Contaminated Runways

How to **get it down** and **safely stopped** with imperfect, even conflicting, information

BY **JAMES ALBRIGHT** james@code7700.com

On Dec. 8, 2005, Southwest Airlines Flight 1248 ran off the departure end of Chicago Midway International Airport's Runway 31C and provided the aviation industry with a wakeup call. There was substantial evidence of pilot error to be sure. But what is even clearer is an institutional error in the way our industry reports, evaluates and applies contaminated runway information.

Even the definition of what constitutes a contaminated runway varies between countries, operators and aircraft manufacturers. Aviation has been in search of a reliable way to quantify what happens to landing distance once a runway becomes contaminated. But we are no closer to a solution today than we were on that snowy day in Chicago.

That isn't to say we are unarmed in this battle. Pilots do have some tools at their disposal, but there is also a lot of judgment involved. You can develop that judgment by understanding what the authorities mean when they say the runway is contaminated, how that contamination is reported, how your aircraft performance charts deal with a runway that isn't dry, and what safety margins are prudent. Then, if you follow sound decision-making with recommended approach, landing flare, reverse and braking techniques, you can make a perfect landing on a less-than-perfect runway with far-from-perfect information.

Runway Contamination Defined

Most U.S. operators have grown up with this Aeronautical Information Manual (AIM) definition: "A runway is considered contaminated whenever standing water, ice, snow, slush, frost in any form, heavy rubber or other substances are present."

The International Civil Aviation Organization (ICAO) and other governmental agencies have tightened up the definitions considerably. European Union Operations Regulations (EU OPS) 1.480 contains what many international organizations are adopting as a standard for identifying runway conditions:

"Contaminated runway" — A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following:

- *Surface water more than 3 mm (0.125 in.) deep, or by slush, or loose snow, equivalent to more than 3 mm (0.125 in.) of water;*
- *Snow that has been compressed into a solid mass that*

resists further compression and will hold together or break into lumps if picked up (compacted snow); or

▶ *Ice, including wet ice.*

"Wet runway" — A runway is considered wet when the runway surface is covered with water, or equivalent, less than specified [above] or when there is sufficient moisture on the runway surface to cause it to appear reflective, but without significant areas of standing water.

"Damp runway" — A runway is considered damp when the surface is not dry, but when the moisture on it does not give it a shiny appearance.

"Dry runway" — A dry runway is one that is neither wet nor contaminated, and includes those paved runways that have been specially prepared with grooves or porous pavement and maintained to retain "effectively dry" braking action even when moisture is present.

Runway Contamination Reported

We know a contaminated runway when we see it, but that contamination isn't reported consistently around the world. We are often unable to turn those measurements into consistent stopping distance factors.

The United States, like most of the world, uses subjective measures based on pilot and ground vehicle reports of braking action. The quality of braking action is described by the terms "good," "fair," "poor" and "nil," alone or in combination. "Fair" is becoming "medium," to bring the terminology in line with ICAO. These reports can be greatly dependent on aircraft type and a pilot's subjective judgment.

Mechanical and electronic decelerometers are in use at some airports. Experience has shown that results obtained from some types of decelerometers are not accurate on water and slush. As a result, you will probably only see decelerometers at climates where the predominant contamination is snow.

Friction reports, given as *mu* (or the Greek letter), range from 0 to 100, where zero is the lowest friction possible and 100 is the highest.

The *AIM* tells us that braking performance starts to deteriorate with any *mu* value below 40. But it also cautions that we cannot make any correlation between *mu* values and the terms "good," "fair," "poor" and "nil."

ICAO Annex 15, Appendix 2, on the other hand, does make such a correlation with its Special Series Notice to Airmen (SNOWTAM):

Many airports throughout Canada are equipped with decelerometers used to obtain an average of the runway friction measurement, which is reported as the Canadian Runway Friction Index (CRFI). The CRFI is graduated from 0 to 1, where anything above 0.8 is considered dry and a rating of 0.5 would be an expected value for a wet runway.

While having a concrete number such as the *mu* can be psychologically reassuring, studies have shown that under certain conditions of thickness and deposits, the friction measurements cannot be relied upon. Advisory Circular 150/5200-30C notes:

"Currently, there is no objective type of measurement of runway surface condition that has been shown to consistently correlate with airplane performance in a usable manner to the satisfaction of the FAA. Pilots and airplane operators are expected to use all available information, which should include runway condition reports as well as any available pilot braking action reports, to assess whether operations can be safely conducted."

Understanding Aircraft Performance Charts

Some pilots view aircraft performance charts for contaminated runways with a degree of suspicion, reasoning they aren't "FAA approved." A quick glance at many aircraft flight manuals would seem to verify that claim.

In many Gulfstreams, for example, each page of the non-contaminated data says "FAA APPROVED." The contaminated data, on the other hand, appears in a supplement that clearly states, "ADVISORY DATA ONLY — NOT FAA APPROVED."

In many Bombardier manuals there is a "DOT approved" statement on both non-contaminated and contaminated runway data, giving them the Department of Transport's (Canada) approval. The Dassault Falcon 2000 manual states, "Approved by EASA on behalf of the Federal Aviation Administration," giving them the European Aviation Safety Agency's approval.

So does that mean contaminated runway data for an airplane built under foreign rules is reliable and that of an airplane built under U.S. rules is worthless? Not at all: 14 CFR 25 aircraft certification doesn't require contaminated runway testing so it simply isn't submitted for FAA approval. That doesn't mean the manufacturer doesn't stand behind it.

When contaminated data is given, however, there does seem to be a wide variety in the way charts are presented. Pilots should understand the basis behind each aircraft's performance numbers before making go/no go decisions.

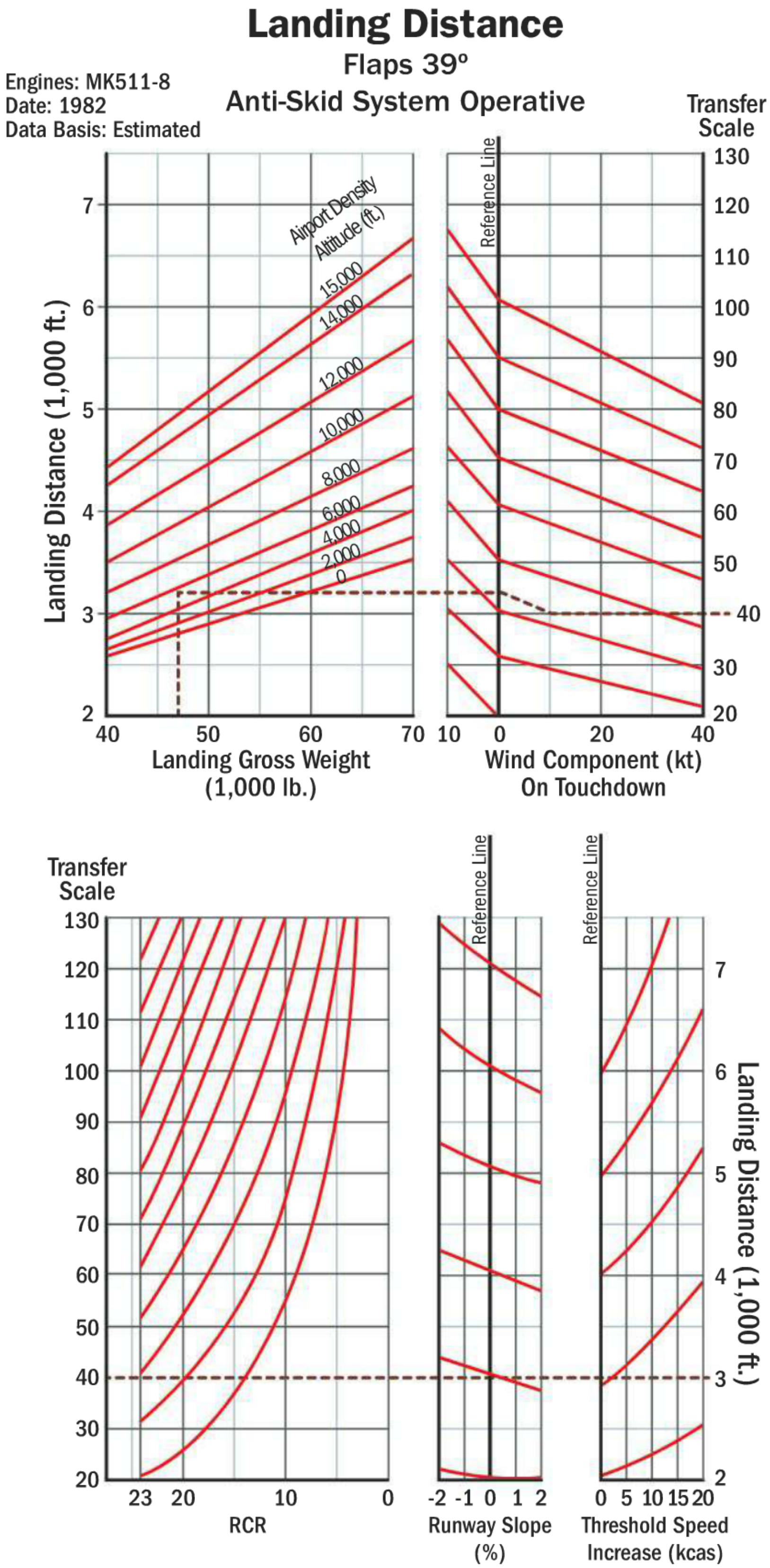
Here are a few questions to ask:

▶ What constitutes a contaminated runway?

Friction Measurements on Each Third of Runway and Friction Measuring Device

Measured or Calculated Coefficient	or	Estimated Surface Friction
0.40 and above		Good — 5
0.39 to 0.36		Medium/Good — 4
0.35 to 0.30		Medium — 3
0.29 to 0.26		Medium/Poor — 2
0.25 and below		Poor — 1
9 – unreliable		Unreliable — 9

(When quoting a measured coefficient, use the observed two figures, followed by the abbreviation of the friction measuring device used. When quoting an estimate, use single digit.)



▶ Do the charts include a safety margin?
▶ What type of touchdown is needed to achieve the charted stopping distances?
▶ Is the use of reverse thrust included?
▶ What type of braking is used? (Is there a particular autobrake setting? Should anti-skid protection be employed to its fullest extent?)

Recommended Safety Margins

The 2005 runway overrun mishap by Southwest Flight 1248 prompted the FAA to issue Safety Alert for Operators (SAFO) 06012, which recommends that 14 CFR 121, 135, 125 and 91K operators conduct a landing performance assessment as close to the time of arrival as practicable. Additionally, the SAFO states crews should add a safety margin of at least 15% to landing distances. While the SAFO does not address general aviation, non-commercial operators would be wise to use the same safety practices.

Very few manufacturers have added the 15% safety margin to published landing performance numbers. Recent Falcon 2000 and Bombardier Global Express flight manuals, for example, do not. But just because the manufacturer has not done so in the past doesn't mean current manuals do not include the margin. Gulfstream recently added the safety margin to most of the landing performance distances in the G450 and G550. It is up to the pilot to know when the additional 15% is needed.

Perfect Techniques

▶ *Compute landing distance using flight manual procedures.* Always compute landing distances using approved flight manual procedures first. You should be aware if these numbers include any kind of "dispatch factor," such as the 14 CFR 135.385(b) 60% rule or the 14 CFR

91.1037(c)(2) 80% rule. These rules and their associated landing field lengths are intended to make departure decisions based on destination conditions, i.e., you cannot take off if you don't expect to be able to land in 60% of the available runway at destination (unless you have a suitable alternate).

▶ *Adjust landing distance for contaminated runway conditions.* If your flight manual includes contaminated runway distances, compute them as well. If your flight manual does not have charts or conversion factors for contaminated runways, SAFO 06012 includes chart above.

If, for example, your unfactored dry distance is 2,400 ft., your factored dry distance will be 4,000 feet and your contaminated landing distance on packed snow will be 4,800 ft.

▶ *Add the SAFO 06012 safety factor.* Multiply your contaminated runway landing distance by 1.15 to determine a contaminated runway landing distance with the 15% safety factor. In our example, the 4,800 ft. becomes 5,520 ft.

▶ *If flight manual numbers say "no go," do not land.* If the contaminated runway landing distance with the safety factor exceeds the runway available, you are done considering this runway. You should either hold until conditions improve or find another runway.

▶ *If flight manual numbers say "go," but are close, consider CRFI numbers.* If the available runway length greatly exceeds the computed landing distance, you are good to go. Just make sure the conditions are equal to or better than what you used in your computations when you show up on final approach. If, in our example, we are landing on a 9,000-ft.-long runway, we should feel confident that we would be able to stop since our computed number with safety factor was less than 6,000 ft.

If the available runway length exceeds the computed runway landing distance, but only by a small margin, you could use the Canadian Runway Friction Index method shown in the Transport Canada *AIM,* Section 1.6.6, to come up with a second opinion.

If you don't have a reported CRFI, you will need a way to convert the reported surface condition to a CRFI equivalent. If your aircraft manufacturer provides a chart to convert subjective measures or *mu* to a CRFI, you should use it. Otherwise, the Transport Canada AIM conversion chart is shown.

In our example, we have bare-packed snow at 10C. Since it is very cold, we reason our braking should be at the top of the 0.12 to 0.31 range so we give ourselves a CRFI of 0.30.

The Transport Canada *AIM* includes two tables to convert landing distance, factored and unfactored, into contaminated runway distances, one with and the other without reverse thrust. The chart that does not consider reverse thrust is shown.

Entering the table from the left with the unfactored, dry landing distance or the "60% Factor" column from the right we can determine a contaminated runway distance. We have to remember to multiply this number by 1.15 to add our SAFO 06012 safety margin. If this distance confirms our earlier number as less than the available landing distance, we will have confirmation that the aircraft should be able to stop within the available landing distance.

In our example, the unfactored dry distance was 2,400 ft. and the equivalent CRFI is 0.30. That turns into a recommended landing distance of 5,260 ft. With our 15% factor we see it is 6,049 ft., a bit higher than our flight manual computed number. If our runway is at least that long, we know we will have our flight manual numbers, plus a safety factor, plus a "second opinion" validating our decision to land.

Runway Condition	Reported Braking Action	Factor to Apply to (Factored) Dry Runway Landing Distance*
Wet Runway, Dry Snow	Good	0.9
Packed or Compacted Snow	Fair/Medium	1.2
Wet Snow, Slush, Standing Water, Ice	Poor	1.6
Wet Ice	Nil	Landing Is Prohibited

*You will need a factored dry runway landing distance. If your flight manual provided unfactored distances, multiply these by 1.667 to obtain factored dry runway landing distances. Then enter the table with the more conservative case of runway condition or braking action to obtain a factor to multiply against your factored dry distance.

Approach

If the runway is contaminated there is a very good chance the weather is less than perfect, so you are going to need the perfect approach. Remember that flying a stabilized approach that arrives over the runway threshold at just the right speed and descent rate, and aligned with the runway centerline will improve your odds for the work yet to come.

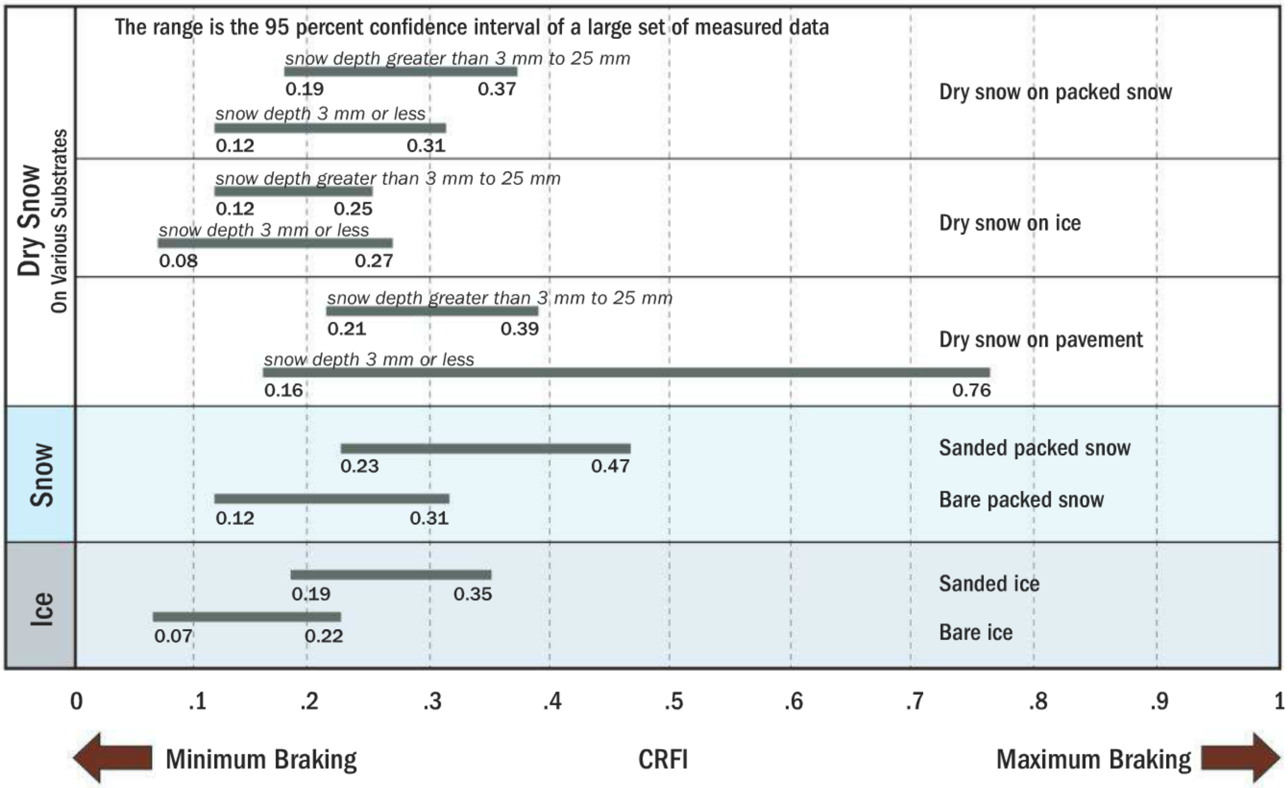
Landing Flare

Your aircraft's demonstrated landing performance is based on very specific landing techniques that are not designed for passenger comfort or applause, but rather to turn the aircraft from an air to a ground vehicle expeditiously and within the touchdown zone of the runway. If you do not normally land this way, you need to practice in the simulator or resign yourself to add hundreds, if not thousands, of feet to your computed landing distances. You should research your aircraft flight manuals for the correct technique.

The Gulfstream G450, for example, is designed to land with a sink rate of 360 ft. per minute (fpm). With the G550 the touchdown is even firmer, 480 fpm. Considering a normal glidepath descent rate is likely to be around 600 fpm the flare is cutting that by less than half. It takes practice to land the airplane this firmly, but if you don't, you will not achieve flight manual landing distances.

Other aircraft may not be as explicit as to how the landing numbers were achieved. Some Global Express manuals, for example, simply state "perform partial flare, and touch down without holding off."

On a contaminated runway, you must make a "positive landing." Many aircraft rely on the pilot arriving over the threshold at a specific speed, reducing thrust and touching down at a specific speed. This precludes any kind of



exaggerated flare if flown "by the book."

Flare distance can be the largest variable in landing distance if not flown properly. No matter how it is specified, you need to follow the manufacturer's procedure if you expect to achieve the manufacturer's performance numbers.

Reverse Thrust

If your aircraft calls for full reverse thrust after touchdown, that's what you need to apply. Most thrust reverse systems are most effective at higher speeds and become mere noisemakers at low speeds. "All of it, as soon as you can," is a good mantra when it comes to reverse thrust.

You also need to understand how this will impact your computed landing distances. With some aircraft, reverse thrust is an added bonus and only makes things better. With others, partial or full credit may be taken for reverse thrust. The Global Express, for example, takes reverser credit for takeoff on wet and contaminated runways and landing on contaminated runways.

The Falcon 2000 takes landing distance credit for reverse thrust except on dry snow, compacted snow and ice. With the G450, for another example, reverse thrust credit is taken only for wet runway takeoffs, never on landing.

Braking

Braking should be accomplished as dictated by the aircraft flight manual. In general, brakes on aircraft without antiskid systems should be applied firmly to achieve maximum braking effectiveness. This point occurs just prior to the point where wheel skidding occurs. If skidding does occur, release brake pressure to stop skidding and reapply pressure with a little less force.

Maximum braking is normally accomplished on aircraft with antiskid braking by holding maximum brake pressure and allowing the antiskid system to operate. Letting up on the brakes defeats the purpose of the antiskid system.

Pilots may notice a pulsating feeling in their feet as the antiskid cycles; this is considered perfectly normal for most systems.

The Perfect Landing

Many of us have trained our entire careers for those silken landings that prompt passengers to ask, "Are we down yet?" How can you be a pilot and not have your ego fed by the applause in back when the first sign of landing is the reverse thrust?

We have to train ourselves, and our passengers, that a perfect landing is one that follows the perfect approach, is on speed in the touchdown zone of the runway, and ends with the airplane exiting the runway in a controlled manner. We have to train to do this on the best, dry runways so that the result is exactly the same on the worst, contaminated runways.

You've probably heard this your entire career and may have even preached it. But now you have to practice what you preach. It is time to relook at the mistakes made by the crew of Southwest Flight 1248 and vow it will not happen again. **B&CA**