## DEPARTMENT OF TRANSPORTATION

### Federal Aviation Administration

### 14 CFR Parts 1, 25, 91, 121, and 135

**[Docket No. 25471; Amendment Nos. 1–48, 25–92, 91–256, 121–268, 135–71]**

**RIN 2120–AB17**

## Improved Standards for Determining Rejected Takeoff and Landing Performance

**AGENCY:** Federal Aviation Administration (FAA), DOT.

**ACTION:** Final rule.

**SUMMARY:** This action amends the airworthiness standards for transport category airplanes to: revise the method for taking into account the time needed for the pilot to accomplish the procedures for a rejected takeoff; require that takeoff performance be determined for wet runways; and require that rejected takeoff and landing stopping distances be based on worn brakes. The FAA is taking this action to improve the airworthiness standards, reduce the impact of the standards on the competitiveness of new versus derivative airplanes without adversely affecting safety, and harmonize with revised standards of the European Joint Aviation Requirements-25 (JAR–25). These standards, which affect manufacturers and operators of transport category airplanes, are not being applied retroactively to either airplanes currently in use or airplanes of existing approved designs that will be manufactured in the future.

**EFFECTIVE DATE:** March 20, 1998.

**FOR FURTHER INFORMATION CONTACT:** Donald K. Stimson, FAA, Airplane & Flightcrew Interface Branch, ANM–111, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, WA 98055–4056; telephone (425) 227–1129, facsimile (425) 227–1320.

**SUPPLEMENTARY INFORMATION:** An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the FedWorld electronic bulletin board service (telephone: 202–512–1661) or the FAA's Aviation Rulemaking Advisory Committee Bulletin Board service (telephone: 800–FAA–ARAC).

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If you are a small entity and have a question, contact your local FAA official. If you do not know how to contact your local FAA official, you may contact Charlene Brown, Program Analyst Staff, Office of Rulemaking, ARM–27, Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, 1–888–551–1594. Internet users can find additional information on SBREFA in the ''Quick Jump'' section of the FAA's web page at http://www.faa.gov and may send electronic inquiries to the following internet address: 9–AWA–SBREFA@faa.dot.gov.

### Background

These amendments are based on notice of proposed rulemaking (NPRM) 93–8, which was published in the **Federal Register** on July 8, 1993 (58 FR 36738). In that notice, the FAA proposed amendments to 14 CFR parts 1, 25, 91, 121, and 135 to improve the standards for determining the accelerate-stop and landing distances for transport category airplanes. The FAA received over 100 comments from 22 different commenters on the proposals contained in NPRM 93–8. As a result of these comments, the FAA has modified some of the original proposals.

As explained in NPRM 93–8, the operator of a turbine-powered category airplane must determine that the runway being used, plus any available stopway or clearway, is long enough to either safely continue or reject the takeoff from a defined go/no-go point. The go/no-go point occurs while the airplane is accelerating down the runway for takeoff when the airplane reaches a speed known as $V_1$.

The assure that the takeoff can be safely continued from the go/no-go point, the length of the runway plus any clearway must be long enough for the airplane to reach a height of 35 feet by the end of that distance, even if a total loss of power from the most critical engine occurs just before reaching the $V_1$ speed. This distance is commonly referred to as the accelerate-go distance.

In case the pilot finds it necessary to reject the takeoff, the runway plus any stopway must be long enough for the airplane to be accelerated to the $V_1$ speed and then brought to a complete stop. This distance is known as the accelerate-stop distance.

The choice of $V_1$ speed affects the accelerate-go and accelerate-stop distances. A lower $V_1$ speed, corresponding to an engine failure early in the takeoff roll, increases the accelerate-go distance and decreases the accelerate-stop distance. Conversely, a higher $V_1$ speed decreases the accelerate-go distance and increases the accelerate-stop distance. When $V_1$ is selected such that the accelerate-stop distance is equal to the accelerate-go distance, this distance is known as the balanced field length. In general, the balanced field length represents the minimum runway length that can be used for takeoff.

The $V_1$ speed selected for any takeoff depends on several variables, including the airplane's takeoff weight and configuration (flap setting), the runway length, the air temperature, and the runway surface elevation (airport altitude). The takeoff performance and limitation charts in the Airplane Flight Manual (AFM) are developed in accordance with the FAA airworthiness standards in subpart B of the Federal Aviation Regulations (FAR), part 25—''Airworthiness Standards: Transport Category Airplanes,'' using data gathered during comprehensive flight tests completed as a part of the FAA's approval of the airplane's type design.

Part 25, subpart B, also prescribes the FAA airworthiness standards for determining the length of runway required for safe landing under various airplane and atmospheric conditions. Landing performance charts must be published in the AFM, and are used by the operator to determine whether a particular runway is long enough for landing.

The FAA, through the general operating rules contained in parts 91, 121, and 135, requires operators to use the appropriate performance and limitation charts published in the AFM to plan their takeoffs and landings.

In NPRM 93–8, the FAA proposed amendments to several sections of parts 25, 91, 121, and 135 concerning the methods for determining and applying the takeoff and landing performance standards for turbine-powered transport category airplanes. Also, the FAA proposed to amend part 1, which contains terms and abbreviations used in the FAR, to add a definition of the term ''takeoff decision speed'' and an explanation for the abbreviation ''$V_{EF}$.''

The proposed amendments retained the fundamental principle that the pilot should be able to either safety complete a takeoff or bring the airplane to a complete stop, even if power is lost from the most critical engine just before the airplane reaches a defined go/no-go point. This principle has formed the basis of the takeoff performance standards required for the type certification of turbine-powered transport category airplanes since Special Civil Air Regulation No. SR–422, effective August 27, 1957. The amendments proposed in NPRM 93–8 were intended to provide a more rational method to take into account the various operational aspects affecting the takeoff distance. By the phrase ''more rational method,'' the FAA means a method that explicitly addresses the specific elements affecting the takeoff distance, rather than providing for critical conditions by applying more restrictive standards to all takeoffs.

If the takeoff performance standards are made more restrictive, longer distances are needed for takeoff. However, the operator cannot change the length of the runway (although a longer runway, if available, could be used). Instead, the operator must usually reduce the airplane's takeoff weight in order to shorten the distance needed for takeoff. The more restrictive the takeoff performance standards are, the more takeoff weight may have to be reduced to be able to operate from a particular runway.

To reduce the airplane's takeoff weight, the operator must either reduce the amount of fuel to be carried, or reduce the number of passengers or amount of cargo to be transported. Since the amount of fuel to be carried is dictated primarily by the route being flown, the operator's only option may be to reduce the number of passengers or amount of cargo to be transported. When the number of passengers or amount of cargo must be reduced for a given flight, the airplane operator can suffer a loss of revenue.

Amendment 25–42, which became effective on March 1, 1978, revised the takeoff performance standards to make them more restrictive. Prior to Amendment 25–42, variations in pilot reaction time were provided for in the AFM accelerate-stop distances by adding one second to the flight test demonstrated time interval between each of the pilot actions necessary to stop the airplane. Typically, there are three such actions. The pilot reduces the power, applies the brakes, and raises the spoilers. Adding one second between each of these actions results in a total of two seconds being added to the time taken by the flight test pilots to accomplish the procedures for stopping the airplane. In calculating the resulting accelerate-stop distances for the AFM, no credit was allowed for any deceleration during this two-second time period.

The revised standards of Amendment 25–42 required the accelerate-stop distance to include two seconds of continued acceleration beyond $V_1$ speed before the pilot takes any action to stop the airplane. This revision resulted in longer accelerate-stop distances for airplanes whose application for a type certificate was made after Amendment 25–42 became effective. Consequently, turbine-powered transport category airplanes that are currently being manufactured under a type certificate that was applied for prior to March 1, 1978, have a significant operational economic advantage over airplanes whose type certificate was applied for after that date. This competitive disparity resulting from applying different performance standards created a compelling need to amend the takeoff performance standards of part 25 without adversely affecting safety. In addition, operational experience indicated a need to specifically address the detrimental effects of worn brakes and wet runways on airplane stopping performance.

Amendment 25–42 was a broad brush approach, applying to all takeoffs, to increase the required accelerate-stop distance. This broad brush approach did not explicitly account for many of the important operational factors that may affect takeoff performance. For example, the standards did not distinguish between dry and wet runways, nor were the effects of worn brakes taken into account. Wet runways and worn brakes typically result in longer accelerate-stop distances than with new brakes on a dry runway. By requiring wet runway performance to be determined and included in the AFM, and by requiring the use of worn brakes to determine the airplane's stopping capability, the proposed amendments would provide additional accelerate-stop distance for the conditions in which it is specifically needed in operational service.

Because wet runways and worn brakes would be specifically addressed in the revised standards proposed in NPRM 93–8, the FAA also proposed to replace the two seconds of continued acceleration beyond $V_1$ with a distance equal to two seconds at the $V_1$ speed. The distance equal to two seconds at constant $V_1$, while shorter than that resulting from the continued acceleration beyond $V_1$ required by Amendment 25–42, is a distance margin that must be added to the accelerate-stop distance demonstrated during flight testing for type certification. The FAA intends for this distance margin to take into account the variability in the time it takes for pilots, in actual operations, to accomplish the procedures for stopping the airplane.

Amendment 25–42 required the two seconds of time delay to be applied prior to the pilot taking any action to stop the airplane. This more restrictive approach assumes that the airplane reaches a higher speed during the accelerate-stop maneuver and, therefore, results in a longer distance than the distance equal to two seconds at constant $V_1$ speed. Inserting the time delay before the pilot takes any action to stop the airplane, however, does not accurately reflect the procedures that pilots are trained to use in operational service. $V_1$ is intended to be the speed by which the pilot has already made the decision to rejected the takeoff and has begun taking action to stop the airplane. The time it takes for the pilot to recognize the need for a rejected takeoff, which occurs before $V_1$ is reached, is considered separately within the airworthiness standards. Therefore, the amendments proposed in NPRM 93–8 were intended to more accurately reflect the rejected takeoff procedures taught in training and the intended use of the $V_1$ speed.

In summary, the purpose of the amendments to the takeoff performance standards of parts 25, 91, 121, and 135, as proposed in NPRM 93–8, was to more rationally reflect the operational factors involved and reduce the impact of the standards on the competitiveness of new versus derivative airplanes. More restrictive standards were proposed for takeoffs from wet runways. In addition, the proposed standards would require accelerate-stop distances to be determined with brakes that are worn to their overhaul limit. Lastly, the two seconds of continued acceleration beyond $V_1$ speed would be replaced by a distance equal to two seconds at $V_1$ speed.

In NPRM 93–8, the FAA also proposed to amend the landing distance standards of part 25 to account for worn brakes. The FAA proposed this change to be consistent with the proposal for taking worn brakes into account for the takeoff accelerate-stop distances. Because airplanes generally require more distance to take off than to land, the allowable landing weight is rarely limited by the available runway length. Therefore, the proposed landing distance rule change was not expected to have a significant effect on the number of passengers or amount of cargo that can be carried.

**International Harmonization of Airworthiness Standards**

For more than ten years, the FAA has been cooperating with the Joint Aviation Authorities (JAA) of Europe to promote harmonization between the FAR, particularly the airworthiness standards, and the European Joint Aviation Requirements (JAR). The aircraft certification authorities of 23 European countries are members of JAA. An annual meeting is held between FAA senior management officials and senior management officials of the JAA member authorities to identify technical subject areas where cooperation is needed to promote greater harmonization between the FAR of the United States and the European JAR. A large portion of these meetings have been open to the public. A comprehensive study of this activity was completed by Professor George A. Bermann, Columbia University School of Law, in May 1991 as a consultant to the Administrative Conference of the United States (ACUS). A copy of Professor Bermann's final report to ACUS, titled: ''Regulatory Cooperation with Counterpart Agencies Abroad: The FAA's Aircraft Certification Experience,'' dated May 1991, is included in the docket. Based on Professor Bermann's report. ACUS has confirmed the administrative appropriateness of this effort and has indicated strong support for this activity in their Recommendation 91–1, titled ''Federal Agency Cooperation with Foreign Government Regulators,'' adopted June 13, 1991.

At the annual FAA/JAA meeting in June 1989, the FAA and JAA discussed the competitive disparity caused by the differences between the takeoff performance standards applied to airplanes that met the later standards of Amendment 25–42, as compared with airplanes that were only required to meet the takeoff performance standards that preceded Amendment 25–42. Even though the airplane types were originally type certificated at different times, thus allowing the use of different amendments, both groups of airplanes are continuing in production and both are competing for sales and for use over some common routes. Airplanes whose designs were type certificated to the standards introduced by Amendment 25–42 could be penalized in terms of the number of passengers or amount of cargo they can carry over a common route, even though the airplane's takeoff performance might be better from a safety perspective than a competing airplane design that was not required to meet the later standards. Currently, most of the transport category airplane types that have been required to meet the later standards of Amendment 25–42 were designed and manufactured outside the U.S. (mostly in Europe). These airplanes are competing for sales against airplanes that were designed and manufactured in the U.S. that were not required to meet the standards of Amendment 25–42. This situation has led to claims by a major European manufacturer of transport category airplanes that this disparity in the airworthiness standards has created an unfair international trade situation affecting the competitiveness of their airplane types of a later design.

At the June 1990 annual meeting, the FAA and JAA agreed to jointly review the current takeoff performance standards and their applicability with respect to airplanes currently in use and airplanes produced in the future under existing approved designs. The goal was to reduce the inequities described above without adversely affecting safety. The study consisted of two parts: First, the current takeoff performance standards were reviewed to determine if they were too restrictive; and second, the merits of making the resulting standards apply retroactively were considered for both airplanes currently in use and airplanes produced in the future under existing approved designs. The FAA and JAA also agreed to initiate substantively the same rulemaking within their respective systems to harmonize the European and U.S. takeoff performance standards for transport category airplanes.

The FAA concluded that the takeoff performance standards of part 25 could be made more rational, and thus less restrictive overall, without adversely affecting safety and proposed to amend the standards accordingly. However, considering the safety benefits and available economic impact information, the FAA could not support a recommendation to make the standards proposed by NPRM 93–8 retroactive to either airplanes currently in use or future production airplanes of designs that have already been type certificated. If additional information to support making these proposed standards retroactive became available at a later date, the FAA proposed to review such information and determine if further rulemaking would be appropriate.

In March 1992, the JAA issued its Notice of Proposed Amendment (NPA) 25B, D, G–244: ''Accelerate-Stop Distances and Related Performance Matters'' to amend the takeoff performance standards of JAR–25. The amendments proposed in NPRM 93–8 were substantively the same as the amendments proposed by the JAA NPA for JAR–25.

**Discussion of the Proposals**

In NPRM 93–8, the FAA proposed the following rule changes:

1. Replace the two seconds of continued acceleration beyond $V_1$ (mandated by Amendment 25–42) with a distance margin equal to two seconds at $V_1$ speed;

2. Require that the runway surface condition (dry or wet) be taken into account when determining the runway length that must be available for takeoff; and

3. Require that the capability of the brakes to absorb energy and stop the airplane during landings and rejected takeoffs be based on brakes that are worn to their overhaul limit.

*Proposal 1*

The FAA proposed to amend the method of determining the accelerate-stop distance prescribed in § 25.109 by replacing the two seconds of continued acceleration after reaching $V_1$ with a distance equal to two seconds at $V_1$ speed. This proposal would reduce the accelerate-stop distance that must be available for a rejected takeoff because the airplane would be assumed to begin stopping from a lower speed (from $V_1$, rather than from the speed reached after two seconds of acceleration beyond $V_1$). The FAA's intent was to replace the most costly aspect of Amendment 25–42 with a requirement that closely represents the pre-Amendment 25–42 criteria of § 25.109, as applied to the certification of recent U.S.-manufactured airplanes.

*Proposal 2*

The FAA proposed to amend § 25.105 to require that airplane takeoff performance data be based on wet, in addition to dry, runways. Section 25.1587(b) would be amended to require that performance information for wet runways be included in the Airplane Flight Manual (AFM). Sections 91.605, 121.189, and 135.379 of the operating rules would be amended to require that wet runways be taken into account when determining the runway length that must be available for takeoff, if wet runway performance information exists in the AFM. Thus, this rule would apply only to airplane designs for which the application for type certification occurs after the amendment becomes effective, and to those previously certificated airplane designs for which the manufacturer chooses to re-certify to the amended standards.

Section 25.109 would be revised to provide the details of how the accelerate-stop distance would be calculated for a wet runway. The FAA proposed the following approach to determining the wet runway takeoff performance: (1) Take into account the reduced braking force due to the wet surface; (2) permit performance credit for using available reverse thrust as an additional stopping force; and (3) permit the minimum airplane height over the end of the runway after takeoff to be reduced from 35 feet to 15 feet. This approach would reduce the risk of overruns during rejected takeoffs on wet runways while retaining safety margins for continued takeoffs similar to those required for dry runways.

The reduced braking force available is the most significant variable affecting the stopping performance on a wet runway. The FAA proposed to revise § 25.109 to specify that the wet runway braking force would be one-half the dry runway braking force, unless the applicant demonstrated a higher wet runway braking force. Under this proposal, the one-half of the dry braking force level would apply regardless of whether the dry runway braking force is limited by the torque capability of the brake (which is the friction force generated within the brake) or the friction capability of the runway surface. Although it can be argued that the torque capability of a brake is independent of the runway surface condition, the proposed use of this simple relationship between wet and dry runway braking capability would depend on using the one-half dry relationship throughout the braking phase.

Data published in Engineering Science Data Unit (ESDU) 71026, entitled ''Frictional and Retarding Forces on Aircraft Types—Part II: Estimation of Braking Force,'' shows that the relationship between wet and dry braking coefficient varies significantly with speed. At high speeds, the wet runway braking coefficient is typically less than one-half the dry runway braking coefficient. At low speeds, the wet runway braking coefficient is typically more than one-half the dry runway braking coefficient. Used over the entire speed range for the stopping portion of a rejected takeoff, however, the wet runway braking coefficient can justifiably be approximated as one-half the dry braking coefficient. The ESDU report is included in the docket.

Under this proposal, § 25.109 would also be revised to permit the use of available reverse thrust when determining the accelerate-stop distance for a wet runway. ''Available'' reverse thrust was interpreted as meaning the thrust from engines with thrust reversers that are operating during the stopping portion of the rejected takeoff. Credit for reverse thrust was included in the proposal because the most significant variable that affects the stopping performance on a wet runway, reduced braking friction, was also included as part of the rational approach to wet runway rejected takeoff.

On dry runways, the FAA proposed to explicitly deny credit for reverse thrust when calculating the accelerate-stop distance. This proposal would codify current FAA policy. Although reverse thrust should and probably would be used during most rejected takeoffs, the FAA believes that the additional safety provided by not accounting for reverse thrust in calculating the accelerate-stop distance on a dry runway is necessary to offset other variables that can significantly affect the dry runway accelerate-stop performance determined under the current standards. For wet runways, credit for reverse thrust would be permitted because taking into account the reduced braking force available on the wet surface, as proposed in this notice, greatly outweighs the effects of these other variables. Examples of variables that can significantly affect the dry runway accelerate-stop performance include: runway surfaces that provide poorer friction characteristics than the runway used during flight tests to determine stopping performance, dragging brakes, brakes whose stopping capability is reduced because of heat retained from previous braking efforts, etc.

The FAA proposed to revise § 25.113 to allow the distance required for a continued takeoff from a wet runway to include taking off and climbing to a height of 15 feet, rather than the height of 35 feet required on a dry runway. This lower screen height (which is the height of an imaginary screen that the airplane would just clear with the wings in a level attitude when taking off or landing) would reduce the balanced field length $V_1$ speed, thereby reducing the number of high-speed rejected takeoffs on wet runways. The FAA considers lowering the screen height to 15 feet to be an acceptable method of reducing the risk of overruns on wet runways because of the similarity to current rules when operating from dry runways that have a clearway. The minimum height permitted over the end of the runway for current dry runway takeoffs may be 13 to 17 feet, depending on the airplane, when a clearway is present. In addition, a 15-foot minimum screen height and vertical obstacle clearance distance has been allowed for many years by the United Kingdom Civil Aviation Authority for wet runway operations without any problems being reported.

The combination of a clearway with the proposed 15-foot screen height for wet runways could result in a minimum height over the end of the runway of near zero (i.e., liftoff very near the end of the runway), if clearway credit were to be permitted for wet runways in the same manner that it is currently permitted for dry runways. The FAA considers this situation to be unacceptable. The possible presence of standing water or other types of precipitation (e.g., slush or snow) and numerous operational factors (e.g., late or slow rotation to liftoff attitude) emphasize the need to provide more of a safety margin than would be present if liftoff were permitted so near the end of the runway. Therefore, the proposed § 25.113 would not permit the combination of clearway credit and a 15-foot screen height. The FAA proposed to modify § 25.113, however, to ensure that the presence of a clearway does not result in requiring longer runway lengths than if there were no clearway.

In addition to the reduced screen height for wet runways, the minimum vertical distance required between the takeoff flight path defined in § 25.115 and obstacles (e.g., trees, hills, buildings, etc.) would be reduced by a corresponding amount. To accomplish this, the FAA proposed to revise § 25.115 to state that the takeoff flight path shall be considered to begin at a height of 35 feet at the end of the takeoff distance.

This revised definition of the takeoff flight path would apply equally to dry and wet runways, even though the height of the airplane at the end of the takeoff distance (i.e., the screen height) for wet runways is proposed to be only 15 feet. The effect of this proposal would be to make it possible to use the flight path information currently contained in the AFM even if the runway is wet. Because the screen height would be reduced from 35 feet to 15 feet for a wet runway, the height of an airplane at any point in the flight path will therefore be approximately 20 feet lower from a wet runway than from a dry runway. Under this proposal, the airplane's actual height over obstacles would be reduced by approximately 20 feet when taking off from a wet runway.

Under the current regulations, the airplane's flight path must be higher than any obstacles by a combination of an increment of height and an increment of gradient (i.e., the slope of the flight path). Although this proposal would reduce the height increment by approximately 20 feet, the gradient increment would be unchanged. As the distance from the end of the takeoff distance increases, the gradient increment provides an increasingly greater portion of the total height difference between the airplane and the obstacle. Therefore, the effect of reducing the height increment over obstacles by 20 feet diminishes as the distance from the end of the takeoff distance increases.

*Proposal 3*

The FAA proposed to amend § 25.101(i) to require that accelerate-stop and landing distances must be determined with all the airplane brakes at the fully worn limit of their allowable wear range. Section 25.735 would be revised to require that the maximum brake energy capacity rating must be determined with each brake at the fully worn limit of the allowable wear range. In addition § 25.735 would be amended to add a requirement for a flight test demonstration of the maximum kinetic energy rejected takeoff with not more than 10 percent of the allowable brake wear range remaining.

*Miscellaneous*

Additionally, the FAA proposed to add one new definition and one new abbreviation to part 1, Definitions and Abbreviations.

As a result of their special investigation of rejected takeoff accidents, the National Transportation Safety Board (NTSB) recommended that the FAA clearly define the term ''takeoff decision speed'' ($V_1$) in part 1. This recommendation is contained in the NTSB's Special Investigative Report, ''Runway Overruns Following High Speed Rejected Takeoffs,'' published on February 27, 1990.

Concurring with the NTSB recommendation, the FAA proposed to add a definition of takeoff decision speed to § 1.1 in order to remove apparent confusion over the meaning of this term. The FAA's proposed definition was intended to make it clear that the decision to reject the takeoff, indicated by the pilot activating the first deceleration device, must be made no later than $V_1$ for the airplane to be stopped within the accelerate-stop distance.

The abbreviation $V_{EF}$ is used in several places within part 25. The FAA proposed to amend § 1.2 to add the definition of $V_{EF}$, which currently appears in § 25.107(a)(1). $V_{EF}$ is the speed at which the critical engine is assumed to fail during takeoff.

As stated previously, the FAA did not intend to apply these proposed amendments retroactively to either airplanes currently in use or future production airplanes of designs that have already been approved. However, manufacturers or operators of these airplanes may elect to comply with these proposed amendments by a change to the type design. The benefits of the revision to the time delay criteria of § 25.109 would then be available to relieve the economic burden imposed by Amendment 25–42. The proposed amendments to take into account the effects of wet runways and worn brakes must also be included in such a recertification. The FAA expects that, for airplanes whose certification basis includes Amendment 25–42, most applicants will elect to comply with this proposal because it will be economically beneficial for them to do so.

## Discussion of the Comments

The FAA received over 100 comments from 22 different commenters regarding the proposals presented in NPRM 93–8. The commenters include airplane pilots, manufacturers, operators, and the associations representing them, foreign airworthiness authorities, and another agency of the U.S. government. Because of the increasing emphasis placed on international harmonization of the airworthiness standards, and because the JAA issued substantively the same proposals to amend JAR–25, the FAA also received many comments from foreign and international sources.

In general, the pilots, and the airworthiness authorities of Canada and the Netherlands oppose the proposed amendments unless the FAA imposes the new standards retroactively. Conversely, the airplane manufacturers and operators generally support the proposals as long as they are not imposed retroactively. The JAA strongly supports the proposals, but also believes that these requirements should be imposed retroactively. The association representing European manufacturers supports applying the proposed standards to new derivatives of existing approved designs as well as to completely new airplane designs.

Another issue that generated strong contrasting views concerns the distance needed to align an airplane on the runway for takeoff. Typically, airplanes enter the takeoff runway from an intersecting taxiway. The airplane must then be turned so that it is pointed down the runway in the direction for takeoff. FAA regulations do not explicitly require airplane operators to take into account the runway distance used to align the airplane on the runway for takeoff. The commenters who support retroactivity also support amending the regulations to require operators to take this runway alignment distance into account. Those who oppose retroactivity also oppose proposals to require taking into account the runway alignment distance.

In NPRM 93–8, the FAA stated that ''with the safety benefits and economic impact information available at this time, the FAA cannot support a recommendation to make the standards proposed by this notice retroactive to either airplanes currently in use or future production airplanes of designs that have already been type certificated.'' This conclusion was reached after a review of the estimated costs and the potential benefits that would result from applying the proposed standards retroactively and mandating that operators take into account the runway alignment distance.

It should be noted, however, that one part of the proposed standards has effectively already been imposed retroactively. The FAA has issued airworthiness directives (AD's) concerning brake wear limits for every FAA-certificated transport category airplane with a maximum takeoff weight of over 75,000 pounds. These AD's ensure that the brakes on these airplanes, even when fully worn, can absorb the energy from a maximum energy rejected takeoff.

In addition to the economic impact of retroactively applying the proposed standards, the FAA was influenced by the increasing emphasis on international harmonization of the airworthiness standards. Retroactivity of the proposed standards and the requirement to take runway alignment distance into account, had the FAA decided to proceed with these provisions, would have been accomplished through revisions to the operating rules of the FAR. At the time NPRM 93–8 was being developed, the JAA lacked operating rules with which to impose these requirements. Although the introduction and justification sections of JAA NPA 25B, D, G–244 discussed an intent to apply the standards retroactively, and to require that runway alignment distance be taken into account, the JAA lacked a regulatory mechanism for doing so. Therefore, the proposed standards would not have been harmonized had the FAA proposed such amendments to the part 91, 121, and 135 operating rules.

Shortly thereafter, the JAA published NPA OPS–2, containing proposed JAR operating rules for commercial air transportation (JAR–OPS 1). In this NPA, the JAA proposed to retroactively require operators to take into account the performance effects of wet runways and runways contaminated by slush, snow, ice or standing water, and to require operators to apply adjustments for runway alignment distance. NPA OPS–2 did not address retroactive application of the proposed requirements related to worn brakes. The JAR–OPS 1 final rule, which retained the proposals noted above, was issued by the JAA on May 22, 1995. It becomes effective on April 1, 1998, for operators of airplanes with a maximum takeoff weight of over 10,000 pounds or a maximum approved seating capacity of 20 or more passengers.

Due to the controversial nature of the issues of retroactivity and runway alignment distance, the FAA has decided to: (1) Proceed with the proposed rules without requiring retroactive application of these standards or adding a new requirement concerning runway alignment distance, and (2) recommend that the issues of retroactive application of these standards and runway alignment distance be added to the FAA/JAA harmonization work program. Except in the treatment of these two issues, the final rule adopted by this amendment is completely harmonized with the applicable JAA standards. These two issues reflect differences between the FAA and JAA operating rules; the applicable airworthiness standards of part 25 and JAR–25 are completely harmonized by this amendment and a corresponding amendment to JAR–25.

The harmonization work program is the formal method developed by the FAA and the JAA to harmonize relations and policies. Tasks on the harmonization work program are assigned to FAR/JAR harmonization working groups in accordance with the respective rulemaking procedures of the FAA and the JAA. For the FAA, these tasks are assigned to the Aviation Rulemaking Advisory Committee (ARAC).

The ARAC was established to provide advice and recommendations to the FAA on all rulemaking activity. There are over 60 member organizations on the committee, representing a wide range of interest within the aviation community. Meetings of the committee are open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act. For issues on the harmonization work program, the ARAC assigns members, who work on behalf of the FAA, to the FAR/JAR harmonization working group. Although working group meetings are generally not open to the public, working group task assignments are published in the **Federal Register**, and all interested parties are invited to participate as working group members. Working groups report directly to the ARAC, and the ARAC must concur with a working group proposal before that proposal can be presented to the FAA as an advisory committee recommendation. After an ARAC recommendation is received and found acceptable by the FAA, the agency proceeds with the normal public rulemaking procedures.

Most of the commenters who oppose the proposed rulemaking also claim that the proposals would degrade the level of safety provided by the current standards. Specifically, these commenters oppose the proposal to replace the two seconds of continued acceleration beyond $V_1$ with a distance margin equal to two seconds at $V_1$ speed (Proposal 1), because it would allow an increase in the maximum allowable takeoff weight when that weight is limited by the length of the runway. Although the FAA agrees with the commenters on the effect of this particular proposal on takeoff weight limits, and discussed this effect in NPRM 93–8, the FAA disagree that safety is degraded when this proposal is considered in combination with the other proposals presented in NPRM 93–8.

In addition to Proposal 1, the FAA proposed other amendments that would make the current standards more stringent. As explained in NPRM 93–8, the purpose of the FAA proposals was to present a more rational approach of explicitly providing for the specific elements affecting takeoff performance, rather than the broad brush approach represented by the two seconds of acceleration beyond $V_1$. The FAA considers the proposed standards for worn brakes and wet runways, which the current standards do not explicitly address, to significantly improve takeoff safety. Combined with Proposal 1, the proposed amendments provide an equivalent or higher level of safety than the current standards.

Depending on whether the runway is wet or dry and on the particular airplane's stopping capability with worn brakes, the maximum allowable takeoff weight for a given runway length could end up being either increased or decreased under the proposed standards. Although its effects are variable, the FAA estimates that Proposal 1 would reduce, on average, the runway length needed for takeoff by 150 feet. For airplanes equipped with typical steel brakes, the proposed worn brake requirements would add an average of 150 feet to the runway length needed for takeoff. The FAA estimates that the proposed wet runway requirements would result in an average increase of 220 feet in the runway length required for takeoff when the runway is wet. It should be emphasized that these estimates are average effects that can vary considerably depending on the airplane type and the specific takeoff conditions. For example, airplanes equipped with carbon brakes or certain heavy-duty steel brakes, usually will be uaffected by the worn brake requirements because these brakes provide the same stopping capability in the worn condition as the new condition. (The proposed worn brake requirement represent an important safety improvement, however, regardless of whether this improvement comes from taking into account a loss in brake capability, or because the requirements act as an incentive to provide brakes that do not suffer this loss in capability.)

Along with this rulemaking effort, the FAA also participated in a joint FAA/industry team to produce the Takeoff Safety Training Aid. This training aid, first made available in August 1992, represents the findings of the team relative to training and procedural actions that could be taken to increase takeoff safety. The goal of the training aid is to minimize the probability of rejected takeoff accidents and incidents by: (1) Improving the ability of pilots to take advantage of opportunities to maximize takeoff performance margins; (2) improving the ability of pilots to make appropriate go/no-go decisions; and (3) improving the ability of crews to effectively accomplish the rejected takeoff procedures. Simulation trials and in-depth analyses of takeoff accidents and incidents were used to develop the training aid material. The FAA urges operators to use the Takeoff

Safety Training Aid in their qualification and recurrent aircrew training programs. The FAA is convinced that adoption of this material will further improve safety during the critical takeoff phase of flight.

The FAA received a large number of comments on the proposed definition of takeoff decision speed ($V_1$), including its relationship to the broader subject of the process by which the pilot recognizes a failure, decides to reject the takeoff, and acts on that decision. One commenter submitted several documents as additional supporting material, including a detailed study of pilot reaction times during rejected takeoff accidents. This commenter, accompanied by several others, believes that the proposed standards inadequately provide for the time it takes the average pilot to complete the recognition, decision, and reaction process. Other commenters support the FAA proposal, and some of these commenters also offered suggestions to further clarify the purpose of the $V_1$ speed.

The diversity displayed in the comments illustrates a great deal of misunderstanding and disagreement regarding the definition and use of the $V_1$ speed. In general, inconsistent terminology used over the years in reference to $V_1$ has probably contributed to this confusion. As noted by the commenters, $V_1$ has been referred to at various times as the critical engine failure speed, the engine failure recognition speed, and the takeoff decision speed.

Special Civil Air Regulation No. SR–422, effective August 27, 1957, originally referred to $V_1$ as ''the critical engine failure speed.'' These same standards, which were later recodified into part 25, defined the accelerate-stop distance as the distance to accelerate to $V_1$, and then to stop from that speed. Although an allowance was required for any time delays that may reasonably be expected in service, SR–422 did not explicitly state where or how the time delays should be introduced relative to $V_1$. For certification purposes, the FAA considered $V_1$ to be the speed at which the pilot took the first action to stop the airplane. Time delays for recognition and reaction to that failure were applied prior to $V_1$, and delays in accomplishing each subsequent action for stopping the airplane were applied after $V_1$. Allowing for the time delays, the actual engine failure was therefore assumed to occur prior to $V_1$.

With Amendment 25–42, effective March 1, 1978, the FAA amended the airworthiness standards to clarify and standardize the method of applying these time delays. $V_1$ was referred to as the ''takeoff decision speed,'' which turned out to be ambiguous in that it could be interpreted to mean either the beginning or the end of the pilot's decision process. The preamble to Amendment 25–42, however, states that ''$V_1$ is determined by adding to $V_{EF}$ [the speed at which the critical engine is assumed to fail] the speed gained with the critical engine inoperative during the time interval between the instant at which the critical engine is failed and the instant at which the test pilot recognizes and reacts to the engine failure, as indicated by the pilot's application of the first retarding means during accelerate-stop tests.'' This same definition was codified as § 25.107(a)(2). Not only is $V_1$ intended to occur at the end of the decision process, but it also includes the time it takes for the pilot to perform the first action to stop the airplane.

The FAA requires applicants to demonstrate, by flight test, the time intervals between $V_{EF}$ and $V_1$, and between each subsequent action taken by the pilot to stop the airplane. FAA pilots and engineers witness and participate in these tests, which must include at least six rejected takeoffs. Because the test pilots know that they are going to reject the takeoff, human factors literature refers to this process as a simple task. In actual operations, the rejected takeoff maneuver is unexpected, and is referred to as a complex task. In consideration of this complex task, the time intervals measured during certification flight tests are increased when the accelerate-stop distances published in the AFM are calculated. These additional time increments are not intended to allow extra time for making a decision to stop after passing through $V_1$. Their purpose is to allow sufficient time (and distance) for a pilot, in actual operations, to accomplish the procedures for stopping the airplane.

The first adjustment is made to the time interval between $V_{EF}$ and $V_1$. During the certification flight tests, the pilot expects to reject the takeoff and reacts very quickly. To take this into account, the time interval used to calculate the AFM accelerate-stop distances must be the longer of either the demonstrated time or one second. This standard has been applied to the certification of every turbine-powered transport category airplane since the late 1960's, and the FAA has not proposed to change it.

The second adjustment concerns the time increment applied after $V_1$. The method of determining this adjustment has varied, but the objective has always been the same—to provide enough time and distance for a pilot to accomplish the procedures for stopping the airplane. Prior to Amendment 25–42, a one-second increment was added to the time interval between each pilot action occurring after $V_1$. For most transport category airplanes, the rejected takeoff involves three separate pilot actions. The pilot applies the brakes, reduces the thrust or power, and raises the spoilers. The applicant defines the order in which the actions occur, but must demonstrate that the resulting procedures do not require exceptional skill to perform. Since the test pilot's first action determines $V_1$, there are typically two pilot actions occurring after $V_1$. Therefore, two seconds of additional time (and the resulting distance) were added to the time intervals determined by the certification flight tests.

Amendment 25–42 changed the method of applying these time increments. The provisions added by Amendment 25–42 require the AFM accelerate-stop distance to be calculated by inserting a two-second time increment after $V_1$, but before the pilot takes the first action to stop the airplane. During this two-second time increment, the airplane continues to accelerate. No further time increments are added to the time intervals between the actions taken by the pilot to stop the airplane.

It is important to note that Amendment 25–42 did not change the certification flight test procedures. The two-second time increment is applied analytically during the calculation of the AFM accelerate-stop distances, not by directing the pilot to delay action for two seconds after $V_1$ during the rejected takeoff flight tests.

The proposal presented in NPRM 93–8 would change the method of applying this two second time increment to a method similar to that existing prior to Amendment 25–42. However, the proposed method uses a distance increment rather than a time increment, to ensure that no credit is taken during this time period for system transient effects (e.g., engine spindown, brake pressure ramp-up, etc.). The distance increment is equal to the distance traversed in two seconds at the $V_1$ speed. Unlike the pre-Amendment 25–42 method, this distance increment cannot be reduced when fewer than three pilot actions are used in the rejected takeoff procedures (e.g., for airplanes using automated systems that take the place of one or more of the usual pilot actions). The FAA considers the distance traveled in two seconds at $V_1$ speed to be the minimum acceptable distance allowance needed to provide for the element of surprise and other operational factors missing from the certification flight test demonstrations.

As long as there are no more than three pilot actions needed to accomplish a rejected takeoff, the accelerate-stop distance is determined using the demonstrated time intervals between pilot actions with no additional time or distance increments applied. For each additional pilot action beyond the first three actions, however, a one-second time (and distance) increment must be added to the demonstrated time interval for that action.

The FAA disagrees with those commenters who believe that the proposed standards inadequately provide for the time it takes the average pilot to complete the recognition, decision, and reaction process. Not only does the FAA require applicants to determine by flight test the length of time needed for the pilot to complete this process, but this demonstrated time interval is also increased to take into account the element of surprise and other operational factors missing from the certification flight test demonstrations.

Operationally, $V_1$ represents the minimum speed from which the takeoff can be safely continued within the takeoff distance shown in the AFM, and the maximum speed from which the airplane can be stopped within the accelerate-stop distance shown in the AFM. Typically, the pilot not flying the airplane will call out $V_1$ as the airplane accelerates through this speed. If the pilot flying the airplane has not taken action to stop the airplane before this callout is made, the takeoff should be continued unless the airplane is unsafe to fly.

One commenter states that airplane manufacturers produce performance data for use by the U.S. military that provides the engine failure speed, rather than the speed at which the pilot must respond to the failure. This commenter believes that the military airworthiness rejected takeoff standards, which provide the crew with the engine failure speed, are safer than the civil airworthiness standards, which provide the crew with the $V_1$ speed. The commenter further notes that many commercial pilots with a military background operate under the belief that the civil airworthiness standards provide equivalent safety to the military standards. In the commenter's opinion, the civil standards provide a lower level of safety, and these pilots have been given a false sense of security.

The FAA is aware of many differences between the civil and military takeoff requirements. These differences are indicative of the different operating needs and environments between civil and military flight operations. For example, the military standards allow liftoff to occur at the very end of the runway and obstacles to be cleared with no safety margin in the event of the failure of the critical engine at the designated "go" speed. In contrast, part 25 requires the airplane to be at a height of 35 feet at the end of the takeoff distance (on a dry runway), and obstacles must be cleared by 35 feet plus an additional safety margin related to the flight path gradient. In summary, the civil and military airworthiness standards provide for safe operations within their respective operating environments. It would be inappropriate, however, to apply unique procedures and techniques from one operating environment to the other.

One commenter noted that the proposed definition for takeoff decision speed tends to perpetuate the confusion over the meaning and use of the $V_1$ speed. The commenter points out that $V_1$ is really a "pilot action speed" that occurs immediately after the pilot makes the decision to reject the takeoff. Another commenter suggests that the proposed definition is technically inaccurate because reducing thrust during a rejected takeoff would not normally be construed as activating a deceleration device. Hence, the commenter suggested alternative wording for the words "the pilot activates the first deceleration device."

The FAA agrees with these commenters and has revised the proposal accordingly. The term "takeoff decision speed" has been deleted both from the proposed definition and from § 25.107(a)(2). The proposal to define takeoff decision speed in § 1.1 is also withdrawn. The adopted definition represents a change to the definition of $V_1$ in § 1.2, rather than an addition to § 1.1. This revised definition clarifies that $V_1$ represents the minimum speed from which the takeoff can be safely continued within the takeoff distance shown in the AFM and the maximum speed from which the airplane can be stopped within the accelerate-stop distance shown in the AFM. In addition, the preamble discussion of the proposals has been edited for additional clarity to present a consistent description of the $V_1$ concept.

The proposed addition of the definition for $V_{EF}$ to § 1.2 is adopted as proposed. One commenter misunderstood this proposal as representing the first time the FAA has sought to define $V_{EF}$. For clarification, the term $V_{EF}$ and its definition were originally added to § 25.107(a)(1) by Amendment 25–42. The amendment adopted in this rule adds the existing definition for $V_{EF}$ to the list of abbreviations and symbols in § 1.2.

In addition to the definitions proposed in NPRM 93–8, one commenter suggests revising the definition of rated takeoff thrust to allow its use for up to ten minutes of operation. The current definition in § 1.1 limits the use of takeoff thrust to five minutes or less. The FAA is currently considering the change proposed by this commenter as part of a harmonization effort with the European JAA. In the interim, the FAA has developed a procedure to review and approve specific requests for the use of takeoff thrust for up to ten minutes duration on transport category airplanes in the event of an engine failure or shutdown.

One commenter recommended adding "wet and dry runway conditions" to the variables listed in § 25.101(e) for which the airplane configuration may vary. The rationale the commenter provides for this recommendation is to encourage optimization of the airplane configuration. The FAA does not believe that the suggested change will accomplish the commenter's goal. Section 25.101(e) does not require applicants to establish an optimum configuration to meet the applicable requirements. Instead, § 25.101(e) allows applicants to establish different configurations (e.g., flap settings) to obtain better performance at different weight, altitude, and temperature conditions.

The same commenter recommends revising § 25.105(a)(2) to require the takeoff data to be determined in the optimum configuration for the takeoff conditions specified in § 25.105(c). The commenter believes that this change would require operators to use the optimum flap setting for takeoff, rather than allow the use of any flap setting that meets the applicable regulations. The FAA does not concur with this recommendations for the following reasons. First, the commenter's recommendation should be directed at the airplane operating requirements, rather than the part 25 airworthiness standards. The effect of the recommended revision to part 25 would be to prohibit takeoff data from being provided for configurations that were not deemed to be the optimum configuration. Second, the commenter does not define how to determine the optimum configuration. The commenter appears to support using the configuration that would provide the shortest takeoff and accelerate-stop distances. However, this configuration also typically results in the poorest climb capability after takeoff, and may not be the optimum configuration from the standpoint of obstacle clearance, noise, standardization of crew procedures, or fuel use.

The FAA received several comments regarding the proposed change to § 25.101(i). One commenter recommends deletion of the proposed requirement to determine the landing distances with worn brakes. This commenter claims that the effects of worn brakes on landing is insignificant, and notes that the FAA does not expect this requirement to reduce the amount of payload that can be carried. The commenter also notes that there has never been a landing incident or accident in which a deficiency in brake energy due to wear was a factor, nor is there any reasonable likelihood that there would ever be one. The commenter goes on to say that the proposed requirement would result in additional certification test and flight manual development costs with no resultant safety benefit to the public.

Although the FAA agrees that the proposed requirement is not likely to reduce the amount of payload that can be carried for most landings, the FAA disagrees that the effects of worn brakes on landing will always be insignificant. The effect of brake wear at the braking energy levels associated with a landing stop depends on the particular brake design. To provide for those cases in which the landing distance is critical, the AFM landing distance data must be based on fully worn brakes. The proposed requirement only specifies the wear condition of the brakes for determining the landing distances. No additional AFM information, and, therefore, no additional flight manual development costs would be required. The proposed requirement also would not necessarily result in additional certification testing. The only flight test that must be performed with worn brakes is the maximum energy rejected takeoff condition, in which the brakes must be worn to within 10 percent of the fully worn condition. All other data must only meet the condition that sufficient data be available from airplane flight tests or wheel-brake dynamometer tests to enable adjustment of all of the takeoff and landing flight test results to the fully worn level. For example, the testing performed to determine the effect of worn brakes on accelerate-stop distances may also be used to determine the effect of worn brakes on landing distances, if it can be shown to be applicable.

Another commenter suggests adding the stipulation that the determination of the accelerate-stop and landing distances must be based on the demonstrated results obtained by flight test in accordance with the proposed § 25.735(g). The FAA concurs with the intent of this suggestion. Instead of modifying the proposed § 25.101(i), however, the FAA is revising the proposed § 25.735(g) and relocating it as a new § 25.109(i). The adopted wording clarifies that the applicant must conduct a flight test demonstration of the maximum brake kinetic energy accelerate-stop distance with no more than 10 percent of the allowable wear range remaining on each of the airplane wheel brakes. This change to the original proposal is also discussed later relative to the comments received on the proposed § 25.735(g).

A commenter proposes a wording change to § 25.101(i) to anticipate possible future brake materials that might show an improving brake performance as the brake wears. This commenter suggests that the proposed requirement should reference the wear condition that dynamometer testing indicates as producing the least effective braking performance. The FAA agrees that the most critical wear condition should be used to determine the stopping distances and energy capacity of the brakes. In practice, however, the FAA believes this condition will always be the fully worn brake. The FAA does not believe that an extensive dynamometer survey of different wear states is warranted.

One commenter suggests that stopping distances be based on brakes that are worn to 90 percent of the allowable wear level instead of the proposed level of fully worn. This commenter states that, in actual operations, it would be virtually impossible for all the airplane's brake assemblies to simultaneously be at the fully worn limit of their allowable wear range. In addition, this commenter believes that such conservatism in determining the stopping distances to be unwarranted when combined with the worn brake requirements relating to brake energy absorption capability. As an alternative, this commenter, joined by a second commenter, proposes that § 25.101(i) optionally allow stopping performance to be based on the actual amount of brake wear existing at the time of each flight. The two commenters state that it is unnecessary and inappropriate for the regulations to assume the worst case capability when satisfactory means to determine the actual capability can be provided. They believe that the proposed regulation would inhibit the development of technical and procedural advances that would take into account the actual wear condition of the brakes.

The FAA does not concur with the recommendation to base the stopping distances on brakes worn to 90 percent of the allowable wear level. Although operators may typically overhaul brakes before they are fully worn, and the brakes on different wheels are usually at different levels of wear, airplanes may legally be operated with all of the brake assemblies in their fully worn condition. The FAA agrees that it would be inappropriate for the regulations to assume the worst case capability when satisfactory means exist to determine the true capability; however, the operational aspects must also be satisfactorily addressed.

Regarding the commenters' proposal to allow stopping distances to be based on the actual brake wear level, the FAA has significant concerns over the operational aspects. Although it may be possible to determine the accelerate-stop and landing distances as a function of brake wear, the FAA considers it unacceptable to use, on a flight-by-flight basis, the brake wear level as an additional takeoff performance variable. The added complexity caused by this additional variable would increase the chances of error in determining the allowable takeoff weight and the takeoff speeds. Also, the FAA questions whether an acceptable means can be developed to accurately and reliably determine the actual wear state of the brake under all operational and environmental conditions. Finally, extensive certification testing would be required to determine the stopping distances as a function of the brake wear level. A linear relationship between these variables cannot be assumed. Therefore, § 25.101(i) is adopted as proposed, except for a minor editorial revision for clarification purposes.

Since the certified accelerate-stop and landing distances will correspond to brakes that are at the fully worn limit of their allowable wear range, the allowable brake wear range must be specified as part of the approved type design for the airplane. This information should be provided on the type certificate data sheet. The allowable wear range should be defined in terms of a linear dimension in the axial direction, which is typically determined by measuring the extension of a pin used to indicate the amount of wear. At the fully worn limit of the allowable brake wear range, the brake must be removed from the airplane for overhaul.

Both favorable and adverse comments were received on the FAA's proposal to amend § 25.109 to replace two seconds of acceleration beyond $V_1$ speed with the distance traversed in two seconds at $V_1$ speed. The commenters who objected to the proposed amendments believe the proposal would reduce safety. One commenter who disagrees with the proposed amendment also states that the comparison between the one-engine-inoperative and all-engines-operating accelerate-stop distances, as required by the proposed § 25.109(a), would become almost meaningless. This commenter claims that ''test pilot response in the order of milliseconds preempts any significant difference in acceleration distance between engine out and all engine acceleration before $V_1$.'' Also, the proposed distance traversed during two seconds at $V_1$ speed is the same for both cases, as is the deceleration distance from $V_1$ until the airplane is stopped.

As discussed previously, the FAA considers the proposed additions of worn brake and wet runway requirements to significantly improve takeoff safety. These additional requirements, along with the proposal to replace the two seconds of acceleration with a distance equal to two seconds at $V_1$ speed, would provide more rational takeoff airworthiness standards and an equivalent or higher level of safety than the current standards. Regarding the comparison of one-engine-inoperative and all-engines-operating distances, the minimum time between the critical engine failure speed ($V_{EF}$) and $V_1$, as discussed earlier, is one second. During the period after $V_1$, unless reducing thrust is the first pilot action following the engine failure, there will be another time interval before thrust is reduced on the remaining operating engine(s). Since thrust reversers may not be used in determining the dry runway accelerate-stop distances, the operating engines (on a turbojet powered airplane) will continue to produce forward thrust. Therefore (for turbojet airplanes), the distance to stop from $V_1$ will usually be longer for all-engines-operating case than for the one-engine-inoperative case. Whether the sum of the accelerate and stop distances is greater for the all-engines-operating case as opposed to the one-engine-inoperative case depends on the time intervals between $V_{EF}$ and $V_1$, $V_1$ and the pilot action to reduce thrust, and on the engine transient response (spindown) characteristics. For wet runways, in which the effect of reverse thrust would be included, the stopping distance with one-engine-inoperative will usually be longer than that with all-engines-operating. In general, the FAA expects the dry runway accelerate-stop distances to be based on the all-engines-operating case, and the wet runway accelerate-stop distances to be based on the one-engine-inoperative case.

One commenter suggests that the FAA should provide a statement proclaiming that the standards proposed in NPRM 93–8 ''reflect the full intent of the accelerate-stop transition segment AFM distance construction'' and that ''additional time delays are not envisioned.'' This commenter states that FAA advisory material imposed an additional two-second time delay beyond that prescribed by Amendment 25–42, and the commenter desires a clarification that such a situation will not recur. The FAA intends to revise Advisory Circular (AC) 25–7, ''Flight Test Guide for Certification of Transport Category Airplanes,'' to be consistent with this adopted rule and the description of the time delays provided in this preamble discussion regarding the definition of $V_1$.

In reviewing the comments, the FAA discovered that the proposed wording for § 25.109(a) could be interpreted such that speeds greater than $V_1$ need not be considered in determining the accelerate-stop distances. However, the airplane will typically exceed $V_1$ speed during the stop, particularly with all-engines-operating, even when the pilot applies the brakes at $V_1$. The proposed amendments to § 25.109(a) have been modified to clarify that the accelerate-stop distances must include the highest speed reached during the rejected takeoff maneuver. As modified, these proposed amendments to § 25.109(a) are adopted.

The FAA received a large number of comments regarding the proposed method for determining takeoff performance on wet runways. One of the provisions of the proposed method would allow applicants to use a simplified approach to determine the braking capability on a wet runway without the need for specific wet runway flight testing. Based on the extensive wet runway testing conducted over the past 30 years by the National Aeronautics and Space Administration (NASA), the FAA, the aerospace industry, and other organizations around the world (a compilation of which appears in the docket in ESDU item number 71026), the FAA proposed using a braking coefficient of one-half the demonstrated dry braking coefficient. The FAA intended for this one-half factor to be applied even if the dry runway braking coefficient is limited by the maximum torque capability of the brake, rather than the maximum friction capability available from the runway surface.

Several commenters disagree with using a simple one-half factor to determine the wet runway braking coefficient. One commenter feels the factor is arbitrary and that using a simple factor is inappropriate. Another commenter claims that other easily applied methods exist and should be used to provide a wet runway braking coefficient. This commenter believes that the proposed method effectively makes the low speed accelerate-stop data more conservative than the high speed data, which would be the opposite of what the commenter feels should be done to increase safety. These commenters did not propose any alternative methods for determining the wet runway braking coefficient.

Several commenters object to the specific aspect of applying the one-half factor when the dry runway braking coefficient corresponds to the maximum torque capability of the brake. In spite of the explanation provided in the preamble discussion in NPRM 93–8, these commenters oppose this provision on the basis that the maximum torque capability of the brake is independent of the runway surface condition. One commenter conducted laboratory tests of a simulated wet runway to show that the stopping ability of an airplane on a wet runway is not a function of the size or torque limit of the brakes. Another commenter claims that this provision appears to prohibit the effective and safe use of braking capacity up to the limit of the wet runway braking coefficient. This commenter points out that an airplane with brakes that have a low maximum torque capability would be unfairly penalized relative to an airplane equipped with brakes of a higher maximum torque capability. Another commenter questions whether the proposed requirement is a conservative approach resulting from a lack of appropriate test data.

The FAA agrees that the torque capability of the brake is usually not a limiting factor on a smooth wet runway. The FAA proposed applying a factor to the torque limited braking coefficient to represent the varying relationship between the wet and dry runway braking coefficients as a function of ground speed. At higher ground speeds, the wet runway braking coefficient is typically less than one-half the dry runway braking coefficient. At these higher speeds, the dry runway braking coefficient is usually limited by the brake's maximum torque capability. For the typical airplane/brake combination, factoring the torque limited braking coefficient obtained on a dry runway by one-half provides a reasonable approximation to the significantly reduced braking coefficients observed at high speeds on wet runways. Because the total stopping distance for a high speed stop is affected more by the stopping capability at high speeds than at low speeds, applying the one-half factor only to the non-torque limited braking coefficient would be inadequate for determining the total distance needed to stop on a wet runway.

The FAA does not concur with the comment that this proposal would prohibit the safe and effective use of braking capability on a wet runway. This proposal only addressed the method for determining the wet runway accelerate-stop distances presented in the AFM. It would not affect the manner in which the pilot uses the brakes. The FAA recognizes, however, that not all airplanes share the same relationship between $V_1$ speeds and maximum brake torque capability, and that some airplane types could be affected more than others by this provision. In recognition of this potential disparity, the proposed § 25.109(b)(2) would have allowed applicants the option of demonstrating a higher wet runway braking coefficient.

One commenter suggested that an advisory circular may be necessary to provide guidance regarding an acceptable method for demonstrating a wet runway braking coefficient higher than one-half the dry runway value. Another commenter noted that one flight test, for example, performed on a damp grooved runway with excellent friction capability would be an insufficient basis for developing the AFM information applicable to all wet runways. Another commenter recommended a change to the FAA proposal to allow the use of methods other than flight testing to demonstrate a higher wet runway braking coefficient. This commenter believes that in the near future it may become feasible to use data obtained from either an analysis, a simulation of the airplane's braking system, or other sources.

One of the commenters who opposed portions of the FAA proposal submitted an alternative proposal based on the same ESDU 71026 data source used to develop the FAA proposal. The commenter proposes an alternative method to replace the option for demonstrating a braking coefficient higher than one-half the dry runway braking coefficient. The following summary represents a brief synopsis of the commenter's detailed proposal:

a. Derive a standard wet runway braking coefficient versus speed curve from the ESDU 71026 data. This curve, representing the maximum braking coefficient available from the runway surface, would be used for all transport category airplanes as the basis for developing airplane type specific curves.

b. Apply adjustments to this curve to reflect the capability of an individual airplane type's anti-skid system on a wet runway. The anti-skid system capability would be determined either directly from wet runway testing, or a conservative capability (i.e., somewhat worse than would be expected if testing were performed) would be assumed, based on the capability of existing comparable anti-skid systems.

c. Allow higher braking coefficients for suitably maintained grooved or porous friction course runways.

d. Use the brake torque limitations (i.e., the amount of torque the brake is capable of producing) that are determined on a dry runway for both wet and dry runways.

The FAA considers the commenter's proposal to have considerable merit, not just as a replacement for the demonstration option as the commenter proposes, but also as a replacement for the one-half the dry braking coefficient methodology. The commenter's proposal addresses the shortcomings inherent in the NPRM 93–8 methodology of determining the wet runway braking coefficient by applying a single adjustment factor to the dry runway braking coefficient. Under the commenter's proposal, the wet runway braking capability would more accurately reflect the significant variation in braking capability with speed that occurs on a wet runway. Properly reflecting this variation with speed would remove the need to apply a factor to the dry runway brake torque capability.

As adopted, § 25.109(b) has been revised and new §§ 25.109 (c) and (d) have been added to prescribe wet runway accelerate-stop distance standards in a manner consistent with the commenter's proposal. This final rule is based on the same information as the original FAA proposal; however, the methodology for determining wet runway accelerate-stop distances has been changed to more rationally reflect the various factors affecting wet runway braking. The methodology adopted by this amendment provides a more accurate portrayal of wet runway stopping performance than had been proposed in NPRM 93–8.

Significant issues related to the commenter's proposal, which had to be addressed prior to preparing this final rule, included:

a. Defining the standard wet runway braking coefficient versus speed curve, considering the various parameters that affect wet runway stopping performance.

b. Defining a method for determining the capability of an airplane's anti-skid system on a wet runway.

c. Establishing conservative levels of anti-skid capability that could be used in lieu of determining this capability directly from test data.

d. Determining whether a higher braking capability is appropriate for use with grooved or porous friction course runways. (This issue is discussed later along with other comments received on this topic).

ESDU 71026 contains curves of wet runway braking coefficients versus speed for smooth and treaded tires at varying inflation pressures. These data are presented for runways of various surface roughness, including grooved and porous friction course runways. Included in the data presentation are bands about each of the curves, which represent variations in: water depths from damp to flooded, runway surface texture within the defined texture levels, tire characteristics, and experimental methods. From these data, it is readily apparent that wet runway stopping performance is significantly affected by many more variables than dry runway stopping performance. In order to determine the wet runway stopping distance, a value must be specified (or assumed) for each of these variables. Since it would be impractical to try to measure or evaluate each of these variables for every takeoff, the takeoff data must take into account the conditions likely to occur in operational service.

It was the FAA's intent with the proposals of NPRM 93–8 to define a wet runway performance level that would ensure safe operation for the vast majority of wet runway rejected takeoffs likely to occur. This same principle was used in specifying values for each of the variables considered by the adopted wet runway methodology. The resulting accelerate-stop distances, coupled with information provided to operators and pilots concerning the use of these data, should greatly reduce the risk of runway overruns during wet runway operations.

In defining the standard curves of wet runway braking coefficient versus speed that are prescribed by the equations in § 25.109(c)(1), the effects of the following variables were considered: Tire pressure, tire tread depth, runway surface texture, and the depth of the water on the runway.

*Tire Pressure*

The effect of tire pressure is taken into account by providing separate curves (i.e., equations) in § 25.109(c)(1) for several tire pressures. As stated in the adopted rule, linear interpolation may be used for tire pressures other than those listed. To provide additional safety, § 25.109(c)(1) requires applicants to base the accelerate-stop distances on the maximum tire pressure approved for operation. Operating at a tire pressure that is lower than the maximum tire pressure approved for that airplane will tend to improve the airplane's stopping capability on a wet runway. Typically, manufacturer recommended tire pressures are a function of airplane weight; for operations at less than the maximum approved weight, the recommended tire pressure would be less than the maximum approved tire pressure.

*Tire Tread Depth*

The degree to which water can be channeled out from under the tires significantly affects wet runway stopping capability. Airplane tires have ribbed grooves around the circumference of the tire for this purpose. The texture of the runway surface plays an equally important role. ESDU 71026 provides braking data for both ribbed and smooth tires on runways of different surface textures. A method is also provided in ESDU 71026 for assessing the effects of tire wear. As ribbed tires wear, the depth of the ribbed grooves decreases, impairing their ability to channel water out from under the tire.

Surveys conducted by U.S. airplane and tire manufacturers, and information from major tire retreaders, indicate that the typical groove depth remaining at the time of tire removal can vary from about 1.5 to 5 mm. Airplane manufacturers' maintenance manuals usually recommend removal when the tread depth is less than 1⁄32 inch (1.2 mm), although operation with zero tread depth is not prohibited. Loss of tread depth is not the sole criterion for tire removal, however. Tires with significant tread depth remaining may be removed for other reasons. Also, it is unlikely that all the tires on a particular airplane would be worn to the same extent.

The standard curves (i.e., equations) of braking coefficient versus speed prescribed in § 25.109(c)(1) are based on a tire tread depth of 2 mm. Since the tread depth of new tires is usually 10–12 mm, 2 mm represents no more than 20 percent of the original tread depth. FAA Advisory Circular 121.195(d)–1A, which provides guidance for determining operational landing distances on wet runways, specifies that the tires used in flight tests to determine wet runway landing distances should be worn to a point where no more than 20 percent of the original tread depth remains. Therefore, the adopted rule, which reflects industry practice, is also consistent with existing FAA guidance in this area.

*Runway Surface Texture*

ESDU 71026 groups runways into five categories. These categories are labeled ''A'' through ''E,'' with ''A'' being the smoothest and ''C'' the most heavily textured ungrooved runways. Categories ''D'' and ''E'' represent grooved and other open textured surfaces. Category A represents a very smooth texture (an average texture depth of less than 0.004 inches), and is not very prevalent in runways used by transport category airplanes. The majority of ungrooved runways fall into the category C grouping. The curves represented in § 25.109(c)(1), as adopted, represent a texture midway between categories B and C.

*Depth of Water on the Runway*

Obviously, the greater the water depth, the greater the degradation in braking capability. The curves prescribed in § 25.109(c)(1) represent a well-soaked runway, but with no significant areas of standing water.

In summary, the curves prescribed in § 25.109(c)(1) represent the maximum tire-to-ground braking coefficient likely to be available from a wet runway during a rejected takeoff. They were derived by interpolating between the curves presented in ESDU 71026 for runway surface categories B and C, adjusted to represent tires with 2 mm tread depth remaining, and extrapolated to cover the range of $V_1$ speeds to be expected. The resulting curves were then smoothed and reduced to a mathematical form for inclusion in the rule. The capability for a particular airplane type to achieve this braking coefficient depends on: (1) The amount of torque its brakes are capable of producing, and (2) the performance of its anti-skid system. How the revised regulation addresses these two components is discussed in the ensuring paragraphs.

The torque capability of the brakes is evaluated during the flight testing that applicants conduct to determine the dry runway accelerate-stop distance. Since the torque capability is independent of the runway surface condition, the torque capability demonstrated by the dry runway flight tests also represents the maximum torque available during a wet runway stop. As adopted, § 25.109(b)(2)(i) limits the stopping force from the wheel brakes used to determine the wet runway accelerate-stop distance to the stopping force determined in meeting the requirements of § 25.101(i) (worn brakes) and § 25.109(a) (the dry runway accelerate-stop distance). This provision prohibits applicants from using a brake torque that exceeds the dry runway torque limits when determining the wet runway accelerate-stop distance.

An airplane's anti-skid system varies the braking action to prevent locked wheel skids and to maximize stopping performance to the extent possible. How close the anti-skid system comes to obtaining the maximum braking friction available between the tires and the runway is referred to as the anti-skid system efficiency.

As adopted, § 25.109(c)(2) requires applicants to adjust the maximum tire-to-ground wet runway braking coefficient determined in § 25.109(c)(1) for the efficiency of the anti-skid system. Applicants will have the option of either determining the anti-skid system efficiency directly from flight tests on a wet runway, or using one of the anti-skid efficiency values specified in § 25.109(c)(2). Regardless of which method is used, an appropriate level of flight testing must be performed to verify that the anti-skid system operates in a manner consistent with the efficiency value used, and that the system has been properly tuned for operation on wet runways.

For applicants using the anti-skid efficiency values specified in § 25.109(c)(2), a minimum of one complete wet runway stop, or equivalent segmented stops, should be conducted at an appropriate speed and energy to cover the critical operating mode of the anti-skid system. This testing can be performed as part of the anti-skid compatibility testing on a wet runway that is already required for brake and anti-skid system approval under § 25.735. Therefore, for applicants using the anti-skid efficiency values specified in § 25.109(c)(2), no additional flight tests need actually be performed. Existing flight test may need to be modified somewhat to ensure that appropriate data are obtained to verify that the anti-skid system operates in a manner consistent with the efficiency value used, and that the system has been properly tuned for operation on wet runways.

As revised, § 25.109(c)(2) identifies three different classes of anti-skid systems, and specifies a unique efficiency value associated with each one. This classification of anti-skid system types and the assigned efficiency values are based on information contained in Society of Automotive Engineers (SAE) Aerospace Information Report (AIR) 1739, title ''Information on

Anti-Skid Systems.'' The efficiency values prescribed in § 25.109(c)(2) represent the worst system performance expected for each type of system after being properly tuned for operation on wet runways. The SAE document is available in the public docket for this rulemaking.

The three classes of anti-skid systems represent evolving levels of technology and differing performance capabilities on dry and wet runways. On/off systems are the simplest of the three types of anti-skid systems. For these systems, full metered brake pressure (as commanded by the pilot) is applied until wheel locking is sensed. Brake pressure is then released to allow the wheel to spin back up. When the system senses that the wheel is accelerating back to synchronous speed (i.e., ground speed), full metered pressure is again applied. The cycle of full pressure application/complete pressure release is repeated throughout the stop (or until the wheel ceases to skid with pressure applied).

Quasi-modulating systems, the second type of anti-skid system, attempt to continuously regulate brake pressure as a function of wheel speed. Typically, brake pressure is released when the wheel deceleration rate exceeds a preselected value. Brake pressure is re-applied at a lower level after a length of time appropriate to the depth of the skid. Brake pressure is then gradually increased until another incipient skid condition is sensed. In general, the corrective actions taken by these systems to exit the skid condition are based on a pre-programmed sequence rather than the wheel speed time history.

Fully modulating systems, the third type of anti-skid system, are a further refinement of the quasi-modulating systems. The major difference between these two types of anti-skid systems is in the implementation of the skid control logic. During a skid, corrective action is based on the sensed wheel speed signal, rather than a pre-programmed response. Specifically, the amount of pressure reduction or reapplication is based on the rate at which the wheel is going into or recovering from a skid. Also, higher fidelity transducers and upgraded control systems are used, which respond more quickly.

For applicants who elect to determine the anti-skid efficiency directly from flight tests, sufficient flight testing, with adequate instrumentation, must be conducted to ensure confidence in the efficiency obtained. Although additional flight testing will be necessary, the FAA does not expect applicants to use this method for determining the anti-skid efficiency unless proportionate benefits (i.e., an increase in takeoff weight) are obtained. A minimum of three complete stops, or equivalent segmented stops, should be conducted on a wet runway at appropriate speeds and energies to cover the critical operating modes of the anti-skid system.

As adopted, § 25.109(b)(2)(ii) also requires applicants to adjust the wheel brakes stopping force to take into account the effect of the distribution of the normal load between braked and unbraked wheels at the most adverse center-of-gravity position approved for takeoff. The stopping force due to braking is equal to the braking coefficient multiplied by the normal load (i.e., the effective weight) on the braked wheels. The location of the airplane's center-of-gravity, which is a function of the airplane's configuration and how it is loaded (i.e., the position of passengers, baggage, cargo, etc.), affects how the load is distributed between braked and unbraked wheels. Typically, the nose wheels of transport category airplanes are unbraked, although some airplanes also have some of the main gear wheels unbraked). This effect must be taken into account for the most adverse center-of-gravity position approved for takeoff. The most adverse center-of-gravity position is that which results in the least load on the braked wheels.

For the following reasons, the FAA regards the wet runway methodology issued in this final rule to be a logical outgrowth of the proposal published in NPRM 93–8. First, the final rule methodology relies on the same technical basis as the original proposal. Second, it responds to a comment raised during the NPRM 93–8 public comment process. And third, it is consistent with the overall intent of this rulemaking, which is to more rationally address relevant operational factors rather than applying more restrictive standards to all operating conditions. This methodology also provides applicants with the ability to better control any increased costs resulting from the addition of wet runway accelerate-stop requirements to part 25, while ensuring safer wet runway operations. Depending on the desired balance between manufacturing costs (including design and flight testing) and operational capabilities, an applicant can make informed choices regarding design characteristics (e.g., type of anti-skid system, takeoff speeds) and the level of wet runway testing to perform (i.e., use of the anti-skid efficiency values provided in the rule versus determining the efficiency directly from flight tests).

The FAA recognizes that extensive guidance material will be necessary to assist applicants in complying with the wet runway accelerate-stop distance requirements incorporated in this amendment. Published elsewhere in this issue of the **Federal Register** is a notice of availability for a proposed revision to AC 25–7, ''Flight Test Guide for Certification of Transport Category Airplanes.'' A request for comments is included in that notice of availability. The proposed revision includes detailed guidance for:

a. Using reverse thrust in determining wet runway accelerate-stop distances;

b. classifying the types of anti-skid systems;

c. Verifying the type of anti-skid system installed on the airplane and that it is properly tuned for operation on wet and slippery runways;

d. Determining the anti-skid efficiency value; and

e. Developing an analytical model of wet runway braking performance in accordance with § 25.109(c).

One commenter points out that many operators already use a form of wet runway takeoff performance data, which is provided to them by the airplane manufacturers as unapproved guidance information. These data, used on a voluntary basis to provide additional safety on wet runways, are typically developed using criteria similar to those proposed in NPRM 93–8. Another commenter believes that the proposed wording for §§ 91.605(b)(3), 121.189(e), and 135.379(e) would result in retroactive changes to those airplanes for which the AFMs contain wet runway information carried over from previous foreign certifications. (Some foreign certification authorities, notably the United Kingdom Civil Aviation Authority, have required wet runway performance information to be included in the AFM.) This commenter notes that use of such data has not been required in the past in U.S. operations and does not necessarily reflect the standards proposed in NPRM 93–8. Although the commenter supports the proposal in general, it is suggested that the wording be changed to specify that the wet runway requirements apply only to airplanes certificated after the proposed amendment becomes effective.

The FAA acknowledges that airplane manufacturers have for many years produced guidance information, including takeoff performance data, for wet runway operations. In general, the FAA supports the voluntary use of these available data to provide additional safety on wet runways for existing transport category airplanes, as long as compliance with the applicable airworthiness and operating rules is maintained.

The FAA did not intend, by the proposed wording §§ 91.605(b)(3), 121.189(e), and 135.379(e), to effectively apply the proposed wet runway standards retroactively. Operators should be aware that the approved portion of the AFM (containing the operating limitations) for a U.S. operator should only reflect the FAR and should not contain extraneous information carried over from a foreign certification. Such information may, however, appear in an unapproved portion of the AFM as supplementary guidance information. Operators may use this information (as long as it does not conflict with the FAR), but are not required to abide by it.

The FAA does not agree with the comment to limit application of the proposed operating rules only to those airplanes certificated after this amendment becomes effective. Some manufacturers have elected to comply with the standards proposed in NPRM 93–8 prior to the adoption of this final rule. The AFMs for the affected airplane types contain takeoff and accelerate-stop distance limitations for takeoffs on wet runways, and operators must comply with these limitations, regardless of the date the airplane was certificated. Therefore, these amendments to §§ 91.605(b)(3), 121.189(e), and 135.379(e) are adopted essentially as proposed, but with a clarification that this provision applies to operating limitations, if they exist, associated with the minimum distances required for takeoff from wet runways. As discussed earlier, further consideration of retroactive application of the requirements adopted by this final rule will be added to the FAA/JAA harmonization work program.

Several commenters recommend that the proposed standards be revised to allow a higher wet runway braking coefficient to be used for grooved runways or runways treated with a porous friction course (PFC) overlay, without the need for additional flight testing. These commenters point out that runway friction measurement tests show that a wet runway with grooves or a PFC surface overlay has much better friction characteristics than a smooth surface. According to these commenters, providing credit for the improved stopping capability on these surfaces will result in significant public safety benefits by helping to expedite future runway improvements and by providing a strong incentive to properly maintain these surfaces. The commenters believe it is neither necessary nor in the public interest to avoid or defer this issue, considering the significant effort that has already been made by airport operators, both domestic and foreign, to improve runway surfaces.

To facilitate timely action on this issue, these commenters propose that the FAA initially adopt a value that the commenters consider to be very conservative (i.e., a much lower wet runway braking coefficient than would be expected). Most of these commenters propose using a wet runway braking coefficient for grooved and PFC runways equal to 70 percent of the dry runway braking coefficient, although one commenter proposed a factor of 80 percent. For comparison purposes, one commenter reports that tests conducted using a Boeing 737–300 airplane showed wet grooved runway braking capability that was equal to, or in some cases greater than, 95 percent of that obtained on a dry runway. The commenters note that a longer term rulemaking activity could be undertaken in the future to establish a higher factor, if warranted.

One of these commenters provided information relative to grooved and PFC runway credit in Japan. This commenter states that the Japanese Civil Aviation Bureau allows a wet runway braking coefficient of 70 to 80 percent of the dry runway value to be used for grooved or PFC runways. In Japan, Most of the runways at civil airports are grooved, and periodic friction surveys are conducted to assure that the surfaces are properly maintained. These surveys are done by using a combination of visual inspections and friction measuring devices.

The FAA agrees that grooved and PFC runways can offer substantial safety benefits in wet conditions. The FAA has taken an active role since the late 1960's in evaluating the benefits of these runway surface treatments and supports their use throughout the U.S. Tests conducted by the FAA, NASA, and others confirm that applying a factor of 70 percent to the dry runway braking coefficient, as proposed by the commenters, would conservatively represent the stopping performance on properly designed, constructed, and maintained grooved and PFC runways. A summary of these test data has been placed in the docket. The actual friction capability of grooved and PFC runways varies, however, depending on variables such as groove shape, depth, and spacing, method used to construct the grooves, type of pavement surface, volume and type of airplane traffic, frequency of pavement evaluations, and maintenance. The FAR currently do not contain mandatory standards regarding the design, construction, and maintenance of grooved or PFC runways, but AC 150/5320–12B, ''Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces,'' provides relevant guidelines and procedures.

The FAA concurs with the commenters' proposal and agrees that it presents an opportunity to provide an additional incentive for airport operators to install and maintain grooved and PFC runways. The FAA agrees that 70 percent of the dry runway braking coefficient conservatively represents the stopping performance on properly designed, constructed, and maintained grooved or PFC runways. Using a simple factor applied to the dry runway braking coefficient is appropriate for grooved and PFC runways because the braking coefficient's variation with speed is much lower on these types of runways.

As noted in the earlier discussion of the parameters affecting wet runway stopping performance, ESDU 71026 contains data corresponding to grooved and PFC surfaces. An evaluation of the ESDU data reveals that using a surface texture mid-way between surfaces D and E in combination with typical anti-skid efficiencies provides approximately the same airplane stopping performance as using 70 percent of the dry runway braking capability.

In response to the comments regarding grooved and PFC runways, a new § 25.109(d) is adopted to establish an optional wet runway braking coefficient for grooved or PFC runways. The braking coefficient for determining the accelerate-stop distance on grooved and PFC runways is defined in § 25.109(d) as either 70 percent of the value used to determine the dry runway accelerate-stop distances, or a value based on the ESDU data and derived in a manner consistent with that used for ungrooved runways. Section 25.105(c)(1) is revised to allow applicants, at their option, to provide data for grooved and PFC runways, in addition to the smooth surface runway data that is currently required. In addition, the existing § 25.109(d) is revised to remove the words ''smooth'' and ''hard-surfaced'' and redesignated as § 25.109(h).

Section 25.1533(a)(3) is amended to allow wet runway takeoff distances on grooved and PFC runways to be established as additional operating limitations, but approval to use these distances is limited to runways that have been designed, constructed, and maintained in a manner acceptable to the FAA Administrator. In conjunction, §§ 91.605(b)(3), 121.189(e), and 135.379(e) of the operating rules are amended to limit the use of the grooved and PFC wet runway accelerate-stop distances to runways that the operator has determined have been designed, constructed, and maintained in a manner acceptable to the FAA Administrator. The page(s) in the AFM containing the wet runway accelerate-stop distances for grooved and PFC runways should contain a note equivalent to the following: ''These accelerate-stop distances apply only to runways that are grooved or treated with a porous friction course (PFC) overlay that the operator has determined have been designed, constructed, and maintained in a manner acceptable to the FAA Administrator.''

Airplane operators who wish to use the grooved or PFC runway accelerate-stop distances must determine that the design, construction, and maintenance aspects are acceptable for each runway for which such credit is sought. In making these determinations, operators may rely on certifications from airport operators or independent evaluations of runways. In either case, it is expected that operators will be able to demonstrate that their determinations are well founded. Acceptable runways should be listed in Part C of the operator's approved operations specifications (for those operators required to have operations specifications).

FAA AC 150/5320–12B provides guidance regarding grooved and PFC runway construction and maintenance techniques that are considered acceptable to the Administrator. These criteria for obtaining operational approval to use the grooved and PFC wet runway accelerate-stop distances are consistent with the guidance provided in AC 121.195(d)–1A for approval to use operational landing distance for wet runways. After adoption of this final rule, the FAA also intends to include this information in an update to AC 91–6A, ''Water, Slush, and Snow on the Runway.''

Under the proposals for §§ 25.109 (c) and (d) in NPRM 93–8, wet runway accelerate-stop distances may include the additional stopping force provided by reverse thrust; however, including this stopping force would be prohibited when determining the dry runway accelerate-stop distances. Most of the commenters supported the proposal for wet runways, although several commenters noted that several important aspects were not addressed. These aspects include issues such as reliability of the trust reversers, piloting procedures, controllability in crosswinds, flight test methods, etc.

The FAA agrees that detailed guidance material is needed, relative to thrust reversers, to define an acceptable means to comply with the proposed requirements of § 25.109(c). As mentioned earlier, the FAA intends to propose specific guidance material soon as part of a revision to AC 25–7. In general, the FAA intends to propose that: (1) Acceptable procedures should be developed and demonstrated, including the time needed to accomplish these procedures; (2) the responses and interactions of airplane systems should be taken into account; (3) the recommended level of reverse thrust should be easily obtainable under in-service conditions (e.g., by providing a detent or other tactile method of thrust selection); (4) directional control should be demonstrated with maximum braking on a wet runway with a ten-knot crosswind from the most adverse direction; (5) the probability of failure should be no more than 1 per 1000 selections; (6) inoperative thrust reversers at dispatch should be taken into account; (7) satisfactory engine operating characteristics should be demonstrated; and (8) appropriate flight tests should be conducted to determine the effective stopping force provided by reverse thrust, and to validate the total stopping force provided by all of the decelerating means.

One commenter proposed an amendment to the existing § 25.109(c) to clarify that a finding of ''safe and reliable'' for any deceleration means other than wheel brakes must take into account the interactions and interdependencies of the various systems involved, and that consistent results must be expected under all conditions covered by the AFM. This comment is directed primarily at a landing situation in which slippery runways and higher than normal approach speeds could thwart or delay sensing logic for determining whether the airplane is on the ground. Consequently, the operation of any deceleration means that can only be activated on the ground (e.g., ground spoilers and thrust reversers) would also be delayed.

Under the existing §§ 25.109(c) and 25.1309, the FAA already reviews the system operation and inter-compatibility issues that would be addressed by the commenter's proposed changes to § 25.109(c). Therefore, the FAA considers these proposed changes to be unnecessary.

One commenter noted that the same reasons in the FAA's proposal for denying accelerate-stop distance credit for the use of reverse thrust on dry runways also apply to wet runways. Therefore, if dry runway accelerate-stop distances need the safety margin provided by not including the effects of reverse thrust, then so do the wet runway accelerate-stop distances. The FAA does not concur. As stated in the discussion of the proposal, the FAA believes that the additional safety provided by not accounting for reverse thrust in calculating the accelerate-stop distance on a dry runway is necessary to offset other variables that can significantly affect the dry runway accelerate-stop performance. Examples of variables that can significantly affect the dry runway accelerate-stop performance include: runway surfaces that provide poorer friction characteristics than the runway used during flight tests to determine stopping performance, dragging brakes, brakes whose stopping capability is reduced because of heat retained from previous braking efforts, etc. Although these variables may also be present for wet runways, their effects are adequately covered by the adopted method of determining the stopping capability on a wet runway. This method provides a margin of safety by using conservative assumptions regarding runway surface texture, tire tread depth, tire inflation pressure, anti-skid efficiency, etc.

Despite the reasons the FAA presented in NPRM 93–8 for denying accelerate-stop distance credit for the use of reverse thrust on dry runways, several commenters propose that reverse thrust credit be permitted, at least to the extent that it offsets any performance degradation due to worn brakes. These commenters claim that the majority of the factors degrading accelerate-stop performance have been taken into account; therefore, it would be appropriate to include the positive effect of reverse thrust. These commenters also note that reverse thrust capability is provided on nearly all commercial jet transport airplanes, current thrust reversers are reliable, flightcrews are trained to use reverse thrust, and its use is a normal part of operational stopping procedures. Also, the probability of a thrust reverser failing to operate, combined with the probability of all brakes being at the fully worn limit, is very low, and there would be an even lower probability of these factors occurring in combination with a takeoff rejected from a critically high speed. Under the proposal offered by most of these commenters, the dry runway accelerate-stop distance would be required to be the greater of either: (1) The distance determined using new brakes without reverse thrust, or (2) the distance determined using worn brakes with reverse thrust. Since item (1) corresponds to the current standards, this proposal would not reduce the accelerate-stop distance to less than what is currently required. The effect of the commenters' proposal would be to offset any loss in stopping capability associated with worn brakes.

As stated previously, the FAA considers that the additional safety provided by not including the effect of reverse thrust for the accelerate-stop distance on a dry runway is necessary to offset other variables that can significantly affect the dry runway accelerate-stop performance. The effect of these other variables on the dry runway accelerate-stop distance are unchanged by this rulemaking. Although the part 25 airworthiness standards are being made more stringent by adding requirements related to worn brakes and wet runways, the overall effect of these additions are partially offset by the change in the method used to account for the time it takes the pilot to perform the procedures for rejecting the takeoff. Further alleviating provisions are inappropriate because they would unacceptably reduce the level of safety. Therefore, §§ 25.109(c) and (d) are amended as proposed in NPRM 93–8, except that they have been re-designated as paragraphs (e) and (f), respectively.

As part of the proposed wet runway standards, §§ 25.13 (a) and (b) would allow the airplane's height over the end of the runway (known as the screen height) to be reduced from 35 feet on dry runways to 15 feet on wet runways. Some commenters object to reducing the screen height for wet runways, stating that safety margins would be reduced for takeoffs that are continued following an engine failure. One commenter would accept a reduced screen height only if operators are first required to use the configuration that provides the best short field performance. The FAA response to the latter comment was provided in the discussion of the commenter's proposed change to §25.105(a)(2).

The FAA proposed reducing the required screen height for wet runways to re-balance the available safety margins, in a manner that does not impose significant costs on airplane operators, when taking off from a wet runway. On a wet runway, the distance needed to stop the airplane increases significantly due to the reduced braking effectiveness. On the other hand, the distance needed to complete a continued takeoff is generally unchanged from that needed for a dry runway. By reducing the required screen height on a wet runway, a lower $V_1$ speed can be used. The effect of lower $V_1$ speeds will be to reduce the number of rejected takeoffs that occur on wet runways, and to reduce the speed from which these takeoffs are rejected. The latter effect is considered especially important because the braking capability on a wet runway is significantly poorer at higher speeds.

As noted by one of the commenters, any reduction in the number of takeoffs that are rejected will produce an equal number of additional continued takeoffs. Because of the lower $V_1$ speed, the airplane's height over the end of the runway for these takeoffs, as well as the ensuring flight path, will be lower than would normally be achieved on a dry runway. If a clearway area is available, however, the minimum height of the airplane over the end of a dry runway may, under the current standards, be as low as 13 to 17 feet. On this basis, the FAA considers a minimum screen height of 15 feet to be acceptable when the runway is wet.

Allowing the screen height to be reduced on wet runways also reduces the cost burden imposed on airplane operators by the wet runway standards. By taking into account the degraded braking capability on wet runways, these standards may reduce the maximum weight at which the airplane would be allowed to take off from a given runway. If a screen height of 35 feet were retained for wet runways, an even greater reduction in takeoff weight capability could be necessary.

In the proposed §25.113(c), the FAA intended to require that the minimum screen height on a wet runway with a clearway would not be lower than either: (1) 15 feet, or (2) the screen height that could be achieved if the runway were dry. A clearway is an area at least 500 feet wide beyond the departure end of the runway that has not obstacles protruding above a 1.25 percent upward sloping gradient. On a dry runway, up to one-half of the distance traversed between liftoff and a height of 35 feet may be over the clearway. As noted earlier, the screen height (i.e., the height at the end of the runway) achieved on a dry runway with clearway may end up being as low as 13 feet. Accordingly, a higher takeoff weight is possible when a clearway is present. The words ''but not beyond the end of the runway'' included in the proposal for § 25.113(b)(2) would effectively require the wet runway screen height to be not less than 15 feet. Under the proposed wording, therefore, the presence of clearway could not be used to increase the takeoff weight on a wet runway. Also, in some instances, the minimum screen height on a wet runway would be higher than that for a dry runway.

Several commenters expressed confusion over the discrepancy between the FAA's intent, as expressed in the preamble to NPRM 93–8, and the proposed wording for §§ 25.113(b) (2) and (c). One commenter noted that the words ''but not beyond the end of the runway'' appear to inappropriately introduce an operating rule into the type design standards. This commenter also notes that the quoted phrase does not appear in the JAA's equivalent NPA. This commenter further suggests that removing the quoted phrase would accomplish the FAA's stated intent of allowing a very limited takeoff weight increase on wet runways when clearway is present.

Another commenter recommends that maximum clearway credit be permitted in combination with the 15-foot screen height on a wet runway. The commenter notes that $V_1$ speed could then be reduced even further, thus providing additional safety in the event of a rejected takeoff on a wet runway. The FAA infers that this commenter is proposing that half of the distance traversed between liftoff and a height of 15 feet be permitted to occur over the clearway. Because of the parabolic shape of the flight path, the airplane may end up being only five to eight feet high at the end of the runway. The point at which the airplane lifts off would thus be very near the end of the runway. As discussed in NPRM 93–8, the FAA considers such a situation to be unacceptable. The possibility of standing water on the wet runway, or operational considerations such as a late or slow rotation to the liftoff attitude, emphasize the need to require liftoff to occur well before the end of the runway.

Other commenters, including an international association representing airplane operators, suggest that the potential benefit provided by the FAA's intended proposal regarding clearway on a wet runway is so small that it is insignificant. These commenters are willing to accept the slight conservatism associated with prohibiting credit for clearway in conjunction with the 15-foot screen height on wet runways in favor of simplifying and clarifying the rule language. The FAA concurs with this comment and is amending § 25.113 accordingly. The phrase ''but not beyond the end of the runway,'' contained in the proposed § 25.113(b)(2), is removed. The proposed § 25.113(c) is clarified to prohibit a screen height of less than 15 feet on a wet runway. If the limiting takeoff distance is determined by the all-engines-operating condition, where the minimum height at the end of the takeoff distance remains 35 feet, clearway credit is allowed on a wet runway in the same manner as it is allowed on a dry runway. Also, § 25.113 is amended to add the provision that in the absence of clearway, the takeoff run is equal to the takeoff distance. This provision is added only to ensure completeness of the definition of takeoff run within the airworthiness standards and is in accordance with standard industry practice. The current requirement does not define the takeoff run when clearway is not present.

Some commenters apparently misunderstand some aspects of the wet runway standards, especially the effect of §§ 25.109(b)(1) and 25.113(b)(1). These sections require the accelerate-stop and takeoff distances on a wet runway (at the wet runway $V_1$ speed) to be at least as long as the corresponding distances on a dry runway (at the dry runway $V_1$ speed). These requirements therefore ensure that the maximum takeoff weight for a wet runway can never be higher than that allowed when the runway is dry. In practice, applicants should use the following procedure to determine takeoff performance when the runway is wet. First, conduct the takeoff performance analysis assuming the runway is dry. Then, repeat the analysis using wet runway data, including the wet runway $V_1$ speed. The lowest takeoff weight from these analyses is the maximum takeoff weight that can be used when the runway is wet. For this takeoff weight, determine and compare the accelerate-stop and takeoff distances applicable to both dry and wet conditions. The longer of each of these accelerate-stop and takeoff distances apply when the runway is wet.

The FAA received only one comment related to the proposed change to § 25.115(a). This proposed change would allow the airplane's height over any obstacles to be reduced by an amount corresponding to the reduced screen height allowed when taking off from a wet runway. The commenter suggested that the current obstacle clearance criteria should be updated to represent more realistic operational conditions. The commenter is referring to the criteria used to evaluate whether the obstacle must be cleared vertically, or whether an operator can consider the obstacle to be laterally outside of the airplane's path. The FAA is currently developing an advisory circular that will address this issue in detail. Therefore, § 25.115(a) is amended as proposed.

The FAA received several comments on the proposed changes to § 25.735.

One commenter proposed that § 25.735(f) refer to the wear condition that provides the least effective braking performance. This comment is related to a similar comment regarding § 25.101(i). As discussed in response to the earlier comment, the FAA believes that the fully worn condition will always provide the least effective braking performance.

This commenter also suggests that the flight test proposed under § 25.735(g) is unnecessary. The commenter proposes that a flight test should be required only if poor correlation exists between dynamometer test results and flight test results. The commenter also believes that a rejected takeoff may not represent the most severe stopping condition. For example, landing at the maximum landing weight with the flaps retracted may involve higher stopping energies. For this reason, the commenter suggests that § 25.735(g) refer to the most severe stop rather than a rejected takeoff.

The flight test proposed in § 25.735(g) is the only flight test that would be required to be conducted at a specific brake wear level. The FAA considers this test to be a necessary demonstration of the airplane's ability to safely stop under the most critical rejected takeoff condition. For the remainder of the flight testing to determine the rejected takeoff and landing stopping distances, the brakes may be at any wear level desired by the applicant (including new brakes). Dynamometer testing could be used to determine the difference in stopping capability between fully worn brakes and the brake wear level used in the flight tests. This difference would be applied to the flight test results to determine the stopping distances for fully worn brakes.

For the purposes of this demonstration, the FAA considers the maximum kinetic energy rejected takeoff to be the most critical stopping condition. Therefore, the FAA does not concur with the commenter's suggestion to replace the reference to rejected takeoff in the flight test demonstration with a reference to the most severe stop. However, from a brake approval standpoint, the FAA agrees that the brakes, in the fully worn condition, should be capable of absorbing the energy produced during the most severe stopping condition. The FAA has tasked a harmonization working group with recommending new or revised requirements for approval of brakes installed on transport category airplanes, and this working group is expected to recommend proposed standards addressing this issue.

Another commenter suggests that the flight test demonstration referenced by the proposed § 25.735(g) should include a two-second overshoot of $V_1$, before applying the brakes, to allow for the average pilot response time. The FAA does not concur with this comment because $V_1$ represents the highest speed at which the pilot should take the first action to reject the takeoff. Also, the procedures used during the flight test demonstration, including the time at which the pilot applies the brakes, should be consistent with the rejected takeoff procedures provided by the applicant in the AFM.

One commenter proposed that § 25.735(f) be clarified to allow for other devices inherent in a particular airplane design that may be used to dissipate energy. Failure to allow such credit, claims the commenter, will diminish the value of technological improvements in energy dissipation devices that are likely to be introduced to improve airplane stopping performance under wet runway conditions.

The current § 25.735(f) allows for the use of the same decelerating means to determine the brake kinetic energy capacity rating as are used to determine the dry runway accelerate-stop distances. The energy absorption capability of the brake is generally more of a concern on a dry runway than on a wet runway because of the difference in deceleration capability. To receive credit for energy dissipation devices that are likely to be introduced to improve airplane stopping performance under wet runway conditions, these devices must also provide proportionate benefits when the runway is dry, as well as meet the safety and reliability criteria of the amended § 25.109(e). Within these constraints, the FAA will consider any technological improvements in energy deceleration devices at the time such devices are proposed for evaluation.

Two commenters suggest that the proposed amendment to associate the brake energy rating of § 25.735(f) with brakes in the fully worn condition is inappropriate and could lead to confusion during the brake approval process. These commenters concur with the intent that each wheel-brake assembly, when fully worn, be capable of absorbing the maximum kinetic energy for which it is approved. However, these commenters note that the kinetic energy level defined in § 25.735(f) is the same energy level used in Technical Standard Order (TSO)–C26c for demonstrating the capability of the brake to successfully complete 100 landing stops with no refurbishment or other changes made to brake system components (except for one change in brake lining material). (TSO–C26c contains minimum performance standards for aircraft landing wheels and wheel-brake assemblies and specifies the brake dynamometer tests to demonstrate compliance with these standard.) Because of the relationship between § 25.735(f) and the TSO, any change to the definition of the energy level in § 25.735(f) would presumably also apply to the TSO. Since the TSO 100-stop test is intended to verify that the brake has acceptable structural durability, rather than to demonstrate the capability to successfully complete a high energy stop in the fully worn condition, the combination of the worn condition with the TSO energy level would be inappropriate. A brake that is fully worn at the beginning of the 100-stop test would be unable to successfully complete the test.

One of the commenters notes that the TSO also requires a test involving one stop at the maximum rejected takeoff kinetic energy. According to the commenter, it is this test that should be conducted with a fully worn brake. The energy rating demonstrated by this test is not explicitly referenced in part 25, but is contained in JAR–25 as JAR 25.735(h). The commenter proposes adding JAR 25.735(h) to part 25 to harmonize the two standards and to help clarify the application of the worn brake requirements. This commenter also suggests adding references to the applicable TSO and clarifying that the formula provided in § 25.735(f)(2) need only be modified in cases of designed unequal braking distributions. Uneven braking distributions can unintentionally occur during flight tests, but this characteristic cannot be predicted during the design or qualification stages for which § 25.735(f)(2) is relevant.

The FAA concurs with these proposals. As amended, § 25.735(f) defines the landing kinetic energy rating to be used during qualification testing per the applicable TSO or other qualification testing used to show an equivalent level of safety, as necessary to obtain the approval required by § 25.735(a). The proposed reference to a fully worn brake is inappropriate in this section and has been removed. In the proposed revision to AC 25–7, for which the notice of availability is published elsewhere in this issue of the **Federal Register**, the FAA proposes to clarify that the relevant TSO 100-stop test may begin with a brake in any condition representative of service use, including new. In addition, a new § 25.735(h), based on JAR 25.735(h), has been added. This section is similar to § 25.735(f), but defines the rejected takeoff, rather than the landing kinetic energy rating used in the applicable TSO. Unlike the landing brake kinetic energy rating, the rejected takeoff brake kinetic energy rating must be demonstrated with a fully worn brake. Finally, both the revised § 25.735(f)(2) and the new § 25.735(h)(2) require the referenced formulae for determining the brake energy capacity rating to be modified only in the case of designed unequal braking distributions. The format of the existing § 25.735(f)(2), with respect to this provision, has been adjusted to conform to **Federal Register** formatting guidelines, and the new § 25.735(h)(2) has been formatted similarly. With these changes, the final rule better matches the intent of the NPRM 93–8 proposals, and also harmonizes these sections with JAR–25.

The FAA intends to revise TSO–C26c to be consistent with these amendments to § 25.735. The Aviation Rulemaking Advisory Committee (ARAC) has been chartered with recommending appropriate changes to the TSO. Currently, the FAA envisions issuing the revised TSO, applicable to transport category airplanes, under a new designation, TSO–C135.

One commenter suggests that the proposed § 25.735(g) should be deleted. This commenter believes that this proposed flight test requirement is misplaced in the brake design and construction section of part 25. The commenter suggests that this issue should be addressed in the flight test guidance provided in AC 25–7.

The FAA concurs that the proposed flight test requirement would be better placed elsewhere, but does not concur with completely removing it from part 25. As stated previously, the FAA considers this test to be a necessary demonstration of the airplane's ability to safely stop under the most critical rejected takeoff condition. In addition, the FAA intends for this test to determine or validate the AFM accelerate-stop distance for this condition. Therefore, the proposed § 25.735(g) has been reworded to clarify that the airplane must stop within the accelerate-stop distance and is adopted as § 25.109(i). Existing § 25.735(g), which would have been redesignated as § 25.735(h), remains as § 25.735(g) in the adopted rule.

The FAA received one comment regarding the proposed amendment to § 25.1587(b). The objective of this proposal is to require that takeoff performance information for wet runways be included in the AFM. The commenter agrees with this objective, but notes that § 25.1587(b) addresses performance information other than that which would be affected by the surface condition of the takeoff runway. The commenter suggests that the proposed amendment instead be placed in § 25.1533(a)(3), which addresses operating limitations based on the minimum takeoff distances. The FAA concurs with this comment. Therefore, the proposed change to § 25.1587(b) has been removed, and § 25.1533(a)(3) is revised accordingly. The adopted amendment also corrects a typographical error in existing § 25.1533(a), identified by this commenter, by replacing the reference to § 25.103 with a reference to § 25.109.

One commenter strongly endorses a requirement to add a takeoff performance monitor to the flight deck of all airplanes to help pilots determine whether a takeoff should be rejected or continued. The commenter notes that modern transport category airplanes already contain most of the necessary instrumentation. According to the commenter, all that would be needed would be a display and a dedicated processor to compute the data to be displayed.

The FAA has participated in past evaluations of systems designed to monitor the performance of the airplane during the takeoff. Such systems typically compare the airplane's actual performance, as determined by airplane instrumentation, with the performance predicted by the AFM. If the airplane's performance is less than predicted, the performance shortfall would be indicated by the monitor. In addition, the takeoff speeds, $V_1$ and $V_R$, could be correlated with the point on the runway at which they should be reached. This information could assist pilots in determining whether it is safer to reject or to continue the takeoff.

The FAA supports efforts at improving the go/no-go decision process. Advisory Circular 25–15. ''Approval of Flight Management Systems in Transport Category Airplanes,'' provides a means to obtain FAA approval of a takeoff performance monitor function as part of a flight management system. However, takeoff performance monitors are not yet sufficiently reliable nor are they sophisticated enough to warrant requiring their addition to the flight deck of transport category airplanes. Varying winds during the takeoff or a runway with a variable slope may cause the monitor to provide a false indication. The FAA is also concerned that the number of high speed rejected takeoffs could increase as pilots delay action to determine, for example, if an initially sub-par acceleration is corrected. Also, unnecessary rejected takeoffs could occur as a result of small differences between the predicted airplane acceleration and the actual airplane's acceleration as determined by the onboard instrumentation. A takeoff performance monitor would need to consider all of the variables reflected in the takeoff performance data, such as atmospheric conditions, airplane flap setting, thrust level (including reduced and derated takeoff thrust), runway length, slope, and surface condition, etc. It is possible to design such a system, but current systems have not demonstrated a safety benefit over the information currently available to the pilot.

The same commenter recommends that the FAA undertake a study using research simulators to validate airplane/pilot performance in obstacle limited takeoffs with engine failures. The objective of this study would be to determine if there is a high degree of reliability that the combined airplane/pilot performance is acceptable. The commenter feels that such a study is essential to considerations of lower screen heights, tailwind takeoffs, and pilot decision making when the takeoff weight is limited by obstacle clearance considerations. In the interim, the commenter suggests that the FAA adopt more stringent obstacle clearance criteria, such as those contained in the International Civil Aviation Organization's (ICAO) Annex 6, Attachment C, Paragraph 3—Takeoff Obstacle Clearance Limitations.

Section 25.111 currently requires applicants to determine the airplane's takeoff path, which begins with the start of the takeoff roll and ends approximately 1,500 feet above the takeoff surface. Under § 25.111(d), applicants must conduct flight tests to ensure that the airplane can achieve the takeoff path presented in the AFM. The takeoff path data, and the flight test demonstrations, must be based on the procedures established by the applicant for operation in service, and assume that one engine fails at $V_{EF}$. Except for automatic propeller feathering and retraction of the landing gear, the airplane configuration must remain constant, and changes in power or thrust that require action by a pilot may not be made until the airplane reaches a height of 400 feet above the takeoff surface.

In addition to the takeoff path determined under § 25.111, § 25.115 requires applicants to determine the net takeoff flight path. The net takeoff flight path begins at the end of the takeoff distance and is equal to the takeoff flight path with the gradient of climb reduced by: 0.8 percent for two-engine airplanes; 0.9 percent for three-engine airplanes; and 1.0 percent for four-engine airplanes. These adjustments to the airplane's demonstrated climb gradient capability represent a safety margin for use in complying with the obstacle clearance requirements prescribed by the applicable operating rules. For airplanes operated under parts 121 or 135, the net takeoff flight path not only must clear all applicable obstacles, but must clear them by a height of at least 35 feet.

The current airworthiness standards already address the issues the commenter proposes for further study. For each part 25 airplane type design, applicants must conduct flight tests to validate the capability of the airplane, using normal piloting actions, to achieve the published flight path. Safety margins are then added to ensure that this flight path adequately clears all applicable obstacles.

The obstacle clearance criteria recommended by ICAO would require airplane operators to consider a larger ground area to be under the takeoff flight path when determining which obstacles must be cleared vertically. An obstacle that can be considered to be cleared laterally under current FAA practices may have to be cleared vertically under the ICAO recommendations. This change could result in restricting the amount of cargo or passengers to be carried because the airplane's vertical flight path capability is directly related to its takeoff weight. The FAA is currently drafting an advisory circular to provide standardized guidelines regarding the extent of the ground area that must be considered when determining which obstacles must be cleared vertically.

## Regulatory Evaluation Summary

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) Will generate benefits that justify its costs as defined in the Executive Order; (2) will not have a significant impact on a substantial number of small entities; and (3) will not constitute a barrier to international trade. These analyses, available in the docket, are summarized below.

In order to analyze the potential net costs of the rule, this evaluation considers a hypothetical production program for a representative new type certification. This example assumes that: (1) Incremental certification costs are incurred in year ''0'', (2) production starts in year ''4'', (3) the first airplane enters service in year ''5'', (4) 50 airplanes are produced per year for ten years so that total production equals 500, (5) each airplane is retired at the end of its 25 year design service goal, and (6) the discount rate is 7 percent.

The analysis of incremental costs is divided into two cases: one which assumes a brake design that exhibits little decline in brake performance with wear, and another which assumes a brake design that exhibits a decline in brake performance with wear.

In the former case, the average reduction in dry runway accelerate-stop distance associated with the revised 2-second-at-$V_1$ requirement is greater than the average increase in accelerate-stop distance associated with the worn brake requirement. This will result in a reduction in operating costs of approximately $5,105 per airplane per year, or $128,000 per airplane over its service life (in nominal terms). However, approximately one third of takeoffs would be conducted using the wet runway accelerate-stop distance. Under the production run and cost assumptions enumerated above, the wet runway amendments will add approximately $2,700 to operating costs per airplane per year, or $68,000 per airplane over its service life. Therefore, net operating costs under this design assumption will decline by approximately $2,400 per airplane per year, or $59,400 per airplane over its service life. Total costs (including consideration of incremental certification and development costs), then, will be reduced by approximately $28.9 million for the 500 airplane fleet over its 34 year service life. On a discounted basis, total fleet costs will be reduced by approximately $7.5 million.

In the case where brake performance is assumed to decline with wear, the average reduction in dry runway accelerate-stop distance associated with the revised 2-second-at-$V_1$ requirement is offset by the average increase in dry runway accelerate-stop distance associated with the worn brake requirement. Again, however, the wet runway requirements will add approximately $2,700 (in nominal terms) per year per airplane to operating costs. Therefore, lifetime incremental costs (again including consideration of incremental certification and development costs) for the 500 airplane fleet are approximately $34.9 million, or $9.6 million on a discounted basis. It should be emphasized, however, that FAA anticipates that future airplane models will incorporate brake designs that exhibit little reduction in braking force with wear.

The rule will have significant safety implications owing to the fact that it creates economic incentives for manufacturers, operators, and airports to adopt procedures which reduce takeoff hazards. While these ancillary safety benefits are not directly valued in this economic analysis, they are discussed in a qualitative way below.

The rule's worn-brake provisions will have important safety impacts. For airplanes that continue to make use of brake designs in which braking capacity declines with wear, the rule provides an incentive to reduce the specified level of allowable wear in return for some reduction in accelerate-stop distances. In this way, accelerate-stop distances are more closely related to actual brake performance.

Existing regulations do not distinguish between dry and wet runway surface conditions. The accident history, however, shows that wet runway rejected takeoff overrun accidents account for a disproportionate share of the total. In fact, the wet runway rejected takeoff accident rate (involving substantial damage or hull loss) is seven times greater than the dry runway accident rate. The rule enhances safety by taking into account this hazardous takeoff condition. First, it directly increases accelerate-stop margins for wet runway conditions. Second, it creates an economic incentive to develop more stringent maintenance programs for skid-resistant runway surfaces.

*Regulatory Flexibility Determination*

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires agencies to review rules which may have ''a significant economic impact on a substantial number of small entities.'' FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, specifies small entity size and cost thresholds by Standard Industrial Classification (SIC). Entities potentially affected by the rule include manufacturers of transport category airplanes (SIC 3721) and operators of aircraft for hire (SIC 4511).

There are no manufacturers of transport category airplanes that meet the SIC 3721 size threshold for small entities (75 employees). However, small air carriers operating transport category airplanes could be affected by the rule. Order 2100.14A defines a small carrier as one owning 9 or fewer aircraft. The definition of ''significant economic impact'' varies by air carrier type: for operators whose fleets consist entirely of aircraft having a seating capacity of more than 60 passengers the threshold is $123,445, for other operators the threshold is $69,005.

Under the most conservative (that is, most costly) compliance assumptions, the rule will increase operating costs by approximately $2,700 per airplane per year; or $24,300 per year for a nine-airplane fleet. Assuming that all incremental certification costs are passed on to the operator, the rule would increase the price of an airplane by $1,570. When this is amortized over the 25-year life of the airplane (assuming a 7% discount rate), the incremental cost per airplane is approximately $126 per year or $1,134 per year for a nine-airplane fleet. An upper-bound estimate of the annual impact of the proposed rule to small operators, then, is approximately $24,300+$1,134=$25,434. FAA holds, therefore, that the rule will not have a significant economic impact on a substantial number of small entities.

*Unfunded Mandates Reform Act*

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104–4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed ''significant intergovernmental mandate.'' A ''significant intergovernmental mandate'' under the Act is any provision in a Federal agency regulation that will impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

The rule does not contain any Federal intergovernmental or private sector mandate. Therefore, the requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply.

*Trade Impact Assessment*

Recognizing that nominally domestic regulations often affect international trade, the Office of Management and Budget directs Federal agencies to assess whether or not a rule or regulation will have the effect of lessening the restraints of any trade-sensitive actively. The FAA determines that the subject rule will reduce barriers to international trade.

The rule collectively places U.S. and foreign transport airplanes on a more equitable basis regarding their marketability. The standardization of certification criteria between the FAA and the Joint Aviation Authorities (JAA) of Europe, and the equalization of safety levels for pre- and post-Amendment 25–42 airplanes eliminates the slight comparative disadvantage experienced by certain foreign airplanes. The requirement regarding the two-second margin allows European-produced airplanes certified under Amendment 25–42 to become slightly more competitive against current production U.S. airplanes that were not certified under Amendment 25–42 by marginally expanding their takeoff envelope.

## Federalism Implications

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this final rule will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

## International Civil Aviation Organization (ICAO) and Joint Aviation Regulations

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with ICAO Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that this rule does not conflict with any international agreement of the United States.

**Paperwork Reduction Act**

In accordance with the Paperwork Reduction Act of 1990 (44 U.S.C. 3501 *et seq.*). there are not reporting or recordkeeping requirements associated with this rule.

**Regulations Affecting Intrastate Aviation in Alaska**

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in Title 14 of the CFR in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such regulatory distinctions as he or she considers appropriate. Because this final rule applies to the certification of future designs of transport category airplane and their subsequent operation, it could affect interstate aviation in Alaska. The Administrator has considered the extent to which Alaska is not served by transportation modes other than a aviation, and how the final rule could have been applied differently to intrastate operations in Alaska. However, the Administrator has determined that airplanes operated solely in Alaska would present the same safety concerns as all other affected airplanes; therefore, it would be inappropriate to establish a regulatory distinction for the intrastate operation of affected airplanes in Alaska.

**List of Subjects**

*14 CFR Part 1*

Air transportation.

*14 CFR Part 25*

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

*14 CFR Part 91*

Aircraft, Airmen, Aviation safety, Reporting and recordkeeping requirements.

*14 CFR Part 121*

Air carriers, Aircraft, Airmen, Aviation safety, Charter flights, Reporting and recordkeeping requirements, Safety, Transportation.

*14 CFR Part 135*

Aircraft, Airplane, Airworthiness, Air transportation.

**Adoption of the Amendment**

In consideration of the foregoing, the Federal Aviation Administration amends 14 CFR parts 1, 25, 91, 121, and 135 of the Federal Aviation Regulations (FAR) as follows:

## PART 1—DEFINITIONS AND ABBREVIATIONS

1. The authority citation for part 1 continues to read as follows:

**Authority:** 49 U.S.C. 106(g), 40113, 44701.

2. Section 1.2 is amended by adding a new abbreviation ''$V_{EF}$'' and revising the description for the abbreviation ''$V_1$'' to read as follows:

### § 1.2 Abbreviations and symbols.

* * * * *

$V_{EF}$ means the speed at which the critical engine is assumed to fail during takeoff.

* * * * *

$V_1$ means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. $V_1$ also means the minimum speed in the takeoff, following a failure of the critical engine at $V_{EF}$, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

* * * * *

## PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

3. The authority citation for part 25 continues to read as follows:

**Authority:** 49 U.S.C. 106(g), 40113, 44701–44702, 44704.

4. Section 25.101 is amended by adding a new paragraph (i) to read as follows:

### § 25.101 General.

* * * * *

(i) The accelerate-stop and landing distances prescribed in §§ 25.109 and 25.125, respectively, must be determined with all the airplane wheel brake assemblies at the fully worn limit of their allowable wear range.

5. Section § 25.105 is amended by revising paragraph (c)(1) to read as follows:

### § 25.105 Takeoff.

* * * * *

(c) * * *

(1) In the case of land planes and amphibians:

(i) Smooth, dry and wet, hard-surfaced runways; and

(ii) At the option of the applicant, grooved or porous friction course wet, hard-surfaced runways.

* * * * *

6. Section § 25.107 is amended by revising paragraph (a)(2) to read as follows:

### § 25.107 Takeoff speeds.

(a) * * *

(2) $V_1$, in terms of calibrated airspeed, is selected by the applicant; however, $V_1$ may not be less than $V_{EF}$ plus the speed gained with critical engine inoperative during the time interval between the instant at which the critical engine is failed, and the instant at which the pilot recognizes and reacts to the engine failure, as indicated by the pilot's initiation of the first action (e.g., applying brakes, reducing thrust, deploying speed brakes) to stop the airplane during accelerate-stop tests.

* * * * *

7. Section 25.109 is amended by revising paragraph (a), redesignating paragraph (b) as paragraph (e) and revising the introductory text, redesignating paragraph (c) as paragraph (g) redesignating paragraph (d) as paragraph (h) and revising the first sentence, and adding new paragraphs (b), (c), (d), (f), and (i) to read as follows:

### § 25.109 Accelerate-stop distance.

(a) The accelerate-stop distance on a dry runway is the greater of the following distances:

(1) The sum of the distances necessary to—

(i) Accelerate the airplane from a standing start with all engines operating to $V_{EF}$ for takeoff from a dry runway;

(ii) Allow the airplane to accelerate from $V_{EF}$ to the highest speed reached during the rejected takeoff, assuming the critical engine fails at $V_{EF}$ and the pilot takes the first action to reject the takeoff at the $V_1$ for takeoff from a dry runway; and

(iii) Come to a full stop on a dry runway from the speed reached as prescribed in paragraph (a)(1)(ii) of this section; plus

(iv) A distance equivalent to 2 seconds at the $V_1$ for takeoff from a dry runway.

(2) The sum of the distances necessary to—

(i) Accelerate the airplane from a standing start with all engines operating to the highest speed reached during the rejected takeoff, assuming the pilot takes the first action to reject the takeoff at the $V_1$ for takeoff from a dry runway; and

(ii) With all engines still operating, come to a full stop on dry runway from the speed reached as prescribed in paragraph (a)(2)(i) of this section; plus

(iii) A distance equivalent to 2 seconds at the $V_1$ for takeoff from a dry runway.

(b) The accelerate-stop distance on a wet runway is the greater of the following distances:

(1) The accelerate-stop distance on a dry runway determined in accordance with paragraph (a) of this section; or

(2) The accelerate-stop distance determined in accordance with paragraph (a) of this section, except that the runway is wet and the corresponding wet runway values of $V_{EF}$ and $V_1$ are used. In determining the wet runway accelerate-stop distance, the stopping force from the wheel brakes may never exceed:

(i) The wheel brakes stopping force determined in meeting the requirements of § 25.101(i) and paragraph (a) of this section; and

(ii) The force resulting from the wet runway braking coefficient of friction determined in accordance with paragraphs (c) or (d) of this section, as applicable, taking into account the distribution of the normal load between braked and unbraked wheels at the most adverse center-of-gravity position approved for takeoff.

(c) The wet runway braking coefficient of friction for a smooth wet runway is defined as a curve of friction coefficient versus ground speed and must be computed as follows:

(1) The maximum tire-to-ground wet runway braking coefficient of friction is defined as:

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| Tire Pressure (psi) | Maximum Braking Coefficient (tire-to-ground) |
|---|---|
| 50 | $\mu_{t/g_{MAX}} = -0.0350\left(\frac{V}{100}\right)^3 + 0.306\left(\frac{V}{100}\right)^2 - 0.851\left(\frac{V}{100}\right) + 0.883$ |
| 100 | $\mu_{t/g_{MAX}} = -0.0437\left(\frac{V}{100}\right)^3 + 0.320\left(\frac{V}{100}\right)^2 - 0.805\left(\frac{V}{100}\right) + 0.804$ |
| 200 | $\mu_{t/g_{MAX}} = -0.0331\left(\frac{V}{100}\right)^3 + 0.252\left(\frac{V}{100}\right)^2 - 0.658\left(\frac{V}{100}\right) + 0.692$ |
| 300 | $\mu_{t/g_{MAX}} = -0.0401\left(\frac{V}{100}\right)^3 + 0.263\left(\frac{V}{100}\right)^2 - 0.611\left(\frac{V}{100}\right) + 0.614$ |

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Where—

Tire Pressure=maximum airplane operating tire pressure (psi);

$\mu_{t/gMAX}$=maximum tire-to-ground braking coefficient;

V=airplane true ground speed (knots); and

Linear interpolation may be used for tire pressures other than those listed.

(2) The maximum tire-to-ground wet runway braking coefficient of friction must be adjusted to take into account the efficiency of the anti-skid system on a wet runway. Anti-skid system operation must be demonstrated by flight testing on a smooth wet runway, and its efficiency must be determined. Unless a specific anti-skid system efficiency is determined from a quantitative analysis of the flight testing on a smooth wet runway, the maximum tire-to-ground wet runway braking coefficient of friction determined in paragraph (c)(1) of this section must be multiplied by the efficiency value associated with the type of anti-skid system installed on the airplane:

| Type of anti-skid system | Efficiency value |
|---|---|
| On-Off | 0.30 |
| Quasi-Modulating | 0.50 |
| Fully Modulating | 0.80 |

(d) At the option of the applicant, a higher wet runway braking coefficient of friction may be used for runway surfaces that have been grooved or treated with a porous friction course material. For grooved and porous friction course runways, the wet runway braking coefficent of friction is defined as either:

(1) 70 percent of the dry runway braking coefficient of friction used to determine the dry runway accelerate-stop distance; or

(2) The wet runway braking coefficient defined in paragraph (c) of this section, except that a specific anti-skid system efficiency, if determined, is appropriate for a grooved or porous friction course wet runway, and the maximum tire-to-ground wet runway braking coefficient of friction is defined as:

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| Tire Pressure (psi) | Maximum Braking Coefficient (tire-to-ground) |
|---|---|
| 50 | $\mu_{t/g_{MAX}} = 0.1470\left(\frac{V}{100}\right)^5 - 1.050\left(\frac{V}{100}\right)^4 + 2.673\left(\frac{V}{100}\right)^3 - 2.683\left(\frac{V}{100}\right)^2 + 0.403\left(\frac{V}{100}\right) + 0.859$ |
| 100 | $\mu_{t/g_{MAX}} = 0.1106\left(\frac{V}{100}\right)^5 - 0.813\left(\frac{V}{100}\right)^4 + 2.130\left(\frac{V}{100}\right)^3 - 2.200\left(\frac{V}{100}\right)^2 + 0.317\left(\frac{V}{100}\right) + 0.807$ |
| 200 | $\mu_{t/g_{MAX}} = 0.0498\left(\frac{V}{100}\right)^5 - 0.398\left(\frac{V}{100}\right)^4 + 1.140\left(\frac{V}{100}\right)^3 - 1.285\left(\frac{V}{100}\right)^2 + 0.140\left(\frac{V}{100}\right) + 0.701$ |
| 300 | $\mu_{t/g_{MAX}} = 0.0314\left(\frac{V}{100}\right)^5 - 0.247\left(\frac{V}{100}\right)^4 + 0.703\left(\frac{V}{100}\right)^3 - 0.779\left(\frac{V}{100}\right)^2 - 0.00954\left(\frac{V}{100}\right) + 0.614$ |

**BILLING CODE 4910–13–C**

Where—

Tire Pressure=maximum airplane operating tire pressure (psi);

$\mu_{t/gMAX}$=maximum tire-to-ground braking coefficient;

V=airplane true ground speed (knots); and

Linear interpolation may be used for tire pressures other than those listed.

(e) Except as provided in paragraph (f)(1) of this section, means other than wheel brakes may be used to determine the accelerate-stop distance if that means—

* * * * *

(f) The effects of available reverse thrust—

(1) Shall not be included as an additional means of deceleration when determining the accelerate-stop distance on a dry runway; and

(2) May be included as an additional means of deceleration using recommended reverse thrust procedures when determining the accelerate-stop distance on a wet runway, provided the requirements of paragraph (e) of this section are met.

* * * * *

(h) If the accelerate-stop distance includes a stopway with surface characteristics substantially different from those of the runway, the takeoff data must include operational correction factors for the accelerate-stop distance. * * *

(i) A flight test demonstration of the maximum brake kinetic energy accelerate-stop distance must be conducted with not more than 10 percent of the allowable brake wear range remaining on each of the airplane wheel brakes.

8. Section 25.113 is amended by revising the introductory text of paragraph (a) and revising paragraph (a)(1), redesignating paragraph (b) as paragraph (c) and revising it, and adding a new paragraph (b) to read as follows:

**§ 25.113 Takeoff distance and takeoff run.**

(a) Takeoff distance on a dry runway is the greater of—

(1) The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 35 feet above the takeoff surface, determined under § 25.111 for a dry runway; or

* * * * *

(b) Takeoff distance on a wet runway is the greater of—

(1) The takeoff distance on a dry runway determined in accordance with paragraph (a) of this section; or

(2) The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 15 feet above the takeoff surface, achieved in a manner consistent with the achievement of $V_2$ before reaching 35 feet above the takeoff surface, determined under § 25.111 for a wet runway.

(c) If the takeoff distance does not include a clearway, the takeoff run is equal to the takeoff distance. If the takeoff distance includes a clearway—

(1) The takeoff run on a dry runway is the greater of—

(i) The horizontal distance along the takeoff path from the start of the takeoff to a point equidistant between the point at which $V_{LOF}$ is reached and the point at which the airplane is 35 feet above the takeoff surface, as determined under § 25.111 for a dry runway; or

(ii) 115 percent of the horizontal distance along the takeoff path, with all engines operating, from the start of the takeoff to a point equidistant between the point at which $V_{LOF}$ is reached and the point at which the airplane is 35 feet above the takeoff surface, determined by a procedure consistent with § 25.111.

(2) The takeoff run on a wet runway is the greater of—

(i) The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 15 feet above the takeoff surface, achieved in a manner consistent with the achievement of $V_2$ before reaching 35 feet above the takeoff surface, as determined under § 25.111 for a wet runway; or

(ii) 115 percent of the horizontal distance along the takeoff path, with all engines operating, from the start of the takeoff to a point equidistant between the point at which $V_{LOF}$ is reached and the point at which the airplane is 35 feet above the takeoff surface, determined by a procedure consistent with § 25.111.

9. Section 25.115 is amended by revising paragraph (a) to read as follows:

**§ 25.115 Takeoff flight path.**

(a) The takeoff flight path shall be considered to begin 35 feet above the takeoff surface at the end of the takeoff distance determined in accordance with § 25.113(a) or (b), as appropriate for the runway surface condition.

* * * * *

10. Section 25.735 is amended by revising paragraphs (f) introductory text and (f)(2) and adding a new paragraph (h) to read as follows:

**§ 25.735 Brakes**

* * * * *

(f) The design landing brake kinetic energy capacity rating of each main wheel-brake assembly shall be used during qualification testing of the brake to the applicable Technical Standard Order (TSO) or an acceptable equivalent. This kinetic energy rating may not be less than the kinetic energy absorption requirements determined under either of the following methods:

(1) * * *

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel-brake assembly may be derived from the following formula, which must be modified in cases of designed unequal braking distributions.

$$KE = \frac{0.0443WV^2}{N}$$

Where—

KE=Kinetic energy per wheel (ft.-lb.);

W=Design landing weight (lb.);

V=Airplane speed in knots. V must not be less than $V_{S0,}$ the power off stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and

N=Number of main wheels with brakes.

* * * * *

(h) The rejected takeoff brake kinetic energy capacity rating of each main wheel-brake assembly that is at the fully worn limit of its allowable wear range shall be used during qualification testing of the brake to the applicable Technical Standard Order (TSO) or an acceptable equivalent. This kinetic energy rating may not be less than the kinetic energy absorption requirements determined under either of the following methods:

(1) The brake kinetic energy absorption requirements must be based on a rational analysis of the sequence of events expected during an accelerate-stop maneuver. This analysis must include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or powerplant forward thrust, and (if more critical) the most adverse single engine or propeller malfunction.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula, which must be modified in cases of designed unequal braking distributions:

$$KE = \frac{0.0443WV^2}{N}$$

Where—

KE=Kinetic energy per wheel (ft.-lb.);

W=Airplane weight (lb.);

V=Airplane speed (knots);

N=Number of main wheels with brakes; and

W and V are the most critical combination of takeoff weight and ground speed obtained in a rejected takeoff.

11. Section 25.1533 is amended by revising paragraph (a)(3) to read as follows:

### § 25.1533 Additional operating limitations.

(a) * * *

(3) The minimum takeoff distances must be established as the distances at which compliance is shown with the applicable provisions of this part (including the provisions of §§ 25.109 and 25.113, for weights, altitudes, temperatures, wind components, runway surface conditions (dry and wet), and runway gradients) for smooth, hard-surfaced runways. Additionally, at the option of the applicant, wet runway takeoff distances may be established for runway surfaces that have been grooved or treated with a porous friction course, and may be approved for use on runways where such surfaces have been designed constructed, and maintained in a manner acceptable to the Administrator.

* * * * *

## PART 91—GENERAL OPERATING AND FLIGHT RULES

12. The authority citation for part 91 continues to read as follows:

**Authority:** 49 U.S.C. 106(g), 1155, 40103, 40113, 40120, 44101, 44111, 44701, 44709, 44711, 44712, 44715, 44716, 44717, 44722, 46306, 46315, 46316, 46502, 46504, 46506–46507, 47122, 47508, 47528–47531; Articles 12 and 29 of the Convention on International Civil Aviation (61 Stat. 1180), 902.

13. Section 91.605 is amended by revising paragraph (b)(3) to read as follows:

### § 91.605 Transport category civil airplane weight limitations.

* * * * *

(b) * * *

(3) The takeoff weight does not exceed the weight shown in the Airplane Flight Manual to correspond with the minimum distances required for takeoff, considering the elevation of the airport, the runway to be used, the effective runway gradient, the ambient temperature and wind component at the time of takeoff, and, if operating limitations exist for the minimum distances required for takeoff from wet runways, the runway surface condition (dry or wet). Wet runway distances associated with grooved or porous friction course runways, if provided in the Airplane Flight Manual, may be used only for runways that are grooved or treated with a porous friction course (PFC) overlay, and that the operator determines are designed, constructed, and maintained in a manner acceptable to the Administrator.

* * * * *

## PART 121—OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS

14. The authority citation for part 121 continues to read as follows:

**Authority:** 49 U.S.C. 106(g), 40113, 40119, 44101, 44701–44702, 44705, 44709–44711, 44713, 44716–44717, 44722, 44901, 44903–44904, 44912, 46105.

15. Section 121.189 is amended by revising paragraph (e) to read as follows:

### § 121.189 Airplanes: Turbine engine powered: Takeoff limitations.

* * * * *

(e) In determining maximum weights, minimum distances, and flight paths under paragraphs (a) through (d) of this section, correction must be made for the runway to be used, the elevation of the airport, the effective runway gradient, the ambient temperature and wind component at the time of takeoff, and, if operating limitations exist for the minimum distances required for takeoff from wet runways, the runway surface condition (dry or wet). Wet runway distances associated with grooved or porous friction course runways, if provided in the Airplane Flight Manual, may be used only for runways that are grooved or treated with a porous friction course (PFC) overlay, and that the operator determines are designed, constructed, and maintained in a manner acceptable to the Administrator.

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## PART 135—OPERATING REQUIREMENTS: COMMUTER AND ON-DEMAND OPERATIONS

16. The authority citation for part 135 continues to read as follows:

**Authority:** 49 U.S.C. 106(g), 40113, 44701–44702, 44705, 44709, 44711–44713, 44715–44717, 44722.

17. Section 135.379 is amended by revising paragraph (e) to read as follows:

### § 135.379 Large transport category airplanes: Turbine engine powered: Takeoff limitations.

* * * * *

(e) In determining maximum weights, minimum distances, and flight paths under paragraphs (a) through (d) of this section, correction must be made for the runway to be used, the elevation of the airport, the effective runway gradient, the ambient temperature and wind component at the time of takeoff, and, if operating limitations exist for the minimum distances required for takeoff from wet runways, the runway surface condition (dry or wet). Wet runway distances associated with grooved or porous friction course runways, if provided in the Airplane Flight Manual, may be used only for runways that are grooved or treated with a porous friction course (PFC) overlay, and that the operator determines are designed, constructed, and maintained in a manner acceptable to the Administrator.

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Issued in Washington, DC on February 10, 1998.

**Jane F. Garvey,**

*Administrator.*

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