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Entry-level snow grooming
Level 1.0 – session 2

Reference:

Slope Preparation and Slope Maintenance – The Handbook for Practitioners
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Elaborated by:
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Table of contents

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1. Introduction

1.1 The PRO ACADEMY mission statement

PRO ACADEMY supports the development of newcomers, advanced operators and experienced professionals who prepare slopes for world-class competition racing.

PRO ACADEMY is a training curriculum for the development of the professional snow-groomer operator.

PRO ACADEMY offers a wide range of innovative techniques and skills for working with snow in a mountain environment.

PRO ACADEMY offers efficient and economic slope preparation techniques.

PRO ACADEMY´s objective is to bring out the professional in each and every snow-groomer operator.

1.2 The operator's manual

The operator's manual contains important information that every operator needs to operate the vehicle safely and efficiently.

Newcomers and advanced operators alike must read and understand everything in the manual. Prior to the start of each season, before starting to operate a new snow groomer the operator always has to read through and understand everything in the manual.

Each snow groomer comes with its own copy of the operator's manual. The operator's manual must be carried in the cab at all times!

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2. Medium snow

Snow is the ski area's most valuable asset. That's why it is so important to work the snow carefully, in order to maintain the slope for as long as possible, especially in the spring.

2.1 Differentiation according to type of origin

2.1.1 Natural snow

Natural snow or new snow is a form of crystalline precipitation in the winter that develops in clouds.

It all starts with water vapor. As water vapor cools in the atmosphere it condenses and forms minute water droplets. These droplets of super-cooled water accumulate on crystal nuclei (such as dust particles, for example) and freeze. The longer these crystals remain in the cloud, the more water droplets accumulate. The water vapor in the atmosphere also precipitates onto the crystal and encourages its growth. The basic shape of every snow crystal is hexagonal.
Snowflakes ultimately take shape as falling crystals join together. The size of the snowflakes depends on the temperature. If it is warmer than -5 °C (23 °F) large snowflakes form, but at lower temperatures and if relative humidity is low it is more difficult for the individual crystals to aggregate and only small snowflakes form.

Freshly fallen natural snow is a highly porous material with very many air inclusions and very low density.
The snow-groomer operator's job is to process the freshly fallen snow in such a way as to produce a snow structure that is as homogeneous and compact as possible. Turning freshly fallen natural snow into a compact snow pack means processing the snow 2-3 times with the snow groomer. The snow also has to go through the freezing process imposed by the rhythm of day and night.

2.1.2 Technical snow

Technical snow is man-made with machinery and is used for localized improvement of the snow cover on the ground.

There are various kinds of snow guns, and broad distinctions are drawn between 3 main categories:

- propeller cannons,
- snow lances,
- all-weather snow guns;

Water and compressed air always form the basis for technical snow.

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The snow guns atomize the injected water and mix it with the stream of air or compressed air.
The water is atomized under high pressure in the nozzles and sprayed into either a stream of air produced by a propeller (propeller gun) or the ambient air (snow lance).

Certain nozzles in the array inject compressed air, producing a water/air mixture. This admixture of air atomizes the water even more finely so that it forms ice nuclei, on which surrounding droplets can collect. During flying time in the air, these water droplets then form completely frozen or semi-frozen snow crystals.
Technical snow is characterized by very high density; this is why it is considered very hard-wearing.

2.2 Distinction by property

Snow also has to be classified by certain properties. The way in which the snow groomer behaves varies depending on the type of snow. Consequently, the way in which the snow is worked in slope preparation has to be adapted accordingly.

Broadly speaking, as regards slope preparation distinctions are drawn between 3 main types of snow.

2.2.1 Dry snow

Dry snow is generally cold snow with a low moisture content. It can occur as powder snow or as graupel, which is sometimes also called snow pellets or soft hail. Dry snow will not bond into clumps under pressure. Instead, the individual snow crystals "grow together" over a certain period of time. This process is called sintering.

Dry snow mostly occurs in the depths of winter. This snow is easy to process or not so easy, depending on density and snow temperature.
More tilling power is needed to work dry, high-density snow, but normally the snow groomer has plenty of grip on snow like this. Good grip at the tracks means high thrust and very good climbing and steering abilities.

2.2.2 Damp snow

Damp snow is snow that has been warmed by external influences (temperature, weather conditions) so that it has a higher moisture content than dry snow.
Damp snow can be shaped into clumps under pressure, so it is very good for making snowballs. However, water cannot be squeezed out of damp snow.

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Damp snow can occur in the early part of the winter, in the depths of winter, and also in late winter. Snow of this type is considered heavy, so the snow groomer is under more load.

Damp snow is usually encountered only in the topmost layer. The underlaying layers in the snow pack generally consist of dry snow. In some cases there is not enough binding between dry snow and damp snow, and this causes layering in the snow cover.

2.2.3 Wet snow

Wet snow is very heavy and wet, it also clumps and water can be squeezed out of it. In the parlance of slope preparation, wet snow is often referred to as slushy snow or spring snow.

Wet snow is common in late winter, but also frequently after several days of warm weather. The high water content ranks slushy snow as very heavy snow, which has a direct effect on the snow groomer's performance.

As long as the slushy snow is only on the surface, the snow groomer climbs and steers well. If the softening extends right through to the underlying layers, however, it is vital to avoid over-processing the snow.

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3. Operating a snow groomer

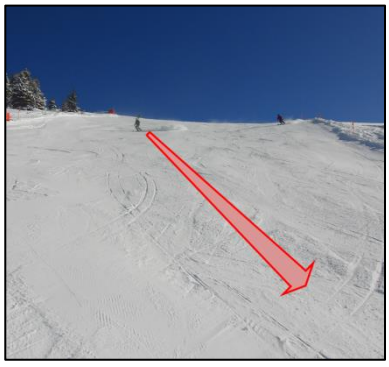
3.1 Driving a snow groomer

It is not particularly difficult to drive a snow groomer, but the skill with which the snow groomer is driven can have a huge effect on the costs and efficiency of slope preparation!

- The objective of daily slope preparation is to return the slope to perfect condition for visiting skiers and snowboarders the next day.
- Shortcomings in the quality of the slope surface caused by driver's mistakes have to be rectified immediately, to make sure that they do not put slope users at risk the following day.
- In the snowy and cold weeks of winter, critical and exposed spots have to be built up sufficiently to prevent them from becoming bare of snow as spring approaches.
- While work is in progress, driving speed has to be continuously matched to the local slope and snow conditions. As a rule, driving speed during slope-preparation operations should be 9 - 14 km/h (5.5 - 8.7 mph).

For safety's sake, snow-groomer operators always have to obey several of the rules of physics when carrying out their daily work.

For example, it is important to be aware at all times of the vehicle's center of gravity and its downgrade force.
Another very important point is the fall line in any given section of the slope. The fall line is the line on the surface that follows the direction of the steepest gradient. A good way of visualizing this fall line is to imagine water flowing downhill.



Because of the downgrade force, the snow groomer will always tend to follow the slope's fall line. This fact has a big influence on climbing ability and lateral stability, and also on the snow groomer's stability when it is traveling downhill.

3.1.1 Driving and preparation, uphill gradients

The snow groomer needs good climbing ability if it is to be used safely and efficiently for driving on and preparing ski slopes.

This ability depends on the following points:
- the snow groomer's center of gravity and the steepness of the slope,
- the properties of the snow and the condition of the surface, and also the structure of the ski slope,
- the contact patch and the traction of the tracks;

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In the early part of the winter, it is particularly important to handle the first snow very carefully. When only this first snow is on the ground it is all too easy for the snow groomer to dig dirt and stones up out of the ground and mix them with the snow cover.

Before setting off uphill, always assess:

- the steepness and of the downhill slope and possible cross-slope gradients,
- the properties of the snow,
- the structure of the ski slope;

Dangers of driving on uphill gradients:

- Particularly in soft snow and slope conditions, the snow groomer can dig itself in and become stuck on the uphill gradient.
- The vehicle can slip backwards on the loose snow.
- If one track loses traction the vehicle can lurch sideways and slip sideways down the gradient.
- Spinning tracks can scrape dirt and stones up to the surface, where they spoil the snow cover.

Tips for driving safely on uphill gradients:

- a sensitive touch on the throttle enables the tracks to establish and maintain their maximum traction,
- avoiding steering movements helps keep forward progress smooth,
- in critical cases, follow the slope's fall line;

3.1.2 Driving and preparation, downhill gradients

There are greater dangers involved in driving on downhill gradients. If snow conditions are poor, once a vehicle has set off downhill under certain circumstances it might no longer be possible to extricate it from difficulties by reversing uphill.

For driving on downhill gradients, study:

- steepness of the slope,
- cross-slope gradient,
- snow properties,
- structure of the ski slope,
- exit area below the descent;

A snow groomer traveling downhill can start to slip if the tracks lose traction. So it is essential for the operator to check constantly that both tracks are in motion all the time. Regaining control of a vehicle once it has started to slip is difficult at best, and may in fact prove impossible.

If it starts to slip, a snow groomer will invariably slip down along the fall line!

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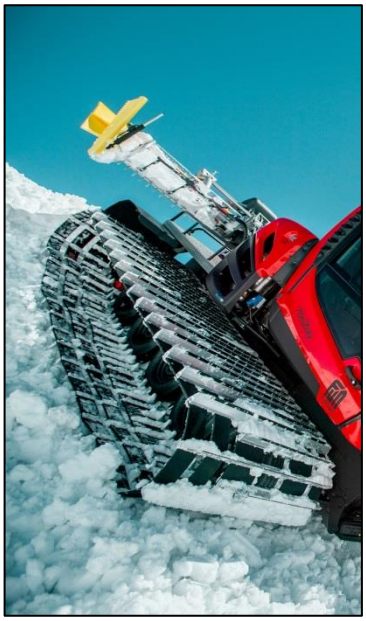
The following are contributory causes in cases when a snow groomer starts to slip:

- **Poor ski-slope conditions:**
  - soft snow conditions,
  - layers of snow of different densities (e.g.: technical snow on top of a layer of new snow),
    etc.
- **Technical causes:**
  - ice on the track cleats,
  - fault affecting mechanical components of the vehicle (e.g.: tracks, winch cable, etc.),
  - fault at the anchor point (poor design, bad ground, ground not frozen, etc.);
- **Operator's mistakes:**
  - driving too fast and moving onto the gradient at excessive speed,
  - moving onto the gradient at an angle,
  - not using the cable winch effectively,
  - etc..



Compliance with the following points goes a long way toward ensuring safe downhill driving:

- drive slowly onto the downhill slope,
- make sure the angle of approach to the slope is correct; avoid steering movements on steep slopes,
- regular maintenance and checking of the snow groomer,
- utmost concentration on the part of the operator, and correct, precise use of all the components (e.g.: speed potentiometer, tiller functions, etc.),
- maintenance of a safe distance from the vehicle in front;

When operating a vehicle with a fixed engine speed, reduce engine speed for driving downhill.
This keeps the vehicle from gaining too much speed and prevents the diesel engine from over-revving. With this mode of operation too, it is important to reduce the vehicle's speed on the approach to the edge of the terrain and to enter the slope correctly.

Do not take the vehicle onto a slope unless you are absolutely sure that it can be maneuvered in safety!

3.2 Steering a snow groomer and turning around

A snow groomer is steered by changing the speed of the individual tracks.

On uphill passes in particular, the vehicle's weight presses the rear track cleats into the snow. The result is that as they turn over the drive sprocket, the track cleats rip into the snow and shovel it up.

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"Turning around" is the technical term for reversing the direction of travel.

There are various ways to turn a snow groomer around. The advantages and disadvantages of each are listed to show which of these possibilities should be used by preference in a given set of circumstances.

The following are important points in regard to turning a snow groomer around:

- **Before turning around:**
  - possible hazards (persons, structures, vehicles,...),
  - turning area (size, depth of snow,...),
  - snow properties (icy, hard, wet,...),
  - situation of the turning area (steep or level terrain),
  - sub-base (stones, rock, grass,...);
- **While turning around:**
  - check that the danger zone is empty of persons and vehicles,
  - perform the maneuver slowly and with caution,
  - lift auxiliary equipment clear,
  - reduce winch pulling force to a minimum,
  - make sure that both tracks are in motion at all times;

3.2.1 „Two-way“ turn

This is the preferred way of turning a snow groomer, because it is the gentlest of all turning maneuvers.

Advantages:

- little wear and tear on the vehicle,
- little wear and tear on the sub-base,
- minimum ripping open of the snow cover,
- minimum need for snow,
- clean slope finish possible;

Disadvantages:

- more concentration needed,
- more space needed;

When turning the vehicle around in this way, it is very important to perform the maneuver correctly. To perform the turning maneuver correctly, the fall line must be known and the vehicle's downgrade force has to be used!

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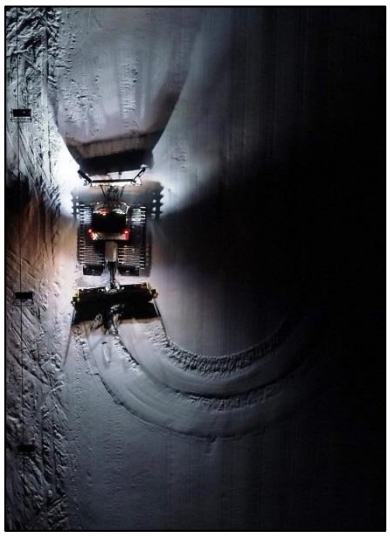
3.2.2 Turning around by "describing an arc"

The machine is turned around by driving a curve (radius 2 – 20 meters and more). This system of turning around is mostly used outside of the slope and in most ski areas there are designated turning areas.

The radius of the curve to be driven must be observed here. This substantially influences the loading and the forces that affect the machine and auxiliary equipment during the turning maneuver.

a) Radius greater than 4 meters



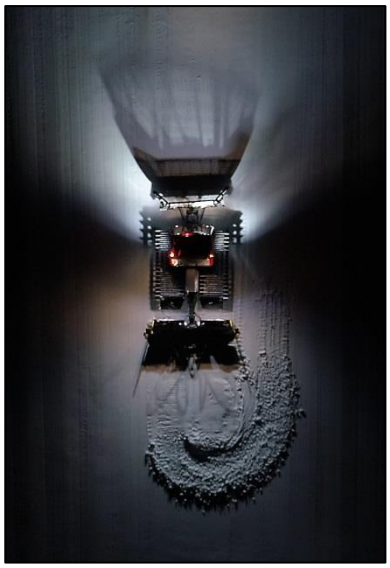
Advantages:

- little wear and tear on the vehicle,
- little wear and tear on the sub-base,
- less need for concentration;

Disadvantages:

- more space needed,
- slope sub-base is badly ripped up (if the same turning area is used repeatedly);
- more snow needed,
- clean slope finish only partly possible;

b) Radius less than 4 meters



Advantages:

- little space needed;

Disadvantages:

- high load on the tracks,
- high load on the running gear,
- increased ripping up of the snow cover,
- vehicle digs itself in,
- more snow needed,
- clean slope finish only partly possible;

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3.2.3 Turning around by "track counter-rotation"

When turning around by counter rotation of the tracks, the machine turns on its own axle (turning radius 0 meters). This is done by turning the semi-circular steering wheel completely or by the opposite pivoting of the sticks. This moves one track forwards and the other one backwards.

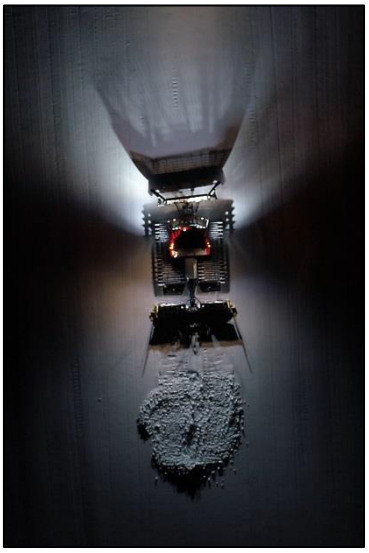
Turning around by track counter-rotation is a maneuver that should be resorted to as an exception only!

Advantages:

- minimum space needed,

Disadvantages:

- high load in the vehicle,
- high load on the tracks,
- high load on the running gear,
- slope is badly ripped up,
- the vehicle digs itself in badly,
- more snow needed;



3.3 Working with the blade

The blade is an essential tool for working with a snow groomer and it is the first step in slope preparation.

In order to restore the smooth surface of a ski slope, the blade always remains filled with an appropriate quantity of snow as the vehicle advances. The operator uses the full range of blade movements to adapt the position of the blade to the surface of the slope and the work to be done.

The operator smooths the surface of the slope by cutting off the tops of mounds and then filling in the troughs behind them. This process is known as cutting and filling.

Ski-slope preparation usually starts at the edge of the slope.
The blade is angled so that it bulldozes the snow from the edge of the slope toward the middle. Only as much snow is shifted to the inside as was shifted outward by the skiers and snowboarders using the slope.
On the next pass, the loose wall of snow is spread so as to level the surface of the slope. The excess snow is again shifted inward toward the middle of the slope.

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3.3.1 Cutting angle

The roll function is used to set the cutting angle of the blade. With the roll cylinder fully retracted, the blade is only resting with its spine in contact with the surface of the snow. The blade teeth do not bite into the snow, so they cannot cut.

The blade's cutting angle has to be adjusted and corrected constantly as work progresses. Ideally, the toothed rail contacts the surface of the snow over its entire length and the blade spine is raised about 2-3 cm (0.8 - 1.1 inches).

Inadequate cutting angle	Correct cutting angle
	
Effects: - blade "skids" over the surface of the snow, - longitudinal waves between the individual grooming lanes, - poor climbing ability and maneuverability because the contact patch of the tracks is smaller than it should be, - poor stability on downhill passes, - poor appearance of the finished slope because of irregular contact of the tiller, - poor tiller quality because the track cleats are biting too deeply into the snow;	**Effects:** - blade "cuts" the snow, - irregularities can be efficiently smoothed out, - high performance by the vehicle, - good appearance of the finished slope because the tiller lies flat, - good climbing ability and maneuverability, - good stability on downhill passes, - less load on the tracks;

3.3.2 Blade wings

The angle to which the blade wings are opened varies, depending on the work in hand. With the wings open the snow can simply slide out to the side. When the wings are closed the snow stays inside the blade and cannot escape to the side. Some situations call for one blade wing to be opened and one closed.
In certain working situations, it may happen that one blade wing is open and one blade wing is closed. This setting is used primarily to shift the snow from one side of the vehicle to the other.

The main jobs of the blade wings are:

- to create a level contact surface for the tracks and the tiller,
- to cut the snow off at the edge of the ski run and convey it inward (sideways shifting of the snow),
- to prevent the snow from escaping at the sides (blade wings closed);

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A distinction is drawn between outer and inner blade wing.
The inner blade wing is always the wing toward the side where the slope has not yet been prepared.
The outer blade wing is the wing at the edge of the slope or, as applicable, on the side where the slope has already been prepared.

Particularly when cutting off snow at the edge of the slope, it is important to keep each blade wing open to the ideal angle.
Because the tracks and the tiller project past the width of the blade, they rise up over the snow curb left by the blade.

The consequences of this situation are:

- **For tracks, running gear and vehicle frame:**
  - breakage of track cleats, cleat bolts and guide bows,
  - overstretching of the track belts,
  - accelerated wear of the track deflectors,
  - unnecessary loading on the vehicle frame;
- **For the tiller and its components:**
  - poor appearance of the finished slope because of inadequate contact with the slope surface,
  - accelerated wear or breakage of the side finishers,
  - risk of damage to tiller motors, hydraulic hoses and rear implement carrier;

Incorrect opening angle	Ideal opening angle
	

The inner side wing has the job of conveying the snow inward (toward the part of the slope that has not yet been prepared). Here too, it is important to work with the blade wing set to the ideal opening angle.
If the inner blade wing is not opened far enough the snow has difficulty slipping off to the side, which in turn has a negative effect on the performance and the steering of the vehicle.

Advantages of having the inner blade wing open wide enough:
- the snow slides off easily toward the inside,
- good vehicle performance,
- good steerability;

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3.4 Using the tiller

3.4.1 Tiller depth (cutting angle)

As a rule, the effective cutting depth of the tiller teeth into the surface of the snow is 1.5 to 2 cm (0.6 - 0.8 inch). At this depth the tiller processes enough snow to create a perfect slope surface.
If the cutting angle is deeper more force is needed, fuel consumption goes up accordingly and the vehicle's performance drops off perceptibly.

Remember:
The greater the penetration depth, the more snow will be processed.
BUT
The greater the penetration depth, the more force is required!

Constantly correcting the settings (switch between upslope and downslope operations) will help ensure the quality of the slope finish, in combination with maximum operating efficiency.

Advantages of an ideal cutting angle setting are:

- **Uphill drive:**
  - the tiller drive draws less power from the engine,
  - reduction in fuel consumption,
  - more engine power available for propelling the snow groomer,
  - excellent corduroy patterning because the tiller teeth do not penetrate too deeply;
- **Downhill drive:**
  - higher engine braking effect because the tiller takes more load,
  - excellent corduroy patterning because the tiller teeth penetrate to adequate depth,
  - better discharge of the processed snow to the tiller finishers;

Some vehicles feature electronic control for automatic adaptation of the cutting angle. However, this is no guarantee for a perfect slope finish.
The operator has to check the settings continuously and make changes whenever necessary!

3.4.2 Tiller speed

The tiller speed setting should not be higher than is necessary to achieve perfect slope quality. Selecting an unnecessarily high speed setting reduces the vehicle's performance and increases its fuel consumption.
Because of the different engine speeds and driving speeds for upslope and downslope passes, tiller speed has to be adapted constantly.

Remember:
The higher the speed, the finer the snow will be processed.
BUT
The higher the speed, the more force is required!

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The tiller speed differs depending on whether the vehicle is working an uphill or a downhill pass.

a) Uphill drive:

Driving uphill means that more power is needed, so engine rpm is higher and driving speed is slower.
Reduce tiller speed for working upslope!

Advantages of reducing tiller speed:
- the tiller drive draws less power from the engine,
- more engine power available for propelling the snow groomer,
- reduction in fuel consumption,
- better slope surface in soft snow conditions;

b) Downhill drive:

Driving downhill means that less power is needed, so engine rpm is lower and driving speed is faster.
Increase tiller speed for working downslope!

Advantages of increasing tiller speed:
- better slope surface because tiller throughput is higher,
- the tiller drive draws more power from the engine, so the braking effect is increased,
- better discharge of the processed snow to the tiller finishers;
- less edge wall formation;

3.4.3 Contact pressure – Floating position – Counter-pressure

Signs for INCORRECT contact pressure:

	Excessive contact pressure	Insufficient contact pressure
Uphill drive	- poor climbing ability, - poor maneuverability, - tracks spinning, - visible transitions between the lanes in extreme corn snow;	- slope finish lacks homogeneity, - small accumulations of snow behind the tiller (snow is blown through underneath the tiller finisher);
Downhill drive	- formation of edge walls because too much snow is shifted, - slipping of the vehicle because of the running gear, - vehicle lurching to the side;	- slope finish lacks homogeneity;

Remember:
The higher the contact pressure (down pressure), the better the quality of the slope!
BUT
The higher the contact pressure (down pressure), the poorer the performance of the vehicle!

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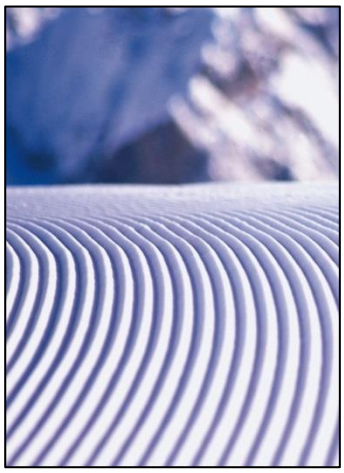
3.4.4 Horizontal floating position – Active swing



The rule of thumb is:

Uphill passes and flat terrain:
Tiller in sideways floating position (except on cross-slope gradients)

Downhill passes:
Tiller locked in centered position

Advantages of activated sideways floating position:

- vehicle steers better,
- less load on the rear implement carrier,
- optimum cover for the track marks in curves,
- perfect slope finish in curves;

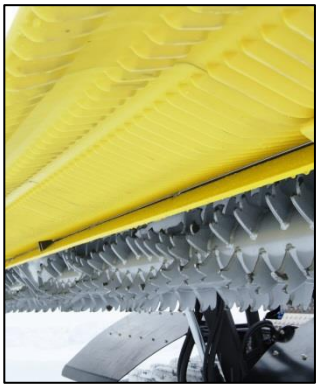
The operator can also actively steer the tiller and swing it out.

This function is needed primarily:

- to cover the track marks left by a vehicle slipping sideways,
- to stabilize a slipping vehicle on cross-slope gradients,
- to assist steering in critical snow conditions,
- when passing obstacles;

3.4.5 Snow-transport flap (tiller box volume)

Some tillers have a function for continuous adjustment of the tiller box volume. The purpose is to process or transport in the tiller box a larger or smaller quantity of snow, depending on the type of snow to be processed. The snow-transport flap can be set to any position between 0 and 100 % and the setting has to be chosen to suit the prevailing type of snow.



Snow-transport flap opened:
Small quantity of snow is transported = Fast discharge to the tiller finishers

Snow-transport flap closed:
Large quantity of snow is transported = Discharge to the tiller finishers is delayed

Important point to remember about snow-transport flaps:
Snow and ice accumulating between the snow-transport flaps and the tiller finishers can prevent the flaps from opening. It is important to clear ice from between the snow-transport flaps and the tiller finishers at regular intervals, or else to allow the accumulated ice on the vehicle to thaw off in the garage with the flaps closed. Before starting operations fully open the flaps before lowering the tiller into the snow for the first time.

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3.4.6 Tiller box blocked – clear

A tiller with a movable tiller box is known as a "Flex" tiller. The movable tiller box enables the tiller to adapt more closely to the snow cover, and ski-slope quality benefits accordingly. Flex tillers can be blocked to prevent this movement, either hydraulically by means of a control in the cockpit, or mechanically directly at the tiller.

Whenever a perfectly flat surface is required, it is advisable to lock the tiller.

This applies for example, to:

- preparation of snow park elements,
- working in very soft snow,
- preparing cross-country skiing trails,
- preparing connecting roads;

Ice accumulating between the tiller boxes can restrict movement. If this happens the tiller can no longer adapt correctly to the terrain. Thaw off this ice at regular intervals.

Elaborated by:
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4. Preparing a ski slope

4.1 Performing bulldozing work

Bulldozing work is any operation in which snow is moved with the blade. "Bulldozing work" is a term that summarizes a very wide variety of tasks in snow grooming.

4.1.1 Spreading technical snow

Under certain circumstances, spreading mounds of technical snow can involve a certain amount of risk for the vehicle and also for the operator. Consequently, it is important to approach this job in the right way and to exercise caution throughout!

As a rule the mounds of snow are bulldozed away in layers from top to bottom and spread outward.

Work steps for leveling out a mound of snow:

Step 1: Climbing the mound of snow

There is no one rule that covers every eventuality for climbing a mound of snow. The mound has to be inspected and the easiest way of climbing it chosen. When climbing the mound, it is important to check constantly to ensure that both tracks are always making contact with the surface of the snow and paralleling the vehicle. The blade is used to prepare the necessary contact patch for the tracks.

Step 2: Rounding off the top

After the mound has been climbed, the blade is used in short runs to round off the top to all sides and neutralize the dangers. When rounding off the top, it is important to create a relatively level working flat without steps, sharp drops and/or large chunks of snow (= dangers).
The flatter the surface, the easier is the next step in the procedure!

Step 3: Spreading the available snow

The mound of snow now has to be cut down in thin layers. A new line should be taken for each pass so as to produce as flat a surface as possible. Always keep the engine at the optimum speed for the job to prevent the tracks from spinning.

When spreading snow, take care not to create the following obstructions:

- steps and edges,
- large longitudinal and cross-slope waves,
- depressions dug out by spinning tracks,
- severe sideways angles,
- large chunks of snow;

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Step 4: Sequence of operations

The longer work continues at the same place, the softer and more powdery the sub-base will become. If the sub-base is too soft, it is advisable to move on and continue working on the next mound of snow.

After only about 3 – 4 hours the snow at the original location will have sintered to a firmness that allows work to be resumed there.

4.1.2 Pushing the snow back into place on sections of a ski slope

If the users of the slope have moved a lot of snow downhill and to the sides, the snow might have to be pushed back into place before the slope can be prepared with the tiller. The job of "pushing in" involves bulldozing the snow back uphill to the worn patches and refilling the snow depot in these areas.

Remember: The snow has to be pushed back to where it came from!

The following parameters have to be considered before the snow is pushed back into place:

- type and slope inclination of the section of the ski slope or trail,
- degree of wear and tear of the ski slope section,
- snow composition**;**

The extent to which snow is carried away from the various sections by slope users and the locations where it is deposited depend on the nature of the section of the slope.

A broad distinction is drawn between 2 types of slope section:

Curve	
Snow is removed:	**Snow is deposited:**
- entry to curve, - inside of curv;	- outside of curve, - exit from curve;

Straight	
Snow is removed:	**Snow is deposited:**
- middle of the slope - higher part - approach to an obstacle	- outsides - lower part - directly at the obstacle

Essentially, the extent of bulldozing work depends on the degree of wear and tear on a given section of the slope. So it is very important for the operator to know about conditions on the slope during the previous day's skiing. Push only as much snow uphill as the skiers have carried downhill. However, this snow has to be positioned correctly.

Elaborated by:
Florian Profanter

4.1.3 Harvesting natural snow

Natural snow is sometimes "harvested" when it is available in large quantities off the ski slope.

The procedure for bulldozing the snow over lengthy distances is as follows:

- Always follow exactly the same line when bulldozing the snow. After a number of trips the snow escaping past the ends of the blade will have formed side walls, creating what is sometimes referred to as a bulldozing lane.
- When reversing, take care not to force the tracks up against the side walls. Taking care in this way will help protect the tracks and keep the bulldozing lane in good shape.
- Ultimately, and starting at the back, the side walls of the bulldozing lane will also be bulldozed onto the ski run, so that as much snow as possible will have been harvested.

Opening the blade wings to about 75 % makes the blade wider, so the bulldozing lane will automatically be wider as well!

Dangers involved in pushing in snow:

- damage to the blade, the vehicle frame and the tracks, caused by contact with obstructions such as stones, rock, tree roots, etc.,
- damage to infrastructure such as snow-making hydrants and shafts by the vehicle,
- derailment of the tracks due to:
    - poor contact surface for the tracks,
    - difficult snow conditions,
    - unprofessional reversing (track climbs the snow wall);

4.1.4 Clearing roads

In winter it is often necessary to keep roads and tracks clear of snowdrifts. When spring returns, in many ski areas the snow on the roads is bulldozed down so that the roads will be bare of snow and dry and can be opened to vehicular traffic as early as possible.

Tips and requirements for clearing roads:

- correct choice of vehicle - size has to be suitable for the roadway,
- do not fully retract hydraulic cylinders,
- open the blade wings wide enough to create a good contact surface for the tracks and keep the snow discharging smoothly to the sides,
- basic knowledge of the dangers of avalanches, both loose-snow and slab type,
- ideally, work only in conditions of good visibility;

Risks involved in clearing roads:

- damage to the vehicle on account of unprofessional work,
- vehicle slipping over the downhill embankment (curb),
- triggering slab avalanches above and below the roadway;

Elaborated by:
Florian Profanter

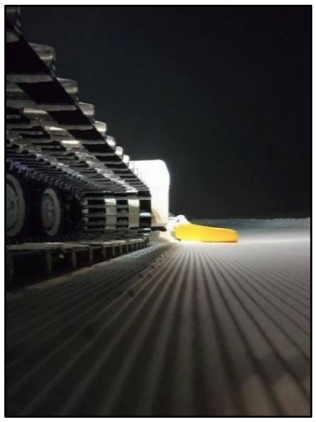
4.2 Methods for slope preparation

The term slope preparation is applied to all procedures that require the rear tiller, in other words in which the snow on the surface of the slope is tilled by the tiller.

4.2.1 Adjacent tracks

In this mode of slope preparation, adjacent tracks are laid down consecutively to finish the slope. Each new track slightly overlaps the preceding track to produce homogeneous transitions from one track to the next.

Close attention should be paid here to ensure that the tracks overlap.



The softer the snow conditions, the more overlapping of the tracks will be necessary.
On the contrary, this also means the harder the snow conditions, the less the tracks should overlap.

Overlapping means preparing the surface of the slope twice!
Excessive overlapping has a negative effect on the efficiency of slope-preparation operations.

4.2.2 Driving in fleet formation

When 2 or more snow groomers work in formation to prepare the slope, they are said to be working in fleet formation.

Important points for working in fleet formation:

- keep a safe distance behind the vehicle in front,
- avoid dazzling other operators,
- avoid driving errors,
- plan turning points well,
- coordinate every turn and execute the turns with precision;

Advantages:

- big area prepared in short time,
- good opportunity for inexperienced operators to learn more about their profession;

Disadvantages:

- Efficient compensation for changes in the width of the ski run is not possible,
- time is lost turning the vehicles around in tight turning spaces,
- time can be lost if even one of the operators makes a mistake,
- critical areas might not receive the attention they deserve;

Elaborated by:
Florian Profanter

4.2.3 Preparation at lifts

The entrance and exit areas at lifts require regular maintenance and preparation. The condition of these areas can have a huge effect on the efficiency of the lifts in transporting slope users to the top of the runs.

An **entrance to a ski lift** should incline slightly inwards (towards the turnstile) and be even. With higher volumes of skiers, a well usually forms and this must be evened out daily.

The **lift exit** must be horizontal and must have a specific slope gradient, which is stipulated by the cableway inspectorate and/or lift manufacturer. A well also usually forms at the lift exit and this too must be filled in again daily.

With T-bars and tow lifts, particular attention is to be paid to the **entrance track**. This must be horizontal and should not have any side inclination. Moreover, the entrance track should be created so that this leads directly below the tow rope. Because the skiers always travel in the same track, ice often forms in the entrance track. This must be tilled daily to prevent the risk of injury to inexperienced skiers.

There is a great deal of technical equipment installed at the top and bottom stations of lifts (and all along the tow track of a tow lift). Any contact with an element of a lift can easily result in damage extensive enough to put the lift out of operation!

Work at and alongside lifts demands the utmost concentration from the snow-groomer operator. It is vital to avoid collision between the snow groomer and lift elements or turnstiles!

Elaborated by:
Florian Profanter

5. Special applications

Snow grooming vehicles are not used only for preparing ski slopes, they are also utilized for a variety of "special jobs".

5.1 Maintaining cross-country skiing trails

5.1.1 Classic trail

A classic trail is prepared by using what are known as "track profiler plates" to cut parallel-groove tracks in the flattened ski trail. Depending on the region, width of the cross-country trail track and section of the trail, 1, 2 or more parallel-groove tracks can be cut.

While preparing a classical cross-country track, it is important that the skiing track as well as the track for the ski poles be as smooth as possible. The settings of the tiller and the driving speed are critical here.

5.1.2 Skating trail

A skating trail is a trail that has been worked with the tiller in the ordinary way. Track profiler plates are not needed for preparing a skating trail, which means that these trails can be prepared with an "ordinary" snow groomer.

Important for preparation of a skating track:

- The skating track should be as level as possible and free of surface irregularities.
- Avoid the longitudinal grooves that can be caused by clumps of snow in the tiller.
- When "big" snow groomers are used to prepare skating tracks, the tiller boxes have to be locked in the centered position if the groomer has a flex tiller (flex function disabled).

5.2 Preparing trails for snowmobiles

In some countries special trails are laid for snowmobiles. Special requirements apply to these trails. The tracks of the snowmobiles use up the snow quickly and relatively high and very compact cross-waves form. These waves have to be smoothed out at regular intervals to keep the trails safe for the users. Vehicles for preparing snowmobile trails have either a tiller or a special sled.

The blade is used to slice the top off the wave and bulldoze the snow into the trough behind it. The sled is attached to the back of the vehicle and pulled along by it. It flattens small irregularities and spreads the snow across the entire width of the vehicle.

Elaborated by:
Florian Profanter

With various hydraulic functions the operator can influence the way in which the sled works and consequently the finished result:

- **Cutting depth:**

By setting the depth of the blades the operator determines how deeply they bite into the snow and how much snow is processed.

- **Jockey wheels:**

Jockey wheels at the rear of the sled can be lowered hydraulically for crossing roads and patches that are bare of snow.

5.3 Transporting persons

The number of passengers transported depends on the size and design of the passenger transport cab. Under no circumstances is it permissible to carry more than the number of passengers allowed by the manufacturer.
The responsibility for the passengers resides 100% with the snow-groomer operator!

Before the vehicle moves, the operator has to check that:

- all passengers are appropriately equipped and strapped in,
- the lock of the passenger cabin is engaged,
- the safety devices are in full working order,
- the door of the passenger cabin is closed;

Style of driving with passengers on board:

- with foresight and care,
- no sudden steering maneuvers,
- no sudden braking maneuvers,
- gentle progress over crests / waves;

The selected route must be safe and selected so as to avoid every possibility of unforeseen hazards.

5.4 Transporting materials

In principle, it is possible to transport objects and goods on a snow groomer.

Possibilities for transporting materials:

- blade and/or front sub-frame,
- load platform,
- tow hook;

The maximum payload for all the different possibilities is stated in the operator's manual and it is not permissible to attempt to carry heavier loads.

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5.4.1 Transporting snow guns

The usual way of transporting a mobile snow gun is to hook the snow gun to the blade. A mobile snow gun can weigh more than 1000 kg (2200 lbs). A snow gun is a bulky object and it has a high center of gravity.

Risks involved with transporting snow guns are:

- accidental detachment from the blade,
- toppling against the cab,
- collision with the cantilever arm of the winch;

Measures for accident prevention::

- comply with the manufacturer's specifications in the operator's manual,
- secure the load firmly so that it cannot slip out of position or work loose,
- continuous checking and monitoring by the operator of:
    - snow gun's center of gravity - correction with the blade,
    - clearance between snow gun and the surface of the slope,
    - slope conditions on the route ahead;

5.5 Front snowblower

The front snowblower is mounted on the front sub-frame instead of the front blade. It is powered hydraulically by the tiller pump.
While working with a front snowblower, it is important to keep the diesel engine steadily in the green rpm range. In a vehicle steered by a steering wheel, driving speed of about 0.5 - 1 km/h (0.3 - 0.6 mph) if controlled entirely by means of the drive potentiometer.

Points to remember while working with a front snowblower::

- Before starting operations with a front snowblower, secure the working area well and mark it clearly as an out-of-bounds danger zone!
- Make sure that the danger zone is empty of persons and vehicles!
- When starting the front snowblower, do not pick up snow until the discharge turbine has reached full speed.
- To prevent clogging of the chutes, allow the front snowblower to run on until it is completely empty of snow before shutting it down.
- Do not overload the front snowblower!

When a front snowblower is in operation, the size of the danger zone increases to as much as 60 meters (200 feet), depending on the direction of the discharge chute!

Elaborated by:
Florian Profanter

6. Maintenance for the operator

The maintenance of technical equipment includes for example adjusting, lubricating, preserving, topping up, adding or changing fluids and lubricants or consumables (e.g. fuel, lubricant or water) and regular replacement of wear parts. Cleaning is also part of maintenance. Systematic maintenance of the snow groomers is essential for smooth and therefore economical operations. Maintenance has to be carried out at regular intervals and by trained, qualified personnel.

All maintenance intervals and the tasks that have to be performed on the individual components are described in the operator's manual.

6.1 Daily maintenance

The daily checks must be performed before placing the snow grooming device into use:

- visual inspection of the vehicle and the auxiliary equipment for any possible damage and wear,
- check of all fluid levels,
- check for leaks,
- inspection of all lighting and warning equipment,
- etc.

A careful look around and underneath the vehicle enables potential problems to be spotted at an early stage and rectified. To facilitate checking on the next working day, the vehicle should be cleared of snow and ice when the day's work is done, and if possible it should be parked in a heated garage.

If the cab, the load platform and/or the winch have to be tilted for checks and maintenance work to be carried out, all the measures specified in the operator's manual have to be implemented and complied with!

Crush hazard if components can drop!

- Remove all loose items before tilting the driver's cab or the load platform.
- Park the vehicle on level ground if possible.
- Engage the parking brake, switch off the tiller drive, set the direction-of-travel switch to the neutral position.
- Lower auxiliary equipment at the front and rear.
- Insert and correctly anchor all safety props provided for the purpose!.

Elaborated by:
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6.1.1 Cleaning

A clean and tidy workplace improves concentration and helps prevent fatigue!

- Remove dirt and cable grease from all windows and mirrors.
- Keep all steps and grips clean and free of oil and grease.
- Remove cable grease, dirt and traces of rust residues from the cab and the vehicle.

Foreign matter of many different kinds can accumulate on the vehicle, so many different solvents and cleaning agents are needed. It is important to make sure that the cleaning agent is suitable for the purpose and compatible with the various materials.

Use only water for cleaning the winch cable; never attempt to clean the winch cable with chemical cleaning agents!

6.1.2 Fueling

Along with diesel fuel, modern snow groomers need urea for the exhaust after-treatment system. It is essential to maintain absolute cleanliness when refilling the urea tank. Even minute quantities of water and/or other liquids can lead to problems with the exhaust after-treatment system.

Bear the following points in mind when refueling a snow groomer:

- whenever possible, fill the fuel tank as soon as work is finished for the day,
- make sure that the fuel filler neck and the pump nozzle are clean,
- clear the pump nozzle and the fuel filler neck of ice and snow, if necessary,
- store urea properly – follow the manufacturer's instructions,
- handle diesel fuel with care – risk of environmental damage;

6.1.3 Lubricating oils

A snow groomer uses lubricating oils of various kinds. Distinctions are drawn between engine oil, hydraulic oil and gear oil. Each oil has its own job to do and its own properties. So it is vitally important to make sure that the different kinds of oil are not intermixed. Even minute quantities of the wrong kind of oil can cause damage to various components.

- Always comply with the oil specifications stated by the vehicle manufacturer.
- Comply with the storage regulations and shelf-life dates stated by the oil manufacturers.
- Use only clean containers and equipment for filling the sub-assemblies and topping up oil levels.
- Dispose of used oils and waste oil in accordance with the applicable regulations.
- Clean up spillages immediately with an absorbent cloth - risk of environmental contamination!

Elaborated by:
Florian Profanter

6.1.4 Coolant

The coolant has to remove heat from the internal combustion engine and keep the operating temperature steady. So it is important to make sure the proportions of water and antifreeze in the mixture are correct. If the proportion of water in the coolant mixture is too high the water pump is not correctly lubricated. If there is too much antifreeze the coolant will not absorb enough heat and the engine might run hot.

- Do not mix antifreeze additives of different kinds.
- Use only antifreeze additives that comply with the manufacturer's specifications.

6.2 Other maintenance work

In addition to the daily maintenance work, there is additional maintenance work that must be performed at regular intervals such as lubricating the machine or repairing various components.

6.2.1 Grease

To prevent excessive wear, all moving elements on the snow groomer have grease nipples. These lubrication points have to be greased regularly in accordance with the information set out in the maintenance chart. In some cases, different lubricating greases have to be used at individual lubrication points.
The maintenance chart is in the operator's manual, along with the information about the intervals for regular lubrication.

- Use only lubricating greases that comply with the manufacturer's specifications.
- Clean the grease nipples before connecting the grease gun.
- Take care to use an appropriate quantity of grease.

6.2.2 Tightening torques

In order to do their job properly, threaded fasteners have to be tightened to a certain tightening torque. If threaded fasteners are not tightened enough the bolted joints can work loose. If the threaded fasteners are overtightened they can overstretch and break. A special torque wrench is used for tightening the threaded fasteners.

The tightening torques for the individual components are either listed in a standard table or specified in the operator's manual..

Always tighten threaded fasteners to their specified tightening torque:

- tracks (threaded fasteners for track cleats, tire guides and chain locks),
- running gear (running wheels, drive sprockets, etc.),
- threaded fasteners for auxiliary equipment (blade, tiller),
- threaded fasteners for the cable winch,
- etc..

Elaborated by:
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Always reset torque wrenches to their zero setting after use, check them constantly to ensure that they are in full working order and have them calibrated regularly!

6.2.3 Battery

Normally, a snow groomer has two 12-volt batteries. They are needed for starting the diesel engine.

Various hazards and risks are associated with these batteries:

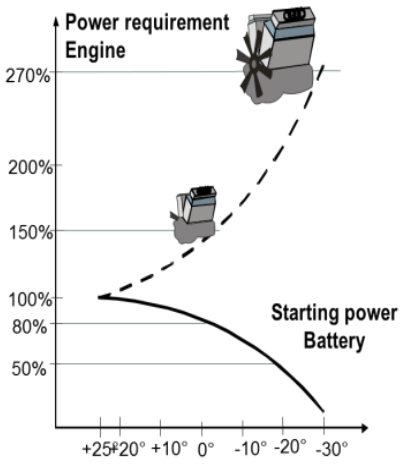
- risk of explosion due to hydrogen gas forming,
- risk of caustic burns from battery acid,
- risk of sparking if:
    - battery terminal connectors are poorly connected,
    - crocodile clips of battery chargers are applied to battery terminals,
    - tools are left on top of the batteries;

If a jump start is required, it is essential to consult the operator's manual for the vehicle!

Snow groomers generally have an external electricity connection for preheating the engine's cooling system.This preheating brings the engine's cooling system up to temperature, making the diesel engine easier to start at low ambient temperatures.

The graph shows how the power needed to start the diesel engine increases as temperature drops, while at the same time battery power decreases.

Using this preheating system reduces the load that engine starting places on the batteries and the starter motor.



6.2.4 Headlight system

The headlights installed on snow groomers can be of various types. They include halogen, xenon and also LED headlights.

Maintenance work on the headlight system can involve certain risks:

- eye injury due to harsh light,
- additional hazards associated with xenon headlights:
    - caution: High voltage - DANGER TO LIFE,
    - health risk due to gases;

Particularly in regions where the water has a high lime content, the glass lenses of the headlights have to be cleaned regularly. Do not use aggressive or abrasive cleaners, because they would damage the glass lenses.

Elaborated by:
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6.2.5 Electrics - electronics

There are many different safety fuses and relays installed in a snow groomer. The safety fuses protect the electrical system and the relays carry out various control commands.

Safety fuses:

- replace a blown fuse only with a fuse of the same amperage rating,
- never attempt to jumper or repair safety fuses and never use a higher-amperage fuse as a replacement for a blown fuse;

Relays:

- Replace a defective relay only with a relay of identical type;

If welding work needs to be performed, it is imperative to comply with the operator's manual.

There is a risk of damaging electronic components!

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