



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Takeoff Performance Data for
Operations on Contaminated Runways

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This advisory circular (AC) provides guidance and standardized methods that data providers, such as type certificate (TC) holders, supplemental type certificate (STC) holders, applicants, and airplane operators, can use when developing takeoff performance data for transport category airplanes for operations on contaminated runways. This AC also promotes the use of consistent terminology for runway surface conditions used among data providers and FAA personnel.

If you have suggestions for improving this AC, you may use the Advisory Circular Feedback form attached at the end of this AC.

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1 **PURPOSE.**

This AC provides guidance and standardized methods that data providers, such as TC holders, STC holders, applicants, and airplane operators, can use when developing takeoff performance data for operations for transport category airplanes on contaminated runways. This AC also promotes the use of consistent terminology for runway surface conditions used among data providers and FAA personnel.

2 **APPLICABILITY.**

- 2.1 The guidance provided in this document is directed towards airplane manufacturers, modifiers, foreign regulatory authorities, FAA transport airplane type certification engineers, flight test pilots, flight test engineers, and their FAA designees.
- 2.2 The guidance in this AC is neither mandatory nor regulatory in nature and does not constitute a requirement. This AC is written in response to an Aviation Rulemaking Committee (ARC) recommendation to provide guidance to manufacturers for a standardized approach for computing contaminated runway performance data.
- 2.3 This material does not change or create any additional regulatory requirements, nor does it authorize changes in, or permit deviations from, regulatory requirements.
- 2.4 The guidance provided in this AC can be used both for new airplane designs and for previously certificated airplane designs. See section 10 of this AC for additional information on applying the guidance in this AC to previously certificated airplane designs.

3 **RELATED DOCUMENTS.**

3.1 **Regulations.**

The following Title 14, Code of Federal Regulations are referenced in this AC. These regulations are available at the [U.S. Government Printing Office website](http://www.gpo.gov).

- Section 25.101, *General (Performance)*.
- Section 25.105, *Takeoff*.
- Section 25.107, *Takeoff speeds*.
- Section 25.109, *Accelerate-stop distance*.
- Section 25.111, *Takeoff path*.
- Section 25.113, *Takeoff distance and takeoff path*.
- Section 25.115, *Takeoff flight path*.

3.2 **Advisory Circulars.**

The following ACs are referenced in this AC. These ACs are available at the [FAA website](#). If any AC is revised after publication of this AC, you should refer to the latest revision.

- AC 25-7C, *Flight Test Guide for Certification of Transport Category Airplanes*, dated October 16, 2012.
- AC 25.939-1, *Evaluating Turbine Engine Operating Characteristics*, dated March 19, 1986.
- AC 150/5200-28E, *Notices to Airmen (NOTAMs) for Airport Operators*, dated October 8, 2015.

3.3 **Other Documents.**

- FAA Order JO 7930.2Q (or later revisions), *Notice to Airmen (NOTAM)*, dated December 18, 2015.
- European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 25.1591, *The Derivation and Methodology of Performance Information for Use when Taking-off and Landing with Contaminated Runway Surface Conditions*.

4 **BACKGROUND.**

- 4.1 On August 6, 2007, the FAA tasked the Takeoff and Landing Performance Assessment (TALPA) ARC, among other tasks, to provide advice and recommendations for establishing airplane certification and operational requirements (including training) for takeoff and landing operations on contaminated runways.
- 4.2 The TALPA ARC completed its actions and delivered its recommendations to the FAA on July 7, 2009. Although the Committee recommended adopting regulations requiring TC holders to produce takeoff performance data for operations on contaminated runways, the FAA does not currently plan to initiate rulemaking on this issue. However, this AC provides guidance and standardized methods that data providers can use, at their option, to develop takeoff performance data for operations on contaminated runways. Data created following the recommendations of this AC would address the Committee recommendations. That data would also be consistent with the terminology used for airport reporting of runway conditions.

5 **DEFINITIONS.**

5.1 **Dry Runway.**

A runway is dry when it is neither wet, nor contaminated. For purposes of condition reporting and airplane performance, a runway can be considered dry when no more than 25 percent of the runway surface area (within the reported length and the width being used) is covered by visible moisture or dampness, frost, slush, snow (any type), or ice.

5.2 **Wet Runway.**

A runway is wet when it is neither dry, nor contaminated. For purposes of condition reporting and airplane performance, a runway can be considered wet when more than 25 percent of the runway surface area (within the reported length and the width being used) is covered by any visible dampness or water that is $\frac{1}{8}$ inch (3 mm) or less in depth.

Note: A damp runway that meets this definition is considered wet, regardless of whether or not the surface appears reflective.

5.3 **Contaminated Runway.**

For purposes of condition reporting and airplane performance, a runway is considered contaminated when more than 25 percent of the runway surface area (within the reported length and the width being used) is covered by frost, ice, and any depth of snow, slush, or water. Definitions for each of these runway contaminants are provided in paragraphs 5.3.1 through 5.3.8 of this AC.

Note: The definition of water in the context of condition reporting and airplane performance is the definition in paragraph 5.3.6 of this AC, which is a depth of greater than $\frac{1}{8}$ inch (3 mm). This terminology is consistent with the definitions used in NOTAMs as published in AC 150/5200-28E and Order JO 7930.2Q (or later revisions).

5.3.1 Dry Snow.

Snow that has insufficient free water to cause it to stick together. This generally occurs at temperatures well below 32 °F (0 °C). If when making a snowball, it falls apart, the snow is considered dry.

5.3.2 Wet Snow.

Snow that has grains coated with liquid water, which bonds the mass together, but that has no excess water in the pore space. A well-compacted, solid snowball can be made, but water will not squeeze out.

5.3.3 Slush.

Snow that has water content exceeding a freely drained condition such that it takes on fluid properties (for example, flowing and splashing). Water will drain from slush when a handful is picked up. This type of water-saturated snow will be displaced with a splatter by a heel and toe slap-down motion against the ground.

5.3.4 Compacted Snow.

Snow that has been compressed and consolidated into a solid form that resists further compression such that an airplane will remain on its surface without displacing any of it. If a chunk of compressed snow can be picked up by hand, it will hold together or can be broken into smaller chunks rather than falling away as individual snow particles.

5.3.5 Frost.

Frost consists of ice crystals formed from airborne moisture that condenses on a surface whose temperature is below freezing. Frost differs from ice in that the frost crystals grow independently and, therefore, have a more granular texture.

5.3.6 Water.

Water in a liquid state. For purposes of condition reporting and airplane performance, water is greater than $\frac{1}{8}$ inch (3 mm) in depth.

5.3.7 Ice.

The solid form of frozen water.

5.3.8 Wet Ice.

Ice that is melting or ice with any depth of water on top.

5.4 Loose Contaminants.

Loose contaminants are those contaminants that an airplane's tire will not remain on the surface of without breaking through. Water, slush, wet snow, and dry snow are loose contaminants. For loose contaminants, the depth of the contaminant can affect both the airplane's acceleration and deceleration capability.

5.5 Runway Surface Condition.

The runway surface condition is a description of the contaminants (if any) on the surface of a runway. Takeoff and landing performance data based on runway surface condition may include the effects of the contaminant on braking friction and the effects of contaminant depth on drag as appropriate.

5.6 Solid Contaminants.

Solid contaminants are those contaminants that an airplane's tire will remain on top of and not break through. Compacted snow and ice are solid contaminants. For solid contaminants, the depth of the contaminant does not affect the airplane's acceleration or deceleration capability.

5.7 Slippery When Wet.

A wet runway where the surface friction characteristics would indicate diminished braking action as compared to a normal wet runway.

5.8 Specific Gravity.

The specific gravity of a contaminant is the density of the contaminant divided by the density of water.

5.9 Wheel Braking Coefficient.

Wheel braking coefficient is the ratio of the deceleration force from a braked wheel/tire relative to the normal force acting on the wheel/tire. The wheel braking coefficient is an all-inclusive term that incorporates effects related to the tire-to-ground interaction from

braked wheels only, such as runway surface and airplane braking system (e.g., anti-skid efficiency, brake wear, tire condition, etc.). For the purposes of this AC, the wheel braking coefficient is based on a fully modulating anti-skid controlled braked wheel/tire. The definition of fully modulating anti-skid system is found in AC 25-7C.

6 CONTAMINATED RUNWAY TAKEOFF PERFORMANCE DATA.

- 6.1 If developed using the guidance in this AC, takeoff performance data should be provided in terms of a runway surface condition description for the approved operational envelope for takeoff.
- 6.2 Data for the runway surface condition descriptions contained in table 1 below should be included.

Table 1. Runway Surface Condition—Descriptions and Contaminant Categories

Runway Surface Condition Description	Contaminant Category
Dry	—
Wet	—
Ice	Solid contaminant
Compacted snow	Solid contaminant
Dry snow	Loose contaminant
Wet snow	Loose contaminant
Slush	Loose contaminant
Water	Loose contaminant

- 6.3 For loose contaminants, data should be supplied for the reportable contaminant depths identified in FAA Order JO 7930.2Q (or later revision) up to the maximum contaminant depth for each of these contaminants. Due to issues of potential structural damage from spray impingement, engine ingestion, and significant effects on acceleration capability, the recommended maximum depth for takeoff operations for slush and water is ½ inch (13 mm) unless greater depths are shown to be free of structural damage and engine ingestion issues.

7 **DETERMINATION OF CONTAMINATED RUNWAY TAKEOFF PERFORMANCE DATA.**

- 7.1 Contaminated runway takeoff performance data is determined by calculation, using the takeoff performance model developed from flight tests and used to show compliance with the takeoff performance requirements in subpart B, as modified by the guidance provided in this AC.
- 7.2 Except for the effects of the contaminant on braking friction and drag, the takeoff performance requirements of subpart B applicable to a wet runway should be used in developing the contaminated runway takeoff performance data. This includes the definitions of takeoff distance (§ 25.113(a)(2) and (b)) and takeoff run (§ 25.113(c)(2)) in terms of the height at the end of the takeoff distance and lack of credit for clearway.
- 7.3 For all types of contaminants, the entire runway surface is assumed to be 100 percent covered by the contaminant.
- 7.4 For loose contaminants, the depth and specific gravity of the contaminant is assumed to be uniform.
- 7.5 The wheel braking coefficients that should be used for each type of contaminant are contained in table 2 of this AC.

Note: The wheel braking coefficients table 2 of this AC were determined by the TALPA ARC part 25 working group, based on their experience and accepted performance levels on different surfaces as defined by aircraft certification agencies (e.g., EASA). They were verified to the greatest degree possible by the latest industry flight testing as embodied by the Joint Winter Runway Friction Program, which was active from 1995 to 2004. This AC may be revised if future industry-level acceptance of new information becomes available.

Table 2. Wheel Braking Coefficients as a Function of Runway Surface Condition

Runway Surface Condition Description	Wheel Braking Coefficient
- Frost - Wet (includes damp and 1/8" (3 mm) depth or less of water) 1/8" (3 mm) depth or less of: - Slush - Dry snow - Wet snow	Per method defined in § 25.109(c).
-15 °C and colder outside air temperature: Compacted snow	0.20 ¹
- Wet ("slippery when wet" runway) - Dry snow or wet snow (any depth) over compacted snow Greater than 1/8" (3 mm) depth of: - Dry snow - Wet snow Warmer than -15 °C outside air temperature: - Compacted snow	0.16 ¹
Greater than 1/8" (3 mm) depth of: - Water - Slush	(1) For speeds below 85% of the hydroplaning speed ² : 50% of the wheel braking coefficient determined in accordance with § 25.109(c), but no greater than 0.16; and (2) For speeds at 85% of the hydroplaning speed ² and above: 0.05 ¹ .
Ice	0.08 ¹

¹ These wheel braking coefficients assume a fully modulating anti-skid system. For quasi-modulating systems, multiply the listed braking coefficient by 0.625. For on-off systems, multiply the listed braking coefficient by 0.375. (See AC 25-7C to determine the classification of an anti-skid system.) Airplanes without anti-skid systems will need to be addressed separately on a case-by-case basis.

² The hydroplaning speed, V_p , may be estimated by the equation $V_p = 9\sqrt{P}$, where V_p is the ground speed in knots and P is the tire pressure in lb/in².

8 ACCOUNTING FOR THE DRAG OF LOOSE CONTAMINANTS.

8.1 Loose contaminants (see table 1 of this AC for classification of contaminants) result in additional drag due to the combination of displacement of the contaminant by the airplane tires and impingement of the contaminant spray on the airframe. This contaminant drag provides an additional force impeding acceleration during a takeoff, or assisting deceleration during a rejected takeoff. The actual contaminant depth is likely to be less than the reported depth for the following reasons:

8.1.1 Contaminant depths are reported in field condition reports using specific depth increments as specified in FAA Order JO 7930.2Q (or later revision).

8.1.2 The procedure for reporting contaminant depths is to report the highest depth of the contaminant along the reported portion of the runway surface. Contaminant depths are

unlikely to be uniform over the runway surface (or reported portion of the runway surface), so it is likely there will be areas of lesser contaminant depth.

- 8.1.3 Data should be provided for the specific gravities in the table 3 below.

Table 3. Loose Contaminant Specific Gravity

Runway Description	Specific Gravity
Dry Snow	0.2
Wet Snow	0.5
Slush	0.85
Water	1.0

- 8.2 If the actual contaminant depth is less than the reported value, then using the reported value to determine contaminant drag will result in a higher drag level than actually exists, leading to a conservative takeoff distance and takeoff run, but a potentially optimistic accelerate-stop distance. It is assumed that these effects will offset each other; however, the FAA recommends that data providers consider using 50 percent of the reported contaminant depth when determining both the accelerate and stop portion of the accelerate-stop distance. This will result in a conservative computation of the resultant takeoff distance without being unduly penalizing. The applicant should check to ensure that using half of the contaminant drag for the accelerate-stop computation is conservative for the applicant's airplane configuration.
- 8.3 The FAA finds acceptable the methods for calculating contaminant drag described in EASA AMC 25.1591. Data providers may also use a method that was previously accepted by EASA or has been validated by suitable analysis or test data.
- 8.4 The effect of contaminant drag between rotation and liftoff can be addressed using one of two methods, as described below. There are advantages and disadvantages with each method, but either may be used if supported by an analysis that includes the assumptions used and rationale.
- 8.4.1 Method 1.
Retain the rotation speed (V_R) used for an uncontaminated runway, but adjust the distance from V_R to the end of the takeoff distance due to the increase in distance needed for attaining the takeoff safety (V_2) speed. With this method, there may be a reduction in the speed difference between the liftoff speed (V_{LOF}) and the minimum unstick speed (V_{MU}). Therefore, it should be verified that compliance with § 25.107(e) is maintained.

8.4.2 Method 2.

Increase V_R to ensure that the normal V_{LOF} speed is attained. With this method, the V_{LOF} speed margins to V_{MU} are maintained.

- 8.5 It is recommended that data providers consider the effects of directional controllability associated with crosswind and other factors, such as airplane gross weight, center of gravity position, and takeoff thrust setting. Recommendations or guidelines should be provided to operators to mitigate the effects of these items on directional controllability for different runway conditions. Minimum V_1 and/or crosswind guidance may need to be adjusted in consideration of the reduced controllability following engine failure on a contaminated runway.

9 **CREDIT FOR REVERSE THRUST.**

Accelerate-stop distances associated with contaminated runway takeoff performance data may include credit for the stopping force provided by reverse thrust, subject to meeting the following criteria:

- 9.1 Procedures for using reverse thrust during a rejected takeoff on a contaminated runway should be consistent with the normal procedures for use of reverse thrust during a rejected takeoff on an uncontaminated runway. The procedures should include all of the pilot actions necessary to obtain the recommended level of reverse thrust, maintain directional control and safe engine operating characteristics, and return the reverser(s), as applicable, to either the idle or the stowed position.
- 9.2 Using reverse thrust during a rejected takeoff on a contaminated runway should comply with the engine operating characteristics requirements of § 25.939. The engine should not exhibit any of the adverse engine operating characteristics described in AC 25.939-1 (or later revision). The reverse thrust procedures may specify a speed at which the reverse thrust is to be reduced to idle in order to maintain safe engine operating characteristics.
- 9.3 The time sequence for the actions necessary for the pilot to select the recommended level of reverse thrust should be achievable by the average pilot.
- 9.4 The response times of the affected airplane systems to pilot inputs should be taken into account. For example, delays in system operation, such as thrust reverser interlocks that prevent the pilot from applying reverse thrust until the reverser is deployed, should be taken into account. The effects of transient response characteristics, such as reverse thrust engine spin-up, should also be included.
- 9.5 To enable a pilot of average skill to consistently obtain the recommended level of reverse thrust under typical in-service conditions, a lever position that incorporates tactile feedback (for example, a detent or stop) should be provided. If tactile feedback is not provided, a conservative level of reverse thrust should be assumed.

- 9.6 If the data provider chooses to develop data using the process described in this AC, the effects of crosswinds on directional controllability should be assessed and particular attention paid to the possibility of reverse thrust affecting airflow over the rudder and vertical tail surface. Thrust reverser use may even reduce directional controllability in combinations of crosswinds and low friction conditions. Recommendations or guidelines associated with crosswind takeoffs, including maximum recommended crosswinds, should be provided to operators for the runway surface conditions for which takeoff performance data are provided. A suitable simulation may be used to develop these guidelines for operation on contaminated runways.
- 9.7 If the data provider, in using the process described in this AC, applies credit for asymmetric reverse thrust, then controllability should be accounted for in that configuration. The reverse thrust procedures may specify a speed at which the reverse thrust is reduced to idle in order to maintain directional controllability.
- 9.8 The failure of the thrust reverser to function should be on the order of 10^{-4} or less per takeoff. This specific reliability requirement applies to both single and combinations of failures and takes into account interlock features intended to prevent inadvertent in-flight deployment.
- 9.9 The effective stopping force provided by reverse thrust in each, or at the option of the data provider, the most critical takeoff configuration, should be established by flight test. (One method of determining the reverse thrust stopping force would be to compare unbraked runs with and without the use of thrust reversers.) Regardless of the method used to calculate the effective stopping force provided by reverse thrust, flight tests should be conducted using all of the stopping means on which the accelerate-stop distances are based in order to calculate those distances and ensure that no adverse combination effects are overlooked. These tests may be conducted on a dry runway.
- 9.10 For turbopropeller powered airplanes, the guidance in paragraphs 9.1 through 9.9 above remain generally applicable. Additionally, the propeller of the inoperative engine should be in the position it would normally assume when an engine fails and the power lever is closed. Reverse thrust may be selected on the remaining engine(s). Unless this selection is achieved by a single action to retard the power lever(s) from the takeoff setting without encountering a stop or lockout, it should be regarded as an additional pilot action for the purposes of assessing delay times.
- 10 **GUIDANCE FOR EXISTING TYPE DESIGNS.**
The guidance in this section applies to data already produced to support airplane models already in service.
- 10.1 The following information is intended to facilitate the use of existing data to the maximum extent possible, in order to limit the burden associated with developing and producing new data packages.
- 10.2 Contaminated runway takeoff performance data approved by either the Joint Aviation

Authorities or EASA in compliance with either their contaminated runway type certification or operating requirements are acceptable when using the optional process identified in this AC, with the caveats provided in paragraphs 10.2.1 and 10.2.2 below. The FAA recognizes that such data may not be consistent with the guidance provided in this AC in terms of braking coefficients associated with each runway surface condition description and the magnitude of the contaminant drag for loose contaminants.

- 10.2.1 Data providers should develop data that account for all of the runway surface condition descriptions identified in table 2 of this AC (unless operating limitations prohibit operations on runway surface conditions for which data are not provided).
- 10.2.2 Definitions of the runway surface conditions should be consistent with the definitions provided in this AC. In particular, a damp runway is to be considered wet for airplane performance purposes.
- 10.3 Reverse thrust credit may be included without specifically accounting for reliability or controllability. However, reverse thrust credit should not be used if service history for a particular airplane model indicates unresolved reliability or controllability issues.

11 **DOCUMENTATION.**

11.1 **Data Location.**

The data provider may furnish the contaminated runway takeoff performance data in the airplane flight manual, flightcrew operating manual, quick reference handbook, electronic flight bag, and/or other appropriate locations.

11.2 **Data Label.**

If the data provided is not certified or approved by a certification agency, it should be labeled as “Advisory Data Only” or similar wording.

11.3 **Other Information.**

If a data provider develops contaminated runway takeoff performance data described in this AC, the following information should also be provided:

- 11.3.1 Instructions for use of the data.
- 11.3.2 Definitions of the different runway surface conditions.
- 11.3.3 Recommendations prohibiting taking off on runways with contaminants and depths not covered in the performance data.
- 11.3.4 Any other recommendations associated with use of the contaminated runway takeoff performance data.
- 11.3.5 Statements that the data are based on a uniform depth (for loose contaminants) and uniform coverage of a layer of contaminant with uniform properties throughout.

Advisory Circular Feedback

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) emailing this form to 9-AWA-AVS-AIR500-Coord@faa.gov or (2) faxing it to the attention of the Aircraft Certification Service Directives Management Officer at (202) 267-3983.

Subject:

Date:

Please check all appropriate line items:

An error (procedural or typographical) has been noted in paragraph _____ on page _____. .

Recommend paragraph _____ on page _____ be changed as follows:

In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

Other comments:

I would like to discuss the above. Please contact me.

Submitted by:

Date: