanes are provided in Volume 4, Chapter 3, Section 2.

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 Volume 4, Chapter 3, Section 2.

4-499 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 Volume 4, Chapter 3, Section 2.

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 engine(s) 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. Terminal Instrument Procedures (TERPS) criteria are based on the assumption that the airplane can climb at 200 feet per nautical mile (NM) (approximately 30:1) to the minimum en route altitude (MEA) 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. POIs shall not authorize operators who do not prepare an airport analysis and perform obstacle climb computations to use lower-than-standard takeoff minimums. POIs 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 do 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 order at a later date.

4-500 EN ROUTE PERFORMANCE LIMITS. There are a number of en route performance rules that may limit the weight at which an airplane can be dispatched or released.

A. Part 121 En Route Obstacle Clearance. Part 121 subpart I 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 (three- and four-engine airplanes) can be experienced and the airplane can continue on to the destination or divert 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 4-500E for a discussion of driftdown).

B. Part 135 En Route Obstacle Clearance. Section 135.181 places en route performance limitations on all instrument flight rules (IFR) passenger-carrying operations.

1) Section 135.181 allows passenger-carrying flights under IFR conditions in single-engine airplanes and permits over-the-top operations under limited circumstances (refer to § 135.181(c) and (d)(2)).

2) Section 135.181(a)(2) prohibits operating multiengine airplanes in passenger-carrying IFR operations or 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 (fpm) at the MEA or 5,000 mean sea level (MSL), whichever is higher. There are also other circumstances in which a multiengine airplane can be operated over-the-top (refer to § 135.181(c) and (d)(1)).

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) Extended overwater operations occur when an aircraft other than a helicopter flies more than 50 NM from a shoreline or when a helicopter flies more than 50 NM from a shoreline or an offshore heliport structure. Extended overwater operations do not require specific approval; however, OpSpec B045, which requires the approval of the Flight Technologies and Procedures Division (AFS-400) for issuance, approves these extended overwater operations with a Single Long-Range Communication System (SLRCS).

2) Sections 121.183 and 121.193 limit the release of four-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 that 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 4-500E). 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. Section 135.183 prohibits operators from operating a land airplane over water (except for takeoff and landing) at a weight at which a positive rate of climb of 50 fpm 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 4-500E).

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 § 135.181 or § 135.183 in accordance with 14 CFR part 11 (see Volume 4, Chapter 3, Section 2 for information on exemptions).

1) Driftdown can be defined as a procedure by which an airplane with one or more engines inoperative, the remaining engine(s) at MCT, and while maintaining a specified speed (usually best lift over drag (L/D) × 1.01 percent), 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 that place the driftdown height below the minimum altitude that the airplane is required to maintain by part 121 or 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 part 135 operators who hold exemptions authorizing the use of these procedures), POIs 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 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 (ATC) facilities, and the availability of suitable alternate airports. The operator must provide flightcrews with adequate weather briefings.

4-501 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).

4-502 LANDING DISTANCES. The landing distance may refer to either the runway length available for landing or the distance required by the aircraft landing performance calculations.

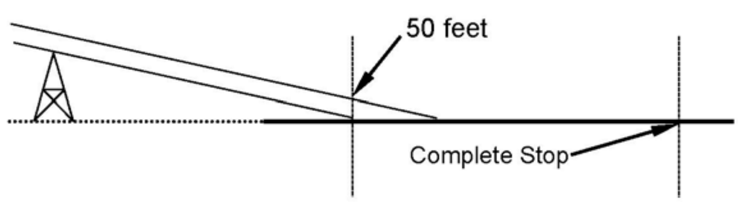
A. Effective Landing Runway Length. The regulations (§§ 121.171 and 135.361) refer to the "effective length of the runway" for landing, which is the distance from the point on the approach end of the runway where the obstruction clearance plane intersects the runway to the far end of the runway. The determination of the effective landing runway length by operators is required only where the Landing Distance Available (LDA) declared distance is not established. Stopways, clearways, and any portion of the runway declared not available and suitable for landing are not included in the effective landing runway length.

NOTE: Refer to Aeronautical Information Manual (AIM) Paragraph 4-3-6, Use of Runways/Declared Distances, for guidance concerning runway declared distances and determination of LDA on runways with and without published declared distances.

B. LDA. The LDA declared distance, where established, is the runway length to be used for landing performance calculations.

C. Required Landing Distance. The required landing distance is established during certification and is the distance needed to completely stop from 50 feet above the runway threshold (i.e., the point at which the obstacle clearance plane intersects the runway (see Figure 4-27, Landing Distance)). In establishing landing performance data, the airplane must approach in a steady glide (or rate of descent) down to 50 feet at speed not less than V_{REF} for the chosen landing flap setting.

Figure 4-27. Landing Distance



D. Factored Landing Distance. The operating regulations (e.g., §§ 121.195, 135.385, and 91.1037) require that the takeoff weight be limited such that the aircraft can land at the intended destination, allowing for normal fuel and oil consumption in flight, within a specified percentage (60 percent for turbojet aircraft) of the effective runway landing length available at the destination airport. The inverse of this percentage (1/.60) is a factor (1.67 in this case) that can be applied to the required landing distance established at aircraft certification to produce the landing runway length required for dispatch. This is referred to as the factored landing distance. The landing distances specified in the AFM may be the required landing distance specified by the certification rules, the factored Landing Distance Required (LDR) by the operating rules, or both.

E. Operational Landing Distance. These distances are advisory performance data (i.e., not required by regulation) which are intended to provide a more accurate assessment of actual landing distance at time of arrival, considering factors which cannot be accurately predicted at time of dispatch, such as runway contaminants, winds, speed additives, and touchdown points. These distances may be based upon the use of reverse thrust, ground spoilers, autobrakes, etc.

4-503 LANDING DISTANCE ASSESSMENT AT TIME OF ARRIVAL. There is no specific regulation requiring operators to assess landing distance requirements at time of arrival, but the FAA encourages operators to adopt such procedures to assure a safe landing can be made. Additionally, the FAA highly encourages operators to utilize their FAA-approved landing performance data and any associated manufacturer-provided supplemental/advisory data in concert with the AC 91-79-generated RCAM braking action codes to conduct an adequate landing distance assessment at the time of arrival. This is particularly important when the landing runway is contaminated or not the same runway analyzed for dispatch calculations.
The following are best practices for conducting a landing distance assessment at time of arrival.

A. Timeliness. The assessment is initially performed when landing weather and field conditions are obtained, usually around Top of Descent (TOD). The assessment includes consideration of how much deterioration in field conditions can be tolerated so that a quick decision can be made just prior to landing if the preceding aircraft provides a Pilot Weather Report (PIREP) of worse-than-expected braking action.

B. Source of Data.

1) When possible, the operational landing distance data used is advisory data based on the recommendations of the current edition of AC 25-32, Landing Performance Data for Time-of-Arrival Landing Performance Assessments. This data may be provided by the manufacturer or developed by a performance data provider.

2) If advisory data for a landing distance assessment at time of arrival is not available from the manufacturer, performance provider data may be used. If performance provider data is not available, the Landing Distance Factors (LDF) from Table 4-11, Landing Distance Factors, may be used. To find the LDR, multiply the certificated (AFM, i.e. dry, unfactored) landing distance by the applicable LDF in Table 4-11 for the runway conditions existing at the time of arrival. If the AFM landing distances are presented as factored landing distances, then that data must be adjusted to remove the applicable preflight factors applied to that data. The LDFs given in Table 4-11 include a 15 percent safety margin; an air distance representative of normal operational practices; a reasonable accounting for temperature; the effect of increased approach speed, reduced wheel braking, and thrust usage (reverse or not); and the additional effect of reduced wheel braking capability on altitude and wind distance adjustment.

3) Currently, the Small Airplane Standards Branch (AIR-690) does not plan to provide aircraft manufacturers with advisory information similar to AC 25-32. In the absence of guidance to manufacturers of part 23 aircraft, operational landing distance data may be based on the recommendations of AC 25-32. This data may be provided by the manufacturer or developed by a performance data provider if manufacturer data is not available. In the absence of guidance to part 23 aircraft manufacturers, the manufacturer or data provider may consider the recommendations in AC 25-32 when creating data for a time-of-arrival assessment. Manufacturer-provided guidance on the use of existing data with the runway condition codes (RwyCC) must be used when available.

Table 4-11. Landing Distance Factors

The following factors are multipliers to the unfactored AFM demonstrated landing distances:

Runway Condition Code	**6**	**5 Grooved/PFC**	**5 Smooth**	**4**	**3**	**2**	**1**
Braking Action	Dry	Good	Good	Good to Medium	Medium	Medium to Poor	Poor
Turbojet, No Reverse	1.67	2.3	2.6	2.8	3.2	4.0	5.1
Turbojet, With Reverse	1.67	1.92	2.2	2.3	2.5	2.9	3.4
Turboprop (see Note)	1.67	1.92	2.0	2.2	2.4	2.7	2.9
Reciprocating	1.67	2.3	2.6	2.8	3.2	4.0	5.1

NOTE: These LDFs apply only to turboprops where the AFM provides for a landing distance credit for the use of ground idle power level position. Turboprops without this credit should use the "Turbojet, No Reverse" LDFs.

C. Runway Condition Considerations. When available for the portion of the runway that will be used for landing, the following are considered:

1) RwyCC,

2) Expected runway conditions (contaminate type and depth), and

3) Pilot braking action report.

D. Aircraft Performance Considerations. The following considerations may impact operational landing distance calculations:

1) Runway slope,

2) Airport elevation,

3) Wind,

4) Temperature,

5) Airplane weight and configuration,

6) Approach speed at threshold,

7) Adjustment to landing distance (such as autoland), and

8) Planned use of airplane ground deceleration devices.

E. Safety Margin. The operational landing distance used for a time-of-arrival landing assessment includes a safety margin of at least 15 percent when based on manual wheel braking.

F. Autobrake Usage. While autobrakes are a part of the aircraft's landing configuration, this landing distance assessment procedure is not intended to force higher than reasonable autobrake selection. For operations when the runway is dry or when the runway is wet, grooved, or Porous Friction Course (PFC) (a relatively thin layer of aggregate sized porous asphalt that allows free penetration of the surface water to the underlying impervious surface course), if the manual braking distance provides a 15 percent safety margin, then the braking technique may include a combination of autobrakes and manual braking even if the selected autobrake landing data does not provide a 15 percent safety margin.

G. Touchdown Point. The touchdown point used in the assessment reflects the assumed air distance. Operational landing data usually includes an allowance for 1,500 feet or 7 seconds of air distance from the threshold to touchdown. An air distance as short as 1,000 feet may be used if an operator's landing assessment procedures include enhancements to minimize the risk of overruns or undershoots, including:

1) Training in touchdown control and short field landing techniques.

2) Identification of required touchdown point and training to assure go-around procedures are initiated, if unable to achieve a suitable touchdown point.

3) Approach guidance and runway markings on the specific runway are consistent with a shorter air distance.

4) Operational data provided to the crew for the specific runway, conditions, and aircraft landing configuration without the need for interpolation.

5) The flight techniques assumed in the creation of the performance data used for a shorter air distance are based on flight techniques to be used in the shorter air distance operation. For example, the assumed speed bleed-off used in the performance data needs to be consistent with the trained flight techniques for flaring the aircraft.

H. Assessment Based on Dispatch Criteria. When the runway is dry, or when the runway is wet and grooved or a PFC, the assessment may be as simple as confirming the runway meets the criteria used for dispatch.

I. Documentation and Training. Published material and training material include the assumptions and limitations on the use of the data provided to do a landing distance assessment at the time of arrival.

RESERVED. Paragraphs 4-504 through 4-520.