Course Preparation and Tracksetting

Snow Physics

The key to setting good tracks and fast smooth skating lanes lies in the snow grooming which is done before tracksetting. Grooming is the working or reworking of snow using special vehicles and attached equipment in order to provide consistent skiing conditions.

The objective in grooming is to create a smooth level trail bed that is firm enough to support the skiers and their poling and at the same time to have enough loose workable snow to mould tracks and shape skating surfaces.

Why Groom Your Ski Trails

- **Grooming helps to make a skier's visit or race fun from start to end**
- **Grooming helps make a ski race fairer**
- **Grooming demonstrates that cross country skiing is not only good exercise but also fun and exciting.**
- **Grooming puts more glide in cross country skiing.**

There is an ongoing debate as to whether grooming is an art or a science. The fact is that the basic medium, snow, comes in a bewildering variety of states, and groomers, in their attempts to define scientifically what is still a very inexact art, have come up with as many definitions of snow types as have the Inuit. For this manual the basic snow terminology, snow conditions, grooming and tracksetting processes will be presented. For a more detailed discussion of snow physics, grooming and tracksetting please refer to the Cross Country Canada Trail Grooming and Tracksetting Manual.

Snow

A knowledge of how snow is altered due to changes in temperature will allow you to better understand what happens when you groom trails in different conditions. It will help you to:

pack the snow to achieve suitable density for a variety of different users

provide the same track conditions for all skiers in a competitive event

extend your skiing season by working the snow the right amount.

Heat Gain and Loss In The Snow Layer

Temperature Gradient

The temperature gradient is the difference in temperature between the snow surface and the ground expressed in terms of degrees Celsius per meter of depth. For example, consider one meter of snow lying on a ground surface the temperature of which is zero degrees Celsius. If the air temperature drops to minus 20 degrees Celsius there is a difference of 20 degree Celsius in one meter of snow depth, or 20 degree Celsius per meter. Because the temperature gradient influences the movement of water molecules within the snow pack, it has a significant effect on changes in snow structure within the snow pack. The physical processes which cause changes at and beneath the surface of the snow are driven by temperature gradient or the lack thereof and by transfer of heat to the snowpack.

For the purpose of grooming, the interfaces which most concern us are:

the ground and snow surface

the air just above the snow surface and the snow surface

the snow surface and the snow one to two centimeters below the snow surface

Factors which affect the above interfaces are:

Incoming Ultra-violet Radiation (sunlight)

This process will heat up the snow and cause melting within the top few centimeters of the snowpack. The amount of warming depends upon the albedo (reflectivity) of the snow, the amount of impurities (dirt) mixed with the snow, and the granular structure of the surface layers.

Machine groomed snow is not highly reflective and therefore a large percentage of the incoming solar radiation is absorbed which may create a significant temperature gradient within the top two to three centimeters or may cause melting of the surface layers.

Outgoing Infra-red Radiation

This cools the snow surface. In clear conditions, in midwinter, outgoing infra-red radiation may cool the snow surface at the same time as incoming radiation warms the snow beneath the surface, creating or enhancing a significant temperature gradient. During a clear cold night, a crystalline deposit of surface hoar may form on the snow surface.

Rain

Rain transfers heat directly to the snow. It may remain as liquid water in the snowpack.

Wind

A warm moist wind results in heat being transferred to the snowpack. A dry wind, while causing the snow to evaporate at a high rate, transfers little heat into the snowpack.

Metamorphism

Process of Rounding

Snow begins to change as soon as it reaches the ground (or at higher temperatures, in the air before it reaches the ground). The rate at which it changes depends upon the temperature. Close to zero degrees Celsius the change is rapid. Below about -20 degrees Celsius there is little discernable change from day to day.

When outside temperatures are moderate or when the snowpack is deep, the temperature gradients within the snowpack will be small. Snow will then change by a process known as “rounding”. The natural process of minimizing surface area breaks down the intricate crystalline snow structure of the ice crystals into smaller, more rounded ice grains. At the same time, because of the reduction in volume of the snow particles, the snowpack consolidates and settles. When snow is first deposited it is light and fluffy, the crystal branches interlocking to form a cohesive mass. After a period of time, water molecules are transferred by vapour movement from the extremities to the body of the crystal. Eventually, the ice grains lose all sign of their previous crystalline structure and become more and more rounded. The larger ice grains grow at the expense of the smaller particles resulting in a uniformity of size within each snow layer.

How Snow Gains Strength and Density

You have probably noticed that soft new snow, when packed, will harden overnight. The process where snow gains strength by the joining together of ice grains, is called Sintering.

In the case of the ski trail, the snow crystals or ice grains are forced close together by the mechanical compaction of grooming equipment, at which time energy is introduced into the snow by the mechanical action, resulting in a partial melt, and thus increasing the density of the snow. As a result a transfer of water molecules, necks of ice form between adjacent grains, strengthening the snowpack. On re-warming, the necks between the ice grains will be reduced thereby weakening or destroying the bond between grains.

Importance of Density

If your trails are to withstand their intended use, you should pay attention to the density of the groomed snowpack. The following table gives typical snow densities and indicates suitable densities for various levels of use. Kilograms/cubic metre (Kg/m^3) is the usual measure of density.

• New Snow	150 - 200 Kg/m^3
• Wind packed snow	250 - 300 Kg/m^3
• Packed with snowmobile alone	300 - 350 Kg/m^3
• Support required for racing basket	>350 Kg/m^3
• Recreation trails (moderate use)	450 Kg/m^3
• Racing trails	500 Kg/m^3 or greater
• World Cup and higher events	540 - 560 Kg/m^3

Details on equipment and the process required to measure snow densities is available through your Cross Country division office or from Cross Country Canada.

The Melt-Freeze Process

When the sun is sufficiently strong to melt the top layers of the snowpack during the day, and when night-time temperatures fall below zero degrees Celsius, cycles of freezing and thawing will occur. In this process smaller grains will melt before larger ones. During the course of a number of melt-freeze cycles, larger grains will grow at the expense of smaller ones. The meltwater wetting the surface of these larger grains eventually re-freezes and firmly cements the grains together. Melt-freeze grains have a tendency to freeze together in clusters, leaving large pore spaces unless packing is done.

Types Of Snow

Falling or Newly Fallen Snow

In cold conditions (-One degree Celsius and lower): The snow will be low density, highly crystalline, possibly interlocking crystals, matting and building up on trees. The snow will be hard to pack if the new snow is allowed to get too deep. It packs well in 10-15 centimeters (four - six inches), layers at temperatures close to zero degrees Celsius, and becomes more difficult to pack as temperature decreases.

In warmer conditions (zero degrees Celsius and above): The snow will be wet and heavy with little remaining crystalline form. If accompanied by wind, the snow is plastered on trees, signs, buildings, etc. It packs easily into a hard, dense layer at temperatures close to freezing and may turn to slush at higher temperatures.

Partially settled Snow (Fresh Powder)

This type of snow has begun the rounding process and, if left alone, will settle and strengthen naturally over a period of time as pore spaces are reduced and sintering occurs Mechanical disturbances such as blading, tilling or packing will reduce the air spaces by pushing the ice grains closer together allowing better sintering. The snow, now “Machine Groomed Powder” becomes both denser and stronger.

Settled Snow

When snow is settled, the grain size becomes smaller and more uniform. Pore space decreases, sintering increases, and density increases. The ability of the snow to re-crystallize due to large temperature gradients, and hence loosen-up, is reduced due to small pore spaces. In continental snow climates such as Alberta and the Rockies, Saskatchewan, Manitoba, Yukon, and North West Territories, a well packed trail system will not present re-crystallization problems. The snow should be packed early and well.

Dry Granular Snow

This type of snow may present itself in three ways:

faceted surface grains. This is unlikely to occur at low elevations of most Cross Country ski areas.

faceted grains in bottom of snowpack. This is common in continental snow climates, but will not be a problem if trails are well packed.

re-frozen melt-freeze grains. These are enlarged grains produced by several cycles of melting and freezing, often a function of over-grooming the same snow pack. They may present as a loose surface layer, but more likely will be frozen clusters which will break up as temperature rises and skier traffic increases. When partial melting has occurred (free water content less than eight percent) it is known as “Corn Snow". Excessive grooming will tend to loosen and enlarge these grains.

Surface layers of refrozen melt-freeze grains (or sugar snow) can be reconstituted (strengthened) in two ways:

It can be mixed with fresh snow, either new snowfall or old dry snow from layers beneath the granular layer.

A power tiller or, for snowmobile groomers, a compaction drag may be used to mill the snow. This reduces the size of the particles, allowing partial melting and sintering to take place.

If melt-freeze cycles continue, the snow will eventually become sloppier, and renovation will be needed. There is little you can do at this stage to alter the physical characteristics of the snow grains. Tilling will help to dry out the snow by exposing more surface area to evaporation. Wind will speed up this process.

Wet Snow

There is an old field "squeeze" test for the definition of snow moisture levels. A handful of snow is scooped up and squeezed in a gloved hand. Dry snow will crumble when released. Moist snow will compact to form a snowball, and water can be squeezed out of a handful of wet snow.

Wet snow creates special problems for groomers. It should **never** be packed or groomed if there is any chance that temperatures will drop later in the day or night. Wet snow which is compacted and later frozen can become a "bullet proof'" groomer's nightmare.

Wet snow can sometimes be broken up into coarse chunks with a front renovator or rotary hoe or tiller and left loose to aerate for several hours before further grooming. This will allow water to percolate downward and encourage evaporation through the increased surface area. Later, when temperatures have started to drop below freezing point, further renovation and tilling can refine the surface layers.

In wet conditions where there is no chance of freezing prior to a race, snow can again be coarsely renovated or tilled to promote drainage and aeration, but final grooming and tracksetting should be left until just before the race. It is normally difficult to till wet snow as it "balls up" in the tiller.

Basic Grooming

Although the discussion of Snow Physics indicates that snow grooming has a science base, it would be far too simple to describe it as a purely scientific activity. One could argue that there is as much art as there is science in the practice. It is certainly true that much can be learned by studying snow crystals and their change processes under a magnifying glass, but for most experienced groomers a few boot kicks in the trail snow and the weather report will often give them all the information they need for a good grooming job. So much of the work relies on the groomer's practical experience with their area, their knowledge of the local climate, and the site's microclimates. With this comes a sense of intuition that can't be described in any formal manual. This makes it very difficult for any individual to be a true grooming *guru*, or for any manual to be considered as *The Bible*. The following discussion is intended as a brief overview of basic grooming processes for race officials and others who are new to the field.

Grooming can be relatively simple or very complex depending on conditions, the desired end product and the time and equipment available. For simplicity, the whole grooming program can be broken down into several basic processes.

Packing

This is a season long process. Ideally, packing should be done with at least every six inches of new snow (with the understanding that this is not always possible when big dumps come). In low snow areas groomers will carefully pack every time more than 2 cm of snow accumulates to gradually build up a base.

Early season packing usually involves running over trail surfaces with light equipment meaning snowmobiles alone initially, followed by snowmobiles towing rollers or other compaction devices. Even high snow regions which normally groom trails with snowcats will find that snowmobile packing is essential until the initial base is set (this can range from 15 to 30 cm or 6 to 12 inches of packed snow depending on the smoothness of the ground surface).

End Result – An Increase in Snow Density

Snowmobile groomers may have to fall back on track packing with snowmobile only at later times in the season for big dumps of snow which would make towing any implements impossible, and even cat groomers will occasionally find track packing useful with unusually heavy snowfalls. But, normally packing will be done with implements.

Snowmobile groomers can pack with two basic types of equipment – rollers, or compaction pans/bars. Rollers offer the advantage of packing snow without dragging or displacement. They can, however, ice up in warm conditions, and working speed needs to be kept low to keep them from bouncing (creating washboard surfaces). Homebuilt rollers can be produced quite easily using various types of pipe, steel culvert, etc, but some of the most efficient units are produced by grooming suppliers such as YELLOWSTONE TRACKSETTING SYSTEMS, and TIDD TECH.

There are several compaction bar/pan devices available from equipment suppliers. The TIDD TECH *Trail Tenderizer* which has been around for more than a decade is a good example of a useful compaction pan when run with the front cutter teeth cranked up. Many groomers prefer compaction bars and pans to rollers for season long packing because they level and smooth the surfaces as they compact and they don't tend to ice up as readily in warm wet conditions. Working speeds still have to be kept low enough to prevent washboarding.

Compactor bars ("C-Bars") are available for larger snow vehicles. These bladelike bars mount at the rear of snowcats. Down pressure and blade trim (vertical angle) are all hydraulically controlled. "C-Bars" are particularly useful for early season packing (assuming a sub-base packed by smaller vehicles) where rocks, stumps, and other obstructions might still be hazards to power tillers, and they may be handy for later season mega –dumps which would clog tillers. Generally though, most cat groomers will routinely pack recurring snowfalls with tiller passes. If compactor bars aren't available particularly heavy snow dumps may have to be track packed before tilling.

Groomers often have little choice about timing for packing. Normally snow will pack and groom best in a relatively narrow temperature range between -10 and 0 degrees Celsius. Extremely cold dry snow (below -20 C) does not pack well, and as a general rule, all grooming of extremely warm snow (above 0 C) should be avoided. Warm wet snow can be a sticky frustrating mess and if followed by a cold spell the resulting icy surface can be dangerous. But, the pressures applied by an impatient skiing public or an upcoming race may force groomers to pack and groom in less than ideal conditions.

Surface Shaping

Most of the time, careful packing will leave trail surfaces smooth enough for tracksetting and skiing, but this isn't always the case. Packing can leave bumps and dips which should be flattened out. Skier traffic and repeated grooming passes can also gradually push snow to trail sides leaving a concave or dished surface. Periodically all of these irregularities should be flattened out, and snow may have to be moved back from trail sides to the middle. In the past, there has been a grooming theory that the ideal trail surface should be crowned (a convex surface higher in the middle than the sides). This would provide better snow depth in the middle where traffic would be highest. It would also make for more efficient ski skating (every skating thrust from the top of the crown results in a downhill glide) and it would make herringboning steep uphills easier for classical skiers since ski tips would not dig into higher side surfaces. A nice theory on paper - but in practice it has proven to be impractical. The excavation required to shave snow from trail sides to move it to the centre is very difficult to do with snowmobile equipment and in low snow regions the risk of digging up dirt and debris is much too high even if snowcats with skilled blade operators are available. The most practical aim for the majority of groomers is to maintain surfaces as flat and as smooth as possible.

For snowmobile groomers drag graders are the basic tool for surface shaping. These can range from home built devices like the old bed-spring drag to commercial units such as YELLOWSTONE TRACKSETTING SYSTEMS *Compaction Drag* or ADVANCE TRACKSETTING SYSTEMS *Renovating Leveller*. They can be used throughout the season to plane and flatten trails. Both the YELLOWSTONE *Compaction drag* and the *ADVANCE Leveller* are approx seven feet long (excluding the hitch). This seems to be a reasonable length for most snowmobile drag grader work. A number of ski and snowmobile clubs have been using longer bed graders (10-12 ft) originally built by BOMBARDIER and other makers for maintaining snowmobile trails. The extra length makes these very effective surface planers, but they can be brutes to tow in steep terrain and they will scrape high spots bare very quickly. In low snow country they have to be used with caution.

The most efficient tools for surface shaping are snowcat multidirectional front U-blades. U-blades can move massive amounts of snow and skilled operators can shape trails with near surgical precision. Again – as with long bed graders – the limiting factor is snow quantity. In most nordic trail systems outside of the heavy snow belts, operators will have relatively little chance to use the blades during regular grooming. Unless there is more than a foot of compacted snow on the trail surface, anything but the most conservative blade use will scrape snow down to the dirt, and dirt in trail snow packs is a nasty problem. Dirt and debris worked into a trail snowpack early in the winter can turn into a season long headache. Unless it is completely buried by a large dump (50 cm or more) regular grooming will continually work dirt up into the trail surface. Gravel and rock chips can foul expensive race waxes, or damage ski bases. More important to the groomer, the discoloration of the snow will cause rapid melt out patches in warm periods. In spite of this cautionary note, the front U-blade is an indispensable tool. It can flatten out and redistribute drifted snow; it can wing in snow from beside trails to fatten up thin spots (assuming that trail sides are relatively smooth and free from stumps, rocks, etc.). Unfortunately, as noted above, many groomers in low snow areas never have the opportunity to become skilful blade operators. For those who may wish to learn more about the art of blading, the best approach would be to arrange to ride along with an alpine groomer on a few shifts. Alpine groomers are the true masters of blade work.

Conditioning

Further snow conditioning processes will be required during a ski season. The following process definitions are somewhat arbitrary, and - obviously - there is considerable crossover between them.

Aging

This is a term used for a complex set of processes touched on in this chapter's earlier section on Snow Physics. Most types of fresh fallen snow require mechanical aging to turn them into suitable building materials for a ski trail surface. Cold dry snow is light and fluffy; it flows easily and resists compaction. Snow aging is a natural process, but mechanical action can speed it up to produce a consistent snow mass which can be shaped into firm tracks and skating surfaces.

The process is started by packing which reduces air spaces, forces snow crystals together, and promotes sintering. It is continued with the surface shaping which will further mill snow depending on the exact implements used. For most grooming operations packing and shaping will provide all of the aging necessary for good skiing. Groomers in low snow areas will rarely want to go further, because skiing traffic and subsequent grooming passes will harden trail surfaces surprisingly fast when regular snowfalls are a rare commodity. And re-grooming hardened old snow becomes increasingly difficult with each successive grooming shift.

There will be situations requiring additional aging passes. High level ski races require firm surfaces, and in deep snow country where snow comes every week, extra work will be necessary to produce hard fast skating surfaces. In addition to shaping surfaces, simple drag graders such as the YELLOWSTONE *Compaction Drag* mill snow quite effectively as the cutting blades move it inwards and then back out, creating high-speed snow crystal collisions. The friction of these collisions produces heat which promotes sintering and speeds up natural aging. Additional drag passes will gradually harden trail surfaces. Cat groomers have the most efficient aging implement, the power tiller, with its cutting teeth mounted on a shift spinning at 1000 rpm or more.

Mixing

This is another part of the conditioning process which can be considered separately, but which is obviously involved in several of the other conditioning stages (surface shaping, aging, renovation). New snow from surface layers can be mixed with older lower snow to produce an "aged" trail surface which will set up and withstand skier traffic much more readily than fresh snow alone. For an opposite effect - trail surfaces which have been turned to boiler plate or otherwise worn out by skier traffic, natural freeze-thaw cycles, or repeated grooming can be rejuvenated by being mixed with lower layers which have not been overused. Mixing is done with the same deep-cutting implements used in heavy renovation.

Renovation

This is a term for a series of processes whose objective is really the opposite to that of packing and aging. Snow which has been hardened excessively through a combination of skier traffic, grooming, and weather conditions must be loosened and converted back into a more powdery form before it can be reshaped into new tracks or a smoother more forgiving skate surface. Renovation may be required at different levels.

End Result – A Reduction in Snow Density

Surface Scarification

Skier traffic and weather conditions will scar up and glaze rail surfaces, but it may not always be necessary to do a deep renovation to buff them up enough for enjoyable skiing. This is true as long as tracks are still sound and icing is not too deep. Light surface scarification by snowmobile drags will touch up lightly glazed, rutted skate lanes. In low snow country especially, groomers can do much to save their snow packs by minimal use of more aggressive renovation. Many homebuilt drags such as the "Magic Carpet" (a piece of chain-link fence with 2 by 4's nailed across the top) or the "Step Tread" (three or four 4-6 ft wide expanded metal stair treads chained together) can scratch up and re-smooth surfaces enough to bring back pleasant skiing. A number of commercial implements will do the job much more efficiently. The levelling graders (YELLOWSTONE *Compaction Drag*, ADVANCE *Renovating Leveller*) can handle light surface scarification if weighted sufficiently. Another old standby for light surface scarification is the TIDD TECH *Trail Tenderizer* with its double front rows of cutting teeth.

In the past few years, the Swedish **JACA** skate surface *Renovator*, and –more recently- Yellowstone Track Systems *Ginzugroomer* and Tidd Tech's G-2 have added a whole new dimension to light equipment trail grooming. The JACA Renovator uses a horizontal cutter bar, while the *Ginzugroomer* and G-2 feature vertical knives . All use electric rams controlled by switches on the snowmobile to raise or lower cutter units. This means that the days of having to stop and get off the snowmobile to adjust depths are no more (being able to control cutting depths on the go reduces the risk of one of the snowmobile groomer's nastiest old bugbears - getting stuck on steep uphills). They allow snowmobile groomers to produce results as professional in appearance as those of any cat operator, but they do so without having to tear up surfaces to any depth. This can be particularly useful whenever quick touchup grooming is required during events (i.e., cleaning up a sprint course between rounds, or removing classical tracks before a following free technique race). In these situations using a cat would leave trail surfaces hopelessly soft.

Deep Renovation

Sooner or later deep renovation will be required. Old tracks which have become worn and icy, and trail surfaces turned hard and glazed by traffic and weather will need to be broken up and refined into snow soft enough to be moulded into new tracks and skate surfaces which allow ski edges to bite.

This can be one of the most challenging processes for groomers –especially for snowmobile groomers in low snow areas. Tools of agricultural origin (discers, harrows, rotary hoes) have been used to break up hard pack snow with mixed results. Most of these implement types tended to be too heavy and aggressive for dependable use behind snowmobiles. They were usually better suited for use behind heavier vehicles like the "*Bombi*", or some of the older types of snowcat. None of the old "Farmer Jones" type implements for snow grooming are currently available in the regular market.

Fortunately, the current market does offer a small range more efficient renovation implements for snowmobile groomers. Most groomers will be familiar with the old BAECHLER Pull Renovators which first appeared in the early 1970's. Many are still in use and many more sit in "bone yards" around the country. The old PL with its two and a half foot horizontal cutting bar could rip up hard snow, but it came up in big chunks and the machine was a notoriously hard pull for snowmobiles in hard conditions on hilly trails. The BAECHLER renovator is still manufactured under license by YELLOWSTONE TRACKSETTING SYSTEMS. YTS has modified it by replacing the original horizontal teeth with a set of vertical cutting knives, which leave a finer textured product and make the pulling a little easier.

The JACA skate surface renovator mentioned above also uses a horizontal cutter. It produces a beautiful fine-grained skate surface when set at shallow cutting depth, but since it is almost five feet wide it could be an extremely tough pull in hard conditions if set for deep cuts. Groomers would have to make repeated passes at increasing depth settings to renovate to track depth. The same would apply to the Tidd Tech *Trail Tenderizer*. The *Tenderizer* comes in four and six foot widths. Two rows of 2-inch long vertical cutter teeth are deployed by cranking the front of the implement pan up or down. This is normally done by hand with the attached trailer type jack, but an electrically operated depth control device which permits adjustments on the fly from the snowmobile is available as an option.

A small Canadian supplier ADVANCE TRACK SETTING SYTEMS promotes its leveling drag (*Renovating Leveller*) as a renovation tool, and it also sells a *Renovator* for deep cutting in hard and icy snow. It is similar to the old BAECHLER PL in width (2-3ft). Again, it would probably require several passes to tear up extremely hard snow to any considerable depth, and depth adjustments are manual (although an electrical control was rumoured to be on the way as of the summer of 2004).

YELLOWSTONE TRACK SYSTEMS' *Ginzugroomer* - already noted for its shallow scarification abilities - also works for deeper renovation. The Ginzu's vertical cutter teeth are mounted on a rotatable spring-tensioned pipe which permits the teeth to pivot out of the way when rocks, stumps or other obstacles are hit. This spring tensioning also produces a cutter action which leaves behind a relatively fine textured loose snow layer quite similar to that produced by power tilling. In very hard conditions – again- multiple passes would probably be needed to get down to depths of 5 cm or more. TIDD TECH's "G-2" which appears to be close to the Ginzu in principle should produce similar results (at the time of writing the writer had not yet had a chance to test a G-2).

Power Tilling

To many skiers and for groomers in deep snow country the whole art and science of snow grooming relies on one tool – the hydraulic tiller. In the right conditions, power tillers mounted behind modern snowcats can handle the whole series of grooming processes from initial packing to light or deep renovation. In areas where fresh snowfalls can be counted on every week, nothing more is needed. Grooming in the snow-rich Okanagan (i.e. Silver Star) is done throughout the winter by sending a big cat with tiller and tracksetters out on the trails every day. In drier parts of the BC interior, and other areas not so blessed tillers have to be used with much more caution. Repeated tilling passes in snow which is not being renewed by fresh snowfalls can do a lot of damage. Tilling is an extremely aggressive process. Snow crystals are rapidly reshaped into smaller more rounded forms, resulting in a more compact denser snow pack. If carried to extremes, tilling can actually reduce snow depth on trails. Snow particles repeatedly ground down to finer size leaving a denser and thinner snow pack. Carried on further, excessive tilling can leave "dead" snow. In this case rather than being too hard trail surfaces become sugary. Snow crystals have been altered so much that they will no longer compact. The only thing that will rejuvenate "dead snow" is an infusion of fresher snow which can come from snowfalls or snowmaking from above – or by bringing up and mixing in fresher snow from lower layers.

The most efficient tool for breaking up old hard pack and mixing with sub layers is the *front renovator*. A wide (2.5 – 4+ m) horizontal cutting blade front mounted on a snowcat cuts and lifts hardpack, leaving a loose chunky layer which is then refined by tilling into a smooth finish surface. The original *Front Renovator* introduced by the Swiss firm, BAECHLER TOP TRACK, is still being manufactured and sold under license by YELLOWSTONE TRACK SYSTEMS. A front renovator variation (an attachment to the snowcat front U-blade) is available from the German *Pisten Bully* maker, KASSBOHRER.

When to Groom ?

There is no single answer to the question of "When to groom?" Generally grooming should be done at times when skiers aren't around. Aside from the obvious safety issues raised by the possibility of skiers running into grooming machinery on trails, fresh groomed snow normally needs time to set up before it is ready to take skier traffic (usually 2 hours minimum - as little as 1 hour in areas with high snow humidity). This normally means grooming at night or very early in the morning. There are also other considerations such as current weather and temperature conditions, and the general condition of the snow pack. As noted previously in the section on packing, grooming is most effective in a relatively narrow temperature range just below the freezing point (0 to -10 C.). Cold dry snow doesn't pack well, so grooming in extreme cold won't be completely productive, but it also won't do any real damage if it must be done. Warm, wet snow is another matter. Whenever possible the best course of action in extremely sloppy conditions is to leave it alone. This is especially true if cold weather is predicted for the immediate future. The extra compaction produced by grooming melting snow can turn trails into armour plate if temperatures drop suddenly.

Still, there will be times when grooming in the slop has to be done, and in some areas (coastal zones, for example) where warm and wet are the norm, there will be no choice. Even in warm periods there may be times when temperatures and surface moisture levels drop enough for productive grooming (usually late night or very early morning). Snowmobile groomers with their limited horsepower will often have to time their work for a small window when snow has cooled and dried enough, but not yet frozen solid.

For ski races grooming should usually be done in the evening before the event, allowing maximum time for set up. Obviously, final grooming and tracksetting may have to be delayed until early morning with completion planned for just before the race if heavy snowfall is predicted

Manual Grooming

Although machines do most of the work there will often be a need for some manual labour in competition and recreational grooming. In thin snow conditions shovellers may have to fatten up thin spots , especially in high wear areas such as tight downhill corners. Cat growser marks and other rough spots left by machines should be raked smooth. During competitions manual groomers with rakes and shovels should be stationed at high speed corners and downhills where hazards (rocks, bare patches, icing) can be expected to turn up under racer traffic. Extra lookouts may be needed on blind corners.

There is an ongoing debate among race groomers about the ruts which form in downhill corners during races. Some argue that ruts should be regularly flattened out before they can become hazards to less competent skiers. Others maintain that they should be left alone (unless obvious hazards such as rocks turn up), since they can actually be useful to high-level skiers. There is no absolute answer to this debate, but the general trend in high-level races (FIS sanctioned events) is to leave ruts alone unless hazards appear.

Tracksetting

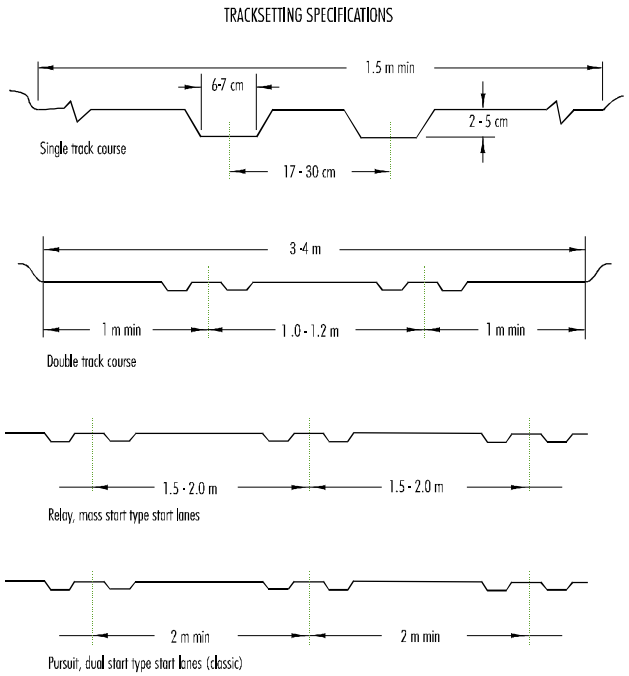
Setting tracks is normally the final step in the whole process of trail grooming. However, with modern equipment it is often done as part of a single grooming pass.

Although skating and the recent shift toward mass starts for most events on the international calendar have reduced somewhat the significance of track setting in competition skiing it is still an important element for many competitions and an essential element for the recreational sport of cross country skiing.

TRACK SPECIFICATIONS

The FIS and Cross Country Canada rules specify standards for track depth, width, and separation for competition track setting. FIS Rule 315.3.2 (ICR 2004) reads as follows:

> "The ski tracks must be prepared so that ski control and gliding are possible without a lateral braking effect by any parts of the bindings. The two tracks should be set 17-30 cm. apart, measured from the middle of each track. The depth of the track should be 2-5 cm, even in hard or frozen snow."



Most tracksetters being marketed today have track moulds which will set tracks within the FIS specification range. On some, distances between track moulds are adjustable. There used to be different specifications for distances between tracks for men's and women's races or for children's races, but these spec's are usually ignored now, and most setting is done by equipment with mould blocks positioned at the factory settings.

Track depths are determined by the thickness of the track moulds. The BAECHLER tracksetters (snowmobile and cat versions) in common use around the country use moulds at the deep end of the FIS specifications (5 cm or 2 in.). YELLOWSTONE TRACK SYSTEMS moulds are usually at the shallow extreme (deeper moulds are available from YTS). In practice skiers seem to notice little difference between shallow or deep tracks, as long as they are well formed. For competition or recreational trails, any of the tracksetters currently being marketed will produce acceptable tracks in the right conditions.

Tracksetting Equipment

There have been some changes in the market over the past decade, especially in the snowmobile equipment lines, but there are still less than a dozen suppliers and the basic types of setter haven't changed very much. There are only two suppliers of snowcat tracksetters ,YELLOWSTONE and BAECHLER . The pan type tracksetter introduced into North America by BAECHLER in the 1970's is still the most common snowmobile setter. BAECHLER is no longer marketing its snowmobile setters in Canada (its snowcat versions often come with KASSBOHRER cats), but YELLOWSTONE TRACK SYTEMS, TIDD TECH, ADVANCE TRACKSETTING, and others manufacture and sell pan type snowmobile track setters. There used to be several sled-type setters around, but the only one now on sale in Canada is the JACA built in Sweden, but sold by a Canadian distributor, (FIRST TRACKS).

All of the current commercial tracksetters use plastic mould blocks to shape and compress snow into tracks. Most of the moulds produce tracks with smooth sloped sidewalls wider at the top to allow for boot/binding clearance. A few tracksetters such as the JACA use a stepped profile mould to provide boot/binding clearance and extra sidewall compression. Most of the modern setters also use metal precutters to slice up and –in some cases- to direct snow towards the outer sidewalls before final shaping by the mould blocks.

Additional Considerations for Snowmobile Tracksetters.

Down Pressure - Weight

The amount of pressure required to mould acceptable tracks will vary with snow conditions. Very little pressure will be needed to shape perfect tracks into soft snow, but as snow hardens more will be needed. Snowcat tracksetters use hydraulic down pressure, but most snowmobile tracksetters have to rely on auxiliary weights to increase pressure.

Since snowmobile groomers have to manhandle their equipment, tracksetters should not be too heavy to haul around. Removable weights can add the extra down pressure needed for tracksetting in harder snow conditions. These can be in the form of steel plates (YTS), concrete blocks (JACA), lead (older BAECHLER), and in dire extremes *homo sapiens* (much of the track set for the 1988 Olympic races was done with an assistant sitting on the tracksetter - primitive, but effective).

Track Removal

All race courses and many recreational trails have sections which should not be trackset (sharp downhill curves, for example). Tracksetters which can lift or scrub out tracks eliminate the tedium of having to get off and manually rake out tracks. There are two ways to leave untracked sections while tracksetting. One is to lift the moulding blocks off the snow. The other is to rake out tracks after they have been set.

Snowrakes-Scrubbing Track after Setting

The older BAECHLER track pans could be fitted with a manually operated flip-down snowrake. JACA 's latest model tracksetter (since year 2000) also uses a rear rake device to wipe out tracks, but it is electrically controlled . The operator can scrub out or begin resetting tracks on the move.

While track rakes are relatively simple and relatively fast-acting, the process of scrubbing out track after setting does have some drawbacks. There is always a danger of stirring up dirt in thin snow sections. And, in some cases, while tracks may appear to have been wiped out the compacted tracks may simply have been filled in with loose snow which will sometimes melt out or evaporate (sublimate) after a few days reopen, allowing the tracks to reappear.

Tracksetter Lifting Devices

A number of devices for raising track moulds out of the snow have been available for some time (i.e. the YELLOWSTONE *Lever lift* , and BAECHLER *Compactor* pan – both of which tilted the pan to elevate track moulds). TIDD TECH's *Trail Tenderizer* uses a light weight track pan mounted on hinges at the rear, with a simple cable and lever to pivot the setter up out of the snow. All of these are manual systems requiring the operator to stop and get off the snowmobile. The track pans available with the newer *Ginzugroomer* and G-2 groomers allow operators to set or remove tracks on the move. Electric rams raise or lower the pans with the flip of a switch on the snowmobile. Being able to take out and reset tracks on the move is particularly helpful when setting competition courses where having to stop to lower the track moulds at the bottom of a steep downhill corner often brings the danger of getting stuck on the following tough uphill.

When to Trackset

As noted above in the grooming section, tracks should be allowed time to set up and harden before skiers use them. This normally means grooming at night or early in the morning. If separate grooming passes are required before tracking the setting should be done shortly after grooming before the groomed snow has hardened. This timing will vary with conditions, but it will usually be within two hours (less in conditions of high humidity).

To provide maximum set up time, competition tracks should be set in the evening before the race. Extremely warm wet conditions may force a delay in tracksetting if there is a chance that a temperature drop in the very early morning hours could freeze tracks into dangerously icy ruts. In such cases grooming and tracksetting may have to be delayed until temperatures have fallen to near the freezing point. A forecast for snow the night before a race may also suggest a delay in tracksetting until just before event start time. If tracks set earlier in the evening have been covered by 5 cm or more new snow resetting may be necessary. If tracks have been hit with less than 5 cm of fresh snow and the race start is near it is usually best to have forerunners or volunteers ski in the tracks rather than attempting a fresh trackset

General Points on Snowmobile Tracksetting

because most tracksetting is done at night the snowmobile should have a rear work light.

tracksetting speeds should be moderate (10-12 km/hr)

on straight sections the driver can keep tracks flowing straight by aiming for a fixed point down the trail.

when setting competition tracks it is useful to have a helper "riding shotgun" to keep an eye on tracks behind while the driver concentrates on the track line ahead. If raking with one of the older pan setters with manual rake or lifter the helper can handle these chores.

if working alone, a kneeling position on the snowmobile is usually best (one knee on the seat, one on the deck). This allows the operator to shift weight as needed and to do quick shoulder checks backwards.

competition tracksetters should carry a hand rake to erase footprints and machine marks.

normally, old tracks should be removed before new tracks are set. It is possible to set over old tracks if tracksetting is done with a renovator. The old BAECHLER Pull Renovator or the TIDD TECH *Trail Tenderizer* with cutter teeth lowered would work. The newer electrically controlled units such as the JACA tracksetter with built in renovator or the tracksetter equipped *Ginzugroomer* make the job much easier.

consider using shallow mould blocks for setting track in low snow conditions.

Competition Tracksetting – Classic Technique

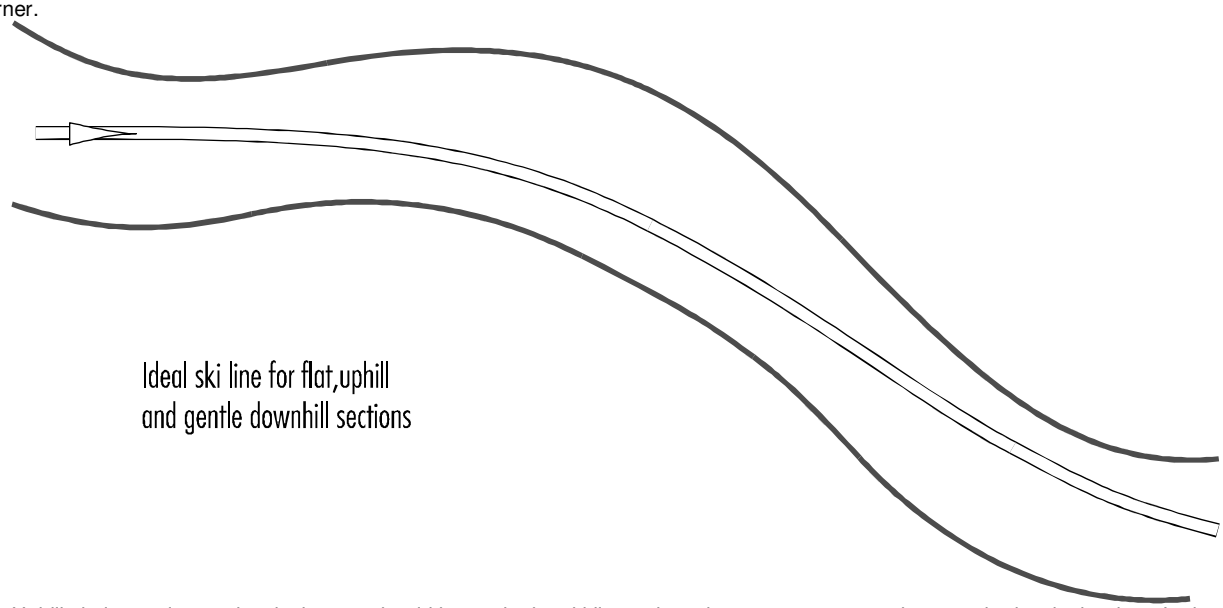
Competition tracksetting has been evolving along with race formats over the past two decades. In the late '70's and early '80's as trails widened and more sophisticated equipment was brought into trail grooming there was a general practice to double track race courses. The arrival of skating in the mid-'80's changed this. The FIS introduced a number of rules and practices in an effort to keep classical skiing alive in international competition. One of these was to specify that classical race courses be set with single tracks in the "ideal skiing line". This meant that groomers could no longer set race tracks with big cats. In what seemed a technological step backwards, they had to go back to using snowmobiles., because only small machines could follow the "ideal ski line" (often called "best line") as it flowed from side to side along the winding course. In the past five years things have changed again. Confronted with falling TV viewer ratings for traditional ski races in Europe, the FIS has changed most races on the international calendar from interval to mass start events in an attempt to increase spectator (and TV advertiser) appeal. At the most recent Olympics and World Championships

there was only a single interval start race for men and one for women. At the same time courses have become shorter and much wider (4 -9 m or more throughout). The general practice now for mass start classical competitions is to double or even triple track courses throughout, leaving steep downhills and corners untracked. Tracksetting can now be done again by big cats with double, triple, or even quadruple tracksetters mounted on rear tillers.

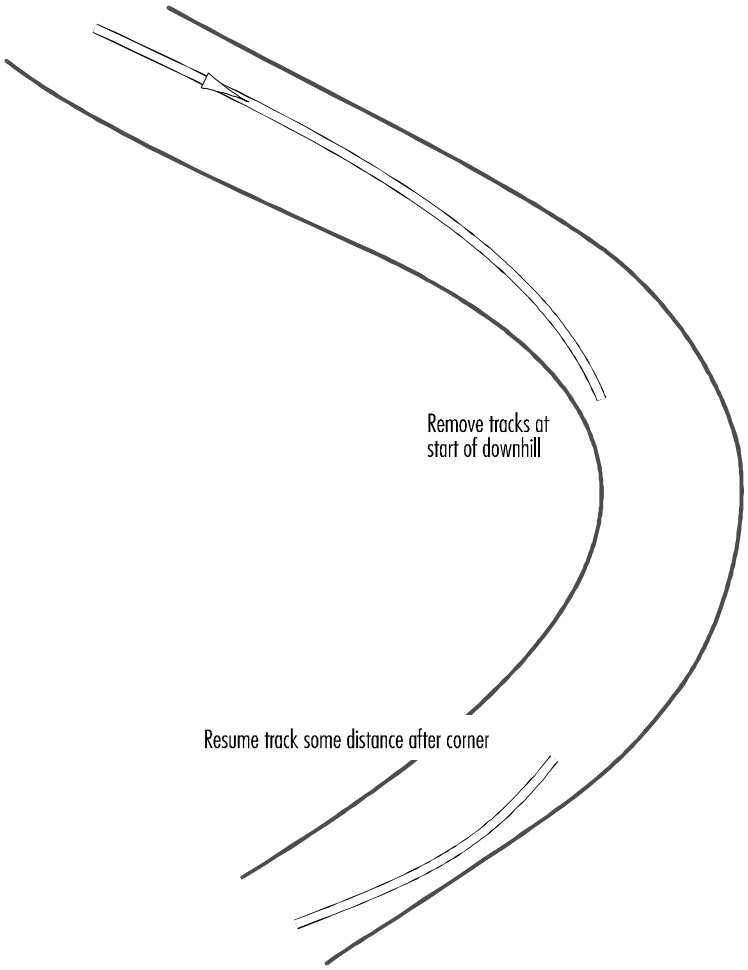
The concept of the "ideal ski line" hasn't completely died. There are still interval start classical races. FIS Rule 315.3.1 (ICR 2004) reads:

> For interval competitions in classical technique a single track should be set along the ideal skiing line of the competition course. The track is normally set in the middle of the course except through curves. In curves there should only be set track where skis can glide unrestrained in the set track. Where the curves are too sharp and the speed is considered to be too high to stay in the track, the track should be removed. To decide the proper course preparation and track setting, the best competitors and highest possible speed must be taken into consideration. In curves the track is to be set close to the fence to avoid the possibility to ski between the track and the fence. (The FIS recommends setting "close to the fence" as a deterrent to skating)

The "ideal ski line" is partly an attempt to discourage skating in classical races, but it also makes sense in a practical way. Perhaps the best way to describe it is to say that it is the line a skier in a hurry would take on a winding course. It is the shortest most direct line. When setting track through a flat "S" section, tracks should flow in as straight a line as possible, cutting corners like a Grand Prix race car driver. The FIS rule specifies that the track be set "close to the fence" to discourage racers from skiing outside the tracks to shorten the distance around the course (when competitors ski outside the course on a curve, it is common to see them take a few skating strides, which is illegal). However, it must not be so close to a corner that the skiers could snag any trailside obstacles. V boards along the inside of such a curve can also be used to prevent the cutting of corners if track grooming equipment is not able to snug up to an inside corner.

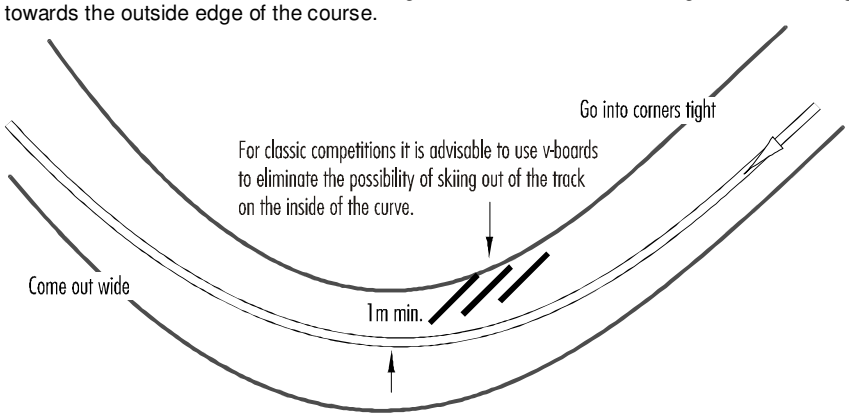


Uphills in interval start classical races should be set in the ski line unless they are steep enough to require herringboning. In that case they are best left untracked. Downhill corners present the biggest challenges of judgment for tracksetting. Sharp downhill corners should not be tracked. Experience is required to determine just where to take tracks out and when to resume them coming out of tight corners. As a general rule track is set following the best line to the upper inside of the corner. Tracks are removed around the corner, and they should not be started again until some distance after the corner. This is to allow skiers to see the tracks and to get themselves set up to step back into them. In fast conditions the untracked zone may have to be lengthened to give skiers more room to see the tracks and prepare for reentry.



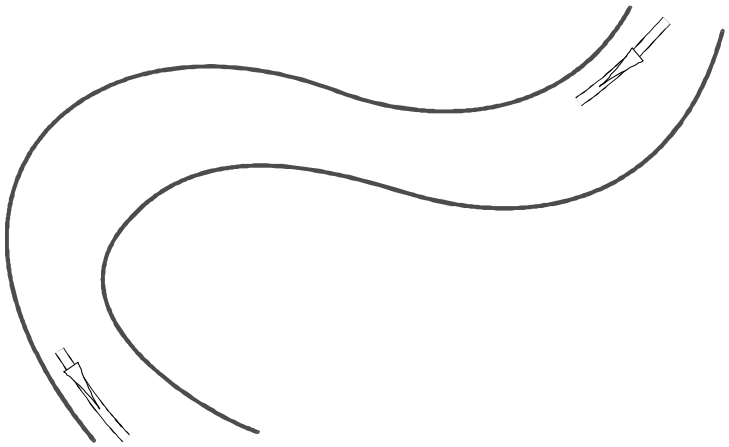
Trackable Downhill Turns

Downhill corners which are moderate enough for skiing in tracks should be set in the ideal ski line. This used to be the norm for both classical and free technique races, but now it tends to be done for interval start classical races only since so many come together in a mass start format. The general rule for setting downhill curves is to go into the corners tight (toward the inside), but to come out wide. (Some of these considerations must be applied in the actual design of the course.) Skiers at race speeds cannot stay in tracks which are set too tightly around curves. This is another one of the areas in which judgment based on the tracksetter's experience and skiing ability is vital. In fast conditions, track lines through curves will have to be straightened, meaning that they will come out of the corners more towards the outside edge of the course.



Trackable Downhill

Short straight sections (30 m. or less) between untrackable corners are best left untracked.



Untrackable Downhill

Competition Tracksetting – Free Technique

In recent years tracksetting for free technique races has practically been eliminated. As little as five years ago the FIS and CCC rules still specified that a single continuous track should be set along the side of free technique race courses (theoretically to accommodate marathon skate technique). The normal practice since the mid 1980's has been to set track only on some downhills. The FIS rule 315.4.1 (ICR 2004) reads:

> For interval start competitions in free technique the course must be well-packed for a width of at least 4 meters. On downhill sections where the tracks are set they must follow the ideal line of the course.

Most free technique race courses are now prepared with no set tracks. An argument can be made for setting track on certain long downhill sections for long races (20km or more) where gliding in the tracks might offer a rest break to some skiers. In that case, at least for interval start races ski line tracks on a few of the longer downhills might be a good idea. The wide courses (4-9m) now required for World Cup, World Championships and Olympic races have enough room to fit in downhill tracked sections without getting in the way of skaters even in mass start events. With mass start races tracks should be considered only for long distance events (20km or more), and only on the longest downhills. It would probably also be best to keep track slightly to the side off the ideal ski line. At the 2002 Olympic courses downhills often had track to the side in the free technique events and many skiers did use them. Local race organizers will have to make their own decisions about setting track in lower level skating races where less proficient skiers might appreciate some track for rest breaks. There are no hard and fast rules about this issue.

Sprint Courses

A course may be anywhere from 0.4 km to 1.4 km long, depending on the age/level of competition, with the longer distances being for the older and stronger skiers. However, the race distances should be no shorter than 0.8 km, which means that, if the course is only 0.4 km long, it should be skied twice each time. 2-lap courses are not recommended because of the significant logistical issues created, but 2 separate loops can be used to make the full course.

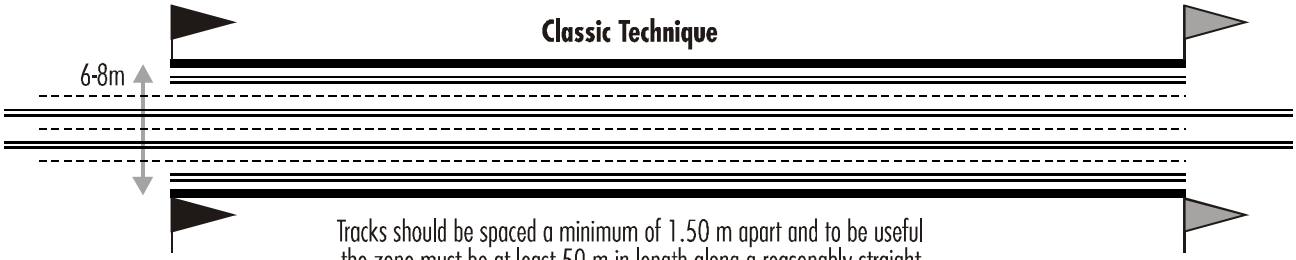
The total climb can be between 0 m and 60 m. It is suggested that the total climb should be no more than 15 m for up to a 0.5 km lap, 30 m for up to a 1.0 km lap, and 45 m for up to a 1.5 km lap.

The width of the trail should be between 6-10 metres, except at the start and finish where it may need to be wider, and on uphills where it should be at least 10 metres wide. It should have some straight stretches on it, some uphills, and some downhills. Generally, the wider the course, the better. The course must be sufficiently wide (see above) and without many sharp corners so that the conditions are equal for all skiers. However, part of the excitement of this type of competition is watching competitors going head-to-head against each other, and watching the strategies and abilities that emerge to pass each other, to navigate curves, to pass competitors on those curves, to pass competitors on the straightaways, etc.

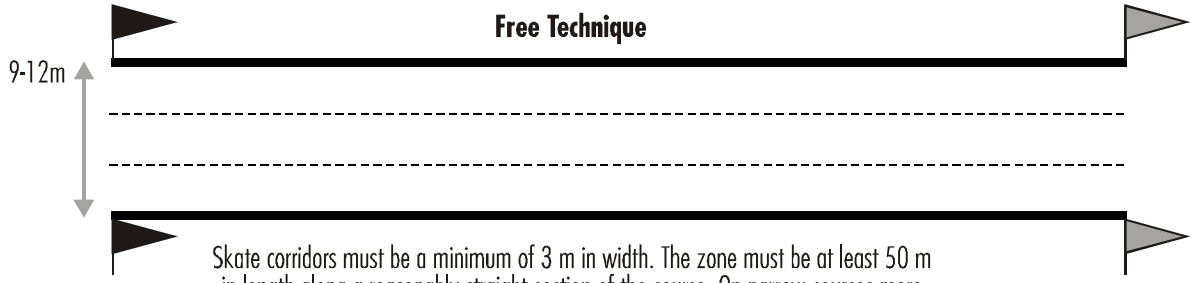
Where there are straight parts on the course, corridors may be marked. The purpose of these corridors is to allow trailing skiers to pass any competitors in their heat if they can, i.e., it forces a leading skier to pick a corridor which he/she must then remain in to allow a trailing skier to try to pass. Rule 340.1.4 forces a competitor who enters a zone where corridors are marked (start area, finish area, and any special corridors outside of the stadium) to remain in their chosen corridor unless they are overtaking another competitor. This rule supports the setting up of corridors on the course to enable passing; otherwise, it is possible for the lead racer to occupy the middle of the trail (which might be the best line) and thus not allow anyone to pass. The corridors should be marked with "stake chasers" (obtainable from survey companies) or sprigs of pine or spruce, anything as long as they are flexible in case they get skied over or hit by skis. They should not be rigid items, such as small flags on wooden sticks, or tape on sticks, etc. as they can catch a ski and trip the skiers.

Overtaking Corridors - sprints, mass starts, relays and pursuit competitions

Intended for courses that do not offer adequate opportunity for overtaking.



Tracks should be spaced a minimum of 1.50 m apart and to be useful the zone must be at least 50 m in length along a reasonably straight section of the course. On narrow courses more of these corridors should be provided. Rules for changing lanes is the same as it is at the finish. Signs must clearly mark the beginning and ending of the corridors.



Skate corridors must be a minimum of 3 m in width. The zone must be at least 50 m in length along a reasonably straight section of the course. On narrow courses more of these corridors should be provided. Rules for changing corridors is the same as it is at the finish corridors. Competitors can be sanctioned for interference if they Intentionaly attempt to block more than one corridor.

Stadium Tracksetting

Interval Start and Finish

This subject is covered in some detail in the chapter on Stadium Layout and Grooming. There has been little change in this aspect of race grooming.

Mass Starts

Mass starts are now used for many international races including new race types such as the pursuit competition –without a break. As a result, the basic rules and methods for setting up mass start zones have some commonality. The usual start for classical and free technique races is still a trackset grid 75 – 100m long with tracks a minimum of 1.2 meters apart (from centre to centre). From this base, the start positions for the chevron and arc formations are laid out. Relays use the arc formation, while other mass start races use the chevron formation if the competitors are seeded into the grid from fastest to slowest. Since this topic is also covered in detail in the Stadium Grooming chapter of this manual, readers should refer to that chapter for fuller details and illustrations.

Setting aesthetically pleasing mass start grids can be a tricky exercise. It is most easily done with snowcats. The large machines will steer in a straight line much more accurately than snowmobiles (they aren't as easily shifted around by small dips and rolls in the snow) and they back up, whereas snowmobiles have to turn around at each end (which can leave quite a mess). Depending on how the track pans are spaced, it may be possible to set 2 or more tracks of the grid on each pass (4 tracks would be possible with one of the new 5 meter cats with quad tracksetters). Even with cats, setting perfectly straight parallel tracks requires skill and patience. At the 2002 Olympics, the Chief of Grooming had to work out a sophisticated laser sighting system to steer the cat and cut tracks which would look perfectly straight and parallel on TV (as demanded by the host broadcaster). Fortunately, most races don't require this level of perfection for a set of tracks which will only be used for a few seconds.

Getting mass start grids aligned perfectly straight and parallel by snowmobile can be a much greater challenge. Many different methods have been used over the years. One of the most effective is to stretch a rope the length of each lane (80-100m), marking the centre of each set of tracks with flags. Flags are set in each lane every 15-20 meters. The tracksetter then drives down the row of flags aiming for each successive flag in front. A helper runs along just ahead of the snowmobile pulling flags just before they are run over.

The start area following the mass start grid can take several forms. If the race is free technique no further tracks will be necessary. An untracked "scramble zone" will lead skiers onto the course. If the race is classical, it becomes much more complicated. There should be a short (10 m.) untracked scramble zone followed by another trackset grid containing roughly half the number of tracks set in the start grid. Another short untracked scramble zone would be followed by two to four tracks exiting onto the course. There are no precise rules

for the length of the tracked sections following the initial grid. This will vary depending on how much room is available in the stadium area and other factors. For most races the chiefs of stadium and course along with the TD will have to work out the details.

Mixed Technique Relays and Pursuits

In the past decade, relays using classical technique for the first two legs and free technique for the last legs have become standard for the Olympic Winter Games and World Championships. At the same time the old pursuit format using a Gunderson start for the second free technique race (now called a Pursuit Competition – With a Break) has been supplemented by the Pursuit Competition – Without A Break, in which skiers use both techniques in a single non-stop race.

For relays, the course into the stadium would have to be tracked to the exchange zone. If this portion of the course is also to be used by a following free technique leg, the tracks should be set to the side. Normally no tracks should be set within the exchange zone, a track to the side (for the second classical leg) should lead to the course. For pursuit competitions –without a break, tracks should be continued from the course to the beginning of the transition zone where skiers switch from classical to skating equipment. Obviously, from this point on no tracks should be set.

Mixed technique races at the high level races work well only if separate course loops are available – one for each technique. This allows the classical loop to be set with multiple tracks (downhills untracked), while the free technique course is completely untracked. This is standard procedure for all top-level international events. If separate courses aren't possible, organizers will have to compromise by setting tracks to the side (again leaving downhills untracked). This would work only with exceptionally wide courses (10-12m).

Popular Ski Competitions (Loppets)

Stadium and course preparation for loppets is covered in both the FIS and Cross Country Canada rules in Section G, Guidelines for Popular Cross-Country Competitions. The start area is prescribed (Rule 384.2.1) as follows:

> The start area should be flat or nearly flat. It should lead directly into the course and should be wide enough to avoid excessive crowding. The start should gradually narrow to the width of the course over a distance sufficient in length to allow competitors to spread out before entering the tracks.

There is no mention of tracksetting. In practice, most loppet organizers find that a trackset mass start grid (100-200 m. long depending on room available) is helpful in organizing the start. This applies to both classical and free technique events. Whether or not the initial grid is followed by sections with reduced numbers of tracked lanes is completely optional. This may be desirable in classical loppets if space permits. In free technique, the narrowing of the mass start fan should be untracked (tracks at the side for classical skiers would be OK if there's room). On course for classical races, double tracks should be set (more if there's room). Downhill corners should be untracked. There used to be some argument for ideal ski line track on downhills, but it would normally be safest to follow the pattern of current elite level mass start competitions and allow skiers who may be traveling in groups to pick their own routes on downhills. The FIS and CCC rules are quite flexible about tracksetting for free technique loppets, suggesting that one single track be set to the side "where possible". Generally it is a good idea to set a side of course track for loppets. It is still not uncommon to see a few classical skiers enter free technique citizen races.

Equipment
Tracked Grooming Equipment

It should be clear from the preceding sections that there are two types of snow grooming – one using small vehicles (snowmobiles), and the other using large vehicles (snowcats). In the past decade, most clubs and other operators maintaining trail systems of 20 km or more have moved into "cat" grooming. Smaller operators still have to put up with freezing their backsides on snowmobiles, and even the cat people have to fall back on snowmobiles at times.

There is no question that snowcats are the most efficient vehicles for snow grooming provided that several conditions are in place. The first, of course, is money. There is a huge difference between the startup costs for snowmobile and cat grooming. A new cat, large or small, will start at around $200,000, and rise depending on the exact size and attachments. And then, of course, there are ongoing maintenance costs, which can also approach the stratospheric. On the other hand, a decent grooming snowmobile can be picked up for $10,000-$12,000, and even relatively sophisticated grooming implements such as the YTS Ginzugroomer will set you back around $4,000 Canadian. In the long term, of course, the efficiency of cats in terms of manpower savings will more than offset the initial costs.

The second major condition which must be satisfied to justify acquiring a cat is snowfall. Groomers in low snowfall regions such as Yellowknife or much of the prairie region will probably encounter one year out of ten in which there is enough snow to use a cat. At the opposite extreme, anyone attempting to maintain a trail system of 20 km or more in the west coast snowbelt can expect nothing but worn out backs and endless frustration if they have to rely on snowmobiles. A final consideration is trail width; if trails aren't wide enough to handle cats, snowmobiles will have to do.

Annoying as it may be, even the best-equipped cat groomers will have to fall back on snowmobiles at times. Early season work, best-line tracksetting, snow drought periods – all demand small machines. At the Canmore Nordic Centre, for example, in five out of six of the years from 1997-2003, snowmobiles did most of the natural snow trail grooming for most of the winters. There simply wasn't enough snow to use the cats. This then raises the problem of finding a suitable small grooming machine.

Since 1995 , when BOMBARDIER stopped production of the Alpine II twin track, finding a suitable grooming snowmobile has been a challenge. Grooming requires a machine with low gearing, able to pull heavy loads at low speeds, without overheating. Most machines currently on the market are geared for speed rather than pulling power. Many groomers are still getting yeoman service from the Alpine twin tracks even though spare parts are no longer carried by the regular dealer network (often meaning that long hunts in the aftermarket

are required). As of 2004 the most successful widely available grooming sled has been the BOMBARDIER Skandic Super Wide Track (24" single track). The Skandic has excellent pulling power (exceeding the Alpine II even), and it has become the basic workhorse snowmobile (even though it is light in the front end which makes steering with a load problematic at times, and there can be overheating). Several powerful liquid-cooled snowmobiles (i.e. the Skandic Wide Track 600, Arctic Cat's Bearcat 640) have also been used for grooming, although many operators have experienced serious overheating problems with liquid-cooled machines. None of the single-track snowmobiles on the market (as of 2004) have been completely satisfactory for trail grooming. An Italian twin track machine, the Alpina, being sold in the U.S. by dealers in Michigan and the east coast, does appear to have some potential. It is a massive snowmobile (approx. 4 ft. wide), with a four cylinder automotive engine (Peugeot), and reports indicate that it will pull impressive loads at low speeds. Unfortunately, costs (approx. $40,000 Can.), the lack of any Canadian dealers, and general questions about parts supplies and service raise questions about its practicality at this time. (Note -- During the 2003-04 season Bombardier introduced a new twin track to the market. The Elite is a touring machine, providing side by side seating for the driver and a passenger. Equipped with twin tracks and a four stroke engine, it should have more than adequate power for trail grooming, but at the time of writing, no field test results had come in.)

Moving beyond snowmobiles, a number of larger tracked vehicles have been used for trail grooming with varying degrees of success. They have included half-track machines such as the TRACK TRUCK, and larger ATV's (i.e. the ARGO). A few of the older differential drive snowcats (various models of the BOMBARDIER Bombi, and SkiDozer, or the THIOKOL cats) are still working trails in spots across the country.

While the old differential drive cats could handle front blades and pull much heavier drags than snowmobiles, trail grooming really entered the modern age with the introduction of hydrostatic drive cats in the mid 1980's. Hydrostatic drive machines are powered by a system of hydraulic pumps and motors. They are much more maneuverable than the older technology cats and they can be fitted with power tillers. There are two general size ranges -small cats (2.5-3 m wide) with power ratings under 200 HP, and big cats (4-5 m width) with 200-300 plus HP. As of 2004 only two major brands were being marketed in Canada, the yellow machines of BOMBARDIER, and the red Pisten Bully's from KASSBOHRER. A few clubs around the country are still running LMC (LOGAN MANUFACTURING CORP) cats, although there hasn't been an active LMC dealership in Canada since the mid '90's.

Small cats (BR 180 and the small Pisten Bully's ranging from the PB130, PB150, PB 160 to the new PB100) would appear to be the best choice for many nordic operations. They can obviously run on narrower trails and in lesser snow depths than big cats, but they are not nearly as common as the big machines. The big units are manufactured in much higher numbers for the alpine ski industry. As a result, the small cats are relatively much more expensive and, since there isn't a major user like the alpine industry sending used cats back into the market, they are much harder to find. Most nordic centres in Canada run with used alpine hill cats. A big cat which may be a little long in the tooth for alpine hill grooming may still have many years of life left for nordic trails, and they can be purchased for prices ranging from $45,000-75,000 (as opposed to $180,000-$200,000 for a new small cat).

Snowmobile Grooming and Tracksetting Equipment

Among small nordic ski clubs there has long been a tradition of making do with homebuilt equipment for trail grooming and tracksetting. While this may still be necessary for some, there are some good products available on the commercial market. Following is a small sampling as of the autumn of 2004. Readers can check the websites listed for further information. It can also be useful to take a look at the website of the Cross Country Ski Areas Association. CCSAA's website provides links to a number of equipment suppliers, and its newsletter often includes advertisements for used equipment.

ADVANCE TRACKSETTING SYSTEMS (www.advancetrack.ca)

The owner has been a snowmobile groomer at the Strathcona Wilderness Centre, east of Edmonton, for several years. They offer a small line of simple, but useful grooming drags and tracksetters. Since they are Canadian, their pricing is in Canadian dollars – a significant cost advantage.

FIRST TRACKS (www.jacatrax.com)

The Canadian distributor for JACA.

MOUNTAIN SNOW EQUIPMENT INC. (www.mtnequipment.com)

A Quebec firm which produces a line of grooming drags for snowmobile and ski trails.

SNOWGROOMERS.NET (www.xcskigroomers.com)

A sample of one of the entries pulled from the CCSAA web. This company sells a line of lightweight drags and tracksetters which it claims can be used with lighter snowmobiles.

TIDD TECH LTD. (www.tiddtech.com)

One of the old timers; started twenty odd years ago in New England, now based in Colorado. Producers of the "Trail Tenderizer" and the new G-2, plus a line of accessories.

YELLOWSTONE TRACK SYSTEMS INC. (www.yellowstonetrack.com)

Doug Edgerton has long sold one of the most complete lines of snowmobile grooming and tracksetting equipment available anywhere. Especially interesting is the new “Ginzugroomer”.