Guidelines
Salting of Cross-Country Ski Courses

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1. Introduction

The International Ski Federation (FIS) and their affiliated National Ski Associations' organisers always aim to provide the best possible conditions for their Cross-County World Cup and FIS competitions. The Cross-Country competition courses should have a snow quality that gives optimal, fair and safe conditions for all participating competitors. However, the snow quality sometimes deteriorates due to warm temperatures, rain, or other conditions, and leads to very soft conditions especially for those competitors starting late. Often we also observe that the course during mass-start competitions becomes increasingly soft resulting in a clear disadvantage for some skiers. In many situations, salting can create a firmer and better snow surface, thus providing conditions that are equal for all the athletes.

Salting of Cross-Country courses has been done for many years, especially at summer-skiing venues; however, there are very few race organisers that are experts at using salt. Organisers of alpine skiing and ski jumping competitions have salted or frozen their courses and hills for a much longer time than Cross-Country, and have expertise that are transferable to Cross-Country. There is also generally a good theoretical understanding of the reaction that happens between salt and water, and how it affects the snow. However, since few Cross-Country venues are using salt regularly, most organisers can significantly improve their practical experience and expertise in this area.

It is also important that the appointed international- and national technical delegates (TD) are able to assist the organisers in the practical process of salting. At larger and important competitions, the TD and jury normally decide when and how to prepare the competition courses and if salt should be used. It is therefore required that this group has a good understanding of how and when salt will influence and alter the snow.

FIS asked, after the 2014/15 competition season, all the participating World Cup Cross-Country skiers if they preferred that the snow was manipulated using salt, or if the snow quality of the competition courses should vary naturally with the temperature, weather and snow-type. A clear majority (66%) of the skiers preferred that the courses were consistently firm, such that it was equal and fair conditions for all the participating athletes. This means that it is important that organisers of large events gain more knowledge of both grooming and salting.

This document is foremost a guideline in the practical part of salting, and attempts to present why, how and when salting best works. In the end, a decision chart is included to assist organisers, TDs and jury members in taking the correct decision when the snow quality seems to effect the competition in a negative way.

2. What is salting and when should it be done?

Salting is foremost a way to make soft snow hard, such that the competition courses become consistently firm. We can say that salt is a “snow hardener”. In addition to understanding the freezing process that salt initiates, it is also important to be clever at other basic elements – understanding the weather forecast, proper base preparation of the courses, watering (in some cases), sufficiently trained crewmembers and correct equipment for spreading the salt.

Salting should be done when the snow is very soft, «rotten» or very wet. The goal of salting is primarily to save the competition and making it fair for all participating skiers, not to just create a faster and easier racecourse.

2.1 What is salt?

There are many types of salt and other chemical components that can be used as «snow hardeners», even sugar can be used. Pure salt consists of natrium and cloride (NaCl), and is most known as table-salt. Other naturally occurring salts (sea-salt, rock-salt, Himalayan-salt etc.) all consist mainly of NaCl, but in addition contain small amounts of other minerals. Road-salt consists mostly of calcium chloride (Ca Cl2).

Nitrogen-based fertilizers can be used as snow hardeners, and some of the most common fertilizers used for this are Urea, ammonium nitrate and ammonium sulphate. In the USA and Canada, ammonium nitrate has been used for many years by alpine race organisers to harden the snow on their competition courses, and many ski jumping organisers have used Urea on the landing hill.

Salt and fertilizers can be purchased in stores servicing the agriculture industry (salt is used for animal feed). The fishing industry uses sea-salt heavily, and sea-salt can of course be purchased on the web (for example www.salt.no).

2.2 Size of the grain

The size of the salt- and fertilizer grain is important for the snow-hardening process. Both salt and fertilizers come in different sizes. Normally table salt and road salt have fine grains, and well as many fertilizers. Sea-salt comes in mixed size flakes, but can also be special-ordered in certain sizes. Some fertilizers are sold in large grain sizes or pellets.

It has been shown that a larger salt or fertilizer grain will sink deeper into the snow while reacting with the water in the snow. A larger grain might also “pack” more energy and help harden the snow in a deeper and stronger way. This process might however take some extra time compared to smaller grains.

Small grains will react faster with the water in the snow, and will not penetrate as deep. This might however result in an icy layer on top.

FIS recommends using sea-salt for salting of Cross-Country courses. Sea-salt usually comes as a mixture of large and small flakes or pellets, and will therefore give the best overall result.

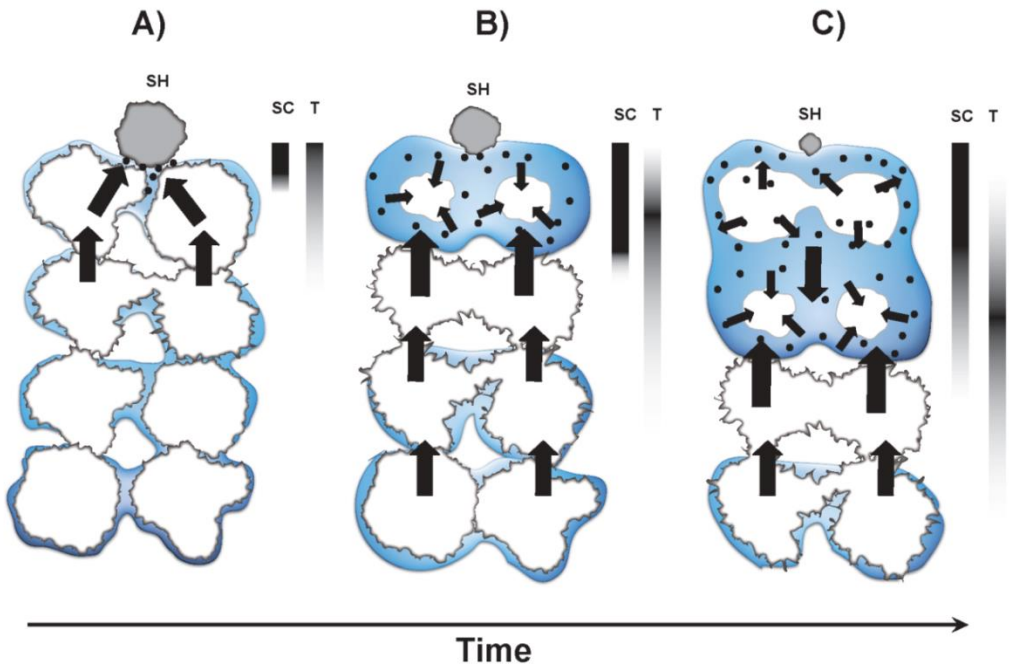
Large salt-grain will sink below the snow surface

2.3 How does the process work?

For the salt hardening process to start, it is required that there is «free» water around the snow crystals (see blue color on figure A below). In practical terms, this means that it should be possible to form a snow-ball with your hands, and optimally see water dripping when squeezing the snow-ball. It is also required that the snow is not so old and worn that it has entirely lost its crystal structure (we often call this snow “sugar snow”).

When grains of salt or fertilizer are dissolved in the water in the snow, it will create a salt-solution that causes a depression of the melting point. Snow- or ice-crystals in contact with the salt-solution will melt (see figure B below). This change of phase from solid (snow) to liquid (water) will require energy or heat. This heat is withdrawn from the surrounding snow (see black arrows in figures A, B and C below), and causes a net cooling and freezing effect such that the snow below the salt-solution will harden. After a short while, as the salt-solution sinks further down into the snow, the crystals on the surface will freeze together (see figure C below). The size of the salt-grain and the water content in the snow will determine how fast and deep the freezing will take place.

Both water and snow are being consumed in the freezing process, but this is not yet tested sufficiently; the amount will vary depending on both snow- and weather. If water is added (via rain, or slight melting from sun or warm temperatures) we know that salting can be done for many days in a row without seriously affecting the snowdepth (see more on this in chapter 4).



SH = saltgrain SC = concentration of the salt solution
T = temperature in the snow layer
The black arrows represent withdrawal of heat
The black color on the bars SC and T means respectively high concentration of salt solution and low temperature.

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

It has been shown that normal sea-salt (NaCl) will start the snow hardening process faster than fertilizers, but that the hardened layer of snow will not always be as strong due to the crystal structure in the snow being damaged a bit by the spontaneous reaction that the salt causes. Fertilizers will not react as spontaneous as salt, and are less damaging to the crystal structure. Fertilizers need, however, higher water content in the snow to start the hardening process, and will therefore in many cases not work as well as salt. However, if there is ample water in the snow, the hardened layer might be stronger using fertilizer than salt.

2.4 How to best spread the salt

Before salt is spread on the Cross-Country competition course, it is necessary to first test a small area outside the course. Depending on the water content in the snow, it should take 15 minutes or less to discover if salting will indeed work.

It is important that the salt is spread in the correct way and with the correct amount. The best method is by using a mechanical spreader mounted behind a grooming machine or a snowmobile. There are several spreaders on the market used for salting of roads or spreading of fertilizers on farmers' fields. It is also possible to mount a spreader on the front of a grooming machine, but this will likely not alter the snow hardening process (a front spreader might in addition cause more corrosion of the batteries and other engine parts).

Examples of spreader used with a snowmobile

Advanced spreader used both at Holmenkollen and at Sognefjellet summer-ski center in Norway

Spreading of salt can also be done manually, and it is then important to throw the salt up in the air (not down onto the snow) such that the grains and flakes can be distributed wider and more evenly. It is important that the salt is spread evenly across the whole width of the course; some “technique-training” for the manual crew is therefore important. It is advisable to use gloves since both salt and fertilizers are hygroscopic (will absorb water) and can make the skin very dry.

Low amounts of salt are required; depending on the water-content in the snow only 50 – 100 kg per km is necessary (for a 6 – 8 meter wide course). This corresponds to 5 – 10 grams per square meter snow. Using more salt than this will not produce a better product. One single grain of salt will normally harden an area (snowball) of more than 5 cm in diameter (see photo below).

Snow after hardening

One single grain of salt

It is very important that the freezing process taking place in the snow is not interrupted too early. It is therefore necessary that the snow and the courses are closed for at least 15 – 45 minutes after applying the salt. If the snow is relatively new and contains lots of water, the hardening process goes rapidly and skiing can take place already after 15 minutes. Old and course manmade snow without as much humidity will take longer time to harden.

It is important to throw the salt up in the air, not down onto the snow.

2.5 The effect of weather and temperature

The water content in the snow is the most important factor in the snow hardening process, and “available” water is necessary for the salt to have an effect.

After successfully applying salt, the snow will normally stay firm for several hours (minimum 5 – 6 hours). However, a rapid increase in air temperature might speed up the process such that the snow will soften earlier than otherwise.

Decreasing air temperature (towards zero C or lower) will reduce the available water in the snow, and the hardening process might slow down, or not even start.

Sun and heat from the sun will melt the surface of the snow, and increase the speed and result of the hardening process.

Dry air (low humidity) will have a negative effect on the hardening process, while high humidity will have a positive effect.

2.6 When will salt NOT work?

Salting will likely not work in the following conditions:

- When the air temperature is at or below zero degrees Celcius
- When there is not enough water in the snow or on the snow surface
- When the snow is «dead» (no crystal structure → "sugar-snow")
- If applied during the competition or while skiers are on the course
    - Because the freezing process is disturbed
- In dry snow conditions
- While it is snowing
    - If snow is forecasted, it is better to wait as long as possible with grooming. Salt can then be applied immediately following the light grooming and tilling/mixing of the new and old snow such that the new snow crystals can bind with the old ones.
- In foggy conditions due to dry air moving in
    - Fog is a sign of changing air humidity, and this might affect the reaction between water and salt in the snow.

Additional considerations:

- During rain or if heavy rain and wind is forecasted, it is important to be careful when salting. The conditions might become very icy when the salt reacts with the rainwater, and wind later dries out the surface and creates ice
- If the snow does not contain enough water, but salt is applied anyhow, the salt might stay «unused» in the snow and/or possibly create even worse conditions (might «dry out» the snow even more)
- Applying too much salt might also have a negative effect by totally "drying out" the snow
- It is also important to consider the necessity of salting during classical technique competitions. Salting will have a considerable effect on the choice of kick wax and base structure, and the TD/jury must discuss if salting should be attempted at all. An important element in this discussion is the current topic of double-polling in classical technique competitions. Firm snow due to salting will create better conditions and encourage double-poling over diagonal skiing with kick wax

2.7 The difference between natural snow and artificial snow

Wet or moist natural snow will react faster with salt than artificial snow. Old artificial snow will react slower than natural snow because it contains larger and rounder snow-crystals with less water surrounding the crystals (the water in artificial snow will drain easier because the crystals are rounder). The larger crystals in artificial snow will also need more time to "bind/freeze together" in the latter part of the snow hardening process (see section 2.3).

3. Correct preparation and equipment

3.1 Snow preparation

The basic principle behind good and firm competition courses is to reduce the amount of air in the snow («pack» the snow), and that a firm base is prepared from the first snowfall. This is best done by using snowmobiles after the first snowfall, then later heavier grooming machines with belts, tiller and compaction bar. The belts are first used to pack the snow followed by the tiller that creates evenly sized snow-crystals that can be better compressed. We often see that an 'old fashion" rigid tiller works better for creating a flat surface than a flex tiller (that is more common in alpine grooming).

Since the heavy belts and the tiller will make the snow soft, it is important that the grooming takes place early enough for the snow to harden (freeze up) before the competition takes place. If there is no snow in the forecast, the grooming should take place the evening prior to the competition or very early the morning of. Grooming should always be done while the temperature is decreasing ("falling") since the snow then will better freeze/firm up.

During warm and clear weather when snow melts during the day, it is however important that the grooming does not take place until some of the humidity in the snow has evaporated. If the grooming takes place in the early evening when the humidity is still high, the overnight freezing will create very icy conditions. It is therefore better to groom later at night or early in the morning after a few hours of evaporation.

In certain snow conditions, it is also important to not groom too often with heavy machines, such that the snow looses its crystal structure. For example, during the Biathlon World Championship in 2015 (Kontiolahti, Finland), the competition courses were mostly groomed using only snowmobiles and Ginzu attachment to avoid creating «sugar snow». This has also been done in other venues.

108 Ginzu, Whistler Olympic Park

3.2 Equipment for grooming and salting

World Cup and other FIS organisers and venues own and use proper large grooming machines and equipment for most conditions. However, in certain conditions old fashion and lighter grooming equipment gives better results, for example after a light snowfall or in conditions where an icy surface needs to be slightly softened. Using a large grooming machine shortly before the competitions will in most cases create too soft conditions. A proper snowmobile with attachments (compactor/roller, Ginzu or drag) will in most cases create better conditions, especially for skating.

The snowmobile must have proper wide and non-abrasive tracks that will not break up the snow surface (wide-track snowmobiles are preferred).

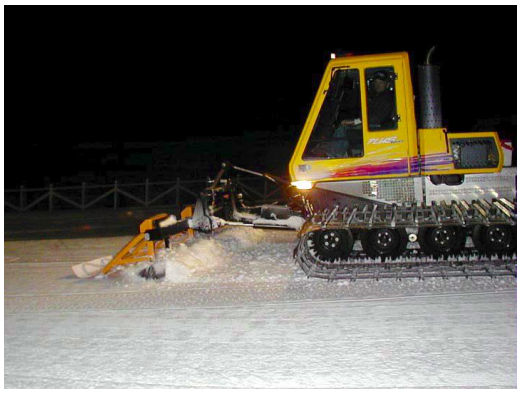
Compactor/roller

Drag

Ginzu

One type of grooming equipment that is not so commonly used is a renovator. The renovator is quick-mounted in front of the grooming machine and will «bring up» and mix the deeper snow level (down to 35 cm). This is in many situations an advantage since this deeper snow contains more humidity and better snow-crystals than the surface snow (5 – 8 cm) typically worked by the tiller. If this humid snow is mixed and tilled with the surface snow, the quality and firmness of the competition course is normally improved.

Renovator



Renovator in use

Sognefjellet og Vik skicenter in Norway are venues that have developed their equipment for salting the snow. At these venues we can find the following equipment:

- Fertilizer/salt spreader on a snowmobile trailer together with a generator, 12 V batry and a 12 V charger
- Digital controlbox (see photo below)
- Large spreader mounted behind grooming machine (type Schmidt Stratos)
- Crane for hoisting/moving large bags of salt (see photo below)
- Large spreader monted on front-blade of grooming machine (type Vicon)
- Ability to adjust the speed and spreading-power of the salt from the cabin of the groomer
- Camera monitor in the cabin to be able to watch the spreading action and the amount of salt being used

4. Practical examples of salting

4.1 Sochi OWG 2014 – Nordic Combined

During the 2014 Olympic Winter Games in Sochi, the Nordic Combined Cross-Country competitions took place at the Ski Jump stadium, where the outrun was used for start and finish. All training and competitions took place on a 2.5 km course. Due to the low elevation of the Ski Jump stadium (and the location near the Black Sea), the organiser was dependent on using artificial snow combined with snow transported from higher locations in the nearby mountains. To avoid soft conditions, salting was heavily used.

Weather

- Temperature up to and above +10 Celsius every day
- Usually no freezing overnight, especially during the second week of the Games
- Mostly sunny; only one day with rain

Snow conditions

- A mix of old natural snow (transported from the mountains) and old artificial snow
- New snow from the experimental “All weather” snow-machine was mixed in with the existing snow prior to each training day

Salting

Testing:
- Was done with Urea, sea-salt (mixed sizes) and a mix of Urea and sea-salt
- Urea only worked when the snow had high water content (snowball dripping water)
- Fine grained sea-salt only hardened the snow on a thin surface layer
- Sea-salt with mixed grains hardened the snow both on the surface and in deeper layers

Process:
- Salt was normally spread 2 – 3 hours prior to the start of the competition
- The salt only worked when there was water in the snow (from rain, added snow or due to melting from the warm sun)
- The overall result was best when the salting was also done for training, warm-up and glide/wax testing
- Due to problems with the mechanical spreader, the salt was applied manually. The courses were not groomed after salting, other than at the stadium and glide-test area using a snowmobile and compactor/roller.
- The hardened snow lasted 3 – 4 hours (or longer); enough for successful competitions
- Approximately 100 kg salt per km was used (8 m wide courses), and more salt did not give better results when tested.

Conclusion
- Salt can successfully be used every day for 2 weeks if water is present in the snow
- «Visible» water (dripping snow-ball) is required for Urea to work; sea-salt needs less water
- The snow hardening process only takes 10 – 15 minutes
- It is important to have an available area for testing types and amounts of salt

4.2 Holmenkollen - 2014 two-day test project

In February 2014, the Oslo City venue staff organized a salting project at the Holmenkollen Nordic venue. A test area was divided into 6 sections, and each part was groomed and salted differently (different amounts, salt applied before or after grooming, etc).

Weather
- The temperature ranged from +2C to +3.5 C, with almost 100% air humidity.
- No freezing at night.

Snow conditions
- Old artificial snow on courses that had been heavily used earlier in the season. The snow had however still a good crystal structure and relatively good water content.

Salting
- Sea-salt (mixed size grains/flakes) was spread in different amounts (from 30 – 100 kg per km depending on which test section) using a mechanical spreader mounted in front of the grooming machine, or by a snowmobile spreader driving behind the grooming machine. The process was repeated on day two.

Conclusion

- Sea-salt works well as snow hardener when the snow contains water and has a good crystal structure
- The snow needs a bit more time to harden when the salt is applied ahead of the grooming machine and tiller
- The snow hardens and lasts equally well if salt is applied ahead or behind the grooming machine
- Higher amount of salt did not produce better results (50 kg per km as good as 100 kg/ km)
- The snow hardening process seems to take a bit longer if salt was also used the day prior.

4.3 Holmenkollen - 2014 FIS & IBU World Cups

- The FIS World Cup in Holmenkollen is normally organized every year in the month of March, both for Cross-Country, Nordic Combined and Ski Jumping. It is often difficult to coordinate an optimal snow preparation for both Cross-Country and Nordic Combined. The snow quality is sometimes jeopardized since the tight competition schedule gives no time to properly salt or groom between competitions.
- The IBU World Cup in Biathlon is also normally organized every year in February or March, and the snow is often affected by the venue's high skier traffic and usage, especially when following the FIS World Cup on the calendar.

2014 weather and snow conditions

- New, wet natural snow on top of old artificial snow, initially high amount of water in the snow.

Salting during the FIS World Cup

- Day 1 (Friday): The competition course was prepared and salted (40 kg per km) the night before the first competition. It was raining heavily during the hours prior to the start of the competition. The conditions were firm and good during the afternoon competition (while other courses that were not salted did deteriorate/soften due to the heavy rain).

- Day 2 morning (Saturday): The course was prepared and saltet (50 kg per km) at 0400 (tilled, salted, and then tilled again). The weather cleared and the air humidity decreased from 100% to 60%. The snow turned a bit soft early in the day, but hardened when the increasing temperature started to melt the surface snow. The conditions were excellent during the 50 km competition.

- Day 2 afternoon (Saturday): The course was groomed and saltet (from spreader mounted in front of the grooming machine) between the 50 km and the Nordic Combined competition. The hardening process did not work, and the snow conditions were very soft during the Nordic Combined competition.

  NOTE: In 2015, the salting process was repeated, but this time with the spreader mounted behind the grooming machine (see photo below), and the Nordic Combined competition had great snow conditions.

March 2015: Salting in Holmenkollen at Frognerseteren in between the 50 km and Nordic Combined race (less than 1 hr before start). Photo taken from the cabin of the grooming machine.

- Day 3 (Sunday): The course was prepared and groomed during the night (tilled, salted, and then tilled). The temperature was never colder than +3 C, and the air humidity increased to 90%. The conditions were excellent for the entire Women's 30 km competition.

Salting during the IBU World Cup

- Day 1 (Monday): Salting started already 3 days prior to the first competition, and approximately 100 kg per km was applied Monday and Tuesday evenings. The weather was clear and warm during the day, with normal freezing during the night.
- Day 3 and 4 (Wednesday and Thursday): Salt (125 kg/km) was spread Wednesday evening. The temperature prior to Thursday's first competition was never above +1 C. The air-humidity was 90%, but the snow was dry.
- The conditions became very soft during the first competition, probably because the snow hardening process never started (too cold or lack of water in the snow).
- Before the second competition taking place 3 hours later, the temperature rose 4 – 5 degrees C, and the salt in the snow started reacting with the melting snow. The conditions were firm and very good during the competition.
- Day 4 and 5 (Friday and Saturday): Salt (100kg/km) was spread in the evening. The temperature during both days was still high. The conditions were excellent during both competitions.

Conclusion

- Water MUST be present for salt to work
- The results of salting are equally good and even faster if salt is applied behind the grooming machine (rather than in front)
- There is no reason to start salting several days ahead of the competition in hope of building a firm base
- It is not necessary to salt in the evening if natural freezing is forecasted (clear weather and relatively cold)
- Rain or water from melting snow can start the snow hardening process if unused salt is present in the snow (this is however not tested properly)

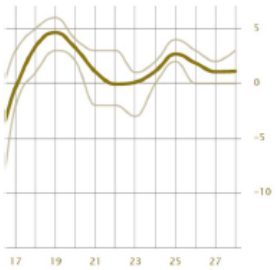
- It is important to let the snow hardening process take place undisturbed after salting (at least 30 minutes)
- The snow can stay hard for up to 10 – 12 hours in some conditions.
- Natural snow reacts faster with salt than artificial snow.

4.4 Nordic World Ski Championship 2015 Falun

The Nordic World Ski Championship was held in Falun in February/March 2015. The event was a great success in terms of spectator enjoyment and the financial results for the organiser. However, there were great challenges in terms of the quality of the snow surface of the competition courses.

Weather

- Warm and above freezing every day, and no freezing even at night
- Relatively low humidity



Snow conditions

- Thick layer of artificial snow having been produced in marginal temperatures and prepared every day all winter leading up to the Championship

Salting

- Salt (NaCl) og Calsium Chlorid (CaCl) was purchased and used (mostly small grains)
- Saltspreaders mounted on both large grooming machines and snowmobile trailers
- A 40 persons large manual «saltspreader group» was organized
- Most of the salting during the Championship was done manually

Results

- Many of the competitions were held in soft snow conditions
- The most unfair day (in terms of snow conditions) was during the men's 15 km individual free technique competition (no salting done); the worst day was during the Men's 50 km competition
- Solutions tried included closing of the competition courses (to «save» the courses), as well as putting the manual saltspreader group on a 10-minute response time (ready for a jury decision)

The organiser's own experiences and conclusion

- Need to reduce grooming with large machines in advance of and during the Championship
- Should use snowmobiles and ATVs with less aggressive belts
- Must test and implement a system for adding water to the snow
- Must be better prepared for changing out or adding new snow onto the courses
- Should improve the communication between the Cross-Country and Nordic Combined juries

4.5 Sommer ski centers and salting

Summer ski centers in Norway have salted systematically for almost 15 years. They have by now a very good practical experience with salting of natural snow, and have also developed their salting equipment during the years. The following main points are taken from talks by or with the operators at Sognefjellet and Vik Skicenter.

Conclusions and experiences

- Salt is used only when the temperature is above 0 degrees Celsius
- Water must be present for salt to start reacting
- Large grain or mixed-size sea-salt is the most efficient and less costly to use
- Salting behind the grooming machine gives the fastest snow hardening result
- 30 – 40 kg salt per km is enough (for a 4 meter wide track)
- It must be at least 6 hours between salting
- It is necessary that skiers are kept off the track for about 30 minutes after spreading the salt
- If there are no freezing at night, it is best to salt early in the morning together with the grooming (the salt spreader can be mounted either in front of or behind)
- If there is freezing at night, and guaranteed warm temperatures and melting during the day, salting can either be done in the evening together with the grooming, or in the morning with a snowmobile and spreader.
- If dry air is moving into the area, salting is not attempted (dry air gives good glide in the snow, while humid air causes suction and poor glide)
- Using salt for many years does not show any visible damage to the vegetation (see photo below)

5. Practical advice

5.1 Salting – when in a time crunch

Standard salt/sea-salt (NaCl) in small grain sizes will normally react faster than using fertilizers, but will result in a weaker snow-layer. The snow hardening might also cause an icy layer on top, which can be softened by skiing or by using a snowmobile and drag. Mixed-size sea-salt will produce a better result (deeper snow hardening and softer top layer).

5.2 Salting – when plenty of time

Course fertilizers and sea-salt with mixed or large grain-size will produce a deep and strong layer of hardened snow.

5.3 Salting – when the snow lacks enough water

Compared with fertilizers, standard salt/sea-salt (NaCl) will more rapidly produce its own water during the snow hardening process and needs less humidity/water in the snow

5.4 Salting – when the snow is wet

Ammonium Nitrate has the highest endothermic effect per gram/mole of all salts or fertilizers, and will normally harden the snow deeper and stronger than any other product. It will not create an icy surface alike small-grained salt. Course Urea and course sea-salt will also give good results when the water content in the snow is high.

5.5 Salting – when the snow is «dead» and has no water in it

In “sugar-snow” conditions (no crystal structure and no water in the snow), salting will not help. Before salting is attempted, new snow, water or both must be added and mixed in with the old snow:

- New snow can be transported from stored and clean snow depots or from shaved ice at local ice arenas. It is important that the snow contains water.

- Watering of the snow can be attempted with water from the local snow production system if hydrants, lances or snow guns are placed appropriately around the course. A large water tank can also be mounted behind the grooming machine (see photo next page). If the problem area is small (one or two uphills only), a normal water hose can be used, or assistance by the local firetruck is perhaps possible.

- In most cases, the snow consist of layers of different consistency, and a front renovator, capable of reaching down to 35 cm (where the tiller can not reach), should be used to mix these deeper layers with the top layer (see photo in section 3). Some of the deeper layers might have more water (higher density) than the top layer and mixing them will cause better freezing and bonding of the snow.

If it is not possible to bring in (or up) new snow or water, the dead top layer must be removed/pushed aside using the blade of the grooming machine (or in other manual or mechanical ways) such that the firmer snow- or ice-layer below is exposed.

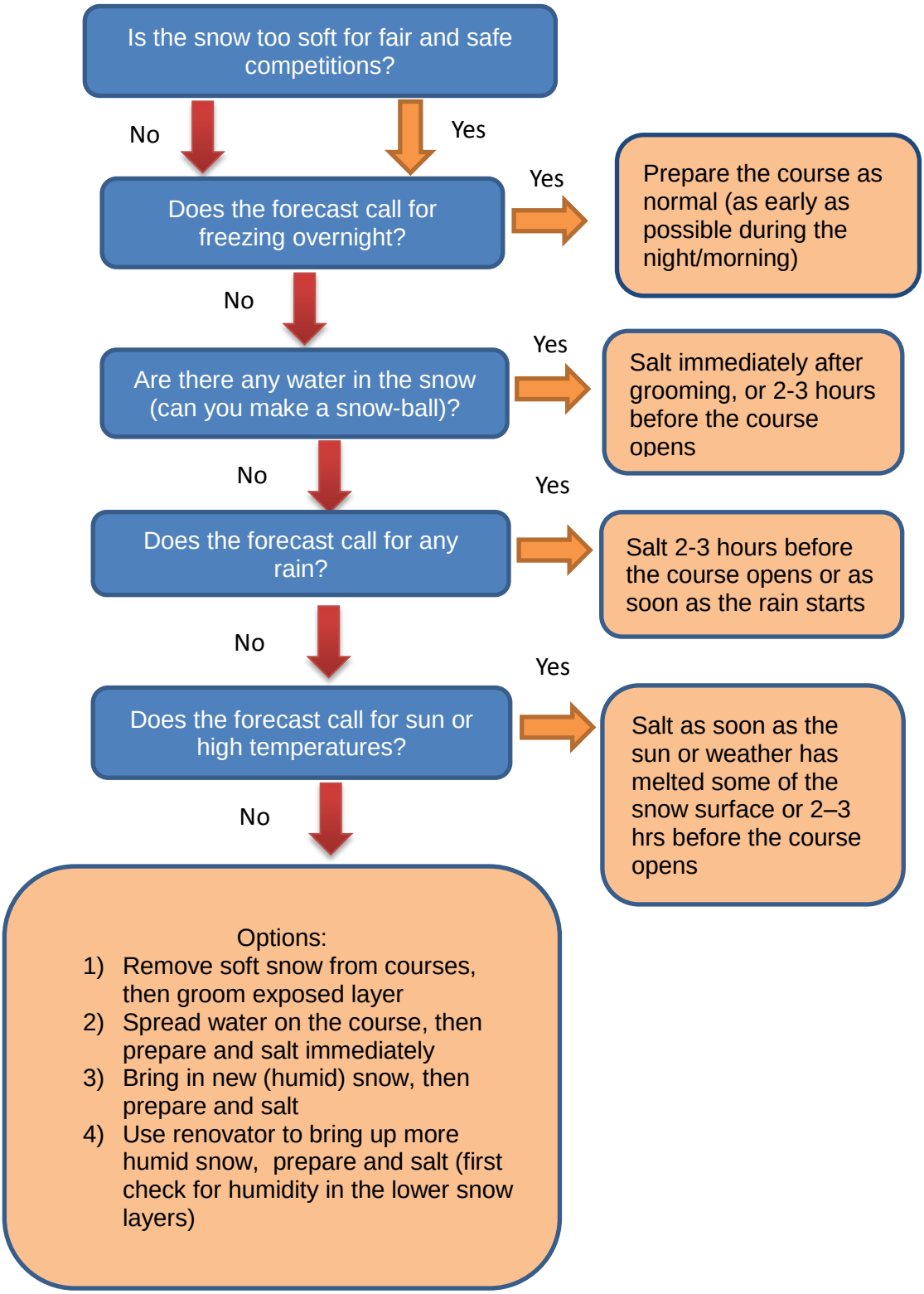
6. Decisions and communication

Salting will influence the technical execution and quality of the competition, and also influence the safety and speed of skiing. It is therefore important that the decision to salt is taken by the jury, where both the Technical Delegate and Chief of Competition are members. Depending on the situation, the Jury can decide to salt the entire course, parts of the course, only “sunny uphills”, all uphills, downhills or corners. This decision must consider the overall goal of salting – to “save” the competition and provide a fair competition without dangerous elements.

It is important to communicate a decision to participants, team leaders, coaches and wax technicians as soon as possible. Salting will alter the wax and the preferred ski-structure, and a decision must clearly and rapidly be communicated - what is planned, where and at what time the salt will be applied. It is also positive if a test area can be salted first, such that wax technicians can start testing wax and skis even while the competition course is being salted and closed.

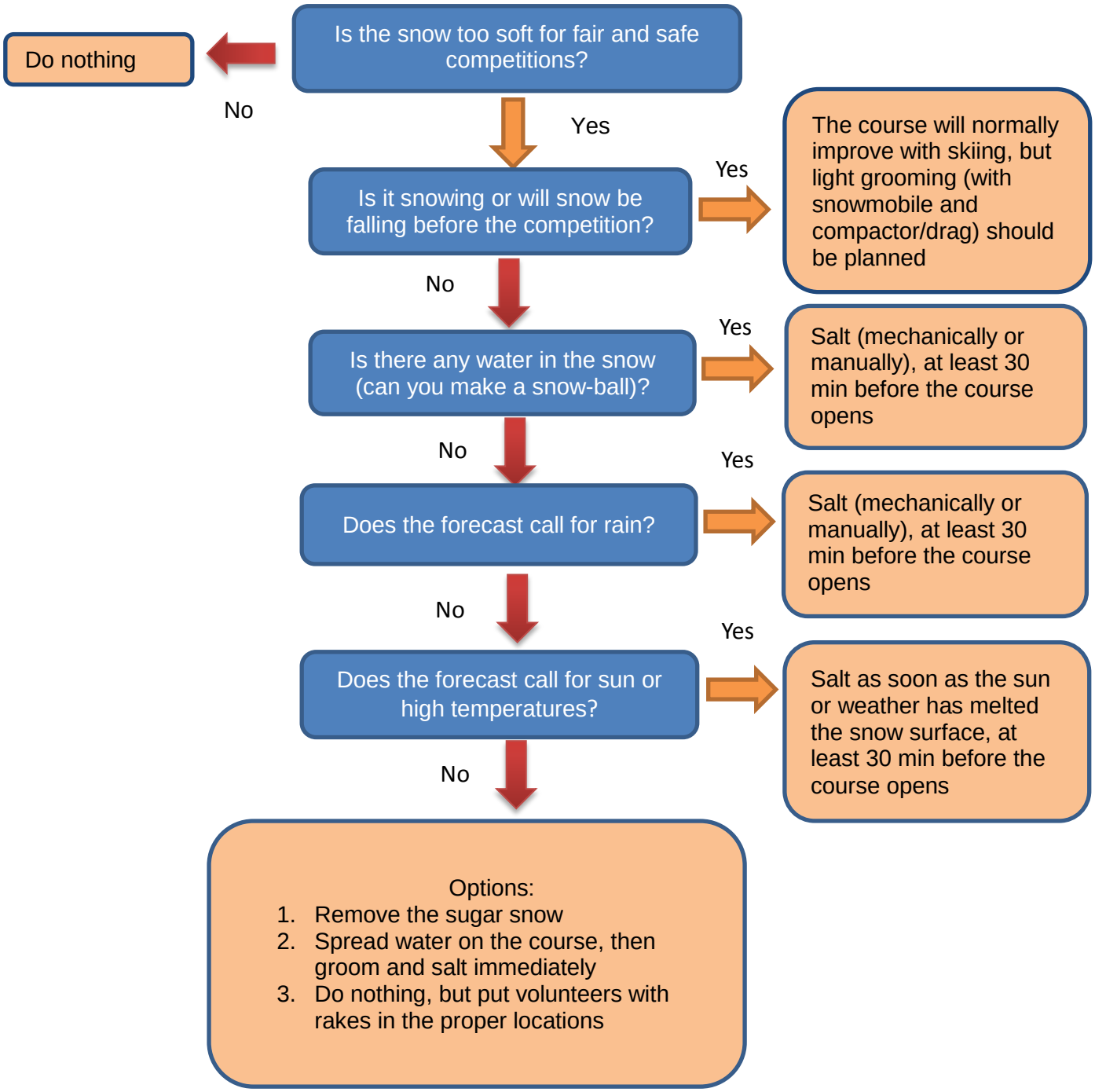
6.1 Decision chart A – the day before competition

At inspection the day prior to competition:



6.2 Decision chart B – the day of competition

At inspection the morning of the competition day (2 – 3 timer before start):



7. Resources

The following persons have given information for this document, and are potential resource persons in regards to the process of salting of Cross-Country course, and equipment for salting:

John Aalberg, FIS and Norwegian Ski Federation (author of document)
Anders Fortun, Sognefjellet, Norway
Asbjørn Hønsi, Vik Skisenter, Norway
Knut Kristiansen, responsible for courses and grooming, Holmenkollen, Oslo City
John Heilig, Nordic Combined TD, Olympic Winter Games, Sochi 2014
Tomas Jons, Chief of Competition Cross-Country, 2015 NWSC Falun