IMPACT OF SNOW AND FREEZING RAIN ON AVIATION AND AIRPORT OPERATION

De-icing of an A330 at Sheremetyevo Int. Airport
Wikipedia – De-icing; Photo: Pereslavtsev A.

Roland Winkler

Outline

- Introduction
- Aircraft – De-/Anti-Icing
- Contaminated Runway
- Meteorological Products

Credit: Wikimedia Commons – Brussels Airport from Belgium – Winter Operations, January 2013

INTRODUCTION

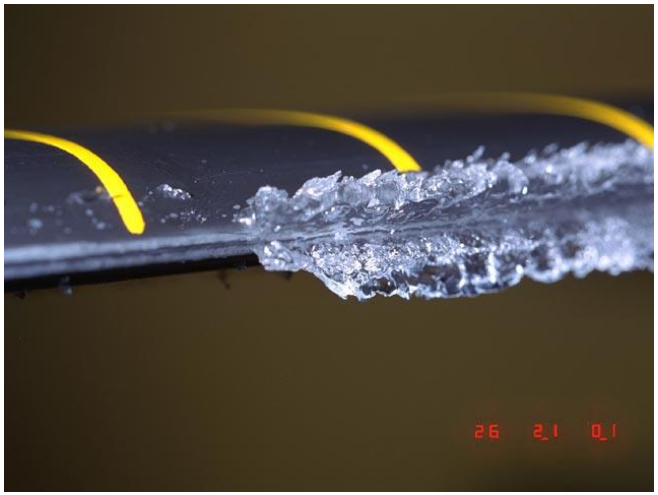
Introduction

Statement of an Airline-Manager

„What our industry earns in summer, it loses in winter."

Credit: Aero International 1/2019; Großbongardt H.; Jahr Media GmbH & Co. KG

Credit: Wikipedia – Icing Conditions; Photo: NASA – http://icebox.grc.nasa.gov/gallery/images/C99_1554.html



Credit: Wikipedia – Icing Conditions; Photo: NASA – http://icebox.grc.nasa.gov/gallery/images/C99_0391 8.html

Introduction

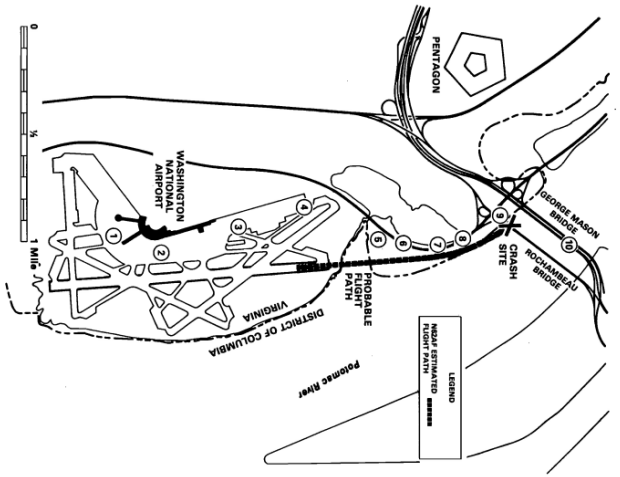
Ice can …

- change profile shape of the wing
  - reduce lift and increase air resistance
  - change angle of attack which aircraft pulls over – stall
  - change stall speed – increase up to 35 %
- partially block or hinder steering and trim
- increase the weight in flight
- block the holes in the pitot tube and static pressure drawer
- break aircraft antennas
- cause the horizontal stabilizer to stall
- cause the propeller to run unevenly and reduce propeller efficiency
- damage the internal engine parts

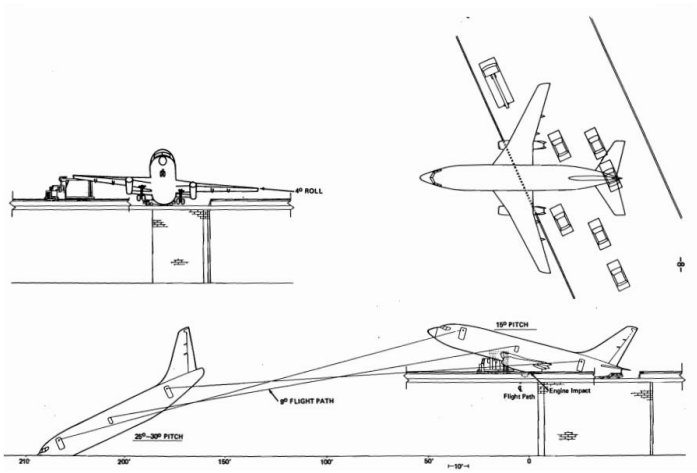
Introduction

Air Florida Flight Number 90
January 13th 1982

Credit: Wikipedia – Air-Florida-Flug 90; Photo: Duijnmayer P.



Contaminated Wings



Credit: National Transportation Safety Board – NTSB-AAR-82-8

Introduction

British European Airways Flight Number 609
February 6th 1958

Credit: Wikipedia – Munich Air Disaster; Photo: Mrs Thain R., scanned by Dunster I.

Contaminated Runway

Credit: Wikipedia – Ground Support Equipment; Photo: Mulag

AIRCRAFT – DE-/ANTI-ICING

Aircraft – De-/Anti-Icing

CAT.OP.MPA.250 Ice and other contaminants — ground procedures Regulation (EU) No 965/2012

a) The operator shall establish procedures to be followed when ground de-icing and anti-icing and related inspections of the aircraft are necessary to allow the safe operation of the aircraft.

b) The commander shall only commence take-off if the aircraft is clear of any deposit that might adversely affect the performance or controllability of the aircraft, except as permitted under (a) and in accordance with the AFM.

Credit: EASA – Easy Access Rules for Air Operations (Regulation (EU) No 965/2012

Aircraft – De-/Anti-Icing

CAT.OP.MPA.255 Ice and other contaminants – flight procedures Regulation (EU) No 965/2012

a) The operator shall establish procedures for flights in expected or actual icing conditions.

b) The commander shall only commence a flight or intentionally fly into expected or actual icing conditions if the aircraft is certified and equipped to cope with such conditions.

c) If icing exceeds the intensity of icing for which the aircraft is certified or if an aircraft not certified for flight in known icing conditions encounters icing, the commander shall exit the icing conditions without delay, by a change of level and/or route, if necessary, by declaring an emergency to ATC.

Credit: EASA – Easy Access Rules for Air Operations (Regulation (EU) No 965/2012

Aircraft – De-/Anti-Icing

Credit: Wikimedia Commons – De-Icing Toronto Pearson Airport's Central De-icing Facility; Photo: Ken Mist; https://commons.wikimedia.org/wiki/File:Deicing_Pearson.jpg

De-/Anti-Icing at VIE:

free icing position and de-icing vehicles available

↓

every aircraft must be registered for de-/anti-icing

↓

at least 30 minutes before published departure time

↓

ATC responsible coordinating de-icing positions and taxiing to them

Aircraft – De-/Anti-Icing

Credit: Wikipedia – Deicing fluid; Photo: Hartmann Nicolas

De-Icing:

- aircraft contaminated (ice, snow, snowrain, …)
- **no precipitation or freezing fog**
- one-step process
- Type I fluid (Propylene Glycol) mixed with hot water (60 to 80 °C) and orange colour additive
- mixing ratio depends on OAT
- newtonian fluid

Aircraft – De-/Anti-Icing

Credit: Wimedia Commons – De-icing; Photo: Visser Maarten; https://commons.wikimedia.org/wiki/File:De-icing_(8256274495).jpg

Credit: Wikipedia – De-icing; Photo: Quintin Soloviev

Anti-Icing:

- (freezing) precipitation and freezing fog
- two-step process
  - De-Icing: removement of frozen deposits (Type I fluid)
  - Anti-Icing: protect the aircraft against re-icing for a certain period
- Anti-Icing fluid – Type IV fluid (Ethylene Glycol) with green coloured additives

Aircraft – De-/Anti-Icing

Generic Holdover Times for SAE Type I Fluids on critical aircraft surfaces

Aluminium:

Outside Air Temperature[1,2]	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets[3,4]	Light Snow, Snow Grains or Snow Pellets[3,4]	Moderate Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 °C and above (27 °F and above)	0:11 - 0:17	0:18 - 0:22	0:11 - 0:18	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05	
below -3 to -6 °C (below 27 to 21 °F)	0:08 - 0:13	0:14 - 0:17	0:08 - 0:14	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10 °C (below 21 to 14 °F)	0:06 - 0:10	0:11 - 0:13	0:06 - 0:11	0:04 - 0:06	0:04 - 0:07	0:02 - 0:05		
below -10 °C (below 14 °F)	0:05 - 0:09	0:07 - 0:08	0:04 - 0:07	0:02 - 0:04				

Composite:

Outside Air Temperature[1,2]	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets[3,4]	Light Snow, Snow Grains or Snow Pellets[3,4]	Moderate Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 °C and above (27 °F and above)	0:09 - 0:16	0:12 - 0:15	0:06 - 0:12	0:03 - 0:06	0:08 - 0:13	0:02 - 0:05	0:01 - 0:05	
below -3 to -6 °C (below 27 to 21 °F)	0:06 - 0:08	0:11 - 0:13	0:05 - 0:11	0:02 - 0:05	0:05 - 0:09	0:02 - 0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10 °C (below 21 to 14 °F)	0:04 - 0:08	0:09 - 0:12	0:05 - 0:09	0:02 - 0:05	0:04 - 0:07	0:02 - 0:05		
below -10 °C (below 14 °F)	0:04 - 0:07	0:07 - 0:08	0:04 - 0:07	0:02 - 0:04				

Credit: FAA – FAA Holdover Time Guidelines, Winter 2020-2021, August 7, 2020

Aircraft – De-/Anti-Icing

Generic Holdover Times for SAE Type IV Fluids

Outside Air Temperature[1]	Fluid Concentration Fluid/Water By % Volume	Freezing Fog or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets[2,3]	Light Snow, Snow Grains or Snow Pellets[2,3]	Moderate Snow, Snow Grains or Snow Pellets[2]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 °C and above (27 °F and above)	100/0	1:15 - 2:40	2:20 - 2:45	1:10 - 2:20	0:35 - 1:10	0:40 - 1:30	0:25 - 0:40	0:08 - 1:10	
	75/25	1:25 - 2:40	2:05 - 2:25	1:15 - 2:05	0:40 - 1:15	0:50 - 1:20	0:30 - 0:45	0:09 - 1:15	
	50/50	0:30 - 0:55	1:00 - 1:10	0:25 - 1:00	0:10 - 0:25	0:15 - 0:40	0:09 - 0:20	CAUTION: No holdover time guidelines exist	
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:20 - 1:35	1:50 - 2:20	0:55 - 1:50	0:30 - 0:55	0:25 - 1:20	0:20 - 0:25		
	75/25	0:30 - 1:20	1:50 - 2:10	1:00 - 1:50	0:30 - 1:00	0:20 - 1:05	0:15 - 0:25		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:20 - 1:35	1:20 - 1:40	0:45 - 1:20	0:25 - 0:45	0:25 - 1:20[7]	0:20 - 0:25[7]		
	75/25	0:30 - 1:20	1:40 - 2:00	0:45 - 1:40	0:20 - 0:45	0:20 - 1:05[7]	0:15 - 0:25[7]		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:20 - 0:40	0:30 - 0:45	0:09 - 0:30	0:02 - 0:09				
below -18 to -25 °C (below 0 to -13 °F)	100/0	0:20 - 0:40[8]	0:10 - 0:20[8]	0:03 - 0:10[8]	0:01 - 0:03[8]				
below -25 °C to LOUT (below -13 °F to LOUT)	100/0	0:20 - 0:40[8]	0:07 - 0:10[8]	0:02 - 0:07[8]	0:00 - 0:02[8]				

Credit: FAA – FAA Holdover Time Guidelines, Winter 2020-2021, August 7, 2020

Aircraft – De-/Anti-Icing

Credit: Wikipedia – Scandinavian Airlines Flight 751; Swedish Accident Investigation Authority – https://reports.aviation-safety.net/1991/19911227-0_MD81_OY-KHO.pdf

Aircraft de-icing starts at positive temperatures

- cooled fuel in the wing tanks
- afterwards on the ground – ice forms on the wing in humid air

- December 27th, 1991; MD-81; SK 751
- overnight stop at Stockholm airport
- de-iced Type I fluid
- 25 sec after take-off a blow could be felt with subsequent vibrations
- failure of both engines

during take-off ice flake off as the wings bent – ice was sucked in by engines

Aircraft – De-/Anti-Icing

Approximate costs of De-/Anti-Icing:

Fluid	per Liter
De-Icing	1,13 Euro
Anti-Icing	2 Euro

Wing De-Icing	Liter
Airbus 320	200
Boeing 767	400
Boeing 777	600

Aircraft	De-icing costs (one time)
Narrow body	2 – 5 000 Euro
Wide body	8 – 13 000 Euro

Credit: Wikimedia Commons – Brussels Airport from Belgium – Winter Operations, January 2013

CONTAMINATED RUNWAY

Runway

Aircraft Overrun and Run-off Incidents and Accidents

Credit: Wikipedia – Runway Excursion Photo: Widyna G. – http://www.airliners.net/open.file/0975371/M/

Credit: Wikipedia – Delta-Air-Lines-Flug 1086; Photo: DeFrancisci Leonard J.; https://de.wikipedia.org/wiki/Datei:Delta_Air_Lines_flight_1086_from_Atlanta_to_New_York_LaGuardia_on_05_March_2015.jpg

Runway

ICAO – Annex 6 Part 1

- Contaminated Runway (more than 25 % covered)
  - water or slush more than 3 mm deep
  - loose snow more than 20 mm deep
  - compacted snow or ice, including wet ice
- Dry Runway
- Wet Runway

Runway

Credit: EASA – Research Project EASA.2008/4 – RuFAB Final Report Vol. 3. Functional Friction

Runway friction characteristics are needed for:

- deceleration of the aircraft after landing or a rejected take-off
- maintaining directional control using ground roll on take-off and landing (cross-wind, asymmetric engine-power, technical malfunctions)
- wheel spin-up at touchdown

Credit: ICAO Doc 9137 AN/898 – Airport Service Manual Part 2 – Pavement Surface Conditions

Runway

Credit: Wikipedia – Flächenenteisung;
Photo: Webb JC, FAA

Adverse runway conditions:

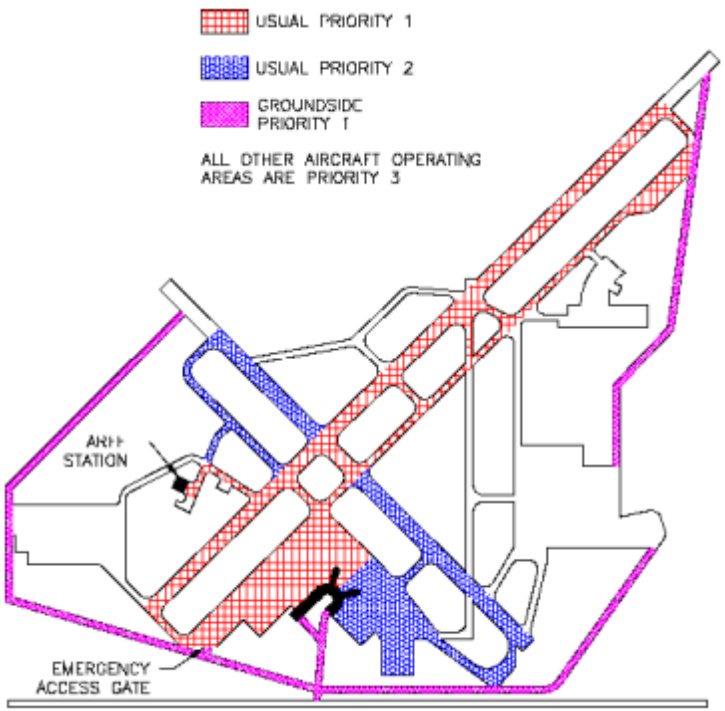
- correction of the performance have to be made
  - increasing runway length
  - reducing take-off weight/mass
  - reducing landing weight/mass

→ **economic impact**

- compensate reduced direction control – allowable cross wind component is reduced

Credit: ICAO Doc 9137 AN/898 – Airport Service Manual Part 2 – Pavement Surface Conditions

Runway



Credit: FAA – Advisory Circular 150/5200-30D; Airport Field Condition Assessments and Winter Operations Safety

Priority for clearance of snow, slush, ice and standing water:

- runway(s) in use
- taxiways serving runways
- apron(s)
- holding bay(s)
- other areas

Credit: ICAO Doc 9137 AN/898 – Airport Service Manual Part 2 – Pavement Surface Conditions

Runway

Credit: Wikimedia Commons – Boston Logan Airport Snow Blowers; Photo: MassDOT; https://www.flickr.com/photos/massdot/5658141911/

Removal of 2.54 cm (1 inch) snow

Annual Airplane Operations (includes cargo operations)	Clearance Time (Hour)
40 000 or more	1/2
10 000 – but less than 40 000	1
6 000 – but less than 10 000	1 1/2
less than 6 000	2

Credit: FAA – Advisory Circular 150/5200-30D; Airport Field Condition Assessments and Winter Operations Safety

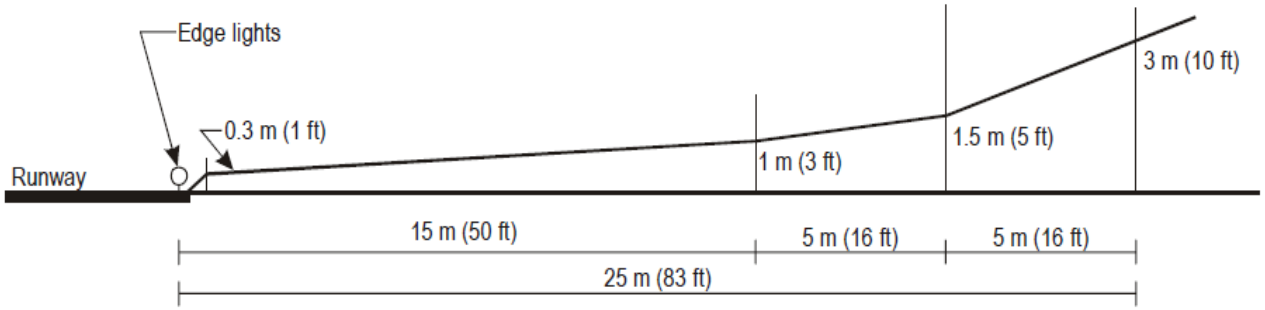
Recommended minimum equipment should include:

- one or more highspeed snowblowers
- remove snow which has a density of 400 kg/m^3
- minimum casting distance of 30 m

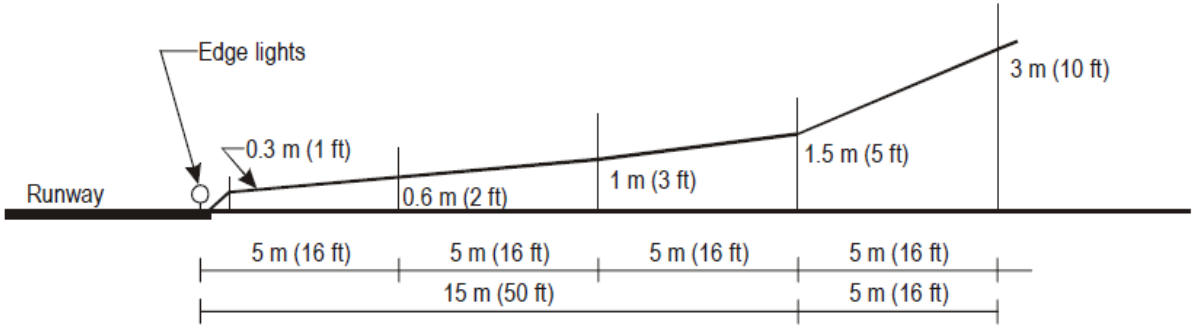
Credit: ICAO Doc 9137 AN/898 – Airport Service Manual Part 2 – Pavement Surface Conditions

Runway

Runway used by very large aircrafts (B-747, MD-11)



Runway used by other than very large aircrafts



Credit: ICAO Doc 9137 AN/898 – Airport Service Manual Part 2 – Pavement Surface Conditions

Runway

Airside Winter-Service at the Vienna Int. Airport:

snow removal – runway(s) and taxiway(s)

- quick removal
  - 25 minutes
  - runway and three landing dependent taxiways
- standard removal
  - 35 minutes
  - runway and six landing dependent taxiways
- complete removal
  - 60 minutes
  - runway, all taxiways and heads of runway

Runway

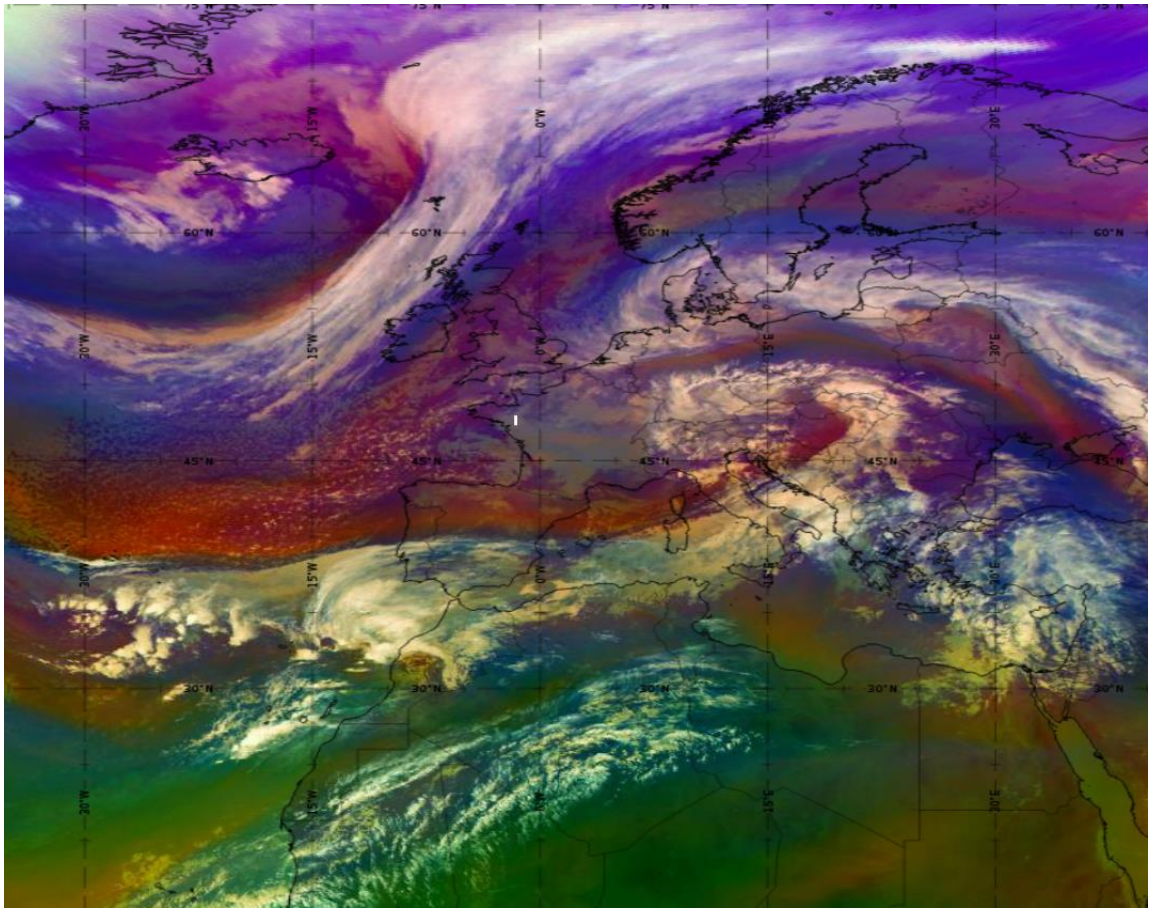
Airside Winter-Service at the Vienna Int. Airport:

- 2 200 000 m^2 runways, taxiways, apron
- corresponds to 330 km motorway
- a runway has an area of approximately 220 000 m^2
- de-icing agent (sodium format as granules, potassium format as liquid); 1 liter ≈ 1 euro
- winter service team up to 300 people
- snow is thrown away in the slopes and taxi area
- removal by truck in the apron area

Runway

Following points must be taken into account when clearing the runways and taxiways:

- type and intensification of precipitation
- exists already a snow covering
- further weather development (e.g. view of CAT)
- wind and runway configuration
- surface temperatur
- braking effect on the maneuvering surfaces

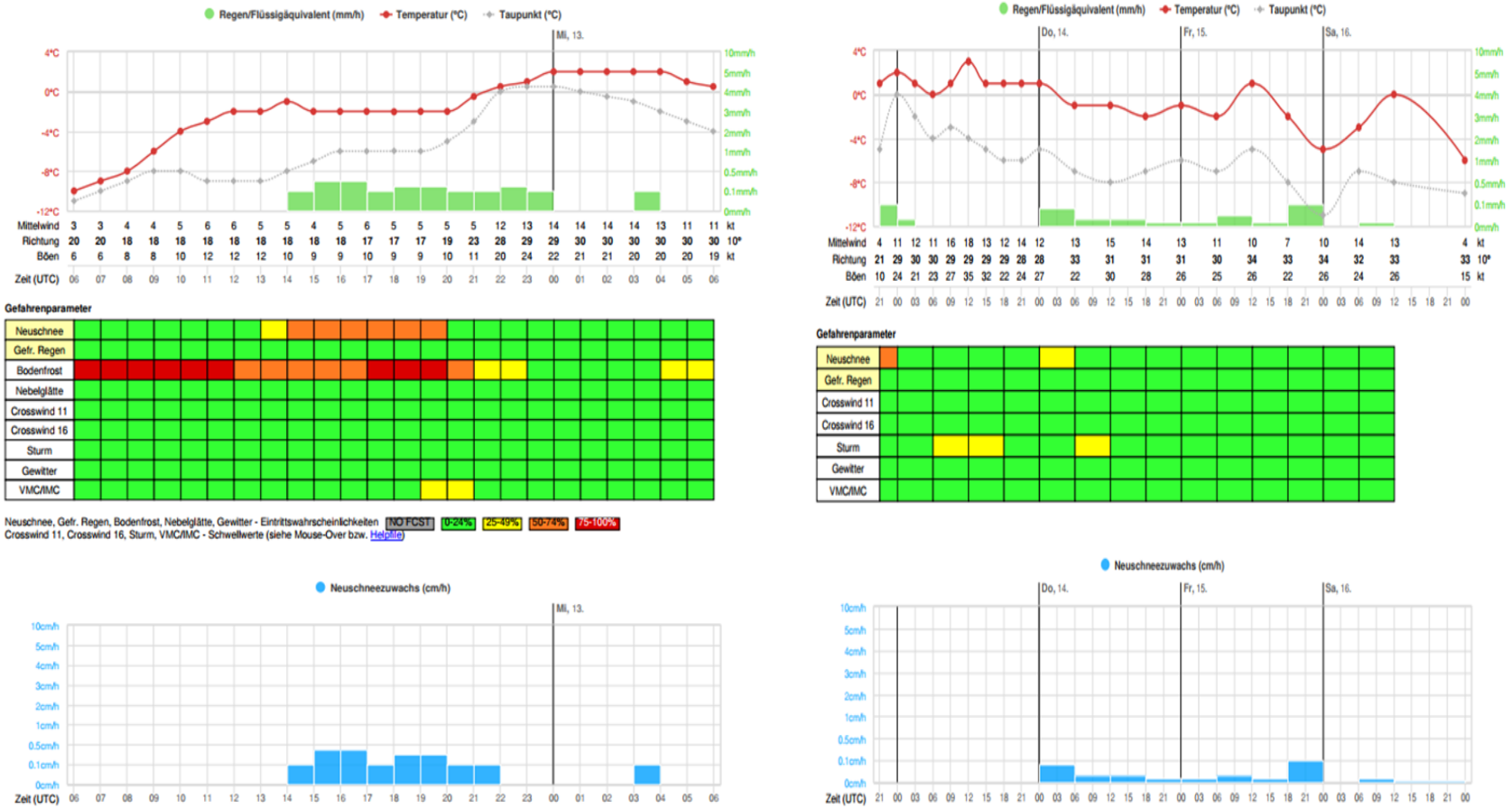


Credit: EUMeTrain – ePort MapViewer; Airmass_RGB – January 6th, 2021

METEOROLOGICAL PRODUCTS

Meteorological Products

Weather Forecast for the Vienna Int. Airport



Credit: Austro Control

Meteorological Products

METAR

METAR LOWW 060720Z 11003KT 4500 **-SN** BR FEW002 OVC004 00/M00
Q1009 **R88/29//95** TEMPO BKN005=

SNOWTAM (last winter part of the METAR)

Terminal Aerodrome Forecast (TAF)

TAF LOWW 120515Z 1206/1312 VRB02KT CAVOK TX01/1214Z TNM10206Z
BECMG 1208/1210 16007KT **–RASN** BKN010
BECMG 1211/1213 **–SN**
PROB30 TEMPO 1211/1213 **–FZRASN**
TEMPO 1213/1223 1200 **SN** VV005
BECMG 1301/1303 30012kt NSW BKN030
TEMPO 1309/1312 32020g30kt 0700 **SHSN** BKN008 FEW020TCU=

Meteorological Products

Aerodrome Warnings:

WOOS51 LOWW 121000
LOWW AD WRNG 1 VALID 121100/121300
FZRA FCST WKN=

WOOS51 LOWW 121000
LOWW AD WRNG 2 VALID 121300/121800
SN 20CM FCST NC=

Aerodrome Warnings: FZDZ, FZRA, SN, HOAR FROST, FROST

SIGMET (FZRA):

WSOS31 LOWW 121000
LOVV SIGMET F01 VALID 121030/121200 LOWW-
LOVV WIEN FIR **SEV ICE (FZRA)** FCST WI N4734 E01165 – N4750 E01545 – N4819 E01610 – N4806 E01712 – N4734 E01165 SFC/FL030 STNR WKN=