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

# Advisory Circular

**Subject:** Runway Overrun Prevention | **Date:** 11/06/07 | **AC No:** 91-79
**Initiated by:** AFS-800 | **Change:**

**1. PURPOSE.** This advisory circular (AC) provides ways for pilots and operators of turbine-powered airplanes to identify, understand, and mitigate risks associated with runway overruns during the landing phase of flight. It also provides operators with detailed information that may be used to develop company standard operating procedures (SOP) to mitigate those risks.

**2. AUDIENCE.**

**a.** This document provides guidance to flightcrews, aircraft operators, certificate holders, program managers, training providers, and pilot examiners that conduct turbine-powered airplane operations or provide support services to such operations. These concepts also apply to other types of airplane operations, and some operators must adhere to more restrictive guidance based on their applicable operations or management specifications.

**b.** Turbine aircraft operators, certificate holders, program managers, training centers, and other support providers should adopt the recommended procedures found in this AC to help mitigate the risk of runway overruns. This should include the creation or revision of SOP, training programs and courseware, and company policies and procedures to reinforce the risk mitigation strategies. For Title 14 of the Code of Federal Regulations (14 CFR) part 91 subpart K, part 121, 125, or 135 operators, these procedures and programs should be incorporated into the certificate holder's or program manager's operations manual system as appropriate. Part 91 turbine operators are encouraged to review this material and to include it in the applicable company documents.

**3. RELATED READING MATERIAL (current editions).**

**a.** AC 25-7, Flight Test Guide for Certification of Transport Category Airplanes.

**b.** AC 60-22, Aeronautical Decision Making.

**c.** AC 120-71, Standard Operating Procedures for Flight Deck Crewmembers.

**d.** AC 121.195-1, Operational Landing Distances for Wet Runways; Transport Category Airplanes.

**e.** Notice 8000.340, Revision of Order 8400.10, Volume 4, Chapters 1 and 2.

**f.** FAA-H-8083-3A, Airplane Flying Handbook.

**4. BACKGROUND.** According to Federal Aviation Administration (FAA) and National Transportation Safety Board (NTSB) information, runway overruns during the landing phase of flight account for approximately 10 incidents or accidents every year with varying degrees of severity, with many accidents resulting in fatalities. The FAA is working in partnership with industry to develop strategies to reduce the number of landing overrun incidents/accidents. A review of runway overrun events indicates that most occur due to either a lack of or nonadherence to SOP. These events continue to occur despite efforts by the FAA and industry to ensure that operators develop SOPs and that flight crewmembers are properly trained and operate in accordance with the SOPs. Therefore, an emphasis on SOP development and a risk mitigation approach is employed in this AC.

**a.** Focused training and testing of crewmembers along with practical planning tools are the keys to avoiding runway overrun events. This emphasis on training and checking should be targeted at initial pilot certification as well as recurrent training and checking events. The training and checking should not be merely academic in nature. These events should emphasize real world aeronautical decision making and use scenario based presentations in order to increase pilot recognition of high risk landing operations.

**b.** Proper identification of the risks will help pilots employ mitigation strategies or eliminate certain risks prior to the landing event.

**c.** Operators are responsible for developing SOPs, and all pilots are responsible for ensuring that they are well-trained, qualified for the intended flight, and meet all of the regulatory requirements for the flight. This responsibility includes the self-discipline to follow company SOPs and/or industry best practices and safety procedures that can prevent runway overrun incidents/accidents regardless of the level of managerial or government oversight. Even the best procedures are ineffective if they are not followed.

**5. DISCUSSION.** This AC is divided into three areas. The first area, in paragraph 6, discusses hazards associated with runway overruns. The second area, in paragraph 7, presents some risk mitigation strategies associated with these hazards. The strategies include the development of SOPs, elements of training course content, checking techniques, and some rules-of-thumb for evaluating the effects of certain conditions on landing distance. The third area, the appendices, provides a centralized source of supporting information useful in developing the training suggested.

**6. HAZARDS ASSOCIATED WITH RUNWAY OVERRUNS.** In order to develop risk mitigation strategies and tools, hazards associated with runway overruns must be identified. A study of FAA and NTSB data indicates that the following hazards increase the risk of a runway overrun:

- A nonstabilized approach,
- Excess airspeed,

- Landing beyond the intended touchdown point, and
- Failure to assess required landing distance to account for slippery or contaminated runway conditions or any other changed conditions existing at the time of landing.

**a. Nonstabilized Approach.** Safe landings begin long before touchdown. Adhering to the SOPs and best practices for stabilized approaches will always be the first line of defense in preventing a runway overrun. A discussion of stabilized approaches is located in Appendix A, paragraph 3.

**b. Excess Airspeed.** $V_{REF}$ is the reference landing approach speed at the landing screen height of 50 feet. This speed is used by pilots as a base from which to calculate speeds used during landing. The reference speed is calculated as a margin over the stall speed. Many part 25 airplanes are certified using a $V_{REF}$ of $1.23 \times V_{SRO}$ where $V_{SRO}$ is the stall speed for the landing configuration. While there are specific circumstances, such as strong gusty wind conditions and potential wind shear environments where adjusting the approach speed is appropriate, it is often done in an arbitrary manner that adversely affects the landing performance of the airplane. The manufacturer's recommended procedure for many part 25 airplanes is to use an approach speed of $V_{REF} + 5$ for both manual landings and autolands. If the additional speed is not bled off by the landing screen height of 50 feet., the added speed is not accounted for in the calculation of runway landing distance required, and the added speed significantly increases the risk of a runway overrun. It is important to understand how the approach speeds are determined and to fly them accordingly to obtain the desired landing performance of the airplane.

**c. Landing Beyond the Intended Touchdown Point.** Aircraft Flight Manual (AFM) landing performance data usually assumes a touchdown point determined through flight testing procedures outlined in AC 25-7A. If the airplane does not touch down at the intended touchdown point or an allowance is not made for the longer touchdown point, it will not be possible to achieve the calculated landing distance.

**d. Failure to Assess Required Landing Distance Based on Conditions at Time of Arrival.**

**(1)** Conditions at the destination airport may change between the time of departure and the time of arrival. SOPs should include a procedure for assessing the required landing distance based on the conditions that are known to exist as you near the destination. As a recommended practice, calculate and discuss the landing distance required after receipt of the automated terminal information service (ATIS), during the descent briefing, and prior to the top of descent. If airport and associated runway surface conditions are forecast to worsen, develop an alternate plan of action in the event that a missed approach or go around becomes necessary.

**(2)** The unfactored landing distances in the manufacturer-supplied AFM reflect performance in a flight test environment that is not representative of normal flight operations. The operating regulations require the AFM landing distances to be factored when showing compliance with the predeparture landing distance requirements. These factors are intended to account for pilot technique, atmospheric and runway conditions, and other items to ensure that the flight is not dispatched to a destination where it will be unable to land. As part of the operator's Safety Management System (SMS) and SOP, the FAA recommends using either factored landing distances or adding a safety margin to the unfactored landing distances when assessing the required landing distance at the time of arrival. This landing safety margin should not be confused with the regulatory predeparture runway requirements.

> **NOTE: Operators should use the appendices, which contain detailed information about all of these hazards, to develop their SOPs. The 15 percent safety margin additive recommended by the FAA is intended only to account for slight variations in achieved performance.**

## 7. RISK MITIGATION.

**a. SOPs.** Well-developed SOPs are the primary risk mitigation tools used to prevent runway overruns. These procedures must be relevant and focused on the end user—the flightcrew. Once SOPs are developed, it is imperative that the flightcrew execute them faithfully to help prevent runway overruns. As a minimum, the SOPs should contain the following procedures directly related to runway-overrun prevention:

- Stabilized approaches, including procedures for executing a go-around if the approach parameters are outside of the stabilized approach criteria,
- Landing distance reassessment at the time of arrival, and
- Use of brakes and other deceleration devices.

**b. Training.** An effective training program is a secondary tool that provides academic knowledge about the subjects related to landing performance. Effective training also reinforces the practical application of the knowledge and the associated SOPs in the cockpit. At a minimum, the operator's training program should contain the following elements directly related to runway-overrun prevention:

- SOPs-operator specific;
- Stabilized approaches;
- Source and conditions of landing distance data contained in aircraft flight manuals or FAA approved destination airport analysis (airplane type specific);
- Landing distance calculation—preflight;
- Landing distance calculation—reassessment at time of arrival;
- Consequences of excess airspeed;
- Consequences of landing beyond the intended touchdown point;
- Use of brakes to include autobrakes, if installed, and deceleration devices (airplane type specific);

- Landing distance rules of thumb; and
- Reasons to initiate a go-around and execution of the go-around maneuver.

This training should be incorporated into type rating training, air carrier training, and into 14 CFR part 61, § 61.55 training conducted at a 14 CFR part 142 training center.

**c. Checking.** Effective checking that emphasizes the subject of aircraft landing performance is an essential tool in preventing runway overruns. Examiners, instructors, and check airman should specifically stress aeronautical decision making and risk management scenarios that incorporate potential runway overruns during the following evaluations:

- Type Rating Practical Tests;
- Pilot in Command Proficiency Checks (14 CFR parts 61, 91K, 121, 125, 135);
- Pilot Proficiency and Competency Checks (parts 61, 91K, 121, 125, 135); and
- Part 61, § 61.56, Flight Reviews.

**NOTE: Runway overrun mitigation strategies should be introduced during flight training and checking to ensure the applicant can apply the principles in a real world environment. For example, the introduction of a scenario incorporating an unexpected change in wind direction, or a change in wind speed, the landing runway, or a change in the runway surface condition would require the applicant to reassess the landing performance. The instructor or the examiner would quickly determine if the applicant has a grasp of the principles and their effect on the safety of the landing. Specific questions should be asked during oral or written examinations to ascertain the applicant's ability to apply the knowledge in a practical matter.**

**d. Rules of Thumb.** The following "rules of thumb" are included to assist the pilot in the application of basic knowledge in order to reinforce the principles associated with runway overrun prevention.

**NOTE: These rules of thumb cannot replace the information contained in the AFM. They are provided to help the flight crewmember recognize the possible increase in risk associated with certain conditions.**

**TABLE 1. CAN U STOP?**

| CAN U STOP? | |
|---|---|
| **C–Calculate** | Use the manufacturer's or company data to determine the landing distance required prior to departure and again prior to landing based on company SOPs. Use the appropriate factors and be sure to consider dry/wet runways and associated contamination, planned touchdown point and speed over the landing threshold, wind speed and direction, inoperative equipment, and special cases. |
| **U–Understand** | The manufacturer's AFM landing data is baseline data, and it is derived based on flight test data. Factors should be applied to the data to adjust it for the current conditions. Pilots should adhere to the operator's SOPs and best operating practices which will result in the safest aeronautical decision making. |
| **S–Stabilize** | Ensure that you understand all the requirements of a stabilized approach and you are able to fly one given the actual conditions. If not—*GO AROUND!* |
| **P–Professional** | Land like a professional using the aircraft's capabilities as described in the AFM and SOPs. *A professional puts safety ahead of style.* |

**TABLE 2. "RULE OF THUMB" ON LANDING DISTANCE CALCULATIONS**

| Condition | Possible Effect on Landing Distance |
|---|---|
| **Non-stabilized Approach** | Unpredictable |
| | |
| **Excess Airspeed** | |
| **Dry Runway** | Additional 300 feet per 10 knots |
| **Wet Runway** | Additional 500 feet per 10 knots |
| **Extended Flare (Floating)** | Additional 2500 feet per 10 knots |
| | |
| **Normal Airspeed** | |
| **Negative Runway Slope** | Additional 10 percent of landing distance per 1 percent downhill slope |
| **Delayed Touchdown** | Additional 230 feet per second (fps) |
| **Excessive TCH** | Additional 200 feet per 10 feet above TCH |
| **Delayed Braking** | Additional 220 fps |

**NOTE: These rules of thumb are compiled from the textual material presented in FAA-H-8083-3A. The values contained in Table 2 are not intended to replace data provided by either the manufacturer or the company to perform calculations with the accuracy required for certification or FAA approval. They are intended as a quick reference for pilots making a landing or go-around decision based on previously calculated landing distances. A practical application of these values is shown in Table 3, Sample Landing Distance Worksheet for Part 91 Operations.**

**TABLE 3. SAMPLE LANDING DISTANCE WORKSHEET FOR PART 91 OPERATIONS**

| | |
|---|---|
| 1. Un-factored AFM landing distance (dry runway) (Baseline data) | 3000 |
| 2. Airspeed additive to be held to the landing threshold, e.g. all of the gust. Max additive of 20 knots. Landing distance increase:<br>Dry runway: 20-30 feet per knot<br>Wet runway: 40-50 feet per knot<br>Extended flare: 250 feet per knot | (5 knot additive)<br>250<br>1250 |
| 3. Add 2 seconds flare time due to gusty winds (results in a 230 ft/sec additive) | 460 |
| 4. Night–No glide path–<br>Assume a 10 foot error. (Add 200 feet to the landing distance) | 200 |
| 5. Any additions caused by minimum equipment list (MEL)/ Configuration Deviation List (CDL) requirements | 500 |
| 6. Subtotal | 5660 |
| 7. Runway condition<br>If wet, add 15 percent of line 6 or use AFM data if available | 850 |
| 8. Contaminated runway adjustment to line 6 per AFM and SOPs | |
| 9. Less than maximum braking<br>Add 20 percent of line 6 or use AFM data if available | 1130 |
| 10. Total of $6+7+8+9$ | 7640 |

**8. REQUESTS FOR INFORMATION.** Contact the General Aviation and Commercial Division, AFS-800, at (202) 267-8212 with questions about the content of this AC.

ORIGINAL SIGNED by

James J. Ballough
Director, Flight Standards Service

# APPENDIX 1. ADDITIONAL INFORMATION

**1. ORGANIZATION.** This appendix divides the discussion of runway overruns during the landing phase of flight into four broad categories:

- Definitions
- The necessity to fly a stabilized approach to the touchdown point
- A discussion of landing performance data
- Landing and braking techniques

**2. DEFINITIONS.**

**a. Actual Landing Distance.** The certified landing distance adjusted for the reported meteorological and runway surface conditions, runway slope, airplane weight, airplane configuration, approach speed, use of auto land or a heads-up guidance system (HUD), and ground deceleration devices planned to be used for the landing. It does not include any safety margin and represents the best performance the airplane is capable of for the conditions.

**b. Braking Action Reports.** The following braking action reports are widely used in the aviation industry and are furnished by air traffic controllers when available. The definitions provided below are consistent with how these terms are used in this guidance. In October 2006, the Federal Aviation Administration (FAA) hosted a Runway Condition Determination, Reporting, and Report Dissemination Workshop. The workshop's Common Terms and Definition Working Group developed a braking action document of standardized definitions and estimated correlations based on runway surface conditions and runway friction Mu values. The following information was developed by this joint industry/FAA group:

**(1) Pilot Weather Report (PIREP).** When braking action conditions less than Good are encountered, pilots are expected to provide a PIREP based on the definitions provided in the table below. Until FAA guidance materials are revised to replace the term Fair with Medium, these two terms may be used interchangeably. The terms "Good to Medium" and "Medium to Poor" represent an intermediate level of braking action, not a braking action that varies along the runway length. If braking action varies along the runway length, such as the first half of the runway is Medium and the second half is Poor, clearly report that in the PIREP (e.g., "first half Medium, last half Poor").

**(2) Correlating Expected Runway Conditions.** The correlation between different sources of runway conditions (e.g., PIREPs, runway surface conditions and Mu values) *are estimates*. Under extremely cold temperatures or for runways that have been chemically treated, the braking capabilities may be better than the runway surface conditions estimated below. When multiple sources are provided (e.g., braking action medium, runway covered with ice and runway Mu is 27/30/28) conflicts are possible. If such conflicts occur, consider all factors including data currency and the type of airplane a PIREP was given from. A valid PIREP or runway surface condition report are more reliable indicators of what to expect than reported runway Mu values.

**(3)** Runway Friction Mu Reports. Mu values in the U.S. are typically shown as whole numbers (40) and are equivalent to the ICAO standard decimal values (.40). Zero is the lowest friction and 100 is the highest Mu friction. When the Mu value for any one third zone of an active runway is 40 or less, a report should be given to ATC by airport management for dissemination to pilots. The report will identify the runway, the time of measurement, the type of friction measuring device used, Mu values for each zone and the contaminant conditions (e.g., wet snow, dry snow, slush, deicing chemicals). While the table below includes information published by ICAO correlating runway friction measurements to estimated braking actions, the FAA cautions that *no reliable correlation exists* and Mu readings are only provided to show the relationship used in other countries which is not supported by the FAA in the United States or for use by U.S. operators operating in foreign countries. Early runway friction measuring device testing for use in determining aircraft runway braking capability indicated that they might generate a value of high correlation, however after more extensive testing it as been determined that no correlation exist between a Mu reading and an aircrafts braking capability. The FAA no longer supports using Mu values *alone* in estimating the aircraft braking capability. Mu values are best used to indicate trend in runway friction capability, however this is usable only if historic Mu values for the same runway surfaces are known which is not normally available to flightcrews or flight operation centers. Runway Mu values *can vary significantly* for the same contaminant condition due to measuring techniques, equipment calibration, the effects of contamination on the friction measuring device and the time passage since the measurement. Therefore, *do not* base landing distance assessments solely on runway Mu friction reports. If Mu is the only information provided, attempt to ascertain the depth and type of runway contaminants, or aircraft braking action report to make a better assessment of actual conditions, Mu values alone may significantly overstate aircraft braking potential.

## TABLE 1. FAA/INDUSTRY AGREED UPON BRAKING ACTION DEFINITIONS

| Braking Action | | Estimated Correlations | | |
|---|---|---|---|---|
| **Term** | **Definition** | **Runway Surface Condition** | **ICAO** | |
| | | | **Code** | **Mu** |
| **Good** | Braking deceleration is normal for the wheel braking effort applied.<br>Directional control is normal. | Water depth of 1/8” or less<br>Dry snow less than ¾” in depth<br>Compacted snow with OAT at or below 15 degreesC | 5 | 40 & above |
| **Good to Medium** | | | 4 | 3936 |
| **Medium (Fair)** | Braking deceleration is noticeably reduced for the wheel braking effort applied.<br>Directional control may be slightly reduced. | Dry snow ¾” or greater in depth<br>Sanded snow<br>Sanded ice<br>Compacted snow with OAT above 15 degreesC | 3 | 35–30 |
| **Medium to Poor** | | | 2 | 2926 |
| **Poor** | Braking deceleration is significantly reduced for the wheel braking effort applied.<br>Potential for hydroplaning exists.<br>Directional control may be significantly reduced. | Wet snow<br>Slush<br>Water depth more than 1/8”<br>Ice (not melting) | 1 | 2521 |
| **Nil** | Braking deceleration is minimal to nonexistent for the wheel braking effort applied.<br>Directional control may be uncertain.<br>**NOTE: NOTE: Taxi, takeoff, and landing operations in Nil conditions are prohibited.** | Ice (melting )<br>Wet Ice | 9 | 20 & below |

**NOTE: Conditions specified as “Nil” braking action are not considered safe. Do not operate on surfaces reported as Nil. Further, the ICAO term “Unreliable” approximates Nil.**

**c. 500-Foot Window.** The 500-foot window is an imaginary window positioned along the approach path 500 feet above the target touchdown point and aligned with the extended runway centerline.

**d. 1,000-Foot Window.** The 1,000-foot window is an imaginary window positioned along the approach path 1,000 feet above the target touchdown point for an instrument approach.

**e. Aiming Point.** The aiming point is the point on the ground at which, if the airplane maintains a constant glide path, and does not execute the round out (flare) maneuver for landing, it would touch the ground.

**f. Incipient Skid.** Operation at the peak of the Mu-slip curve gives the highest braking efficiency. If the level of braking is increased until just prior to tire skid, the coefficient of friction, Mu, can no longer support the force being applied. At the point just prior to tire slip, operation at the peak of the Mu-slip curve gives the highest braking efficiency.

**g. Landing Distance Available.** The length of the runway declared available for landing. This distance may be shorter than the full length of the runway.

**h. Maximum Braking Effort.** Maximum braking effort is defined as maximum brake application by the pilot.

**i. Adjusted Landing Distance.** Is the actual landing distance adjusted for a landing safety margin in accordance with the operator's SOP ? (This should not be confused with the dispatch requirements.)

**j. Target Touchdown Point.** As discussed in FAA-H-8083-3A, the target touchdown point is defined as a touchdown point approximately 1,000 feet down the runway, after which maximum braking effort must be applied if the manufacture's predicted landing distance is to be obtained. Additionally, the operator may define the desired target touchdown point in the operator's SOP.

**k. Touchdown Zone.** As referenced in the Air Traffic Rules and Procedures Service (ATP) Practical Test Standards Guide, the touchdown zone is defined as a point 500-3,000 feet beyond the runway threshold not to exceed the first one-third of the runway. This definition is not used in landing distance performance calculations. The touchdown zone for certification may be as short as the point where a 3.5 degrees glidepath passing 50 feet over the landing threshold, intercepts the runway surface, which is 820 feet past the landing threshold.

**l. Stabilized Approach Concept.** The stabilized approach concept is one in which the pilot establishes and maintains a constant angle glide path, towards a predetermined point on the landing runway. It is based on the pilot's judgment of certain visual cues, and depends on establishing and maintaining a constant final descent airspeed, a constant descent rate, and a specific aircraft configuration.

**m. Runway Overrun Event.** A runway overrun event is a departure of the aircraft from the end of the intended landing runway surface.

**n. Correct Lateral Track.** A correct lateral track is one in which the correct localizer, radial, or other track guidance has been set, tuned and identified, and is being followed by the pilot. Electronic lateral guidance should be utilized whenever provided, even in visual meteorological conditions (VMC). A correct lateral track, when no electronic guidance is provided, is a track along the extended runway centerline and is being tracked by the pilot.

**o. Correct Vertical Track.** A correct vertical track is one in which the correct glide slope, vertical navigation (VNAV), or other track guidance has been set, tuned and identified, and is being followed by the pilot. A correct vertical track, when no electronic vertical guidance is provided, is a vertical track provided by visual vertical guidance (e.g., Visual Approach Slope Indicator (VASI) or precision approach path indicator (PAPI)) and is being tracked by the pilot.

Electronic or visual vertical guidance should be utilized whenever provided, even in VMC. A correct vertical track, in the absence of electronic or visual vertical guidance is a vertical glide path angle of approximately 3 degrees.

**p. Normal Bracketing Corrections.** Normal bracketing corrections relate to small corrections in airspeed, rate of descent, and variations from the lateral and vertical path. Recommended ranges are as follows (operating limitations in the approved aircraft flight manual (AFM) must be observed, and may be more restrictive):

**(1)** Rate of descent ±300 feet per minute (fpm) deviation from the target descent rate.

**(2)** Airspeed ±5 knots indicated airspeed (KIAS) variance from the planned approach speed.

**(3)** Normal bracketing corrections occasionally involve momentary overshoots made necessary by atmospheric conditions. Such overshoots are acceptable. Frequent or sustained overshoots are not normal bracketing corrections and are not acceptable.

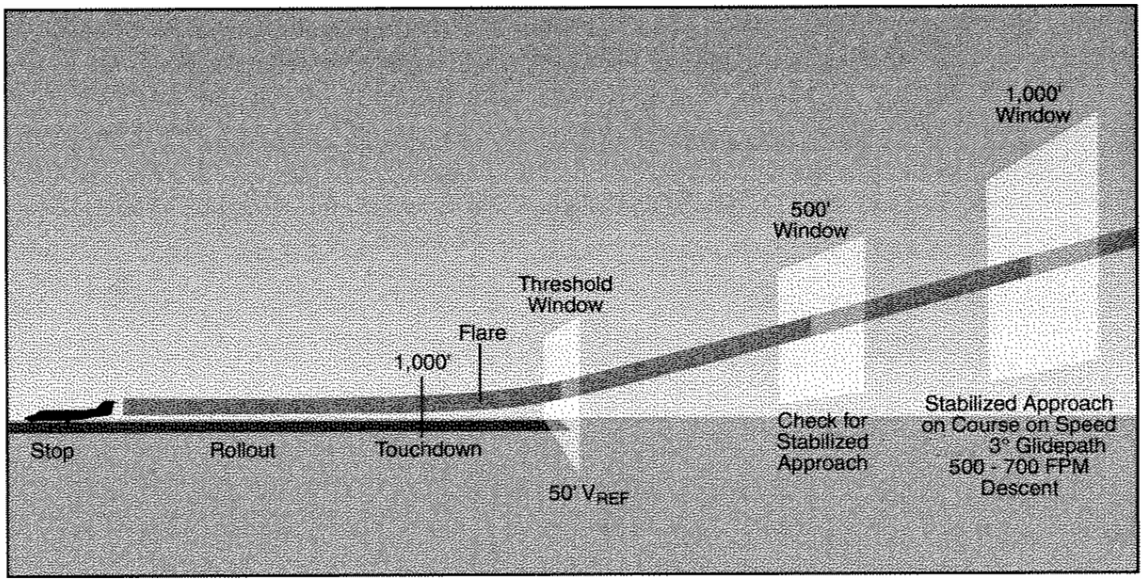
**q. Bank Angle.** As referenced in Advisory Circular (AC) 120-71A, Standard Operating Procedures for Flight Deck Crewmembers, maximum bank angle permissible during approach is specified in the approved AFM or pilot's operating handbook (POH), as applicable, and is generally not more than 30 degrees; the maximum bank angle permissible during landing may be considerably less than 30 degrees, as specified in the applicable manual.

**r. Unfactored or Certified Landing Distance**. The landing distance determined during certification as required by 14 CFR part 23, § 23.75 and part 25, § 25.125. The unfactored landing distance is not adjusted for any safety margin additives. The unfactored certified landing distance may be different from the actual landing distance because not all factors affecting landing distance are required to be accounted for by certification regulations. For example, the unfactored certified landing distances are based on a dry, level (zero slope) runway at standard day temperatures, and do not normally take into account the use of auto brakes, auto-land systems, head-up guidance systems, or thrust reversers. This is considered the baseline landing distance from which all subsequent user calculations emanate.

**s. Factored Landing Distance.** The unfactored certified dry landing distance adjusted for airport and aircraft conditions, and then multiplied by the appropriate factor to satisfy a regulatory predeparture requirement. For example: $[(\text{AFM unfactored dry landing distance} + \text{MEL/CDL penalties}) \times 1.67 = \text{factored dry runway landing distance}]$.

**3. STABILIZED APPROACH CONCEPT.** A stabilized approach is the safest profile, and it is one of the most critical elements of a safe approach and landing operation. There are five basic elements to the stabilized approach:

**FIGURE 1. STABILIZED APPROACH**




**a. Landing Configuration.** The airplane should be in the landing configuration early in the approach. The landing gear should be down, landing flaps selected, trim set, and fuel balanced per the AFM or POH, as applicable. Landing checklist items should be completed. Ensuring that these tasks are completed will help keep the number of variables to a minimum during the final approach.

**b. Stabilize on Profile.** The airplane should be stabilized on profile before descending through the 1,000-foot window in inadvertent instrument meteorological condition (IMC) or through the 500 feet. above touchdown zone elevation (TDZE) window in VMC. Configuration, trim, speed, and glidepath should be at or near the optimum parameters early in the approach to avoid distractions and conflicts as the airplane nears the threshold window. The electronic or visual glide path or an optimum glide path angle of 3 degrees should be established and maintained. For the purposes of this AC, approaches that require a glidepath angle greater than 3 degrees as "special case." The airplane must be in the proper landing configuration, on the correct track, on the correct lateral track, the correct vertical track and the airspeed within the acceptable range specified in the AFM or POH, as applicable. It should be noted, as it applies to stabilized approaches, that following lateral and vertical tracks should require only normal bracketing corrections. An approach that requires abnormal bracketing does not meet the stabilized approach concept, and a go-around should be initiated.

**c. Descent Rate.** The optimum descent rate should be 500-700 fpm. The descent rate should not be allowed to exceed 1,000 fpm at any time during the approach. Approaches that would require a descent rate greater than 1,000 fpm would qualify as "special case."

**d. Indicated Airspeed.** Indicated airspeed should be not more than $V_{REF}$ + 5 and appropriate adjustment for wind or other factors, and never less than $V_{REF}$. There is a strong relationship between trim, speed, and power and it is important to stabilize the speed in order to minimize those variables.

**e. Engine Speed.** The engine speed should be at a setting that allows best response when and if a rapid power increase is needed. The stabilized approach parameters should be confirmed at 500 feet (VMC) or 1,000 feet IMC above airport TDZE. This is approximately 1-2 minutes from touchdown. If the approach is not stabilized at that altitude, a go-around should be considered, if the approach is not stable and on all targets at 50 feet above airport elevation, a go-around should be immediately initiated. *A go-around/balked landing should be executed at any time that the approach is determined to be unstable.*

**f.** There may be specific, airport unique special cases that make transitioning to a stabilized approach difficult due to the unusual circumstances. Examples of special cases are ATC clearances that request airspeeds in excess of those airspeeds normally flown in the terminal area, an exceptionally steep glide slope, and ATC clearances that require an aircraft to remain at altitude to a point where intercepting the normal glide path is difficult to achieve. Operators should develop a SOP for such special cases. Additionally, operators should include the procedures developed to fly specific approaches to specific runways at specific airports in their crew training and checking events.

**g.** A stabilized approach SOP is vital to reducing the potential of a runway overrun during the landing phase of flight. If the pilot determines that a stabilized approach cannot be flown or if an ATC clearance results in the pilot's inability to fly a stabilized approach from the final approach fix (FAF) to the airport, the approach should not be accepted and a go-around should be initiated.

## 4. LANDING PERFORMANCE AND STANDARD OPERATING PROCEDURES.

**a.** A survey of numerous operators' Flight Operations or General Operating Manuals by the FAA's Landing Performance Team indicated that approximately 50 percent of the operators surveyed did not have adequate policies in place for assessing whether sufficient landing distance exists at the time of arrival at the destination airport. Not all operators performed landing distance assessments at the time of arrival nor did all of the operators who performed assessments account for contaminated runway surface conditions or reduced braking action reports, nor did they apply a consistent safety margin to the expected actual landing distance. Operator specific SOPs should be developed for the assessment of landing performance, including the application of a safety margin, to ensure a consistent evaluation of airport conditions at the time of arrival.

**b.** Landing performance is influenced by a multitude of variables. Airplane weight and configuration, use of deceleration devices, airport elevation, atmospheric temperature, wind, runway length, runway slope, and runway surface condition (i.e., dry, wet, contaminated, improved, unimproved, grass, etc.) are all factors in determining landing performance. The condition of aircraft tires, brakes, and systems installed/operative/inoperative (e.g. anti-skid braking, propeller reversing, thrust reversers, etc.), and pilot abilities/technique all have a direct impact on the airplane's ability to come to a full stop after touchdown. Most aircraft manufacturers provide some type of landing performance data to address the above variables, many of which are not required to be included in the AFM landing performance data. However, there is no one standard format in which aircraft manufacturers are required to provide these additional data. The pilot should use all landing data and available information to determine that the airplane's required landing field length does not exceed the landing distance available for each and every landing operation.

**c.** We need to address some basic principles of landing performance data before discussing how variations to the stabilized approach concept affect landing performance.

**(1)** The aircraft manufacturer provides certified landing distance data and the conditions upon which that distance is predicated**.** AFM landing performance data are determined during flight testing using flight test and analysis criteria that are not representative of everyday operational practices. These data are considered unfactored data. It should be noted that some manufacturers provide factored landing distance data that addresses operational requirements. AFM data should be clearly labeled so the pilot may determine the type of data presented and whether the data is factored or unfactored. Some manufacturers provide advisory or supplemental landing performance data in the AFM which may account for conditions such as a dry runway, a wet runway, ground spoilers operative/inoperative, thrust reversers operative/inoperative, and anti-skid operative/inoperative. Unfactored landing distances determined in compliance with certification regulations and published in the FAA-approved AFM do not reflect operational landing distances.

**(2)** Landing distances determined during certification tests are aimed at demonstrating the shortest landing distances for a given airplane weight with a test pilot at the controls and are established with full awareness that operational rules for normal operations require the addition of factors to determine minimum operational field lengths. Flight test and data analysis techniques for determining landing distances can result in the use of high touchdown sink rates (as high as 8 feet per second) and approach angles of 3.5 degrees to minimize the airborne portion of the landing distance. Maximum manual braking, initiated as soon as possible after landing, is used in order to minimize the braking portion of the landing distance. Therefore, the landing distances determined under §§ 23.75 and 25.125 are much shorter than the landing distances achieved in normal operations.

**(3)** To mitigate the risk of a runway overrun, air carriers are required by regulation to multiply the aircraft's actual landing distance by a specified factor associated with a destination or alternate airport, as applicable. The result of this calculation is the required landing field length. at the time of departure, the required landing field length must not exceed the landing distance available.

**NOTE: While some non-air carriers are not required to use a factored distance, they are strongly encouraged to adopt a factored distance as part of their SOP to mitigate the risk of runway overruns.**

**d.** The factor by which the actual landing distance is multiplied is determined within each of the applicable 14 CFR. For the purpose of example, the applicable 14 CFRs part 121, § 121.195; and part 135, § 135.385, state:

"(a) No person operating a turbine engine powered airplane may take off that airplane at such a weight that (allowing for normal consumption of fuel and oil in flight to the destination or alternate airport) the weight of the airplane on arrival would exceed the landing weight set forth in the Airplane Flight Manual for the elevation of the destination or alternate airport and the ambient temperature anticipated at the time of landing.

(b) Except as provided in paragraph (c), (d), or (e) of this section, no person operating a turbine engine powered airplane may take off that airplane unless its weight on arrival, allowing for normal consumption of fuel and oil in flight (in accordance with the landing distance set forth in the Airplane Flight Manual for the elevation of the destination airport and the wind conditions anticipated there at the time of landing), would allow a full stop landing at the intended destination airport within 60 percent of the effective length of each runway described below from a point 50 feet above the intersection of the obstruction clearance plane and the runway. For the purpose of determining the allowable landing weight at the destination airport the following is assumed:

(1) The airplane is landed on the most favorable runway and in the most favorable direction, in still air.

(2) The airplane is landed on the most suitable runway considering the probable wind velocity and direction and the ground handling characteristics of the airplane, and considering other conditions such as landing aids and terrain."

**e.** Without regard to the applicable operational rule, it is incumbent upon the pilot in command to ensure that the flight is conducted in compliance with the applicable CFRs. For predeparture planning purposes, operations conducted under operational rules with no specific regulatory requirements regarding landing distance factors, it is recommended, as a minimum requirement, that the *70-percent rule* be applied for both destination and alternate airports. Landing data must be calculated and analyzed before departure to ensure that regulatory compliance and compliance with company SOPs has been met. Additionally, a reassessment of the landing performance data should occur if a change has occurred in the planned runway, runway surface conditions, meteorological conditions, and in the use of the deceleration devices. However, this is just the first step in reducing the exposure to a potential runway overrun during the landing phase of flight.

**NOTE: *Example.* For planning purposes, if the intended landing runway at the destination airport is a dry, 5,000 feet runway landing distance available, the actual landing distance should not exceed 70 percent of the runway length as indicated in the following calculation:**

$$5{,}000 \text{ feet} \times 70 \text{ percent} = 3{,}500 \text{ feet}$$

**5. FACTORS THE PILOT CAN CONTROL.** While there are factors that the pilot can't control, there are four primary factors pertaining to landing performance data that the pilot can control. It is critical that operators and pilots understand the effects of each of these factors:

- The aircraft landing weight;

- The threshold crossing height;
- The threshold crossing height airspeed; and
- The touchdown point.

**a. Aircraft Landing Weight.** Calculate the anticipated landing weight by starting with the aircraft gross takeoff weight at departure and subtracting the anticipated normal consumption of fuel and oil required to arrive at the destination airport. If en-route fuel burn is less than planned, then the aircraft will arrive at the destination at a weight heavier than planned. Therefore, a recalculation of the aircraft's landing performance must be done prior to attempting a landing maneuver. The pilot may control the landing weight by adjusting fuel burn en route or decreasing fuel load or payload prior to departure.

**b. Threshold Crossing Height (TCH).** Excessive height over the threshold may be the result of an unstable approach and will most likely result in a touchdown beyond the expected touchdown point. From Table 2, it can be determined that an extra 50 feet of height over the threshold will add approximately 1,000 feet to the landing distance.

**(1)** If the pilot crosses the threshold at an angle shallower than the normal 3 degrees, the shallow approach angle effectively increases the landing distance and should be avoided. For example, an approach angle of 2 degrees instead of a recommended 3 degrees will add 500 feet to landing distance.

**(2)** Conducting an approach and landing maneuver that does not adhere to the aircraft manufacturer's profile voids the baseline AFM landing performance data and may result in an unpredictable outcome. The margin of error for the threshold crossing height is +10 feet. Pilots should be aware that the approach angle provided by the glide slope/glide path may be different than the approach angle provided by the precision approach path indicator (PAPI)/ Visual Approach Slope Indicator (VASI). These different angles may result in different TCHs. The landing data from the manufacturer assumes a 50 foot TCH. Pilots must ensure that they know the TCH upon which they are basing their landing distance calculations.

**c. Threshold Crossing Airspeed.** As previously discussed, the correct threshold crossing airspeed is specifically defined. Therefore it is essential to understand the impact of deviations in threshold crossing airspeeds.

**(1)** Proper speed control on final approach is of primary importance. The pilot must anticipate the need for speed adjustments so that only small adjustments are required. As can be seen from Table 2, excess approach speed carried through the threshold window and onto the runway will increase the minimum stopping distance required by at least 20 to 30 feet per knot of excess speed on a dry runway and at least 40 to 50 feet per knot on a wet runway. In addition, the excess speed increases the chances of an extended flare, which increases the distance to touchdown by approximately 230 feet for each additional second in an extended flare. With reference to Table 2, assume that an aircraft carries 10 knots of excess airspeed through the threshold window on a wet runway surface. The wet runway increase in landing distance would be at least 500 feet, and the extended flare would add another 2,500 feet to the landing distance for a cumulative addition of 3,000 feet.

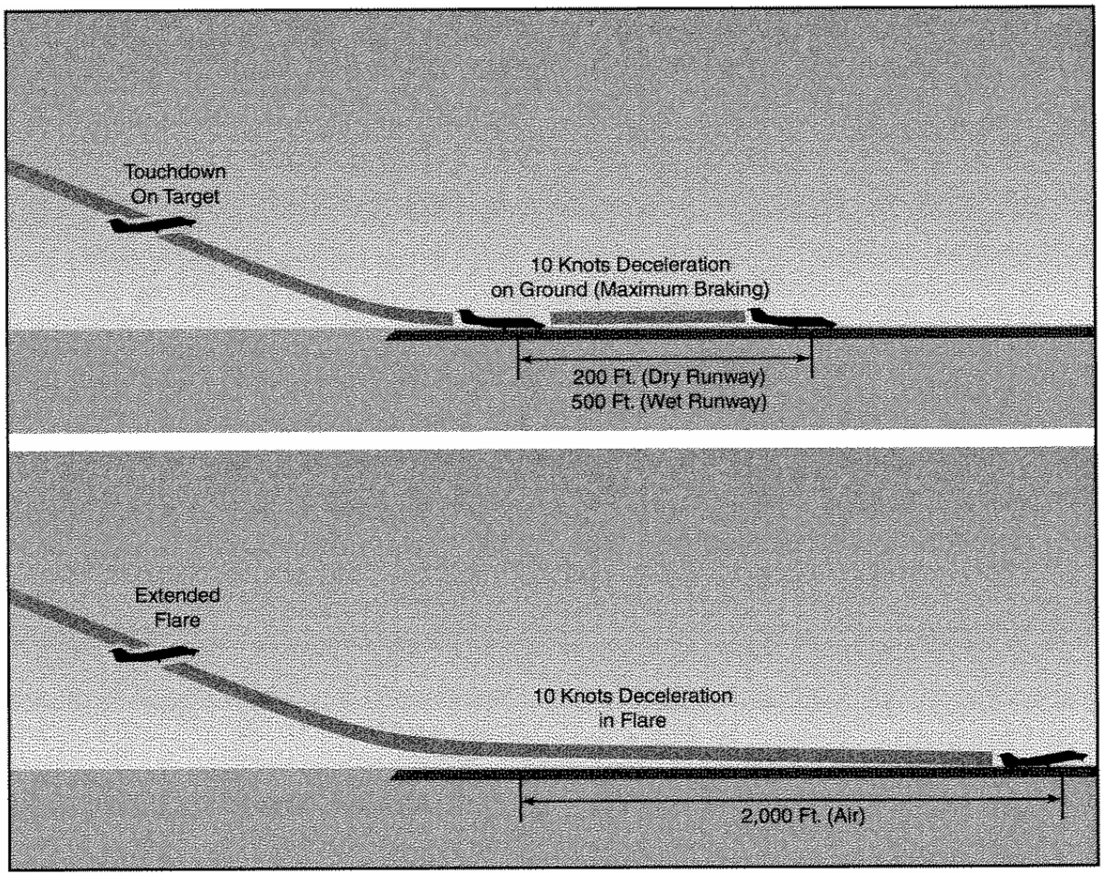
**(2)** It is paramount that the airplane arrives at the approach threshold window on speed. The margin of error for the threshold crossing airspeed is +5/-0 knots. If the pilot has planned to carry additional airspeed beyond the threshold due to gusty surface wind conditions, or other factors, then the effect of this additional airspeed must be included in the actual landing distance. A balked landing maneuver must be executed if the aircraft does not cross the runway threshold at the planned airspeed.

**d. Touchdown Point.** Extended flare and runway slope are two factors which affect pilot control of the touchdown point. Turbine airplanes should be flown onto the runway rather than being held off the surface as speed dissipates. A firm landing is both normal and desirable. An approach flown using a 3.5 degree glidepath with a touchdown at 8 feet/sec. rate of descent will touchdown down at the target touchdown point, which for certification purposes is approximately 1,000 feet beyond the runway threshold. The typical operational touchdown point is in the first third of the runway, and it may be farther down the runway than the 1,`000 feet. point. This additional distance should be accounted for in the landing distance assessment at the time of arrival. Additionally, a negative runway slope affects the touchdown point. According to the Air Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Briefing Note 8.3, each 1 percent of runway down slope increases the landing distance by 10 percent.

**6. LANDING AND BRAKING TECHNIQUE.** The landing, which includes the flare and the touchdown, and the braking technique, are also critical factors in completing a successful approach and landing maneuver. Landing and braking technique are discussed below from a point at the beginning of the approach flare through a point at which the aircraft decelerates to normal taxi speed or has been brought to a full stop.

**a. The Flare.** The flare reduces the approach rate of descent to a more acceptable rate for touchdown. If the flare is extended while additional speed is bled off, *hundreds or even thousands of feet of runway may be used up*. An extended flare may also result in an increase in pitch attitude which may lead to a tail strike A firm landing does not mean a hard landing, but rather a deliberate or positive touchdown at the desired touchdown point. A landing executed solely for passenger comfort considerations, which terminates beyond the TDZ, is not impressive, desirable, or consistent with safety or regulations. It is essential to fly the aircraft onto the runway at the target touchdown point consistent with the operator’s SOP. See Figure 2 as an example of the results of an extended flare.

**FIGURE 2. EFFECTS OF AN EXTENDED FLARE**




**b. Touchdown.** A proper approach and flare positions the airplane to touchdown at the target touchdown point consistent with the operator's SOP. Once the main wheels have contacted the runway, the pilot must maintain directional control and initiate the stopping process. The runway distance available to stop is longest if the touchdown was on target. Once the aircraft is on the ground, ground spoilers, wheel brakes, and reversers, as applicable, are much more effective in slowing the aircraft than the aerodynamic drag produced in the flare maneuver.

**c. Braking.** There are two primary forces available for deceleration during the rollout process: wheel braking, and reverse thrust/propeller reversing, if available. The deployment of ground spoilers, if installed, immediately upon touchdown on the runway has the effect of dumping the lift generated by the wings and placing the aircraft's weight on the wheels, which enhances the effects of wheel braking after touchdown. Deployment of drag devices such as ground spoilers and the selection of thrust reverse or propeller reversing are most effective at higher speeds and are not affected by runway surface conditions. Their application immediately after touchdown provides the greatest benefit.

**(1)** When the runway is wet or slippery, reverse thrust may be the dominant deceleration force just after touchdown. As the aircraft slows down, the wheel brakes become more effective and provide most of the stopping force during the landing rollout. When the runway length is limited, the wheel brakes should be applied fully and immediately after touchdown, and they should not be released until the aircraft slows to a safe taxi speed for the conditions. If the airplane is equipped with autobrakes, manufacturers recommend the use of the autobrakes for all landings on contaminated runways. Generally, autobrakes are applied earlier in the landing roll and with more application pressure than pilot deployed manual brakes. The landing rollout distance will depend on the touchdown speed, the forces applied, and on the timely application of the stopping forces. A firm touchdown at the target touchdown point, followed by the deployment of ground spoilers, the timely selection of thrust reverse (if installed), and the smooth application of max braking will result in the shortest landing distance ground roll, particularly on wet or contaminated runway surfaces. Braking systems and braking procedures vary by airplane make and model. Therefore, adhere to the procedures contained in the AFM for the specific airplane being operated.

**(2)** The nose wheel should be lowered onto the runway immediately after touchdown. Placing the nose wheel on the runway will assist in maintaining directional control. It also decreases the wing angle of attack, thereby decreasing lift and placing more load onto the tires, which increases tire-to-ground friction.

**(3)** As previously discussed, ground spoilers, if installed, should be deployed immediately after touchdown because they are most effective at high speed. Timely deployment of spoilers will increase drag by 50 to 60 percent, but more importantly, deployment of the spoilers increases wheel loading by as much as 200 percent in the landing flap configuration. This increases the tire-to-ground friction force making the maximum tire braking forces available. Many aircraft with auto-spoilers installed require weight-on-wheels to deploy the spoilers, which reinforces the requirement for a positive touchdown.

**(4)** Thrust reversers, if installed, are also most effective at high speeds and should be deployed as soon as possible after touchdown. However, the pilot should not command significant reverse thrust until the nosewheel is on the ground. In the event of an asymmetric deployment, the nosewheel on the ground will aid in directional control. If the thrust reversers deploy asymmetrically, or if the aircraft begins to drift due to a crosswind, close the thrust reversers, and reestablish directional control utilizing the rudder. Once the aircraft track down the runway is reestablished, redeploy the thrust reversers. Use aircraft steering in accordance with the AFM procedures. The pilot should begin braking as soon as possible after touchdown and wheel spin-up. Maximum brake pressure should be applied, without skidding the tires, until the aircraft reaches a safe taxi speed or comes to a full stop.

**(5)** Application of brakes is different for aircraft equipped with a functioning anti-skid braking system than for airplanes without such a system.

**(a) Without Antiskid.** Brakes should be applied firmly throughout the deceleration process, and the pilot must recognize the point that wheel skid occurs. Maximum braking effectiveness occurs just prior to the point where wheel skidding occurs. Should a skid occur, releasing brake pressure can stop skidding and effective braking can be reestablished by reapplying brake pressure firmly until the deceleration process has been completed.

**(b) With Antiskid.** Brakes should be applied firmly throughout the deceleration process. When maximum braking is required, it is accomplished by holding maximum brake application pressure and allowing the anti-skid system to operate. Letting up on the brakes (unless required to regain directional control) defeats the purpose of the anti-skid system. The pulsation caused by the modulation of the brake pressure by the anti-skid system indicates that the anti-skid system is operating normally although the pulsation may be disconcerting to the pilot. Releasing the pedal application when the anti-skid begins to work and alternately applying, releasing and reapplying brake pressure does not enhance braking effectiveness. Pilots should avoid this type of braking technique.

**7. SUMMARY.** A stabilized approach terminating with a landing in the touchdown zone, proper application of aircraft landing performance data, proper deployment of aircraft deceleration devices, and proper braking technique are critical elements to mitigating the runway-overrun risk when landing. The necessity of developing and implementing sensible SOP incorporating these elements for avoiding runway overruns during the landing phase of flight is critical in mitigating this risk. Flightcrews, aircraft operators, certificate holders, program managers, and training providers should develop a program with the following minimum elements:

**a.** SOPs/profiles should incorporate the stabilized approach concept. SOPs must contain appropriate normal and abnormal procedures and profiles that cover contingencies for high and/or hot approaches and inoperative equipment. Company SOPs should specify minimum altitudes for the airplane to be established in a stabilized approach condition. If the airplane is not stabilized, company SOPs should clearly emphasize that pilots should execute a go-around, rather than attempt a landing, from an unstabilized approach.

**b.** Include a description of all the parameters that need to be checked and understood before takeoff in predeparture planning SOPs. SOPs should clearly outline procedures to accommodate changes from the original plan. SOPs should outline proper techniques and procedures to use during the flare, touchdown, and deployment of ground spoilers and thrust reverse (if installed). Also, SOPs should discuss the correct use of brakes, to include autobrakes (if installed) during the ground roll. Preplan contingencies. Include the safety margin (factor) required by company SOPs or the appropriate regulation in all landing distance calculations.

**c.** SOPs should address a process for conducting a landing distance assessment under the conditions existing at the time of arrival. This process should support a determination of conditions which may exist that affect the safety of the flight, and the process should support a decision to proceed to the destination or divert to an alternate. Operator compliance can be accomplished by a variety of methods and procedurally should be accomplished by the method that best suits the operator’s policies and procedures. The operator’s procedures should be clearly articulated and understood by all affected personnel.

**d.** Develop procedures to ensure that a full stop landing, with a reasonable safety margin beyond the actual landing distance, can be made on the runway to be used. The procedures should account for the meteorological conditions affecting landing performance that exist at the time of arrival. These conditions include airport pressure altitude, wind velocity, wind direction, and the surface condition of the runway to be used for landing. Also, the procedures should consider the approach speed, the airplane weight and configuration, and the planned use of airplane ground deceleration devices.

**e.** Include elements that cover all the aspects and assumptions used in landing distance performance determinations in the operator's flightcrew training programs. This training should emphasize the airplane ground deceleration devices, settings, and piloting methods such as flare technique and touchdown point used in determining landing distances for each make, model, and series of airplane. Elements such as braking action reports, airplane configuration, optimal stopping performance techniques, stopping margin, the effects of excess speed, delays in activating deceleration devices, and other pilot performance techniques should be included. Personnel with flight release authority and flight crewmembers should be trained on these elements prior to conducting operations on contaminated runway surfaces. This training should be accomplished in a manner consistent with the operator's training program and instructional methods for pilots. It may be conducted via operations/training bulletins or extended learning systems if consistent with the operator's current methods of training.

**NOTE: Incorporate SOPs into training program curricula where deemed appropriate and necessary. Include SOPs as part of the tasks and events to be checked during initial, recurrent and continuing qualification modules.**

# Appendix 2. Regulatory Considerations

**1.** The spirit of these regulations revolves around predeparture flight planning. The intent of the regulations is to ensure that a flight operation does not begin that cannot reasonably be concluded upon reaching the destination or alternate airport, as applicable.

**2.** It must be recognized that there are differences in the various operating regulations concerning the calculation of landing performance data. These numbers are based on the predetermined conditions that constitute manufacturer's baseline Aircraft Flight Manual (AFM) data. These baseline data must be adjusted for actual operating conditions.

> **NOTE: Some manufacturers advisory or supplemental data may provide landing performance data based on landing weight, airport elevation and temperature, corrected for wind (headwind, tailwind), and slope. The manufacturer may also supply advisory or supplemental data that accounts for runway condition (wet, dry, contaminated) and braking degradation (i.e., anti-skid inoperative, thrust reversers inoperative, etc.). Pilots and operators should be familiar with the data presented in their AFM, and they should be able to apply the data to make operational decisions.**

## 3. DESTINATION REQUIREMENTS of PARTS 121 AND 135)

**a.** According to 14 CFR part 121, § 121.195(b) and part 135, § 135.385(b), the required landing field length for turbine engine-powered large transport category airplanes must allow a full stop landing at the destination airport within 60 percent of the effective length of the runway measured from a point 50 feet above the intersection of the obstruction clearance plane and the runway surface. Effective length of the runway is synonymous with this advisory circular definition of landing distance available. For example, a 6,000 foot runway with 1,000 feet closed by Notices to Airmen (NOTAM) would have a 5,000 foot landing distance available or effective runway length.

**b.** The landing distance calculation required by these regulations is a two step process. The first step is to calculate the landing distance planning performance based on the regulatory requirements such as the 60-percent rule specified in §§ 121.195 and 135.385 or the 80-percent rule specified in 14 CFR part 91, § 91.1037 or § 135.4. The second step requires the calculation of the anticipated landing distance utilizing the AFM data with consideration for conditions such as minimum equipment list (MEL)/ Configuration Deviation List (CDL) items. If the runway is forecast to be wet or slippery, a third calculation would be required to account for the surface conditions by adding 15 percent to the factored dry landing distance. The actual landing distance calculation for a dry runway must yield a landing distance equal to or less than the regulatory landing distance calculation. The landing distance calculated for a wet runway must be less than the effective runway length. These calculations constitute the regulatory requirement for predeparture operational planning.

**c.** As an example, assume the destination airport has a single runway. The usable runway is 7,200 feet long as determined from the airport diagram, and there are no NOTAMs indicating that any portion of the runway is closed. For our example, the runway is wet, and the winds are calm. There are no MEL/CDL items for our aircraft which would affect the landing distance.

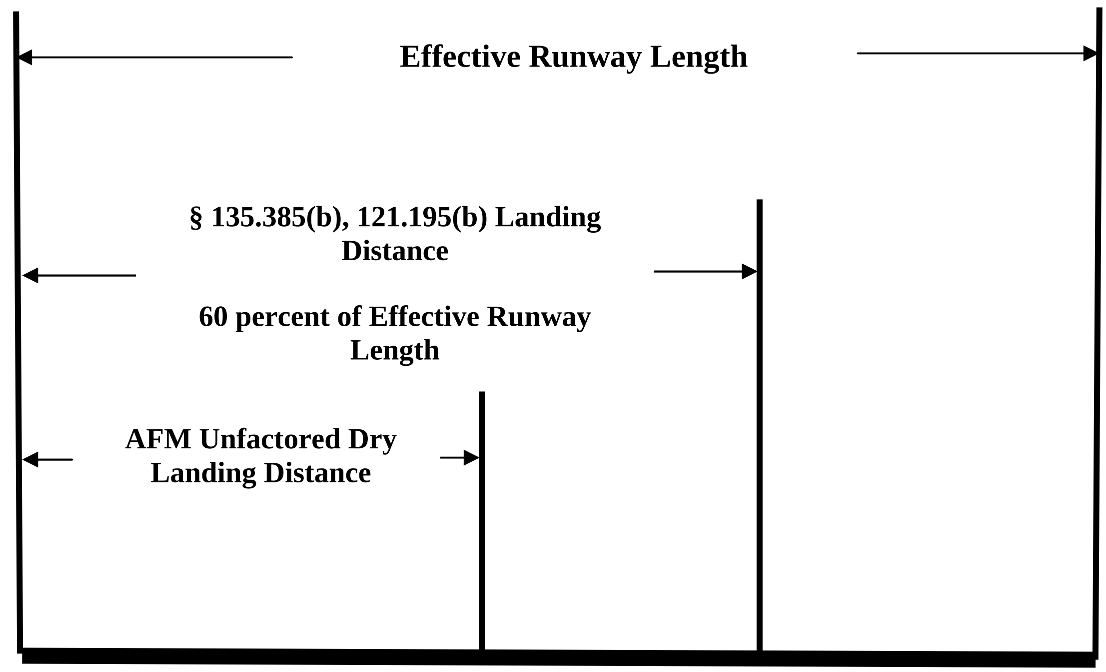
**(1) Step 1.** Calculate the regulatory landing distance based on § 121.195(b) or § 135.385(b). For planning purposes, and for the purpose of determining the allowable landing weight, the crew would plan to land the airplane on the most favorable runway in the most favorable direction in still air. Additionally, it is assumed for planning purposes that the airplane is landed on the most suitable runway considering the probable wind velocity and direction, aircraft ground handling characteristics, landing aids, and terrain. The regulation requires that the airplane can land and stop in 60 percent of the effective runway length. The calculation yields a regulatory landing distance of 4,320 feet $(7{,}200 \text{ feet} \times 60 \text{ percent})$ on a dry runway.

**(2) Step 2.** Calculate the landing distance based on the AFM provided data. The AFM charts or tabulated data yield an unfactored dry runway landing distance of 2,500 feet based on the forecast temperature and pressure altitude of our example destination airport. If the runway was not wet, we would complete the preplanning process by comparing the regulatory landing distance of 4,320 feet to the AFM landing distance of 2,500 feet and determine that the flight meets the predeparture planning requirements and may be operated.

**(3) Step 3.** Since our example destination runway is wet, a third step is required to account for the anticipated increased stopping distance. In our example, § 121.195(d) or § 135.385(d) requires an effective runway length 15 percent greater than the factored dry landing distance to account for the wet runway. In order to calculate the factored dry landing distance, the unfactored dry landing distance from the AFM must be increased by 67 percent. The calculation yields a factored dry landing distance of 4,175 feet $(2{,}500 \text{ feet} \times 1.67 = 4{,}175 \text{ feet})$. The 15 percent additive to the factored dry landing distance required by the regulations to account for the wet runway results in a landing distance of 4,801 feet $(4{,}175 \text{ feet} \times 1.15 = 4{,}801 \text{ feet})$ for predeparture planning purposes. The wet runway landing distance is less than the effective runway length of 7,200 feet and the flight is legal to operate. The calculation of the wet runway landing distance may be simplified by increasing the unfactored dry landing distance derived from the AFM by 92 percent. This method yields the same wet runway landing distance of 4,801 feet $(2{,}500 \text{ feet} \times 1.92 = 4{,}801 \text{ feet})$.

**(4)** Figure 1 is a visual presentation of the 60-percent rule discussed in §§ 121.195(b) and 135.385(b) and in part 121, §§ 121.197 and 135.387(a) which reference required landing distance calculations for destination and alternate airports. A similar visual presentation may be developed for each of the preflight landing distance calculations outlined in Table 1.

**FIGURE 1. SECTIONS 121.195(B) AND 135.385(B) 60-PERCENT RULE**




**(5)** Figure 2. depicts the calculation of the 115-percent rule found in §§ 121.195(d) and 135.385(d). The unfactored dry runway landing distance is converted to a factored dry landing distance by a factor of 67 percent. The factored dry landing distance is increased by 15 percent to account for the reduced braking available on the wet runway. The wet runway landing distance may also be calculated by increasing the AFM unfactored dry landing distance by 92 percent $(\text{AFM Unfactored Dry Landing Distance} \times 1.92 = \text{Wet Runway Landing Distance})$.

**FIGURE 2. SECTIONS 121.195(D) AND 135.385(D) WET RUNWAY 115-PERCENT RULE**

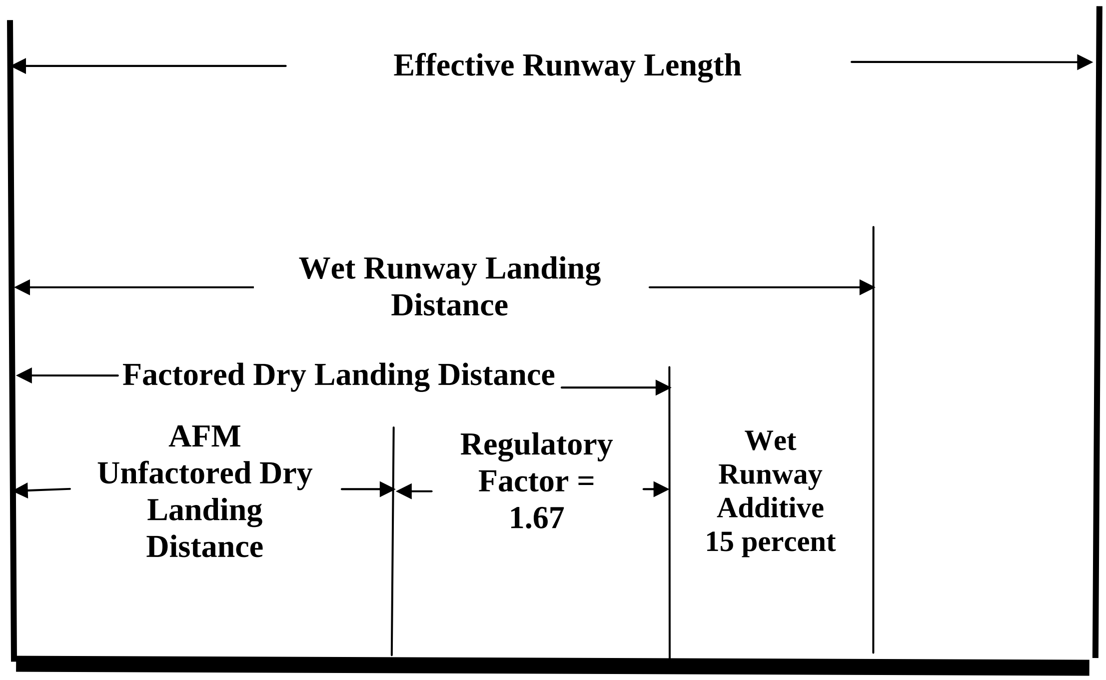


**TABLE 1. REGULATORY PLANNED LANDING DISTANCE CALCULATIONS**

| Regulation | Type of Aircraft | Runway Condition | Percentage of Effective Runway Length |
|---|---|---|---|
| 121.195(b)<br>135.385(b) | Large turbine powered | dry | 60 percent |
| 121.195(c)<br>135.385(c) | Turbopropeller<br>alternate airport | dry | 70 percent |
| 121.195(d)<br>135.385(d) | Turbojet without an approved AFM wet runway landing technique | wet/slippery | 115 percent of § 121.195(b) or 135.385(b) AFM factored dry landing distance |
| 135.385(f)<br>91.1037(c)(2) | Large turbine powered,<br>eligible on demand | Ops Specs/Mgt Specs authorized | 80 percent |
| 121.197<br>135.387(a) | Large turbine powered<br>alternate airport | dry | 60 percent |
| 121.197<br>135.387(a) | Turbopropeller<br>alternate airport | dry | 70 percent |
| 135.387(b) | Large turbine powered,<br>eligible on demand<br>alternate airport | Ops Specs/Mgt Specs authorized | 80 percent |

**NOTE: The calculations depicted in Table 1. are preflight planning calculations. When the flight arrives at the destination, 100 percent of the effective runway length is available for landing. It should be noted that operators with operations specifications (OpSpecs) and management specifications (MSpecs) must complete these calculations in accordance with those directives.**

**d. Part 91 Destination (Suggested).**

**(1)** The unfactored landing distance determined during certification under §§ 23.75 and 25.125, as applicable, is derived utilizing the maximum stopping performance capabilities of the aircraft on a dry runway. The stopping distances published in AFM will be labeled as factored or unfactored distances. Preflight planning requirements for part 91 operators are governed by § 91.103. Operators must calculate predeparture landing distance performance requirements based on the guidance contained in their AFM. Unfactored distances are calculated based on the maximum stopping capability of the airplane on a dry runway. Factored landing distances are derived by increasing the unfactored distance by an actual performance factor of 67 percent.

**(a)** As an example, if the unfactored landing distance determined during certification was 2,500 feet, the factored dry landing distance would be 4,175 feet as shown by the calculation: $(2{,}500 \times 1.67 = 4{,}175 \text{ feet})$. The factored dry landing distance is multiplied by

15 percent to account for increased landing distances on wet runways. This calculation yields a wet runway landing distance of 4,801 feet $(4{,}175 \times 1.15 = 4{,}801\,\text{feet})$.

**(b)** The 15 percent increase in the factored dry landing distance to account for operations on a wet runway surface may also be calculated by increasing the unfactored dry landing distance by 92 percent $(1.67 \times 1.15 = 1.92)$, the unfactored dry landing distance of 2,500 feet multiplied by the 92-percent increase: $(1.92 \times 2{,}500\,\text{feet})$ due to the wet runway yields the same 4,801-foot wet runway landing distance.

**(2)** Some operators may desire to establish SOPs for the calculation of the required data utilizing one of several suggested methods. Although it is not a regulatory requirement for operations conducted under part 91, non-air carriers may include the 60-percent, 70-percent or 80-percent rules in their SOPs. The 80-percent rule applies when the operator:

- Utilizes an FAA approved destination airport analysis,
- Operates under 14 CFR part 91, subpart K or part 135 as an eligible on-demand operator, and
- Operates in accordance with appropriate amended MSpecs or OpSpecs.

**(3)** In the absence of other specific guidance, and to ensure that an acceptable landing distance safety margin exists at the time of arrival, the FAA recommends, as a best operating practice, that a 15 percent safety margin be applied to the actual airplane landing distance at the time of arrival. The 15 percent safety margin accounts for actual performance considering the meteorological and runway surface conditions, airplane configuration and weight, and the utilization of ground deceleration devices.

## Appendix 3. Certification Considerations—Landing Distance Data

The landing distance in the AFM comprises two segments: landing air distance and landing ground roll or ground distance. The landing air distance is the distance from a point where the main gear of the airplane is 50 feet above the landing surface to the touchdown point and the ground distance is the distance from the touchdown point to the point at which the airplane is brought to a stop. For certification purposes, $V_{REF}$ is the landing threshold speed at the 50-foot height as scheduled in the AFM for normal operations. The minimum value of $V_{REF}$ as specified by Title 14 of the Code of Federal Regulations (14 CFR) part 25, § 25.125(a)(2) is 1.23 $V_{SRO}$, $V_{MCL}$, or the speed that complies with the maneuvering capabilities of § 25.143, where $V_{SRO}$ is the stall speed in the landing configuration and $V_{MCL}$ is the minimum control speed in the landing configuration.

**a. Air Distance.**

**(1)** One of 3 acceptable methods for the determination of landing air distance may be used depending on the degree of testing the applicant is prepared to conduct. All 3 differ from the previous demonstration of max performance utilizing steep approaches and high touchdown sink rates. Regardless of which method is selected, satisfactory flight characteristics must be demonstrated in the flare maneuver when a final approach speed of $V_{REF} - 5 \text{ knots}$ is maintained to the 50 foot point.

**(2)** Method 1 involves the use of data developed in previous part 25 zero-wind certifications. These data are subjected to a mathematical analysis to establish landing distances in lieu of measuring airborne distance and speed loss.

**(3)** Method 2 requires the applicant to measure airborne distance or time. The tests must meet the following criteria:

- Fly a stabilized approach using a glideslope no steeper than 3 degrees;
- Maintain an indicated airspeed of $V_{REF}$ to a height of 50 feet above the landing surface with no appreciable change in power setting, pitch attitude, or rate of descent;
- No configuration changes are made below 50 feet with the exception of a power reduction; and
- The average rate of descent at touchdown for each of the 6 landings required for each configuration the applicant desires certified should not exceed 6 feet per second.

**(4)** Method 3 requires that the applicant statistically establish a relationship between airborne distance and the rate of descent at the 50 feet above the landing surface point. Test data are developed on 12 approaches per configuration which the applicant desires to be certified. Test parameters are as follows:

- The maximum approach angle for this method is 3.5 degrees with a range of 2.5 degrees to 3.5 degrees;

- Sink rates at touchdown should be between 2 and 6 feet per second with a maximum sink rate of 8 feet per sec;

- Target speed for the tests should be $V_{REF}$; and

- The air distance used for the AFM landing distance may then be based on a an approach angle of 3.5 degrees, and a touchdown sink rate of 8 feet per second.

**b. Ground Roll Distance.**

**(1)** In order to determine the ground distance component, the applicant may need to conduct measured landing tests covering the landing weight range desired for certification. The following parameters govern the tests:

- The same wheels, tires, and brakes must be used for all tests to substantiate that excessive wear does not occur over multiple applications as required by the provisions of § 25.125(b);

- Brake pressure is in the normal operating range;

- The main gear tire pressure should be not less than the maximum pressure desired for certification at the specific test weight; and

- Nose gear touchdown rate should not be greater than 8 feet per second.

- Brakes may not be manually applied before all main gear wheels are firmly on the ground.

**(2)** In deriving the ground distance component, the landing distances must be calculated using the test data to correspond to the landing distances achieved if the brakes were fully worn. The AFM calculation also assumes a one-second delay from touchdown to activation of the first deceleration device and a one-second delay from the deployment of the first device to activation of the second deceleration device.

**c.** Finally, airplane operating procedures appropriate for the determination of landing distance must be described in the performance section of the AFM. As a minimum, the AFM must include data for standard temperature and zero runway gradient showing the variation of landing distance with weight up to maximum takeoff weight, altitude, and wind. Operational field length factors should be included in the data for both dry and wet runways if the airplane is intended to operate under 14 CFR part 121.

**d.** The importance of adhering to the landing procedures outlined in the AFM cannot be overemphasized. Operators and flightcrews should apply the pertinent safety margins required by either the regulations or by SOP to achieve the intended level of safety. Fly a stabilized approach and at 50 feet above the threshold, close the power levers to idle and fly the aircraft to a firm touchdown. A threshold crossing height above 50 feet will increase landing air distance. For every 10 feet above the standard 50-foot threshold height, landing air distance will increase 200 feet. The AFM assumes that the deceleration devices will be fully deployed by 2 seconds after touchdown. Every second delay beyond the 2 seconds will add approximately 220 additional feet to the landing distance. The maximum braking condition is assumed to be maintained until the airplane reaches a full stop.

## Appendix 4. Certification Considerations—Landing Distance Data Wet and Contaminated Runways

**1.** In accordance with Federal Aviation Administration (FAA) certification rules, the FAA-approved AFM data are determined only for dry runway conditions. Some manufacturers provide supplemental information for operation on wet and contaminated runways which may be used in lieu of the 15 percent additive rule. The data contained in these supplements, although not FAA-approved, are based on the same flight test data that substantiates the FAA-approved dry runway takeoff and landing performance presented in the AFM. Performance is calculated from analytical corrections to dry runway performance utilizing methods appropriate for aircraft certification outside the United States.

**2.** The analytical methods employed to adjust the dry runway performance to account for conditions encountered on wet and contaminated runways are complex and comprehensive. The methods utilized include adjustments for changes in the braking coefficient, precipitation drag, and hydroplaning. Consideration is also given to the contaminant itself.

**3.** The braking coefficient is a measure of the braking efficiency at the contact point between the airplane main tires and the runway. The braking coefficient is the ratio of braking force divided by the weight on the tire. A tire supporting 5,000 pounds with a braking coefficient of 0.5 would be capable of producing 2,500 pounds of stopping force. As contaminants are introduced onto the runway, the braking coefficient is reduced, decreasing the stopping capability of the airplane. A wet runway typically will reduce the braking coefficient by about 50 percent, down to 0.25. Runways contaminated with dry snow typically can reduce the braking coefficient down to about 0.10, or only 20 percent of the braking capability of a dry runway. In other words, what was a 2,500-pound stopping force on a dry runway may now be only 500 pounds on dry snow.

**4.** Precipitation drag comprises two components: Precipitation impingement drag and precipitation displacement drag.

**a.** Precipitation impingement drag is the force created as contaminant spray from the tires impacts parts of the airframe, such as the flaps behind the main gear. Impingement drag assists in slowing the airplane and resists acceleration.

**b.** Precipitation displacement drag is a drag force created as the tire pushes the runway contaminant out of the way as it rolls down the runway. It is the same force you feel when trying to move your hand rapidly through water. As your hand moves, the water is forced out of the way. The faster you try to move your hand, the stronger the resistance. Runway contaminants act much the same way. This force also assists in slowing the airplane during landing or rejected takeoff, and resists acceleration during takeoff.

> **NOTE: Some manufacturers do not include the effects of precipitation drag on landing distances. Their reasoning is that if the effect of precipitation drag is included, it has the nonintuitive characteristic that more of a given contaminant results in a shorter stopping distance. Therefore, if a deeper contaminant level is selected with the intention of being conservative, the**

**result will be the opposite—it will be nonconservative. If less contaminant is there, it will result in a longer distance.**

**5.** It also sets the stage for a particularly hazardous contaminant effect: dynamic hydroplaning. Dynamic hydroplaning is the phenomenon where the airplane tires cannot push the contaminant out of the way fast enough and instead ride up on top of the contaminant. In this process, the tire loses contact with the runway. With the tire and runway no longer in contact with each other, the braking coefficient of the airplane is further reduced to 0.05, a 90-percent reduction in braking capability compared to a dry runway.

**6.** The last element to take into account is the nature of the contaminant itself. Wet and contaminated supplemental performance data consider only water in its liquid and ice states. It is the nature and depth of that water that causes much of the difficulty in determining the impact on takeoff and landing performance. Temperature is an important element in this assessment. Slowly freezing water or melting snow on the runway can become slush, which as temperature decreases can become ice. Each of these conditions affects the stopping performance of the airplane differently. The same contaminant on the same runway over the course of the day can change state due to solar radiant heating, ambient temperature changes, or chemical treatment. These changes affect the braking characteristics of the airplane. The runway that was adequate for takeoff in the morning may not be adequate for landing in the afternoon, simply because the temperature rose and the compacted snow started to melt and turned to wet snow and slush.

**7.** Pilots must determine the condition of the runway surface. Once the surface condition is determined, the pilot must decide whether the standard AFM dry runway performance charts are appropriate or whether the wet and contaminated performance data needs to be consulted. In preparing for takeoff, this decision is considerably easier since the pilot can visually survey the runway. The standard dry runway charts are for a totally dry runway. If, for example, the ramp is too damp to sit down on because of the morning dew, the runway is probably the same. The pilot should consider the use of the wet or contaminated performance data.

**8.** When reviewing the takeoff and landing data, the pilot must select the correct chart. In many cases this is obvious, but there may be conditions, or combinations of conditions, that can make the selection problematic. Careful review of Aviation Routine Weather Report (METAR) or other airport reports may provide sufficient information to make the proper selection. At airports where automated terminal information service (ATIS) is available, surface contamination reports may be included that can be used as a guide. At other airports, no information may be available. Regardless of the source, utilize the information which yields the most conservative performance. If reports indicate mixed runway conditions such as snow and slush, use the chart for the contaminant that results in the longest distance. If no reliable information is available, use the chart for the possible condition that provides the longest distance. Selection of a runway condition that renders a shorter distance should only be based on solid information. The pilot absolutely must resist the temptation to use a less severe runway contamination condition simply because it produces a landing distance that is equal to or less than the available runway length. If the runway may not be long enough for the conditions, select a longer runway elsewhere.

**9.** There are runway surface conditions, such as ice, that are beyond the coverage of the wet and contaminated data. Even the most effective braking systems are ineffective in the presence of a near zero braking coefficient. Additionally, with a zero or near zero braking coefficient, the rolling friction coefficient of all the tires is near zero. Nosewheel steering will be ineffective, and the pilot will not be able to correct for any side force on the airplane, such as a crosswind, once the airplane decelerates to a low airspeed. Under this type of condition, the flight should divert to a runway where better conditions are reported.

**10.** Water on the runway is the most common contaminant dealt with by the pilot, but it still provides several challenges. Is the runway wet? Is there standing water on the runway? For that matter, how wet is "wet"? These are questions for which no clear answers are available. Some manufacturer's wet and contaminated supplemental data provide the following or similar definitions (taken from European standards) for wet and contaminated runways:

**a. Wet Runway.** A runway is considered as wet when there is sufficient moisture on the surface to cause it to appear reflective, but without significant areas of standing water.

**b. Runway Contaminated by Standing Water, Slush, Dry Snow, or Wet Snow.**

**(1)** A runway is considered to be contaminated when more than 25 percent of the runway surface area (whether in isolated areas or not) within the required length and width being used, is covered by surface water more than 3 mm (0.125 inch) deep, or by slush or loose snow equivalent to more than 3 mm (0.125 inch) of water.

**(2)** The "reflective surface" in the wet runway definition and the 3-millimeter depth over 25 percent of the runway require that the pilot be able to see the runway, since these types of conditions are rarely reported to pilots.

**NOTE: The FAA has taken the position that a runway does not need to be reflective to be considered wet. If a runway is contaminated or not dry, that runway is considered wet.**

**11.** If there is any sort of restriction to visibility at the field, or even just low clouds, the pilot will not have sufficient time, once the runway is in view, to ascertain the runway condition and select the appropriate landing distance chart. This requires that the pilot gather the available information prior to approach and make a conservative choice. For example, if there is no clear report of runway condition, but the pilot knows rain has been in the area, that pilot should assume the runway is at least wet. If there is rain actively falling on the runway, standing water should be assumed. If there is any doubt, assume the most conservative condition that requires the longest landing distance.

**12.** Once committed to an operation on a wet or contaminated runway, the pilot should expect a lower level of deceleration than routinely experienced on a dry runway. As an example, consider the landing distances for wet and contaminated surfaces, assuming zero wind and a zero runway gradient. The wind and runway gradient conditions do not require additional corrections. Under these conditions, for the example airplane, a wet runway increases the landing distance over a dry runway by approximately 26 percent. If standing water is present, the landing distance increases approximately 52 percent. Remember that the contaminant only affects the ground roll and braking. It has no impact on the air distance from 50 feet to touchdown, which is included in the landing distance. For this example, the air distance is almost half of the total dry runway landing distance. In the presence of standing water, for the total landing distance to increase 52 percent, the ground braking distance increases 100 percent. This situation might surprise a pilot the first time it is encountered because the deceleration rate on this surface will be only *one-half* of what the pilot might be accustomed to. For any contaminant, the pilot should expect a relatively low deceleration rate in the initial phase of braking. A wet runway may be less severe than other contaminants, but the pilot must remember that any increase in total landing distance will occur entirely in the landing ground roll braking segment.

**13.** Hydroplaning is a significant factor which must be accounted for in determining landing performance on a contaminated runway. The typical takeoff and landing speeds of high-performance jet aircraft are above dynamic hydroplaning speeds. For every takeoff or landing on a contaminated runway, very likely there is a portion of that operation where the airplane is hydroplaning. The key item to remember when the airplane is hydroplaning is that the tires are no longer in contact with the runway, although the aircraft is not airborne. Reverse thrust/propeller reversing, if installed, provides the decelerating force since brakes are essentially ineffective, as is nose wheel steering. All directional control is now via the rudder, and most of the deceleration is due to precipitation drag and aerodynamic drag. These characteristics are included in the distances presented in the contaminated runway supplemental data. It is very important to realize that directional control has not been demonstrated on these surfaces. The pilot should not expect the airplane to be controllable on a contaminated runway, depending on the level of available runway friction, with an engine shut down or with a crosswind. Some manufacturers provide maximum crosswind values, derived through simulation and calculation, for landing on contaminated runways.

**14.** Additionally, runway surface conditions are rarely consistent over the full length of the runway. Even dry runways will present different friction coefficients due to heavy rubber deposits in the touchdown zone and large paint markings such as the 1,000-foot markers or centerline stripes. The degree of runway surface contamination due to ice, packed snow, or standing water varies along the length of the runway. The pilot will sense changes in the deceleration rate as the airplane transitions from one contaminant condition to another.

**15.** How does the pilot differentiate between reduced braking capability and a brake failure with reduced, and occasionally very low, deceleration rates due to runway contamination? The best answer is for the pilot to be thoroughly familiar with all operating characteristics of the airplane. Experience is the best tool. All pilots should take advantage of the opportunity to experience braking capability in the simulator on different contaminants when possible. During stops, take note of the airspeed display in order to relate the change in speed to the kinesthetic perceptions. During the period of maximum brake application after touchdown, the anti-skid system is working to keep the tires on the verge of a skid. The pilot may perceive small, abrupt pulses as the tires occasionally get a solid grip prior to skidding, followed by a short release of brakes to allow the tires to spin up again. As the surface condition becomes more challenging, the anti-skid system will command longer brake releases to maintain a proper level of friction between the tire and the runway. As the airplane decelerates, the braking effectiveness will increase but may never attain dry runway levels. As long as the pilot senses the cycling of the anti-skid system, the pilot knows the brakes are performing to the maximum extent permitted by the runway surface condition. The pilot cannot modulate the brakes better than the anti-skid system. Pilot response time to the changing conditions is measured in seconds, and the anti-skid system can adjust in milliseconds. The best braking performance will occur when the pilot presses hard on the brake pedals and maintains a constant pressure. Let the anti-skid do all the modulation but be sensitive to that same anti-skid operation. Be perceptive and make note of the anti-skid pulses. That is your first-hand knowledge of proper brake operation.

**16.** Every pilot should read and understand the explanatory material presented in the contaminated runway supplemental data before applying the supplement performance information during the pilot's operations. When the pilot thoroughly understands the operation of the anti-skid system, becomes familiar with the runway condition at the destination, and completes and applies conservative landing distance calculations, the pilot will have helped to ensure a safe landing.

> **NOTE: The information presented in this advisory circular must not be used to replace or supplant wet or contaminated runway performance information provided by the manufacturer.**