Use of salt for Cross-Country competition courses

- originally prepared by John Aalberg

INTRODUCTION

- Cross-Country competition organizers and FIS aim to provide the best possible conditions for the competitors, and to provide **safe and equal** conditions for all the competing athletes

- But, we often see soft courses and worn-out snow

IT IS CHALLENGING SOMETIMES ...

INTRODUCTION

- The FIS World Cup CC athletes prefer to have **compact snow surface** for their competitions → equal conditions for all skiers

- In certain conditions, applying salt to the snow will create a harder and better surface to ski on.

  → we have experiences since 2001 (used at Salt Lake Olympic venue)

INTRODUCTION

- Few organizers are experts in using salt
- TDs and jury members have varied knowledge of salting

- It seems to be a need for a practical guideline
  - To explain why and when salting works
  - To explain when salt does NOT work
  - To help make good decisions

WHAT IS SALTING?

- Salting is about making soft snow hard → «snow hardening»
- Salt should be used when snow is too wet or mushy
- Salting should be used to save the competition (i.e. make it fair and safe), not just to speed up the snow or make skiing easier
- Salting for classical competitions should be carefully considered. Salting will dramatically change the tracks, the wax and the ski structure, as well as promote double-polling


AkerSolutions
68
OSLO
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INTERSPORT

TYPES OF SNOW HARDENERS

- Pure salt contains only Natrium Chloride (NaCl)
- Natural salts (sea-salt, rock-salt, himalayan-salt etc) also consist mostly of NaCl, but with small amounts of other minerals naturally mixed in
- Nitrogen fertilizers and other components (also sugar) can also be used as snow hardener:
  - **Ammonium Nitrate (NH4 NO3),** Ammonium Sulphate ((NH4)2SO4), Ammonium Chlorate (NH4 Cl), **Urea (CO(NH2)2)**
  - Calcium Nitrate (Ca(NO3)2 2H2O)
  - Calcium Chlorate = road salt (CaCl2 2H2O)

HOW SALTING WORKS

Chemistry

- Salt + water → some of the ice- or snow grains melt and create a salt-solution
- This physical change from ice/snow to water (solid to liquid) requires heat (energy)
- This causes the surrounding snow to become colder (and freeze or harden/firm up)

In practice

- For salting to work well, you must have ice- or snow crystals and **enough water** in the snow (must be able to make a snowball)

SNOW HARDENING

Scientific Research

Model illustrating the dissolution of the salt (SH), the increasing and infiltrating solute concentration (SC), the withdrawal of heat represented by the black arrows, and the temperature at depth represented by (T)

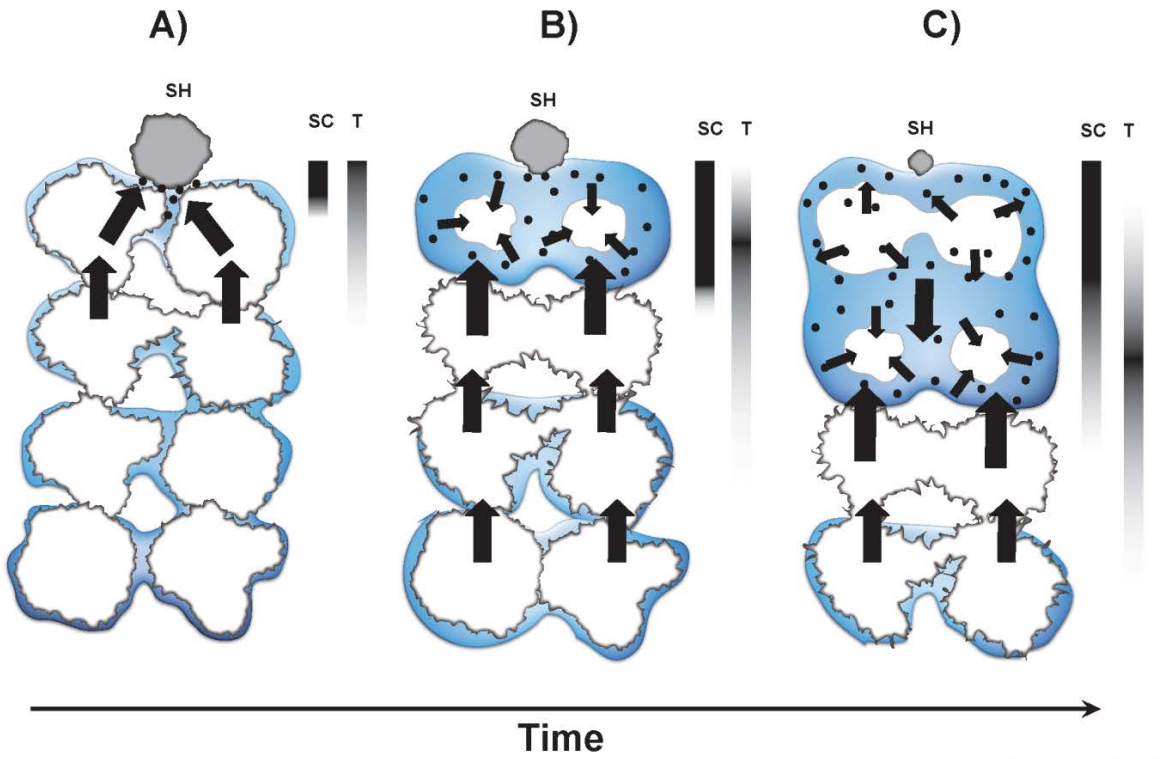
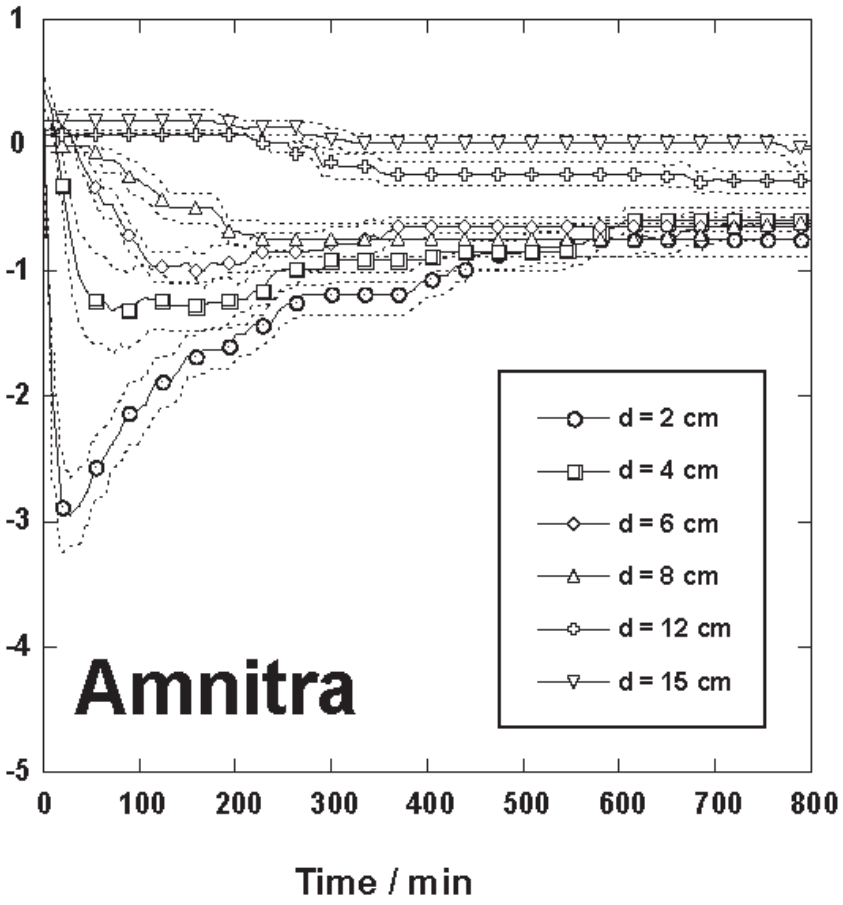
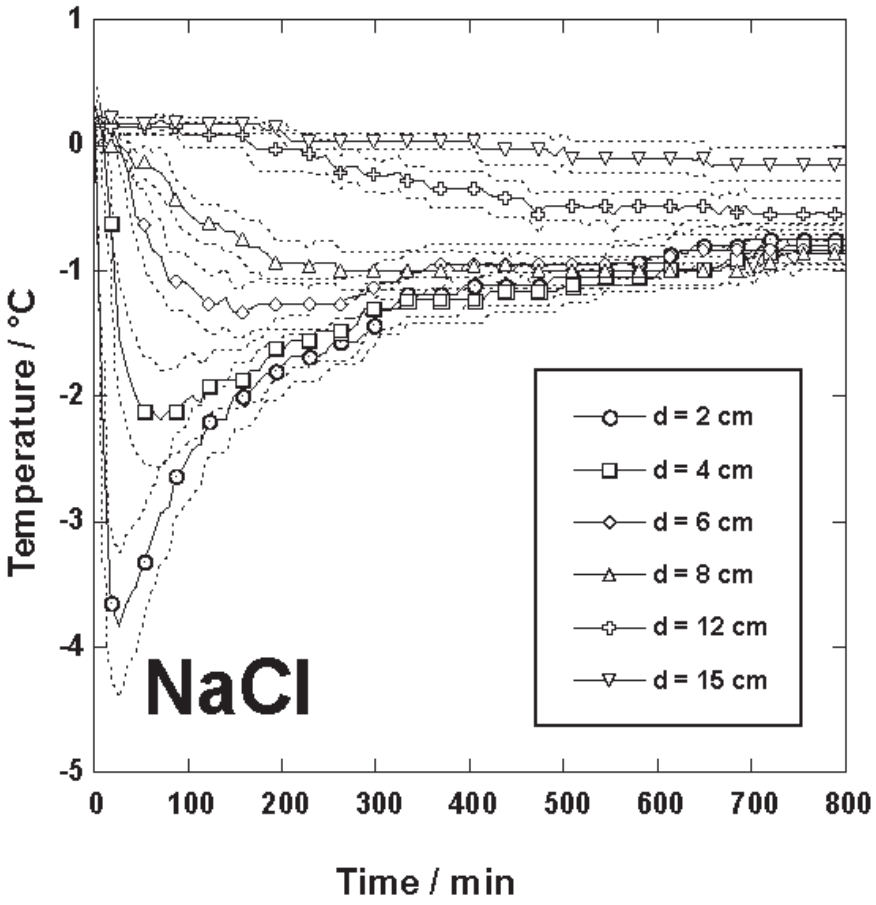


Figure 5.2

Rixen, C; Schneebeli, M., Effects of snow hardeners on the snow cover of ski runs, 2010. Swiss Federal Institude for Snow and Avalance Research.

COMPARISON OF AMMONIUM NITRATE TO NACL

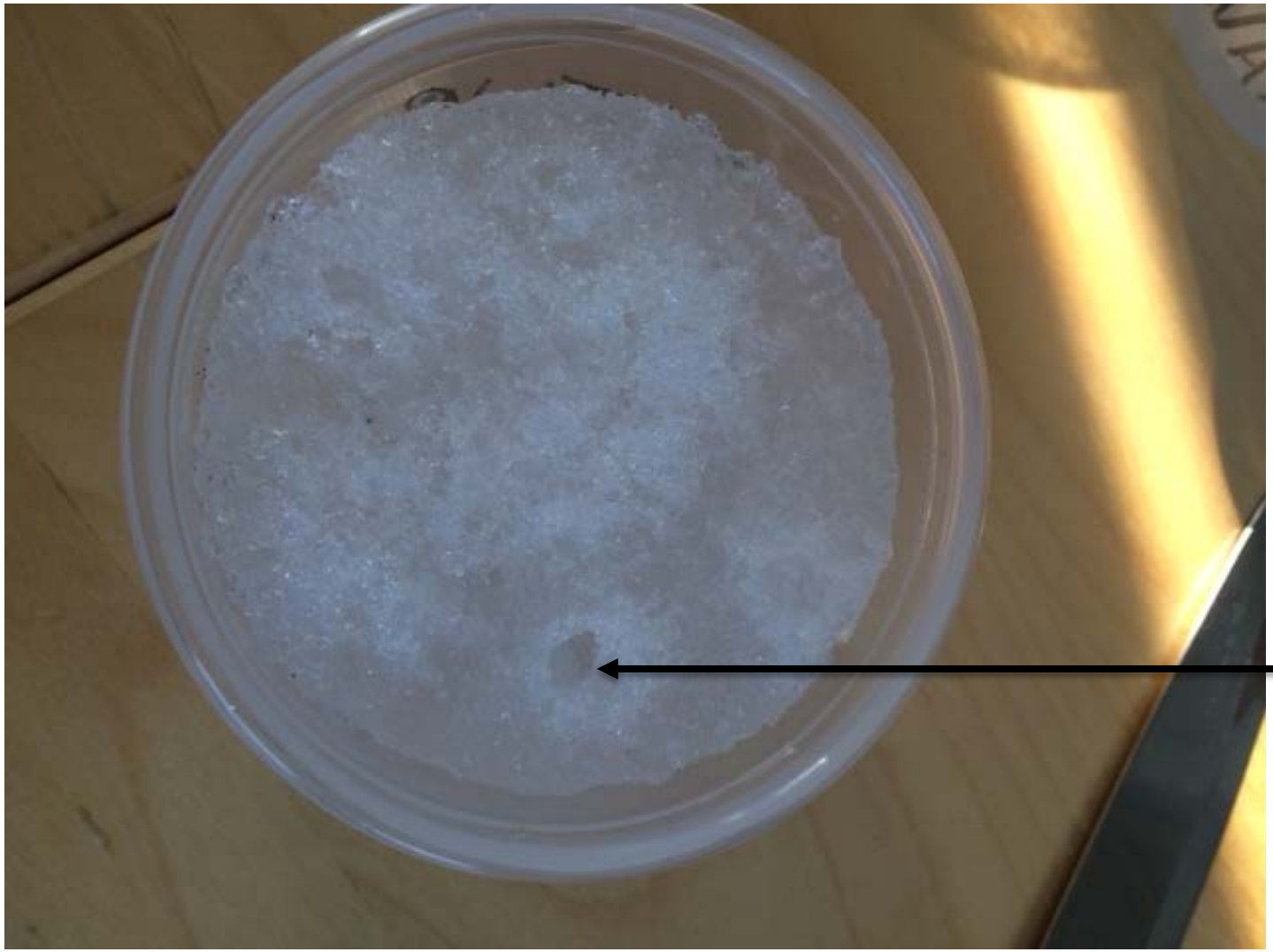




THE SIZE OF THE SALT GRAIN IS IMPORTANT

Size of grains

- Salt and fertilizers can be purchased in different sizes
- Small grains (table salt or road-salt, some fertilizers)
- Large grains (some fertilizers, special made sea-salt)
- Mixed size flakes (sea-salt)
- It is recommended to use a mix of different sizes
  - Coarse salt will have deeper penetration into the snow, slower reaction, longer duration
  - Smaller grains/flakes will work faster, more superficially, have short duration and might make the surface icy/hard



Large saltgrain sinks down into the snow

HOW MUCH SNOW CAN 1 GRAIN OF SALT FREEZE?

Snow after reaction

Salt grain

HOW SALT IS APPLIED

- Always first try salting on a small patch of snow before applying on the ski course
- Salt must be spread evenly and in the right amount
- Spreading is best done by a mechanical spreader mounted behind a groomingmachine or a snowmobile (se photos)
- Spreading can also be done manually by throwing **up in the air** (not down on the snow)


husky


OBOS
GLAVA
KRAFT

Fertilizer spreader:

- 300 or 600 liter
- Hydralic motor
- Adjustable spreader (tied to engine pressure)
- Attached to blade
- Cost (Norway):
  - Spreader: 750 EUR
  - Total cost: 1500 EUR


RONDINI

MANUAL SPREADING

Throw up in the air,
not down

HOW SALT IS APPLIED

- It is important to not break the freezing process by skiing on the snow too early
  - Let the process work 15 – 45 minutes before skiing on the course, depending on how course the snowcrystals are and how much water is in the snow (older and courser snow/manmade snow might need 45 minutes while newer snow with more water in it will react faster).

HOW SALT IS APPLIED

Applying salt

- The correct amount to apply for a Cross-Country (8 m wide trail) is maximum 100 kg per km (with a proper mix of large and small saltgrains) – about 12 grams per 1 square meter
  - 50 kg/km might also be enough
- More salt will not create a better surface

WHEN SALTING DOES NOT WORK

- Salting will likely not work):
  - When the temperature is at or below zero degrees Celsius
  - On dry, fresh natural snow
  - When snow is falling (rain is ok)
  - When there is too little water in the snow or on the snow surface
  - When the snow is «dead» (can not make snowball, and there is no crystal structure)

WHEN SALTING DOES NOT WORK

- Be careful when salting during rain and windy conditions, it might result in very ice conditions
- Fog might reduce the effect of salting (when dry air is moving in)

DIFFERENCE BETWEEN NATURAL AND ARTIFICIAL SNOW – DURATION OF EFFECT

- Humid natural snow will react faster with salt than artificial snow
- Old artificial snow will react a little slower since
  - The larger and older snow crystals contains less water (the water drains easier through the old and rounded crystals)
  - The larger snow crystals will take longer to “bind together” after the salt is applied

PRACTICAL EXPERIENCES

- Knowledge gained by practical experiences and some research/testing at:
  - Sochi Olympic Games Nordic Combined venue
  - Falun 2015
  - Holmenkollen testing (and during multiple World Cups)
  - Summer skiing in Norway

SOCHI 2014 – SALTING AT NORDIC COMBINED VENUE

Weather

- Temperatures up to +10 or more during the day
- Night time cooling typically did not go below zero (especially during the 2nd week)
- Primarily sunny conditions with some clouds, one day of rain

Snow

- Mix of old/transformed natural snow and old/transformed manmade snow
- New snow from “above zero snowmaking system” was added on an almost daily basis during all training days

SOCHI 2014 – SALTING AT NC VENUE

Salting Strategy

Testing

- Testing was done with urea, sea-salt, sea-salt/urea mix, and various types of sea-salt (1-5 pellet size and mixed pellet sizes)

Results of Testing

- Urea was ineffective unless there was visible moisture in the snow (snowball that dripped water)
- Pellet size 1 salt results in shallow hardening on the surface only
- Mixed size salt (powdery to pellet size 5) provided good surface hardening and good depth
- Mixed grain salt seemed to be best

SOCHI 2014 – SALTING AT NC VENUE

Timing/type of application

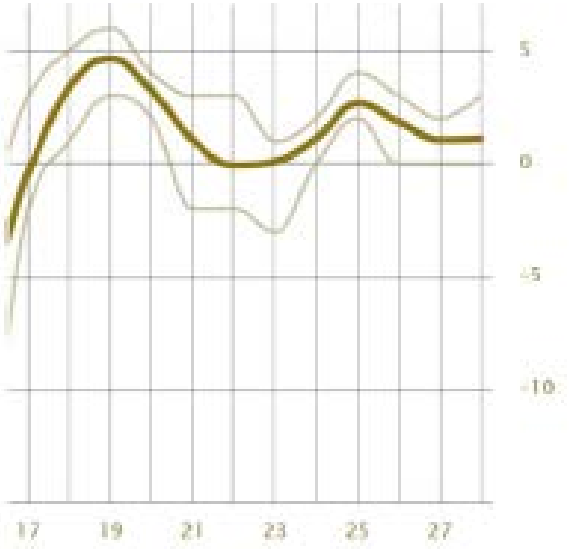
- Salt was applied 2 - 3 hours prior to competition
- Salt did not work well unless there was moisture in the snow (salting earlier had no real effect until there was moisture in the snow, for example by rain or sun melting the snow)
- Salt was applied manually and the snow was typically not groomed after salt application (except in the stadium and a few high use areas (ski testing))
- The application lasted a minimum of 3-4 hours (as long as required for events)
- Minimal application of salt was used (enough to create a reaction within 10-15minutes) – additional salt was not advantageous

SOCHI 2014 – SALTING AT NC VENUE

Summary

- Salt can be applied on a continuous basis for many days in a row (2 weeks) if moisture is present
- Visual moisture is a required component to the reaction of Urea and to a lesser extent the reaction of salt
- Over-application of salt does not improve the result and can be detrimental to the snow condition
- Experimentation and testing is required to determine appropriate application based on snow type/weather/moisture content/duration etc. A “test plot” is very valuable.

FALUN 2015 – NWSC



Weather

- Above 0 C every day
- No freezing at night
- Relatively low humidity

Snow

- Poor quality artificial snow (made in marginal temperatures)?
- Courses groomed every day prior to Championship

FALUN 2015 – NWSC

Salting

Testing prior to WSC during WC 2012-2014

Salt: NaCl og CaCl

Saltspreaders mounted on large grooming machine and behind ATV

40 persons ready with buckets/manual salting (every 200 meter)

Mostly manual salting done

FALUN 2015 – NWSC

Summary

Soft conditions

Most unfair:	15 km interval start
Worst:	50 km
Solutions:	Close courses
	Salt crew on-call (10 min response)

FALUN 2015 – NWSC

Lessons

Less grooming with big machines

Less aggressive belts on snowmobiles and ATVs

Test how to add water

Be preared to exchange the snow (or bring in new snow)

Improve communication between CC and NC juries

HOLMENKOLLEN 2014 - LESSONS

- **Available water in the snow is a MUST**
- Salting behind grooming machine gives fastest reaction and results, and will last almost as long as salting ahead of the grooming machine
- There is no need to salt the days prior to competitions (attempting to build up a firm base)
- It is not recommended to salt if freezing is expected overnight

HOLMENKOLLEN 2014 - LESSONS

- Rain or snowmelt might harden the snow if salt is already in the snow
- Manmade snow reacts slower than natural snow
- Extra amount of salt will not matter (50 kg/km vs. 100kg/km)
- Repetitive salting might give poor results if no new water is added (will end up with less water in snow, and thus less reaction with new salt)
- Firmness can last 10 – 12 hours

Salting at Holmenkollen between Nordic Combined and 50 km races

→ 1 hr before start

LESSONS FROM SUMMER SKIING VENUES

- **Salting of snow is only done when temperature is above 0 C**
- Granular sea-salt is preferred
- Salting on the surface gives fastest result since water is usually on top of the snow surface (when sunny)
- Salt NEEDS water to start the melting/freezing process

Sognefjellet – no visible environmental damage after 10 years of salting

LESSONS FROM SUMMER SKIING VENUES

- Cold at night; warm and soft during day
  - Salting at night if frost is forecasted (tiller depth at 5 – 10 cm) or
  - Salting using snowmobile only in morning (to not ruin groomed surface!), use light roller or drag before/after salting
- Warm both day and night
  - Groom and salt together in same operation early morning using large grooming machine and spreader behind machine (tiller depth 5 – 10 cm)
- Using about 30 – 40 kg salt/km (4 meter wide trail)
- Salting once or twice per day (minumum 6 hrs between); must let process work for 30 min before skiing

GENERAL ADVICE – WHAT TO TO:

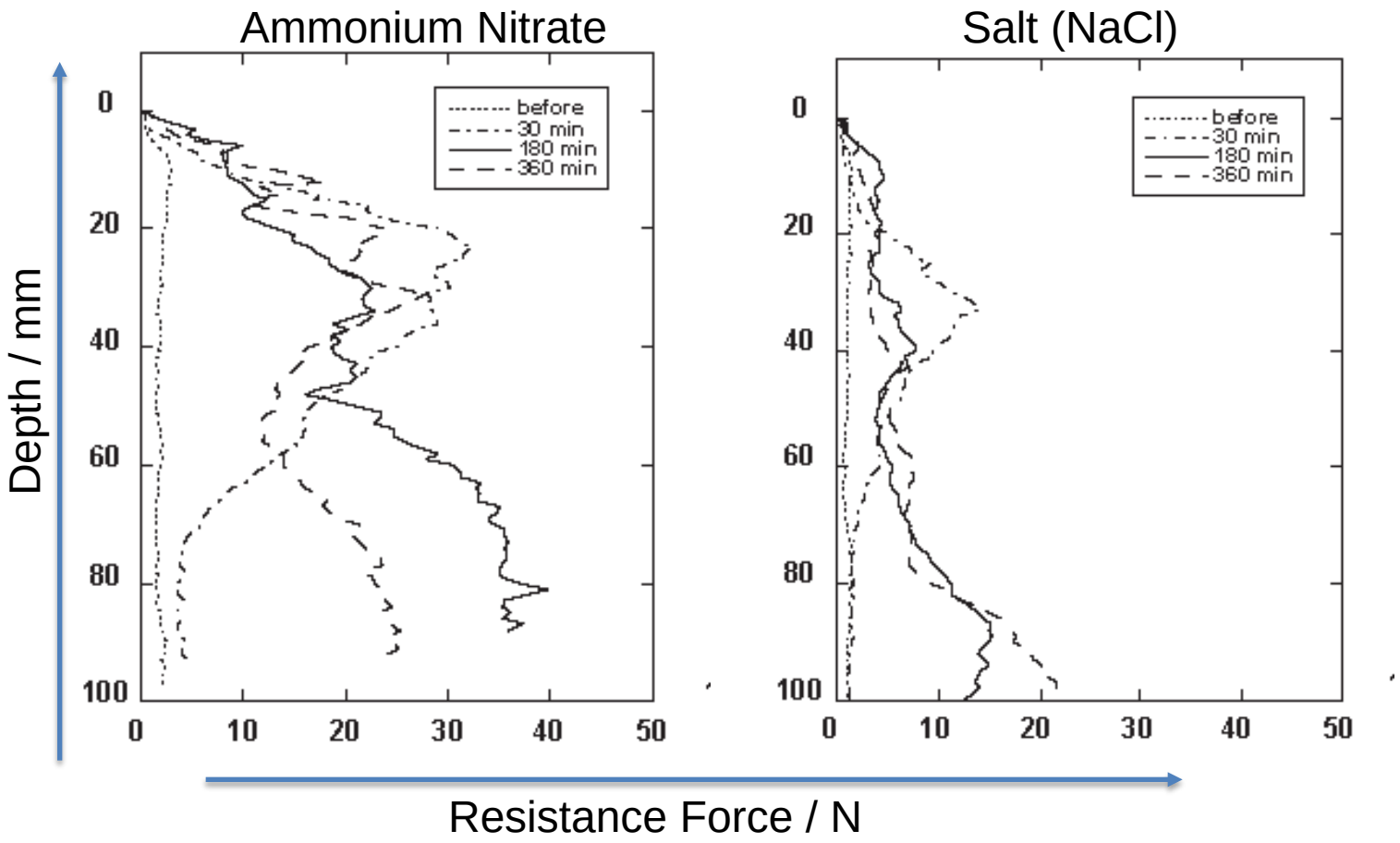
When time matters (not much time before skiing must start):

- Standard NaCl/sea-salt (small salt-grains) will likely work faster that fertilizers, but will result in relatively weaker snow strength. It might also cause a very hard icy layer on top, that might need to be "skied in" or softened up by a snowmobile with a drag. Mixed size salt-grains (both small and large size) will however provide a better surface.

When time is plenty:

- Using sea-salt or fertilizers with course grain (pellets or large flakes) will cause a deeper penetration into the snow, and make the hard surface last longer

SNOW STRENGTH
.... IT'S NOT ALL ABOUT HOW COLD HOW FAST



Rixen, C; Schneebeli, M., Effects of snow hardeners on the snow cover of ski runs, 2010

GENERAL ADVICE

When there is plenty of water in the snow:

- Ammonium Nitrate has the highest “freezing effect” (endothermic effect) per mole (i.e. per gram) of all the salts/fertilizers, and will normally freeze/penetrate deeper into the snow than others, thus making the hard surface thicker and longer-lasting. It will normally also not give as hard (icy) top surface as small-grain sea-salt. Large-grain sea-salt is however a good second option.

When there is little water/humidity in the snow:

- Standard sea-salt (small grains) will more quickly produce its own water, and therefore require less “snow humidity” to react than fertilizers. The salt might cause a very hard icy layer on top, that might need to be "skied in" or softened up by a snowmobile with a drag.

WHAT TO DO WHEN PROBLEM IS APPARENT?

- **Mealy/sugary snow**
  - Must add water (water hose), remove snow or use renovator to bring up moist snow from snowlayer deeper below (will mix with sugar snow), then salt

Renovator

WHAT TO DO WHEN PROBLEM IS APPARENT?

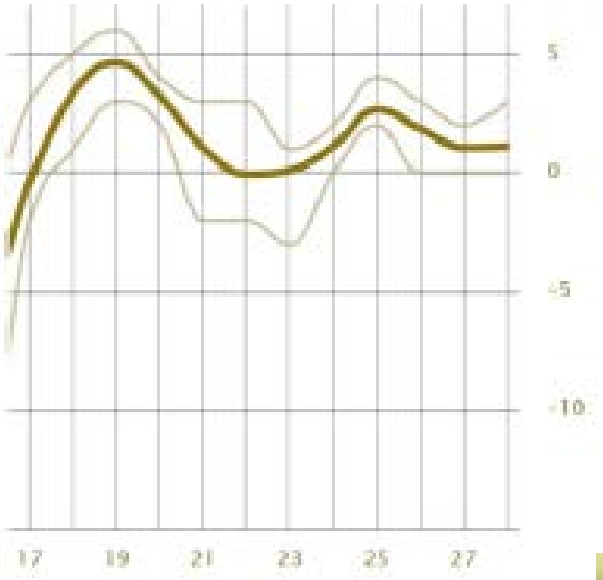
- **Adding water**

  Possible ways to add water:

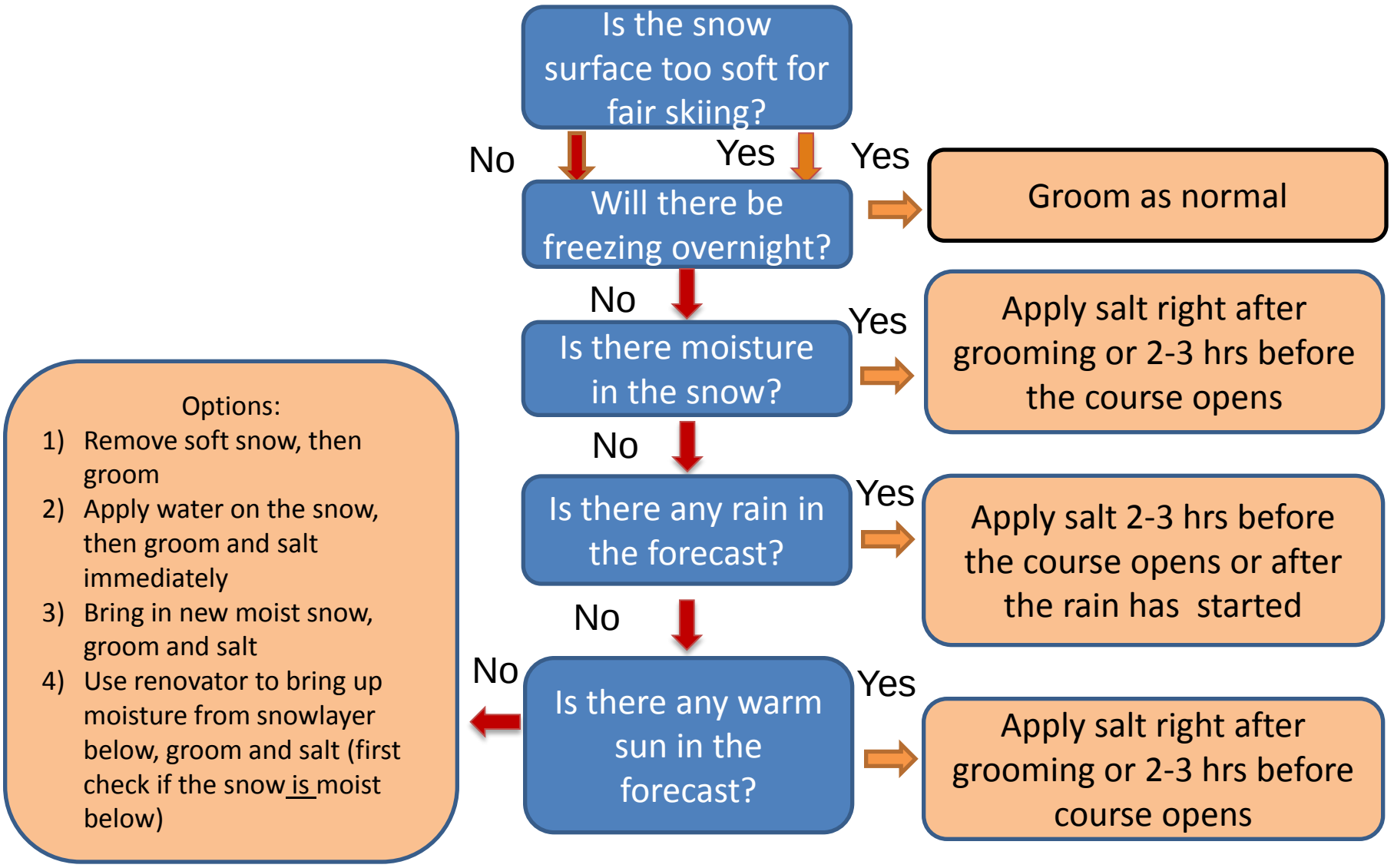
  - Turn on snowmaking system (if hydrants are along the course) and spray water
  - If problem area is limited (one or two uphills), spray water from normal hose if possible (or use firedepartment truck to assist)
  - Install water-tank on large grooming machine or other vehicle (for example on truck with belts – see photo on next page)

  Amount of required water will vary, but several 100 liters per meter trail should be expected (for a 6 m wide trail)

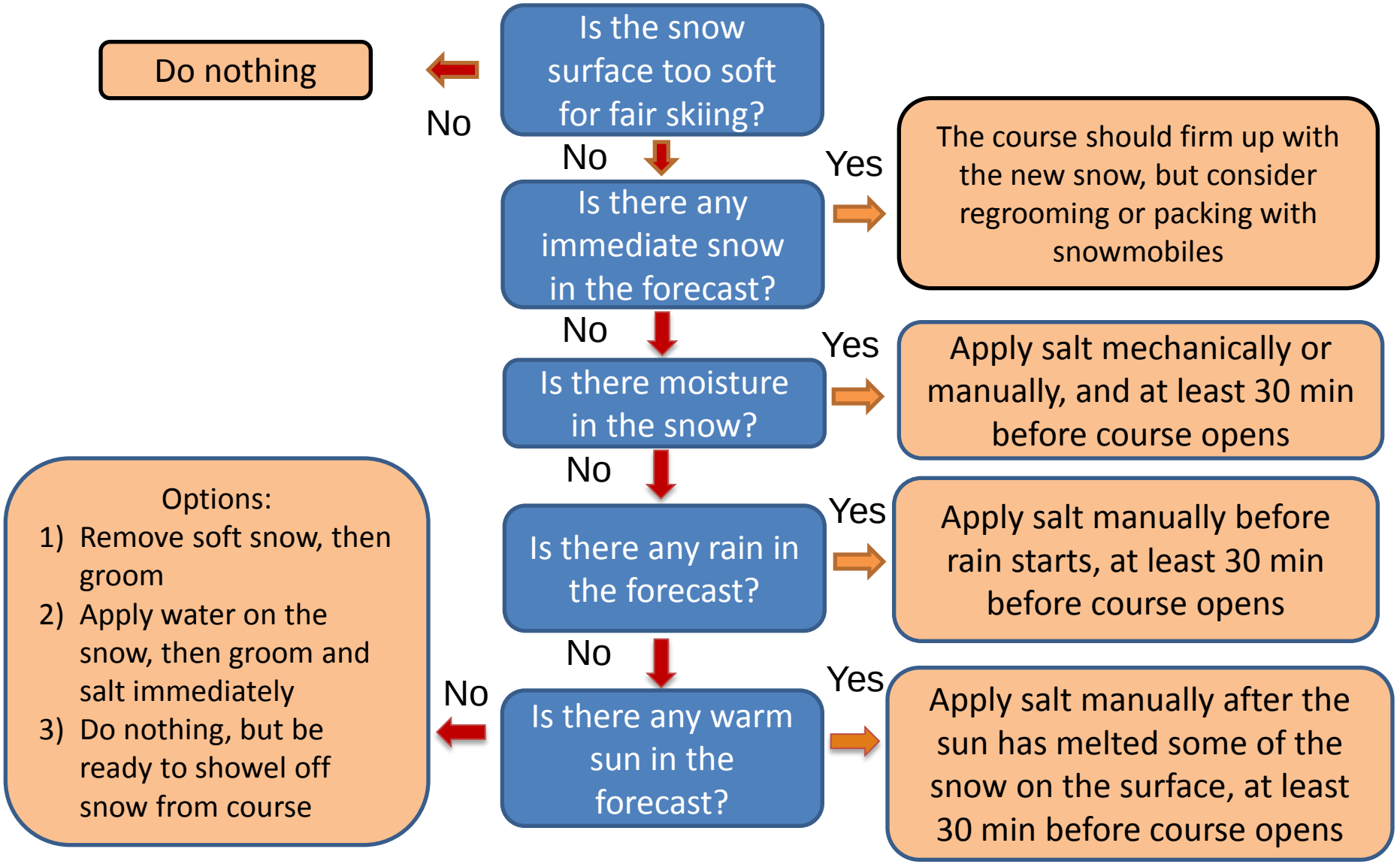
WHAT TO DO WHEN PROBLEM IS APPARENT?



ON DAY BEFORE COMPETITION OR OFFICIAL TRAINING



ON MORNING OF COMPETITION OR OFFICIAL TRAINING



COMMUNICATION

- It is critical to announce in the Team Captains Meeting or otherwise to teams and athletes that salt/snow hardeners will be added and when/what process is going to be used

- It is recommended to salt a test area first, such that skiers can test new skis while competition course is closed

QUESTIONS?