

# CONTAMINATED RUNWAY OPERATIONS

(Adverse weather)

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**Abstract – Guidance for operations on contaminated runways requires continual improvement. The aim of this article is to provide such clarity and direction, keeping in mind that contaminated runway operations still requires judgment and decision-making since no procedures will cover all situations.**

**Keywords - runway contamination, take off limitation, slippery runway, boeing procedures, runway calculation, cross wind take off guidance**

## I. INTRODUCTION

Being in the middle of the winter in Canada, where adverse weather is affecting flying daily and reading of very useful Boeings or Airbus manuals, we can ask many questions about contamination of runways, wind limitations during take-off and landing as well as safe operations and general limitations. As we can see all air carrier operators have their own policy and procedures to deal with winter conditions. However after all we can find that all of them have the same core which is based on test flights of the aircraft producers not important if Boeing or Airbus (Being sure that more than this two manufacturers providing their own bulletins but we will deal only with this two for now because they are the main players on the market now a days.). Let's take an example of flying company in North America operating in winter time. We can show how could be set up such winter operation guidance for air carrier dealing with runway contamination daily. We should use Boeings procedures as well as Transport Canada Regulations.

## II. DEFINITIONS

### A. Runway Conditions

“Trace Conditions – means the presence on a surface of a contaminant that can be visibly detected but cannot be readily measured. Trace conditions are not considered contamination for performance calculation purposes.”(6)

“Wet Runway: A runway that has a shiny appearance due to a thin layer of water less than 1/8” or 3 mm covering 100% of the runway surface. If there are dry spots showing on a drying runway with no standing water, the runway is not considered to be wet.”(2)

“Slippery Runway: A runway that is considered to be more slippery than just a wet surface. This would be a result of freezing rain and/or freezing temperatures.”(3)

“Contaminated Runway: A runway where more than 25% of the runway length, within the width being used, is covered by standing water or slush more than 1/8” or 3 mm deep, or that has an accumulation of snow or ice. A runway may also be considered contaminated with less than 25% coverage if the contaminant is located prior to the midpoint of the runway.”(2)

### B. Runway Contaminants

Slush – Snow mixed with water

Dry Snow – Snow that cannot be easily compacted by hand

Wet Snow - Snow that is easily compacted by hand

## III. CONTAMINATED RUNWAY PROCEDURES

### A. General Limitations

Takeoff and landings are prohibited when:

- Runway condition report unavailable
- Runway friction index is less than .25
- Slush, wet snow, or standing water is more than 0,5 in (13mm)
- Dry snow depth is more than 4 inches (102 mm)

### B. Crosswind Limitations

The crosswind guidelines below are derived from the B737NG Flight Crew Training Manual (FCTM) and the Canadian Runway Friction Index (CRFI)/Crosswind Guidance in the Canadian Flight Supplement. They are a compromise solution which takes into account both

guidelines. The FCTM guidelines are based on a combination of airplane flight test data, piloted simulator trials and engineering analysis, which considered both all-engine and engine-out landings. They were developed based on adverse airplane loading conditions and normal piloting technique, and thus represent conservative results. The Canadian CRFI/Crosswind guidelines are also based on flight tests. These numbers have been adopted for purpose of the example.

Gust effects were evaluated, and seemed to increase the pilot workload without significantly affecting the recommended crosswind guideline. However, Boeing is unable to provide an appropriate gust additive to the steady state guidelines, due to the infinite combinations of gust magnitude, duration, frequency and direction that might be encountered. As a result, we can decide that the crosswind limits include gust factors. For example, takeoff from a snow covered runway has a crosswind limit of 25 knots, including gust factor. If the prevailing wind is 20G30, takeoff would be prohibited.

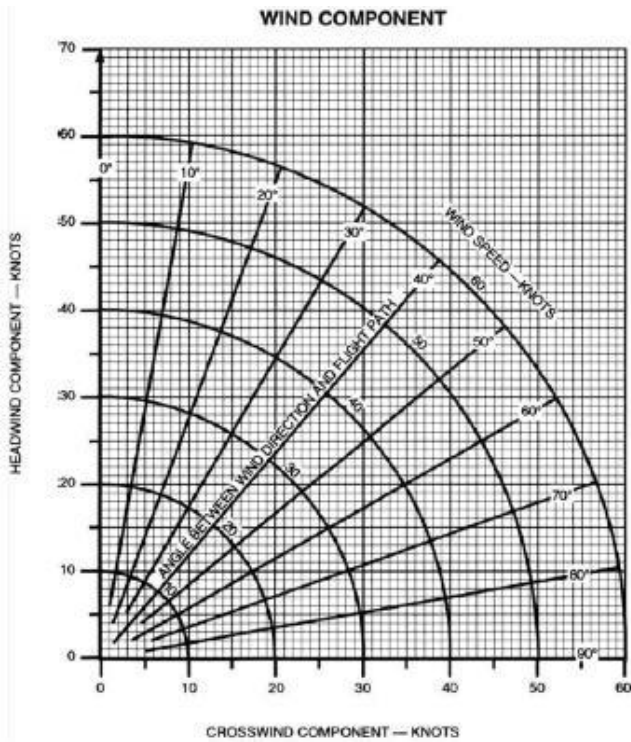


Figure 1. Wind component (1)

Runway Contaminant	Crosswind Component incl. gusts (knots)
Dry	34
Wet	25
Wet snow / standing water / slush	15
Dry snow < 3/4"	25
Compact snow with OAT ≤ -15°	
Dry snow > 3/4"	15
Sanded compact snow	
Sanded ice	
Dry snow on compact snow	10
Compact snow with OAT > -15°	
Bare ice	10
Dry snow on ice	

Figure 2. Runway contamination/wind component (1)

Note: Reduce crosswind guidelines by 5 knots on wet or contaminated runways whenever asymmetric reverse thrust is used. Sideslip only landings are not recommended with crosswind components in excess of 15 knots at flaps 15, 18 knots at flaps 30, or 21 knots at flaps 40. This recommendation ensures adequate ground clearance and is based on maintaining adequate control margin.

C. Runway Condition Determination Flow Chart For Takeoff

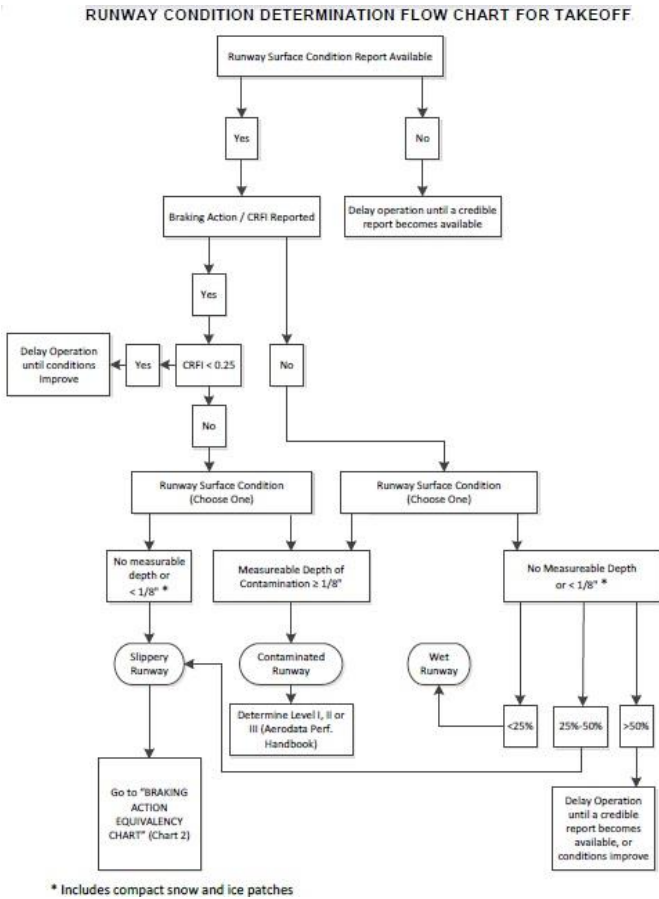


Figure 3. Runway condition determination flow chart for take off (1)

D. Braking Action Equivalency Chart

BRAKING ACTION EQUIVALENCY CHART						
Braking Action	Term	Definition	Runway Surface Condition	Estimated Correlations		
				Code	ICAO Mu	TC CRFI
Good		Braking deceleration is normal for the wheel braking effort applied. Directional control is normal.	<ul style="list-style-type: none"> <li>Water depth of 1/8" or less</li> <li>Dry snow less than 3/4" in depth</li> <li>Compacted snow with OAT at or below -15°C</li> </ul>	5	40 & above	>.49
Good to Medium				4	36 - 39	
Medium (Fair)		Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be slightly reduced.	<ul style="list-style-type: none"> <li>Dry snow 3/4" or greater in depth</li> <li>Sanded snow</li> <li>Sanded ice</li> <li>Compacted snow with OAT above -15°C</li> </ul>	3	30 - 35	.30 - .49
Medium to Poor				2	26 - 29	
Poor		Braking deceleration is significantly reduced for the wheel braking effort applied. Potential for hydroplaning exists. Directional control may be significantly reduced.	<ul style="list-style-type: none"> <li>Wet snow</li> <li>Slush</li> <li>Water depth more than 1/8"</li> <li>Ice (not melting)</li> </ul>	1	21 - 25	<.30 (NOTE - min. CRFI is 0.25 for SWG)
Nil		Braking deceleration is minimal to non-existent for the wheel braking effort applied. Directional control may be uncertain. Note: Taxi, takeoff, and landing operations in nil conditions are prohibited.	<ul style="list-style-type: none"> <li>Ice (melting)</li> <li>Wet ice</li> </ul>	-	20 & below	NA

Figure 4. Braking action equivalency chart (1)

E. Slippery/Contaminated Runway Takeoff

Condition: Departure runway is determined to be slippery or contaminated

Objective: To perform s Slippery/Contaminated Runway TAKEOFF calculation

Caution: Departure runway is not bare and wet

Caution: Departure runway is not bare and dry

Note: Use the following chart to determine which Supplementary Procedure is required for a "BLEEDS OFF" take off.

APU Available	Supp. Procedure Applicable
YES	NO ENGINE BLEED TAKEOFF SP.2
NO	UNPRESSURIZED TAKEOFF SP.2

Figure 5. Unpressurized or No bleed take off chart (1)

- Ensure compliance with contaminated runway limitations

- Consider all the current data to determine the actual condition of the departure runway. This includes (not in any hierarchy): current Automatic Terminal Information Service (ATIS), braking action from Pilot Reports (PIREPS), precipitation falling and current CRFI.
- Use the “RUNWAY CONDITION DETERMINATION FLOW CHART FOR TAKEOFF” to determine (if required) whether the runway is slippery or contaminated.
- Choose One: departure runway is slippery - go to SLIPPERY RUNWAY TAKEOFF CALCULATION or departure runway is contaminated – go to CONTAMINATED RUNWAY TAKEOFF CALCULATION

*F. Slippery Runway Takeoff Calculation*

- Slippery runway analysis charts are provided by Aerodata for all departure runways
- There runway specific charts are BLEESS OFF and assume TOGA thrust for takeoff.
- Use the “BRAKING ACTION EQUIVALENCY CHART” to determine which Slippery Chart to use (GOOD, FAIR/MED or POOR)
- Perform s SLIPPERY RUNWAY TAKEOFF analysis calculation using the appropriate level of braking action cell for the departure runway.
- Always observe the MAX V1 associated with the aircraft limit weight (not actual weight), listed in the applicable Slippery cell for the departure runway.

*G. Contaminated Runway Takeoff Calculation*

- Contaminated runway analysis charts are provided by Aerodata for all departure runways.
- These runway specific charts are BLEEDS OFF and assume TOGA thrust for takeoff.
- Perform a CONTAMINATED RUNWAY TAKEOFF analysis calculation using the appropriate level of contamination for the departure runway.
- Always observe the MAX V1 associated with the aircraft limit weight (not actual weight), listed in the applicable cell for the departure runway. That is LEVEL 1, LEVEL 2 or LEVEL 3.

*H. Slippery/Contaminated Runway Landing*

Condition: Landing runway is determined to be slippery or contaminated.

Objective: To perform a Slippery/Contaminated Runway LANDING Calculation

Caution: Landing runway is not bare and wet.

Caution: Landing runway is not bare and dry.

- Ensure compliance with contaminated runway limitations

- Consider all the current data to determine the actual condition of the landing runway. This includes (not in any hierarchy): current ATIS, braking action from PIREPS, precipitation falling and current CRFI.
- Flight Crew and Dispatchers will utilize all available means to determine runway/airport conditions and maintain timely communications regarding any changes.
- Flight Crews shall analyze all available data for the landing runway and have established a hierarchy for that data.
- Go to “SLIPPERY/CONTAMINATED RUNWAY LANDING CALCULATION”

*I. Slippery/Contaminated Runway Landing Calculation*

- Use FLAPS 40 and AUTOBRAKES MAX
- Using the actual landing weight, enter the Quick Reference Handbook (QRH) “Advisory Normal Configuration Landing Distance” table for FLAPS 40 and existing braking action (use BRAKING ACTION EQUIVALENCY CHART if required)
- Determine actual landing distance adjusted for existing weight and conditions in chart
- Add15% to this distance for landing safety factor
- If required, convert from meters to feet (1m – 3,28FT)

**IV. EXAMPLE OF CONTAMINATED RUNWAY CALCULATIONS**

Situation:

- Airport CYSB RWY 22, usable length 6600 ft
- Runway condition 100% dry snow covered (depth to 1 inch), no reported braking action, no CRFI
- Wind 310/10
- Temperature -17 C
- Takeoff weight 65,0 tons

Question:

- Can we depart? If so, why?
- Can we land? If so, why?

Takeoff:

Step 1 in the procedures is to check with the Limitations. You satisfy by not having a contaminant above 4 inches depth. You satisfy with a wind limit of 15 knots for dry snow (less than ¾ inches) contamination.

Step 2 in the procedure is to consider all the data including ATIS, PIREPS, precipitation and CRFI.

Step 3 is to go to Runway Condition Determination Flow Chart. The chart will take you to “Contaminated Runway”

performance required. Using the Aerodata Performance Handbook, this equates to a LEVEL 1 contamination (using “Dry Snow” as the contaminant definition).

**CONTAMINATION LEVELS**

	Contaminant				Ice Patches
	Water	Slush	Wet Snow	Dry Snow	
Level 1	Heavy rain with up to 1/8" or 3mm flooding	≤1/8" or <3mm	≤1/4" or <6mm	≤1" or <25mm	Ice Patches
Level 2	>1/8" to ≤1/4" or 3mm to 6mm	>1/8" to ≤1/4" or 3mm to 6mm	>1/4" to ≤1/2" or 7mm to 13mm	>1" to ≤2" or 26mm to 51mm	---
Level 3	>1/4" to ≤1/2" or 7mm to 13mm	>1/4" to ≤1/2" or 7mm to 13mm	---	>2" to ≤4" or 52mm to 102mm	---

Figure 6. Contamination levels (1)

Step 4 it to choose between slippery or contaminated. This case requires contaminated. We now proceed to “Contaminated Runway Takeoff Calculation”.

Step 5 is to pull up the contaminated Level 1 chart for RWY 22 at CYSB.

OAT °C	LEVEL 1 CONTAM		
	Flaps 25		
	-10T	+0	+10H
28	433F 1	624F 6	643F 9
26	439F 1	627F 6	646F10
24	445F 1	629F 6	648F10
22	451F 1	631F 6	650F10
20	458F 1	633F 7	652F11
18	465F 1	635F 7	655F11
16	472F 0	638F 7	657F11
14	479F 0	640F 8	660F12
12	486F 0	642F 8	662F12
10	494F 0	644F 8	664F12
0	534F 0	656F10	677F14
-10	582F 0	669F12	689F16
-20	620F 0	681F14	703F18
-30	632F 2	695F16	716*20
	High QNH	+200 per .10"	H
	Low QNH	-200 per .10"	L
	Engine AI ON	-100	I
	Wing AI ON	-100	I

Figure 7. Contamination level 1 (1)

Step 6 advises this is a BLEEDS OFF takeoff and full thrust.

Step 7 states to run the calculation using the Level 1 chart. Based on this chart, max V1 is 114 KIAS, and the weight limit is 67,7 metric tons using temp of -18 and a penalty of 100kg for use of wing and engine anti-ice.

Step 8 reminds you to use the max V1 associated with the limit weight. That was calculated as 114 KIAS in Step 7.

Step 9 use FLAPS 25 performance in the Speed book for VR and V2.

You can now proceed to takeoff, given these conditions.

**V. CONCLUSION**

All kind of operators have their own procedure concerning to safe operations. Some of them have just announced in their operation manuals that manufacturer procedure will be part of their operations. But as experience shows there is need to set up exact rules of dealing with situation as a contamination runway operation. We can see in the article that meteorological situation can lead us into many specific situations and if there are no exact rules we can have some difficulty how to solve it. For this and many other reasons it could be helpful to be prepared for winter operation and have in manuals operational procedure which is processed in detail. As a general guidance holders of air operator certificate can take the information from this article as a curriculum and prepare their own which will fit to their operational requirements. Another possibility could be invention of Civil Aviation Authority which can publish detailed information about contaminated runway operation. In this case operators will be forced to set up the procedure and safety of operation will be enhanced.

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