

SIRWEC 2012 Paper 0068

„New findings in winter maintenance and their implementation in Austria“



Precipitation 0.6 mm to 0.25 mm - Snow height 0.6 cm to 0.25 cm Hoarfrost or slightly visible snowfall											Precipitation 0.25 mm to 0.5 mm - Snow height 0.25 cm to 0.5 cm Very light snowfall												
		Road surface temperature [°C]												Road surface temperature [°C]									
Application rate [g/m²]		-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	Application rate [g/m²]		-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
Traffic during interval	250	16	10	10	10	10	10	10	10	10	10	250	11	10	10	10	10	10	10	10	10	10	10
	500	9	16	27	31	10	10	10	10	10	10	500	11	13	10	10	10	10	10	10	10	10	10
	1.000	6	17	28	30	10	10	10	10	10	10	1.000	12	14	10	10	10	10	10	10	10	10	10
	1.500	6	18	30	10	10	10	10	10	10	10	1.500	12	16	10	10	10	10	10	10	10	10	10
	2.000	6	19	31	10	10	10	10	10	10	10	2.000	13	17	10	10	10	10	10	10	10	10	10
	2.500	7	20	33	10	10	10	10	10	10	10	2.500	14	18	10	10	10	10	10	10	10	10	10
	3.000	7	21	35	10	10	10	10	10	10	10	3.000	14	19	10	10	10	10	10	10	10	10	10
	3.500	8	23	37	10	10	10	10	10	10	10	3.500	15	20	10	10	10	10	10	10	10	10	10
4.000	8	24	38	10	10	10	10	10	10	10	4.000	16	21	10	10	10	10	10	10	10	10	10	
Precipitation 0.5 mm to 0.75 mm - Snow height 0.5 cm to 0.75 cm Light snowfall											Precipitation 0.75 mm to 1.0 mm - Snow height 0.75 cm to 1.0 cm Light/moderate snowfall												
		Road surface temperature [°C]												Road surface temperature [°C]									
Application rate [g/m²]		-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	Application rate [g/m²]		-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
Traffic during interval	250	16	10	10	10	10	10	10	10	10	10	250	22	10	10	10	10	10	10	10	10	10	10
	500	17	10	10	10	10	10	10	10	10	10	500	22	10	10	10	10	10	10	10	10	10	10
	1.000	17	10	10	10	10	10	10	10	10	10	1.000	23	10	10	10	10	10	10	10	10	10	10
	1.500	18	10	10	10	10	10	10	10	10	10	1.500	24	10	10	10	10	10	10	10	10	10	10
	2.000	19	10	10	10	10	10	10	10	10	10	2.000	26	10	10	10	10	10	10	10	10	10	10
	2.500	20	10	10	10	10	10	10	10	10	10	2.500	27	10	10	10	10	10	10	10	10	10	10
	3.000	22	10	10	10	10	10	10	10	10	10	3.000	29	10	10	10	10	10	10	10	10	10	10
	3.500	23	10	10	10	10	10	10	10	10	10	3.500	31	10	10	10	10	10	10	10	10	10	10
4.000	24	10	10	10	10	10	10	10	10	10	4.000	33	10	10	10	10	10	10	10	10	10	10	

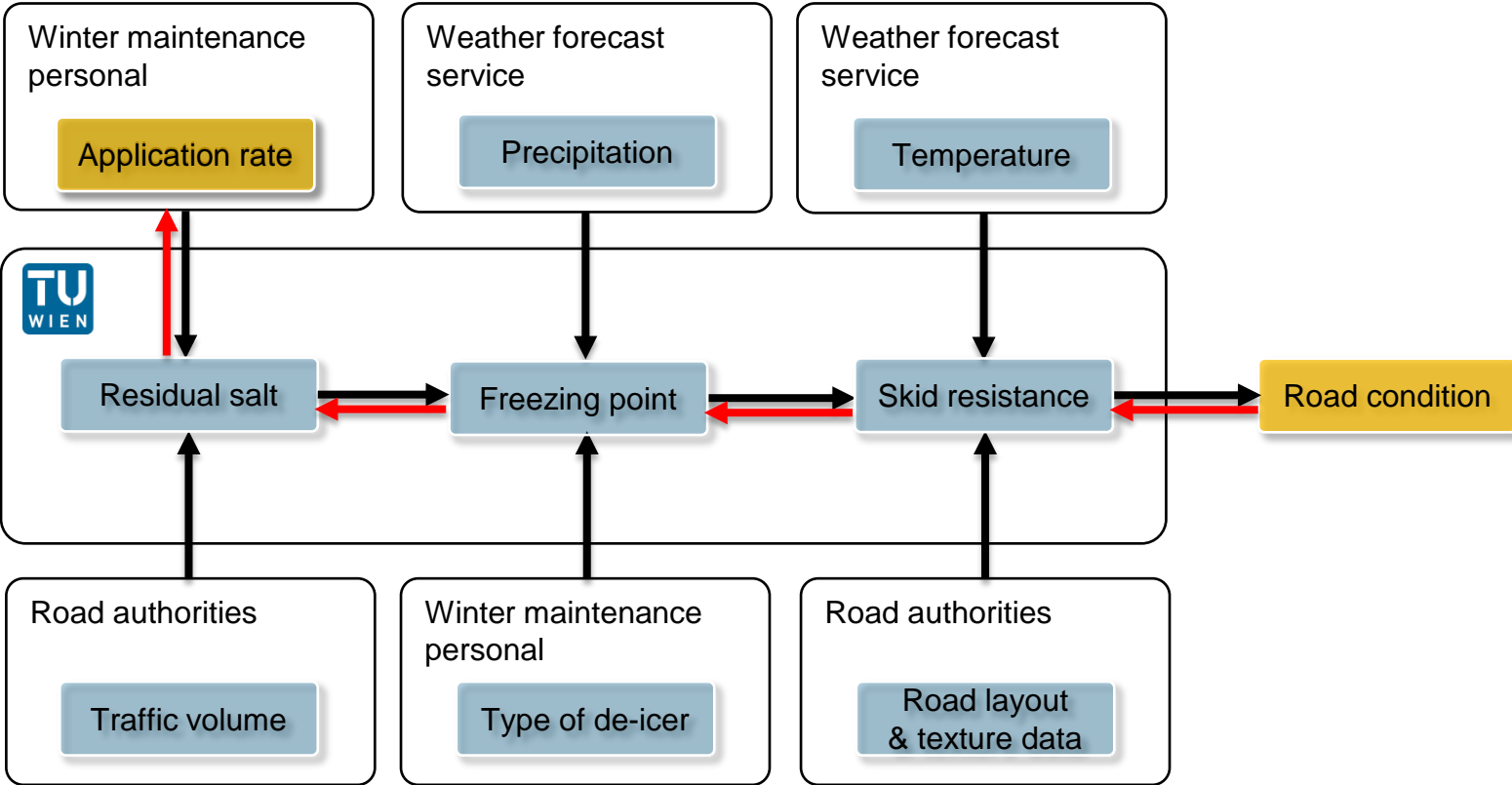


Hoffmann, M. - Nutz, P.

1 Facts – Winter maintenance, salt usage & environment in Austria

- Winter maintenance as a part of road maintenance defines the accessibility during the winter period and is therefore of high importance for the people and the economy in Austria.
Conclusion: Winter maintenance is important
- Winter maintenance from 1st of Nov. to 31st of March is responsible for approximately 20% of maintenance costs on regional roads; respectively 25% to 30% on highways in Austria.
Conclusion: Winter maintenance costs a lot of money
- Road authorities are pressurized by public opinion and existing legislation to provide high road safety standards at all times – but have very limited resources.
Conclusion: Need for optimized winter maintenance standards for all levels of roads
- The ministry of transport, the highway operator (ASFINAG) and the regional governments of Austria pooled funds for the research of winter maintenance with special emphasis on salting.
Conclusion: The guys at the University are cheap – let's see what they can do

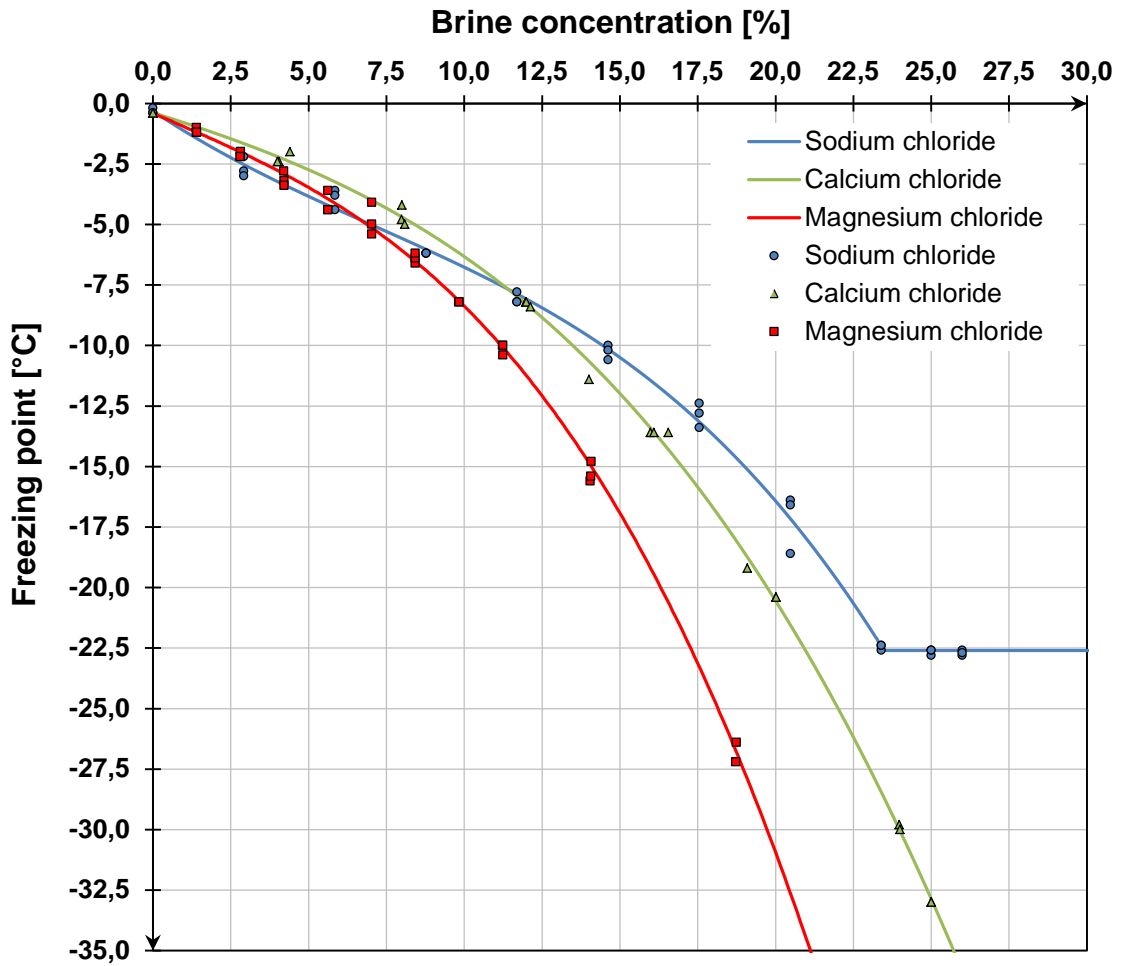
2 Modelling - Salt usage and cost comparison



3 Freezing point of sodium and calcium chloride brines

Freezing point

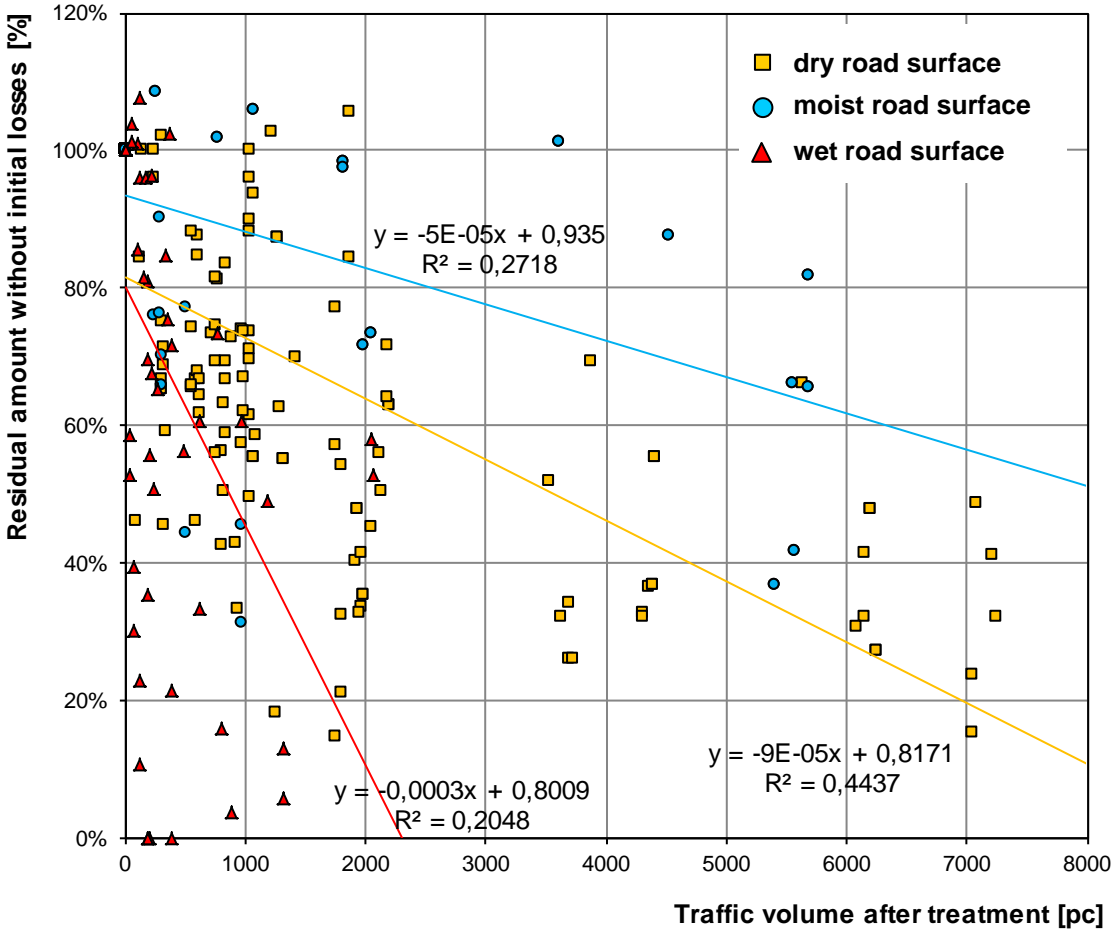
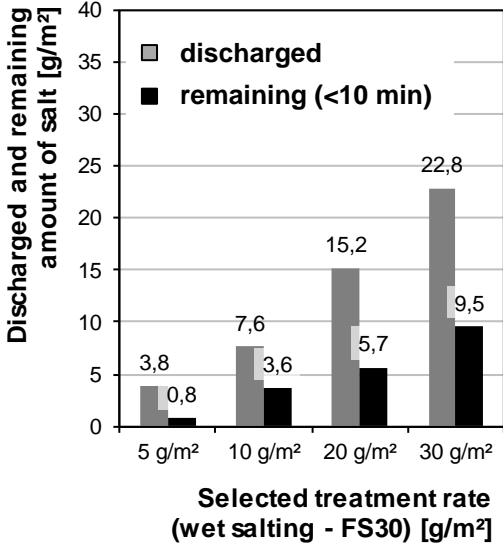
- Thawing if concentration of snow and salt has a lower freezing point as the road
- Cost efficient and mainly used de-icing agent is sodium chloride (NaCl)



4 Residual salt due to discharge losses, traffic and surface condition

Residual salt – FS30

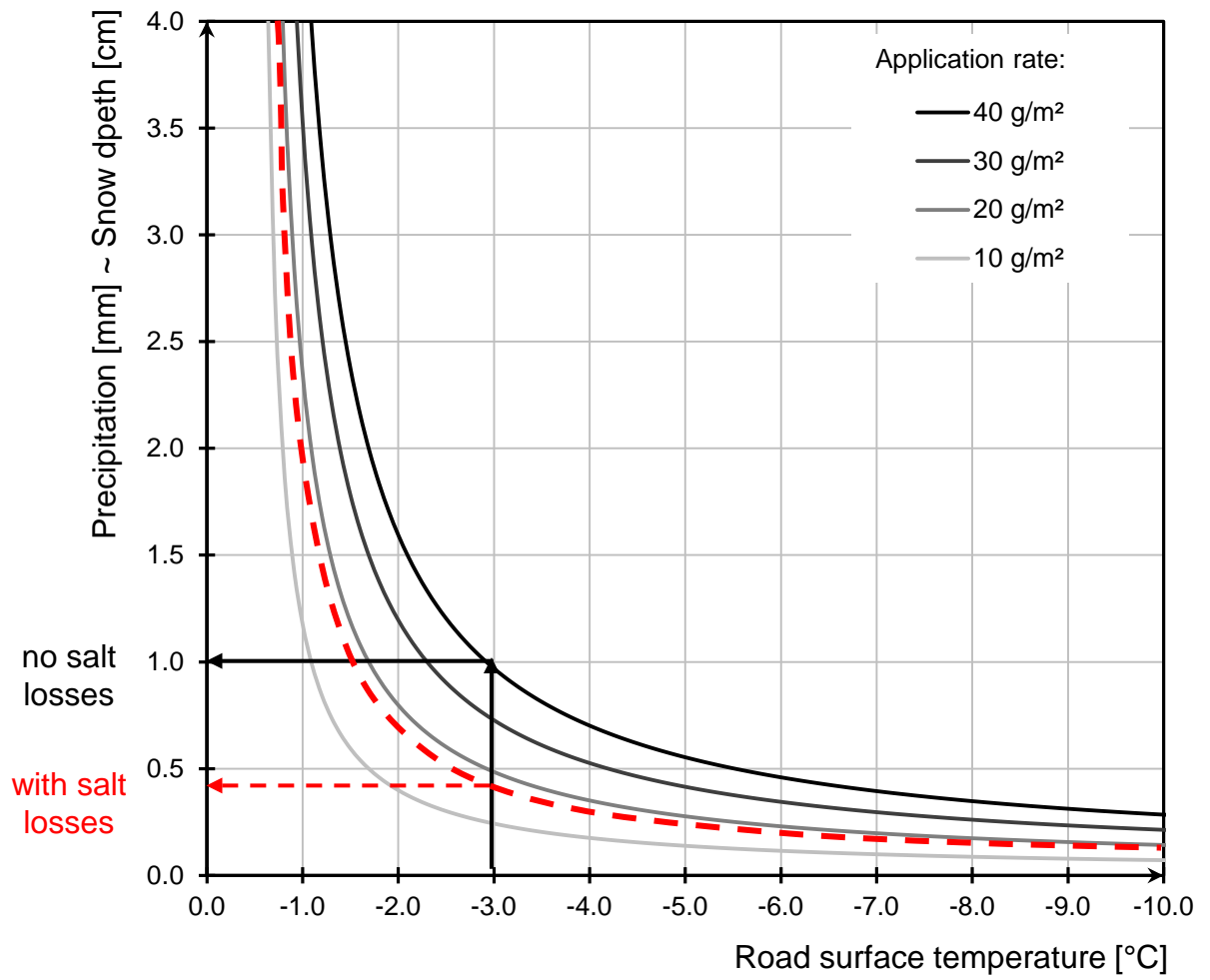
- Results show initial salt losses of around 60%
- Further losses related to traffic & surface conditions



5 Limited de-icing capability of sodium chloride

Freezing point

- Theoretical thawing capacity is very limited
- Salt losses reduce practical thawing capacity
- Results show initial salt losses of around 60%
- Further losses related to traffic & surface conditions



6 Importance of a preventive treatment

Preventive

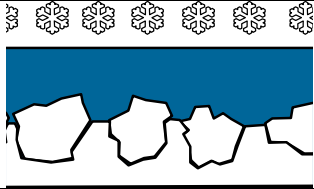
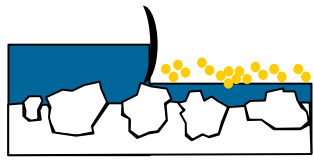
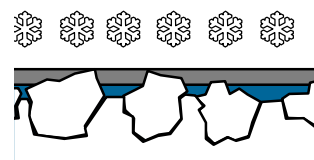
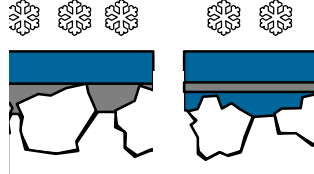
- If physical thawing capacity is exceeded snow on the road is unavoidable.
- To form a release coating an application of 10 g/m² is usually sufficient.
- The release coating is to be renewed with each treatment during snowfall
- After snowfall the remaining snow may be removed with ploughing and salting

Physical mechanism „Preventive treatment“	
	<p>1. Preventive treatment just before snowfall event e.g. 10 g/m² immediately prior to snowfall of about 1 cm/h Road surface temperature = - 5°C Treatment interval = 3 h 3 cm snow height during interval</p>
	<p>2. Dilution and forming of 2 phases 1. Phase snow/ice (about 0% salt) 2. Phase brine below (8% salt) The applied salt is dissolved gradually, until an equilibrium concentration is reached at 8% and -5°C</p>
	<p>3. Snowploughing and salting The brine prevents adhesion of the snow on the road surface and relieves further snowploughing. For salt application applies: remaining snow + applied salt = brine > 8% (Salt consumption depends on quality of ploughing and road condition)</p>
	<p>4. Thaw residual snow (continue with 2) Thaw of the remaining snow and brine formation > 8%; ongoing development according to 2 until end of snowfalls (discharge loss due to traffic and mixing not considered)</p>

7 Possible problems with delayed treatment

Delayed

- Snow is already compressed on the road surface
- Quality of ploughing in this cases is sufficiently lower
- Thawing attempts in such cases will create a slippery brine film on the snow layer

Physical mechanism „Delayed treatment“	
	<p>1. Snowfall and ice formation</p> <p>Snowfall of 1cm/h adds up to 3cm during the interval which are discharged or compressed by traffic.</p> <p>Possibility of ice formation due to high pressure or freezing of snow to the road surface</p>
	<p>2. Snowploughing and salting</p> <p>Increased Ploughing energy needed due to absence of release coating, higher remaining snow volume= higher salt rates needed</p> <p>Residual snow + salt = brine > 8% (Salt consumption depends on quality of ploughing and road condition)</p>
	<p>3. Icy conditions during melting process (2 phases)</p> <ol style="list-style-type: none"> 1. Phase brine on top (>8% salt) 2. Phase snow/ice (about 0% salt) <p>During the melting process >15 - 30 minutes vehicles drive on a layer of ice</p>
	<p>4. (Partial) Thawing of remaining snow</p> <p>With adequate ploughing and salting remaining snow thaw under formation of brine > 8% concentration</p> <p>Otherwise further development as in point 2 of the preventive treatment.</p> <p>With insufficient salting threatens icy conditions.</p>

8 Application rates due to precipitation, temperature and traffic

Precipitation 0,0 mm to 0,25 mm - Snow hight 0,0 cm to 0,25 cm Hoarfrost or slightly visible snowfall											
Application rate [g/m²]	Road surface temperature [°C]										
	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	
Traffic during interval	250	5	16	26	36	10	10	10	10	10	10
	500	6	16	27	37	10	10	10	10	10	10
	1.000	6	17	28	39	10	10	10	10	10	10
	1.500	6	18	30	10	10	10	10	10	10	10
	2.000	6	19	31	10	10	10	10	10	10	10
	2.500	7	20	33	10	10	10	10	10	10	10
	3.000	7	21	35	10	10	10	10	10	10	10
	3.500	8	23	37	10	10	10	10	10	10	10
	4.000	8	24	40	10	10	10	10	10	10	10

Precipitation 0,25 mm to 0,5 mm - Snow hight 0,25 cm to 0,5 cm Very light snowfall											
Application rate [g/m²]	Road surface temperature [°C]										
	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	
Traffic during interval	250	11	32	10	10	10	10	10	10	10	10
	500	11	33	10	10	10	10	10	10	10	10
	1.000	12	34	10	10	10	10	10	10	10	10
	1.500	12	36	10	10	10	10	10	10	10	10
	2.000	13	38	10	10	10	10	10	10	10	10
	2.500	14	10	10	10	10	10	10	10	10	10
	3.000	14	10	10	10	10	10	10	10	10	10
	3.500	15	10	10	10	10	10	10	10	10	10
	4.000	16	10	10	10	10	10	10	10	10	10

Precipitation 0,5 mm to 0,75 mm - Snow hight 0,5 cm to 0,75 cm Light snowfall											
Application rate [g/m²]	Road surface temperature [°C]										
	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	
Traffic during interval	250	16	10	10	10	10	10	10	10	10	10
	500	17	10	10	10	10	10	10	10	10	10
	1.000	17	10	10	10	10	10	10	10	10	10
	1.500	18	10	10	10	10	10	10	10	10	10
	2.000	19	10	10	10	10	10	10	10	10	10
	2.500	20	10	10	10	10	10	10	10	10	10
	3.000	22	10	10	10	10	10	10	10	10	10
	3.500	23	10	10	10	10	10	10	10	10	10
	4.000	24	10	10	10	10	10	10	10	10	10

Precipitation 0,75 mm to 1,0 mm - Snow hight 0,75 cm to 1,0 cm Light/moderate snowfall											
Application rate [g/m²]	Road surface temperature [°C]										
	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	
Traffic during interval	250	22	10	10	10	10	10	10	10	10	10
	500	22	10	10	10	10	10	10	10	10	10
	1.000	23	10	10	10	10	10	10	10	10	10
	1.500	24	10	10	10	10	10	10	10	10	10
	2.000	26	10	10	10	10	10	10	10	10	10
	2.500	27	10	10	10	10	10	10	10	10	10
	3.000	29	10	10	10	10	10	10	10	10	10
	3.500	31	10	10	10	10	10	10	10	10	10
	4.000	33	10	10	10	10	10	10	10	10	10

7 Road safety - Driving and treatment recommendations

1/2

Picture documentary	Road condition	Treatment recommendation	Treatment recommendation	
	Dry road: <hr/> No sleekness expected Surface temperature: -30°C to +60°C High skid resistance, $\mu = 0,6 - 1,0$ <hr/> Hoarfrost possible or expected (usually at 2 - 4 am)	Minimal salting only at hoarfrost: <hr/> No treatment required <hr/> Preventive treatment 5 – 10* g/m ² with beginning hoarfrost	Minimal salting only at hoarfrost: <hr/> No restrictions due to weather based road conditions needed. <hr/> Reduction of the speed by at exposed road sections (e.g. bridges)	
		Moist or wet road: <hr/> Road surface temperature > 0° C Moderate skid resistance, $\mu = 0,4 - 0,7$ <hr/> Road surface temperature ≤ 0° C Moist road Moderate skid resistance, $\mu = 0,2 - 0,6$ <hr/> Road surface temperature ≤ 0° C Wet road Very low skid resistance, $\mu = 0,1 - 0,6$	Salting at temperatures below 0°C: <hr/> No treatment required (Watch temperature!) <hr/> Preventive treatment with 5 – 10* g/m ² Before beginning freezing <hr/> Treatment with 20 to 40* g/m ² before freezing critical Warning messages if black ice forms!	Local ice at sub-zero temperatures: <hr/> Reduction of speed in case of lane grooves <hr/> Caution, black ice possible, Reduction of the speed by 50% at exposed road sections <hr/> Caution, black ice possible, Reduction of the speed by 70% at exposed road sections
		Snow next to wheel tracks: <hr/> No snowfall Wheel tracks free of snow Moderate skid resistance, $\mu = 0,3 - 0,5$ <hr/> Snowfall less than 0,5 cm/interval Low skid resistance, $\mu = 0,2 - 0,4$ <hr/> Snowfall more than 0,5 cm/interval Snow in wheel tracks Low skid resistance, $\mu = 0,2 - 0,4$	Ploughing and salting: <hr/> Ploughing and salting with 10 – 20* g/m ² , to remove remaining snow <hr/> Ploughing and salting with 10 – 20* g/m ² <hr/> Ploughing and salting 10 g/m ² (release coating!) until end of snowfalls, then ploughing and salting with 10 – 20* g/m ²	Adapted driving: <hr/> Adapted driving. Reduction of the speed by 20 to 30% <hr/> Adapted driving to road conditions. Reduction of the speed by 30 to 40% Consider restricted visibility!

7 Road safety - Driving and treatment recommendations

2/2

Picture documentary	Road condition	Treatment recommendation	Treatment recommendation
	Snow in wheel tracks: No snowfall Road covered with snow Low skid resistance, $\mu = 0,2 - 0,3$	Ploughing and salting: Ploughing and salting with 20 – 30* g/m ² , to remove remaining snow	Adapted driving:: Adapted driving. Reduction of the speed by 40 to 50% Adapted driving to road conditions. Reduction of the speed by 60 to 70% Consider restricted visibility!
	Snowfall less than 0,5 cm/interval Low skid resistance, $\mu = 0,2 - 0,3$	Ploughing and salting with 10 – 20* g/m ²	
	Snowfall more than 0,5 cm/interval Very low skid resistance, $\mu = 0,1 - 0,3$	Ploughing and salting 10 g/m ² (release coating!) until end of snowfalls, then ploughing and salting with 20 – 30* g/m ²	
	Very low skid resistance No precipitation Road surface temperature $\leq 0^{\circ}\text{C}$. Very low skid resistance, $\mu = 0,05 - 0,2$	Salting as required: Preventive treatment if possible, Maximum treatment at critical/icy Spots, Further treatments as necessary	Particular caution, walking pace: Follow driving restriction until clearance of road. Pass dangerous areas with walking pace Caution, ice beneath snow layer is not visible and therefore dangerous. Adapted driving to road conditions. Reduction of the speed to walking pace
	Black ice and further precipitation (Snow or rain) Very low skid resistance, $\mu = 0,05 - 0,2$	Maximum treatment until ice is cleared Closure of road sections as necessary. Opening after closure only if skid resistance is sufficient	

Dry and wet roads are usually safe – the developed model allows an optimization of winter maintenance in real time – but responsible driving is still necessary !!!

THANK YOU FOR YOUR ATTENTION