PRECISE SPREADING OF LIQUID (BRINE) WITH GPS AND NOZZLES.

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INTRODUCTION

The purpose of using brine (saturated saline solution, here 24% NaCl) for ice clearing and snow removal is to decrease the use of salt (NaCl or other chemical), but at the same time maintain or increase the level of accesibility and safety.
In this report focus is put on the possibility to decrease the use of salt by spreading salt precise with GPS and brine (liquid) spread with nozzles.

ABSTRACT

90 % of salt spread as liquid (brine), but only 65 % of salt spread as pre-wetted, is active on the road. [1, Fonnesbech 2001].
In the winters of 2005-2007 spreading of liquid by nozzles was the only way the County of Funen used salt (NaCL). Spreading velocity was 70 (80) km/hour.
*The County of Funen **used 50 % less salt** compared with the neighbor counties [2. www.vintertrafik.dk].*
*Liquid spreading caused **less problems in removing snow** compared with spreading of pre-wetted or dry salt.*
*Earlier studies showed **10 % fewer accidents** caused by icy roads, when using liquid spreading through nozzles.*

New Liquid Spreaders:

Accuracy of data collection was excellent (result of control showed data values +-3% precision of what had been spread on the road).

The optimal placement of the salt when spread in 2 lanes is a distribution of 50% in either lane. Tests with the new liquid spreaders have shown a distribution rate of more than 40% in both lanes, which equals 80% of the goal.

GPS-controlled spreading and route navigation makes sure that you are always spreading correctly.

Heavy traffic/motorway.

It is possible to reduce salt quantities in heavy traffic (heavy lane on motorway) [3, Anonymous. 2003].

GPS controlled spreading.

70 km/hour = 19 m/second.
On 100 m road you may have 4 changes in symmetry and width (5 seconds).
It is essential to know if there is a curve requiring salt to be placed at the high level of the road.
It is essential to have GPS-controlled spreading, if you want to use less salt for the benefit of the environment and to ensure optimal safety and accessibility.

MAIN RESULTS

Winter statistic

On www.vintertrafik.dk the Road Directory in Denmark collected data from Winter Service in Denmark. In Figure 1 you have a look of the amount in kg/m² of salt (NaCl) used in the counties in Denmark the winter 2005 – 6. The County of Funen is named "Fyn". The tree counties neighbour to the County of Funen is "Vejle" placed Vest, "Vestsj." Placed East and "Storstr." Placed South East of the County of Funen.
In the winter 2005 – 6 we have more snow in Denmark than normally.
Only the County of Funen use brine spread with nozzles. The County of Funen has less problems with removing snow then when we use pre-wetted or dry salt.

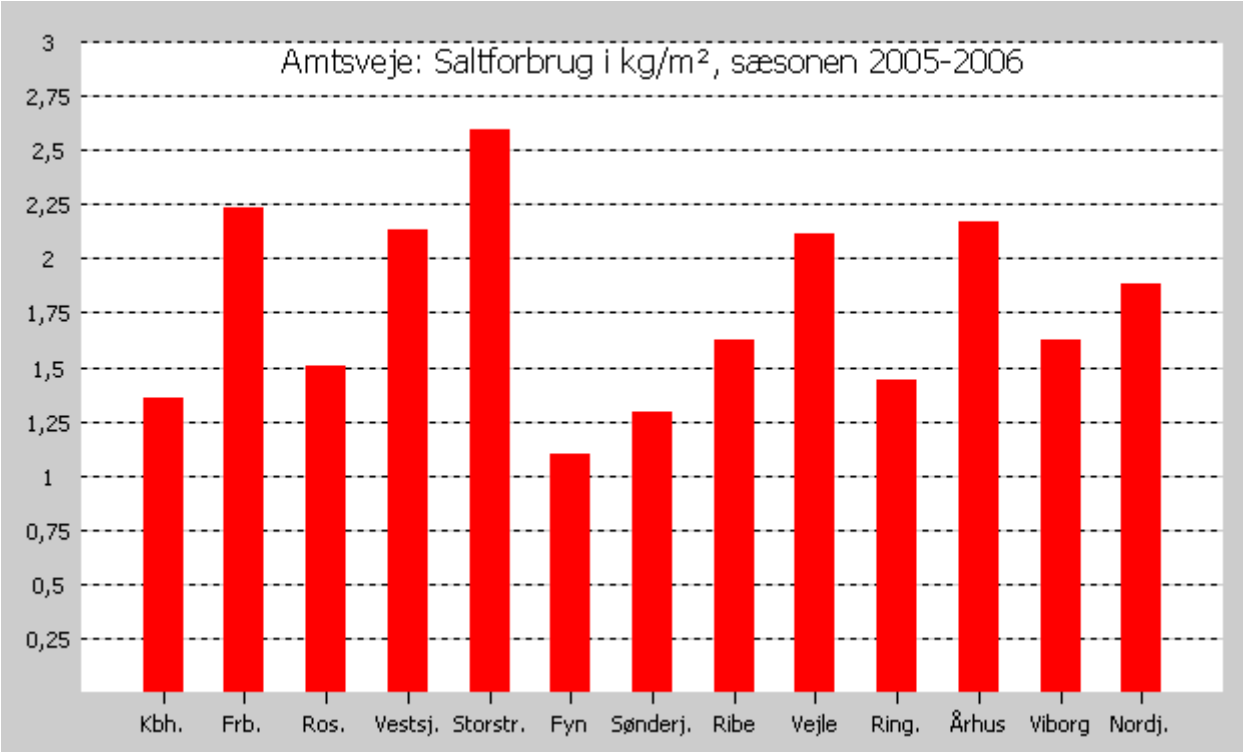


Figure 1, winter 2005 - 6 (www.vintertrafik.dk)

In figure 2 you have a look at the winter 2006 – 7. A winter with less snow than normally.

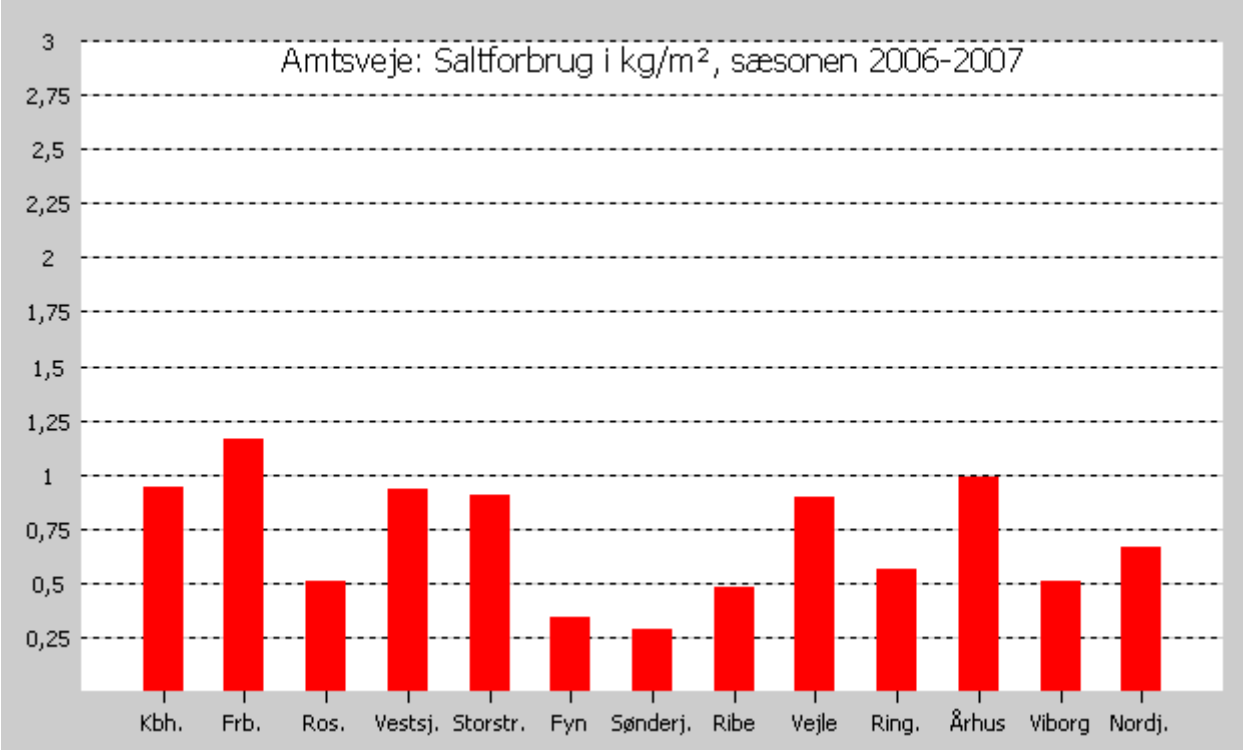


Figure 2, winter 2006 – 7 (www.vintertrafik.dk)

	Salt Kg/m² 2005 – 6	Salt Kg/m² 2006 - 7
Fyn	1,1	0,34
Vejle	2,11	0,89
Vestsj.	2,13	0,94
Storstr.	2,59	0,83

Accidents

In the winters 2003 – 5 (3 winters) used The County of Funen both Brine spread with nozzles and Pre Wetted Salt. In the 3 winters the salt routes with Brine was only with Brine, and the routes with Pre Wetted was only with Pre Wetted Salt. Than it was simply to count the police reported accident cause icy roads. The count show:

Pre-wetted:

Road length: 439 km area: 3.200.000 m² accident: 39

11.3 km road/accident 82.000 m² road/accident

Brine with nozzle:

Road length: 604 km area: 4.400.000 m² accident: 48

12.6 km road/accident 92.000 m² road/accident

10 % less accident *cause icy roads, when using brine.*

The results are before The County of Funen knows how essential it is to place salt at the high level in curves.

New Spreaders

In 2005 the County of Funen should buy 8 new brine spreaders. The County of Funen makes the decision not to describe the spreaders as spreaders with nozzles.

Instead The County of Funen said:

50 % of the price was from how much brine a spreader could use on one tour.
35 % of the price was precisely spreading across the road.
7.5 % of the price was precisely data of how much the spreader had spread.
7.5 % of the price was GPS

Under these circumstances only 2 companies want to sell spreaders to The County of Funen. The best spreaders to the price were from Epoke. It was 14 m³ brine spreaders with Spratronic Nozzles, but without GPS.
Later on The County of Funen buy GPS.
Control show that the spreader on one trip could use 13.98 m³ brine.
Control show the spreading across the road was precisely and data collected show precisely how much the spreader had spread on the road(+- 3 %).

The spreading across the road was so precisely; that we observed a new factor influence where salt was on the road.
"When there is moisture / water (ice) on the road, the salt will run from the high level of the road to the lower level". With other words: "It is not necessary to place salt near the lower level on the road, but it is essential to place salt at the high level in curves."
Remember that motorway normally is curves to the left or to the right. The only way you can sure that you place salt on the high level in curves on motorway is to use GPS controlled spreading.

GPS controlled spreading

When driving 70 km/hour you move 19 m every second. Then is it necessary automatically to adjust spreading width and symmetry. A spreading route of 40 km typically contains between 100 and 200 changes of spreader settings. GPS controlled spreading (in Epoke EpoSat) eliminates the possibility of human errors and achieves a repetition of the route, which is 100% identical every time. Thus the driver may concentrate on steering the vehicle and keeping his focus on the traffic.

Software for route editing
Prior to the winter season the spreading routes are driven through with the typical settings for start/stop of spreading, spreading quantity, spreading symmetry, start/stop of warning light, start/stop of data collection.
The operations manager may use the EpoSat® software to edit routes and change settings. The software allows cutting, copying, insertion of speech messages and addition of ”way points”, whereby a route may be expanded/changed without having to perform a new route recording.
The recorded routes are then transferred to the spreader computer again, and may then be used by the driver for automated spreading.
With GPS controlled spreading you use precisely the same amount of brine (+- 3%) every time you drive the salt route.
When using new brine spreaders with nozzles and GPS controlled spreading the manager know precisely where the salt is placed, and can optimise the routes.
When using GPS controlled spreading compared with **route navigation** is it not necessary that the driver know the route exactly.

BACKGROUND

Results from 1998-99

In the winter of 1998-99, systematic measuring of residual salt from spreading of brine as well as pre-wetted salt was made (reference). A total of 1800 spots were measured for residual salt [1, Fonnesbech 2001].
The test results show that saturated brine is spread more evenly across the road.
Diagram 1 also shows that a larger amount of salt from the brine is still present on the road 2 hours after the spreading, compared to the use of pre-wetted salt.

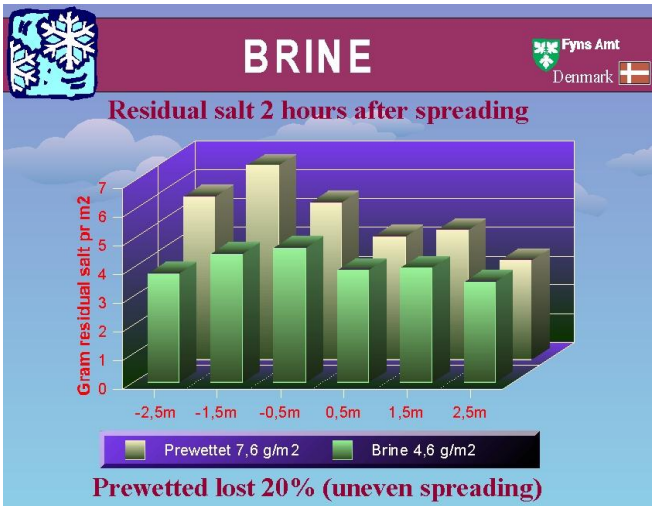


Diagram 1. Cross distribution 2 hours after spreading.
It must be noticed that there is spread 7.6 g NaCl/m² as pre-wetted salt and 4.6 g NaCl/m² as brine.

The uneven spreading of salt from a spreader with dish was proven in 2000 on a great measurement of dish spreaders on Tirstrup (Århus) Airport. [2, Freddy Knudsen, Kim Niels Sørensen 2001].

From the report [1, Fonnesbech 2001]:

"The more even distribution is obtained even though the truck spreading brine is driving with a speed of 70 km/h.

Several statistical analyses have been carried out from the 1800 test results and the following main results have been obtained:
The residual salt measurements give a useable picture of the amounts of residual salt on the carriageway.
That relatively more of the salt from the brine than the pre-wetted salt, is active on the carriageway, is statistically strongly significant, and thereby proven.
About 90% of the salt from the brine are active on the carriageway, but only 60-65% when it comes to the pre-wetted salt.
High traffic intensity has a crucial influence on the degradation of the residual salt.
The following formulas has been obtained
*Residual salt (brine) = -0.012% * TI + 88%.*
*Residual salt (pre-wetted salt) = -0.011% * TI + 64%.*
Where TI indicates the number of passing cars."

Studies on motorway

The experiences go on in 2000-2002 on the motorway across Funen, 3. [Anonymous. 2003]
From the conclusion is:

"*In hoar frost situations 5.2 g of NaCl/m2 was distributed in the form of brine, and 7.7 g of NaCl/m2 in the form of prewetted salt. Nothing in the study indicates a difference in the winter road maintenance.*"

"*Going through the pictorial material and personal observations of the testing area, it is the opinion of the work committee that the "overdosing" by the prewetting spreader in the fast lane is more expedient in a snow situation than the uniform distribution by the liquid (brine) spreader. This study shows that spreading of brine does not have the same positive effect as spreading of prewetted salt.*"

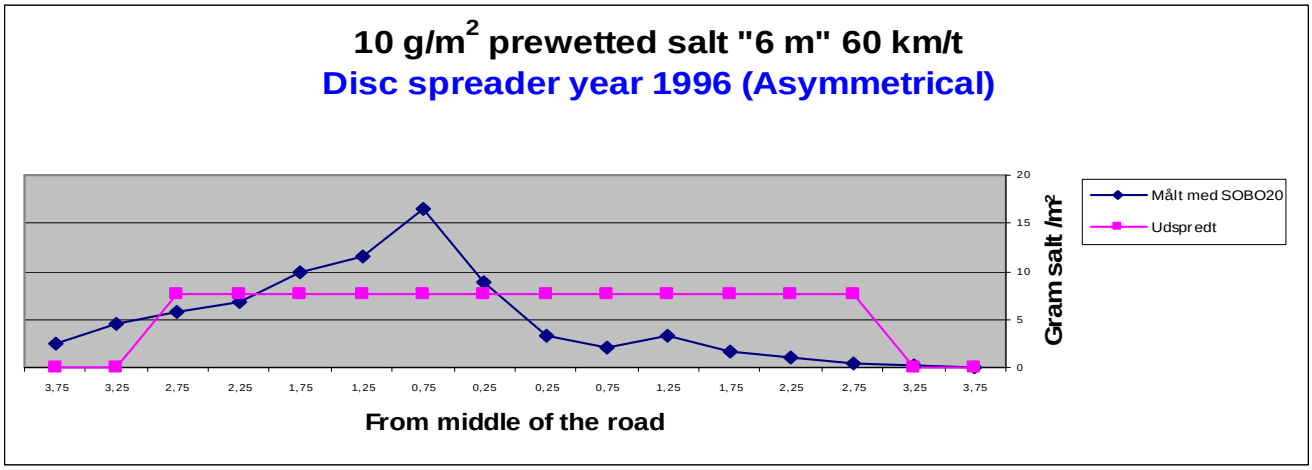
The last conclusions hide from view the fact, that "overdosing" was a fault. Of course in this situation a fault with good result, but a fault you can not control, when you use spreader with disc. (look at diagram 2 and 3, with measurements of dish spreaders with opposite rotation.)
The fault demonstrate that we can use less salt when there is heavy traffic, for example 60 % on the lane with heavy traffic(slow lane) and 100 % on the lane with light traffic(fast lane), [3, Anonymous. 2003].
The fault is later on used positive when spreading brine with nozzles, because with nozzles we can precisely have power over where to place the salt.

Spreading measurements 2004

In 2004 The County of Funen do measurements with SOBO20 to check the spreading from all salt spreaders used in the county. Reports from the measurements are only in Danish. All data from the measurements are in Excel, and it will be relative simple to translate data to English, if someone want to do more studies.
Some result from the measurements shall be publicized here.

Spreading disc with opposite rotation.

When spreading salt with disc it is necessary to know if the disc rotates the one direction or the opposite.
The next 2 diagrams show measurements from 2 spreaders with disc who rotate in opposite direction. Red is the among we try to spread and blue the measurement. The examples here are extremely bad, but at the same time examples of normally spreading situations.



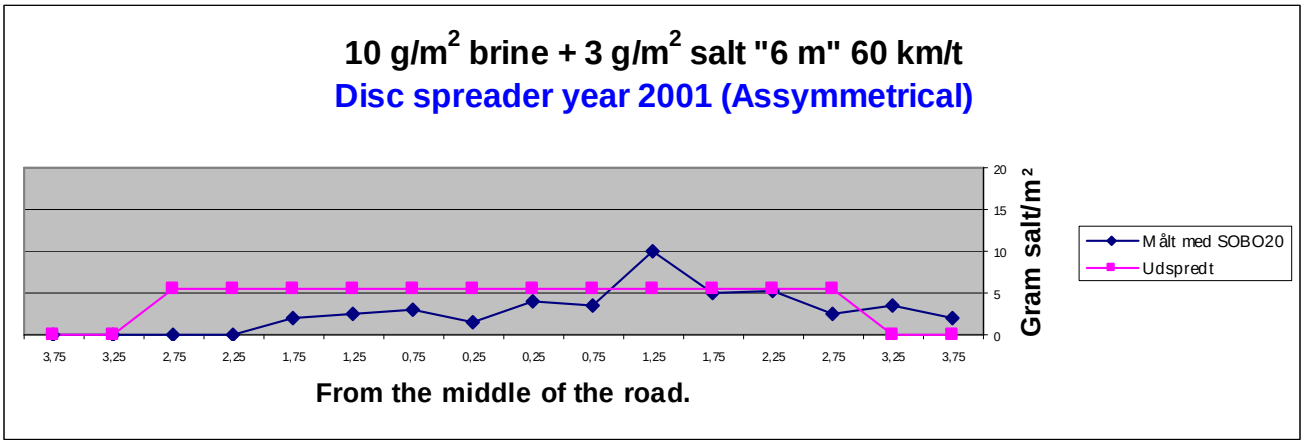
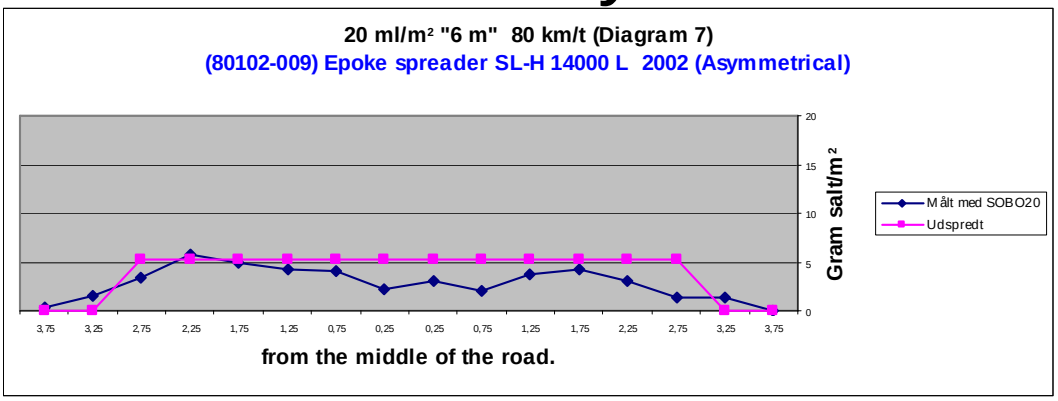


Diagram 2 and 3. Spreaders with opposite rotation of the disc.

Brine spreaders with nozzles

Next are there 2 diagrams showing result from spreading brine with nozzles. The first diagram is spreading 6 m asymmetrical as normal, the next is spreading 6 m asymmetrical on motorway. Notice that we want more salt on the left lane then on the right lane, when it is on motorway.

Nozzles 6 m asymmetrical



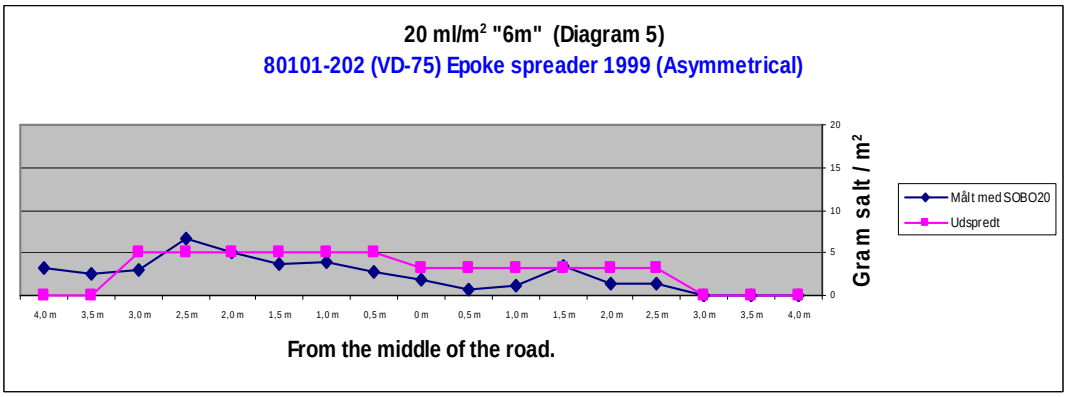


Diagram 4 and 5. Measurements of speading with nozzles. The last diagram is motorway with less salt on the heavy lane.

SOBO 2, salt measurement.

The amount of salt on the road is performed by the electric power of resistance with a so-called saltstick (SOBO 20) and the results are given in whole figures as g/m².

In The County of Funen we had 5 SOBO20 and had done more than 20.000 measurements with SOBO20. From the calibration and use of SOBO20 we have learned:

Don’t use acetone!
Only clear water with conductivity
< 10 mikroSiemens/cm.

The quantity of water in the
measure room has to be 43 or 44 ml

Measure room must repeatedly
be cleared with paper

Accuracy of SOBO20 measurements.

In 2004 The County of Funen do many measurements to know exactly how different spreaders were placing the salt on the road. To have accurate measurements we use 5 SOBO20. On the foto you have a look on 4 of the 5 SOBO 20.

Spreading measurements 2004

Figur 3. Foto from measurements with Sobo20. Every one do 8 measurements across the road.

From the measurements we can take an example:

Sobo 20 measurement 1,75 m to the left and to the right from middle of the road

Arne	22	5
Helge	18	4
Jeppe	19	5
Allan	18	3
Jens Kr.	21	3
Mean value	19,6	4

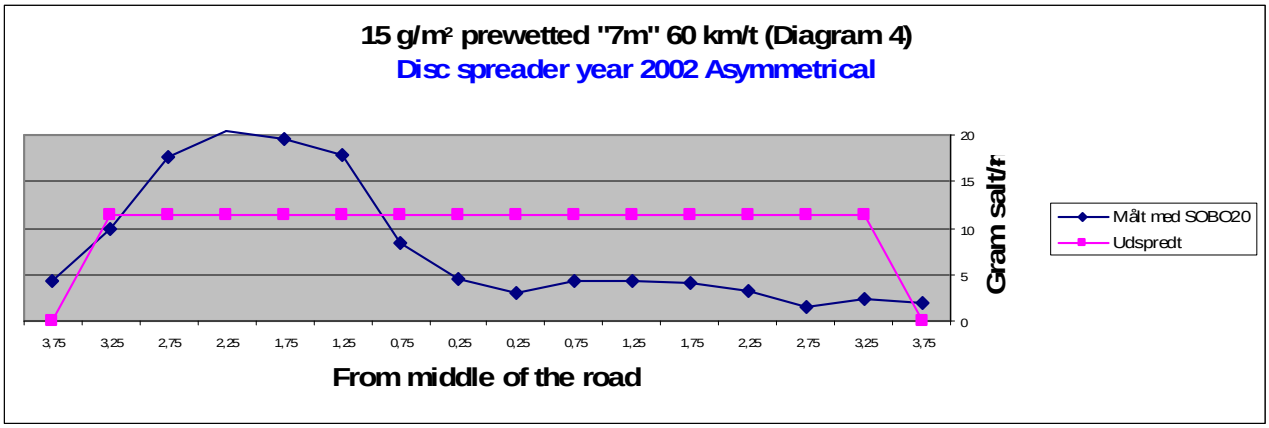
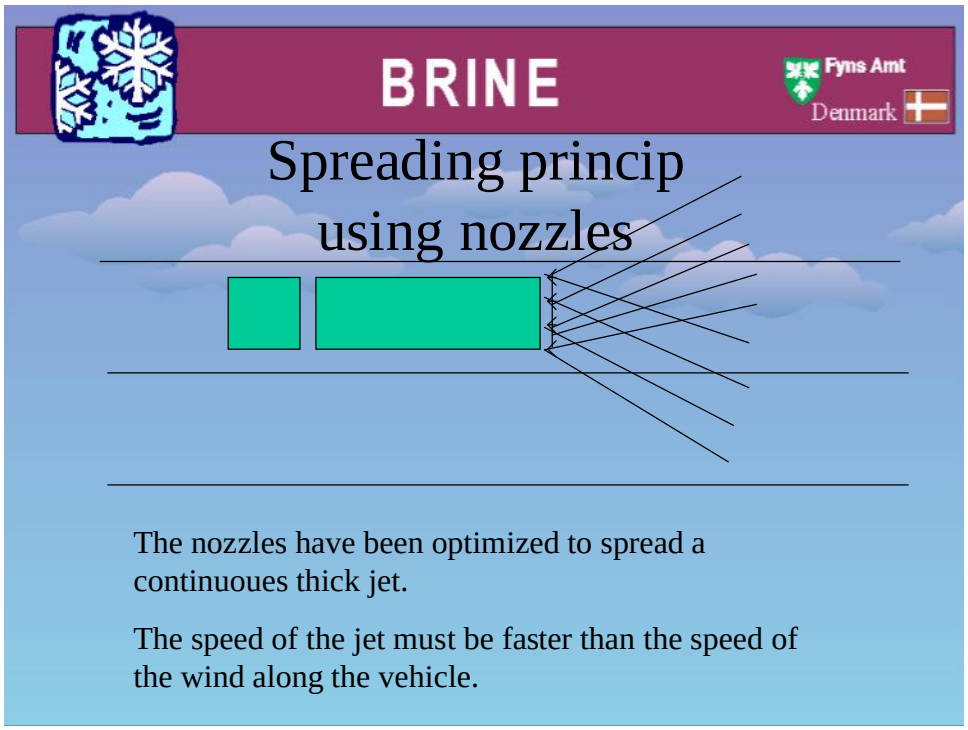


Diagram 6, Example showing result from measurements with Sobo 20. Reed curve is what we wanted. Blue curve is result.

All data from the measurements are in Excel, and you can have a copy, if you want to do more studies.

Spreading technique



Saltconsumption

The normally amount of salt spread in the County of Funen was for preventive treatments:

Temp. 0ºC to - 3ºC and wet / moisture	15 ml/m²	= 4,2 g NaCl/m²
Temp. < - 3ºC and wet / moisture	20 ml/m²	= 5,2 g NaCl/m²
Before snow and glass	35 ml/m²	= 9,8 g NaCl/m²

For curative treatments 35 ml/m² = 9,8 g NaCl/m²

Mixing of brine

The County of Funen has constructed a mixing plant with a 280-m³ container, where the outlet is from the surface and in the mixing phase the brine is circulated to the bottom of the container. Circulation continues till the surface level has a salt concentration of 24 %. If you do not circulate, stratification may occur and accidents will follow, when you are spreading freshwater!
Dissolving of the salt takes place directly in the container. In the container there is mounted a forceful propeller mixer that is started, when mixing is required. When freshwater has been filled into the container, salt is added directly in front of the propeller, which prevent an immediate sedimentation. In practise the system functions even though the plant is very simple. The County of Funen uses vacuum salt for the brine.

VISION

In the County of Funen and now in the Municipality of Northfunen (Nordfynskommune) my vision is

- ***We can use less brine (salt) with GPS-controlled spreading and have less accidents if we place:***
  - ***brine(salt) on the high level on the middle of normally roads***
  - ***brine(salt) on the high level in curves.***
  - ***less brine(salt) on lane with heavy traffic.***

POSTSCRIPT

January 2007 we changed road administration in Denmark. The counties were gone and the small county roads are now municipality roads and the larger roads are state roads. In the winter 2006 –7 all county roads were given the same winter service as before 2007.

REFERENCES

References [2] is only available in Danish language.

1. Fonnesbech J. K., *Ice Control Technology with 20 Percent Brine on Highways*, Transportation Research Record 1741, Transportation Research Board, National Research Council, Washington, D.C., 2001, pp. 54-59.

2. Freddy Knudsen, Kim Niels Sørensen, Vejdirektoratet, Denmark, *"Saltspredningsforsøg"*, rapport nr. 228-2001.

3. Anonymous. 2003. Prewettet salt versus brine on motorway. County of Funen, Danish Environmental Protecting Agency, Epoke A/S and Danish Road Directorate. (http://www.vejdirektoratet.dk/publikationer.asp?page=document&objno=70918)