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Entry-level snow grooming
Level 1.0 – session 1

Reference:

Slope Preparation and Slope Maintenance – The Handbook for Practitioners
ISBN 3-905621-01-0

Elaborated by:
Florian Profanter

Table of contents

Elaborated by:
Florian Profanter

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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!

1.3 History of slope preparation

1922	In 1922, Canadian inventor Joseph Armand Bombardier tested a machine of his own design that was an "over-snow transport vehicle". In 1936 Bombardier patented a number of inventions that are still used for snowmobiles and in slope preparation today. They include for example the rubberized drive wheels and the rubber belts for the tracks. The Bombardier company manufactured tracked vehicles until 2005.

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1942	The term "snowcat" was coined by the Tucker Sno-Cat Company. Founded in 1942, to this day the Tucker Sno-Cat Company manufactures its vehicles in Medford, Oregon (USA).	
1955	It was in the 1950s that snow groomers were first used at ski areas. Up until then the slopes were prepared either by hand or with "snow rollers".	
1960	Front blades first appeared on the slope-preparation scene in the early 1960s. These blades were straight and could be lifted, lowered and tilted to the side, but that was all.	
1962	The Italian company PRINOTH was founded in 1962 and presented the first European prototype "P60".	
1963	The first pressed-down after-rollers were used to compact the new snow.	
1969	Karl Kässbohrer presented the first prototype PistenBully 145. The PB145 was an innovation in slope preparation; the diesel engine and the hydrostatic drive were groundbreaking advancements.	
1973	The first hydraulically powered rear tiller for breaking up snow chunks was introduced.	

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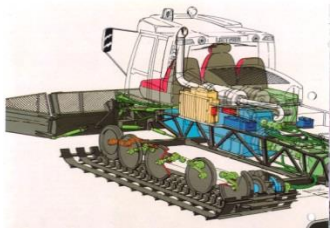
1984	Kässbohrer PistenBully presented the first cable winch for preparing very steep slopes. The carrier vehicle was a PB 200 D.	
1985	The mid-1980s saw the first tests of the Flex tiller, an advancement which was destined to bring about tremendous improvements in slope preparation.	
1989	Another milestone in slope preparation was presented by Kässbohrer PistenBully: The first steerable rear implement carrier on a PB 240 D.	
1991	Italian specialist company Leitner introduced hydraulically adjustable running gear as standard on an LH 500.	
2013	PistenBully presented the PB 600 E+ as the world's first diesel-electric snow groomer in series production.	
To date	All vehicles experience successive power improvements and adaptations of the exhaust emissions values in line with latest standards required by law.	

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2. Technical data

2.1 Definition of technical terms

2.1.1 Slope preparation

The term "slope preparation" refers to the mechanical processing of snow with a tracked vehicle. This is the method used to build, create and maintain skiing surfaces (ski slopes, snow parks, cross-country skiing trails, etc.) for leisure-time and professional skiers. The resulting, typical corduroy patterning in slope preparation is referred to as the "slope finish" and is considered an excellent surface for skiing.

2.1.2 Snow groomer operator

The snow-groomer operator is the person who operates the machine for the mechanical processing of snow. The snow-groomer operator is the key factor in slope preparation.

He should or must:

- Be aware of what a well-prepared ski slope looks like and feels like,
- Have a certain talent for operating vehicles of this kind,
- Be fully aware of the responsibility involved in taking control of a snow groomer, a machine that can cost up to $600,000;

Good hand-eye coordination is essential for operating the snow groomer and in particular the blade. The operator needs a feel for the terrain, the snow and the vehicle in order to operate the blade, tiller and machine skillfully.

The snow-groomer operator:

- Returns slopes used by skiers and snowboarders to pristine condition,
- Compacts freshly fallen new snow,
- Bulldozes man-made technical snow;

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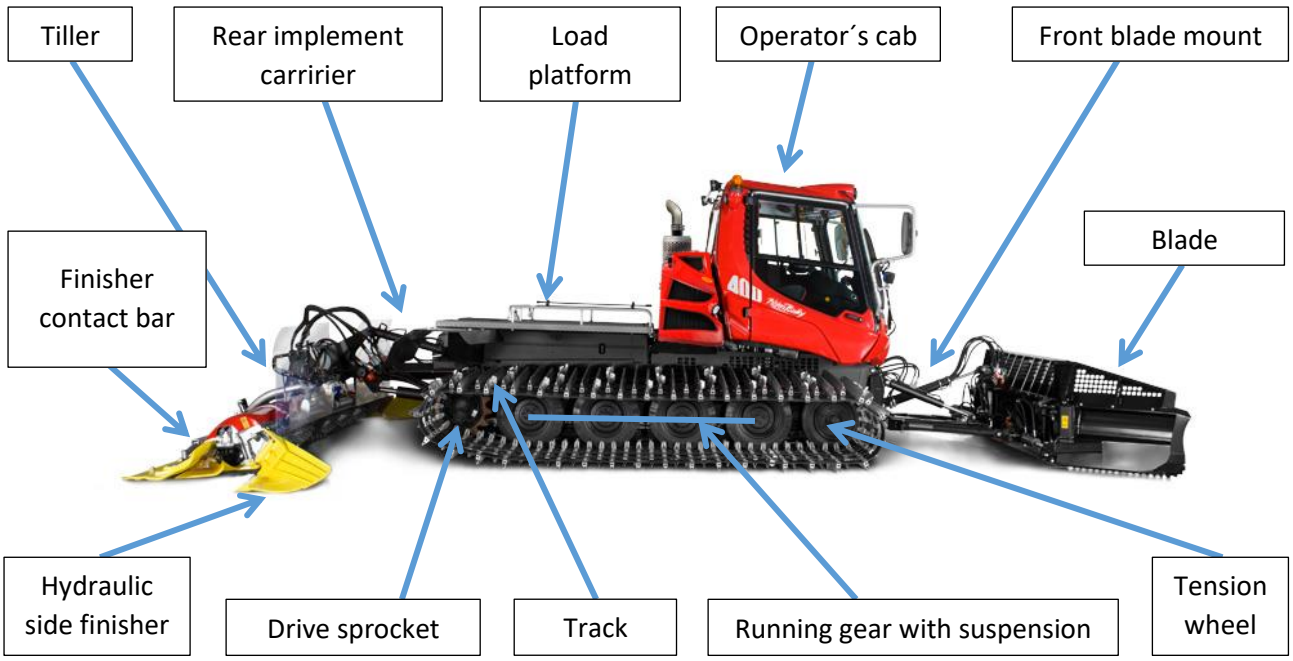
2.1.3 The terminology of slope care



Blade:
The operator constantly adapts the blade to the slope surface, in order to move snow and smooth out mounds. This creates an even surface for the vehicle to move on and a slope surface that skiers will enjoy skiing on.

Tracks:
The key to productive slope maintenance is keeping the tracks from slipping or spinning. Spinning tracks can lead to losses in productivity and also to signs of poor slope quality.

Tiller:
The settings of the tiller shaft influence the quality of the surface to be produced. Precision adjustment of the tiller is very important. This is decisive as regards the quantity of snow that the tiller processes.

Finisher contact bar:
The finisher creates the typical ribbed "corduroy" pattern, the "slope finish". The corduroy slope finish is the last thing left by the snow groomer and the first impression made on skiers/snowboarders the next morning when they arrive to enjoy their day.

Snow-groomer operator:
The snow-groomer operator steers the vehicle and controls the attachments. Responsibility for the quality of the finished slope surface resides with the snow-groomer operator.

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2.1.4 Theory of slope preparation

Slope preparation is a four-step operation. The 4 steps describe the mechanical preparation of the snow to create an optimum slope surface. This theory holds true for all types of snow.

Step 1: The blade

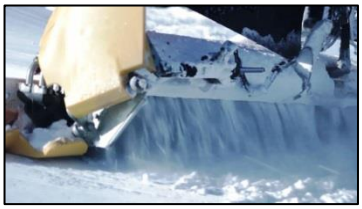
- The blade levels the surface of the snow and processes the snow cover.
- To level the slope surface, it is necessary to cut the tops off the mounds and shift this snow into the neighboring hollows.
- This operation is known as "cutting and filling".

Step 2: The track

- The tracks in combination with the weight of the snow groomer produce compaction.
- They also break down large chunks of snow produced by the processing of the snow with the blade in step 1.
- Assisted by the track cleats, the tracks mix the processed snow into a homogeneous material.

Step 3: The tiller

- With the aid of the tiller teeth, the tiller mixes and pulverizes the snow processed in steps 1 and 2.
- The tilling process is crucial for changing the processed snow into a high-quality and great-looking ski slope.



Step 4: The finisher with contact bar

- With the aid of the contact bar, the finisher compacts the processed snow and seals the surface.
- The goal is to produce a high-quality, great-looking slope.

For working in the vicinity of buildings, lift supports, trees, other snow groomers and other obstacles, the operator must know the overall dimensions of the vehicle and be constantly aware of them. As they gain experience, snow-groomer operators also become skilled at working safely in close proximity to objects.

The ability to move on snow is based on the specific ground pressure of the vehicle. Ground pressure is expressed in kg/cm². Specific ground pressure means the pressure applied by the vehicle to the ground underneath it.
A snow groomer's specific ground pressure is 0.045 - 0.068 kg/cm². The ground pressure applied by a person can be as high as 0.15 - 0.19 kg/cm². Increasing the area of contact with the ground in relation to the weight reduces specific ground pressure. A specific ground pressure of 0.14 kg/cm² or less is recommended for efficient movement on snow. The reduction in ground pressure increases the vehicle's freedom of movement and permits more efficient use of the vehicle on snow.

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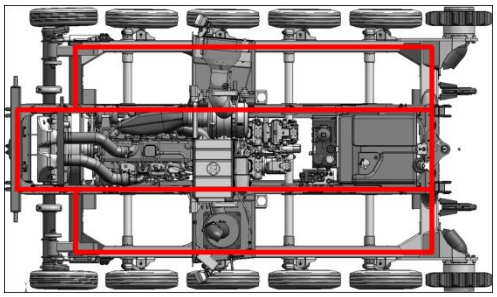
2.2 Vehicle frame and drive system

2.2.1 Vehicle frame



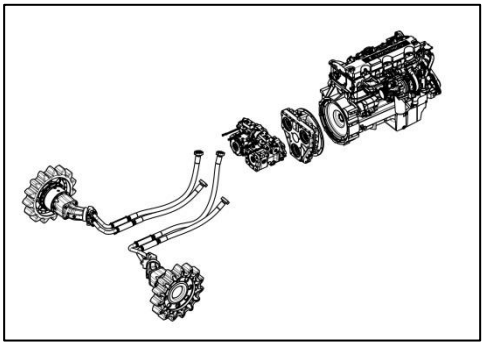
The vehicle frame is the backbone of any snow groomer. The vehicle frame has to be robust and well balanced in all four directions.

The vehicle's running gear has a number of spring elements and can be of independent-suspension or tandem-suspension type. On a vehicle with independent suspension, each running wheel has a spindle axle, which is secured to a swing arm. The swing arm, in turn, is secured to the spring element. The up-and-down movement of the wheel causes the suspension to react, keeping each wheel in the optimum position relative to the ground directly underneath.

The vehicle has several running wheels on each side. The running wheels can be of solid-rubber or pneumatic-tire design. The operator has to know which type of wheels the vehicle has. Pneumatic tires can go flat, solid tires cannot.

The two tension wheels are of the solid-rubber type and they tension the tracks. The tension wheels are mounted on the tensioning axle (front axle). The tracks are tensioned either hydraulically or mechanically. The spring element in each tensioning axle has the job of dampening direct impacts on the tension wheel and vibrations transmitted from the track cleats as they bite into the snow.

2.2.2 Drive system



A diesel engine is the power-plant of the snow groomer, driving the splitter box bolted to the engine. The splitter box splits the motive power from the engine to a number of power take-offs and drives the hydraulic pumps for the propulsion and tiller drives. These hydraulic pumps are bolted onto the splitter box. The snow groomer has three big hydraulic pumps. Two of these pumps (drive pumps) provide motive power, one to the left and one to the right drive motor. One pump (the tiller pump) provides the motive power for the tiller shafts.

A hydrostatic drive is a propulsion system in which a liquid is pressurized in order to drive machinery and perform work. The term "hydrostatic" refers to the conversion of energy from flow and pressure. The biggest advantages of a hydrostatic drive system are continuous acceleration and wear-free deceleration of the vehicle.
A drawback of hydrostatic drive is that on account of an internal loss in the hydraulic circuit (leak-off oil), the vehicle does not come to a complete standstill on gradients. The parking brake is needed for this.

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The hydraulic, ventilated parking brake is standard equipment on every snow groomer.
The parking brake:

- Is operated by the operator
- Should never be used to slow the vehicle
- Keeps the vehicle at a standstill when it is parked
- Engages automatically when the diesel engine shuts down
- Is mounted on each of the final drive assemblies

ATTENTION:
The parking brake may only be applied during idling!

2.2.3 Propulsion drive electronics – vehicle control

The on-board computer controls and administrates all commands relating to operation of the snow groomer..

When the operator turns the steering wheel or moves the steering levers or the joystick, the command initiated is forwarded directly to the on-board computer.

Steering wheel or steering levers control the tracks:

- Acceleration and deceleration of the vehicle
- Steering to the left and right
- Controlling - forward and reverse

The joystick is for controlling the functions of the auxiliary equipment (blade and tiller), and also for controlling additional functions, if any.

By activating different buttons or potentiometers, the driver is able to send electrical impulses from the driver seat to the different hydraulic components (valves, pumps, etc.) of the electromagnets. The valves are so positioned by the respective electromagnets to allow or prevent the oil flow to the hydraulic components.

The hydraulic oil is pressurized (30 – 500 bar) by different pumps. By the electrical signals which are controlling the different valves, the oil is transported via the hydraulic hoses to the required place (hydraulic cylinder, drive engines, etc.) where it carries out his work and moves the relevant component

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2.2.4 Tracks

The caterpillar tracks consist of individual track cleats, which are held together by several fiber-reinforced rubber belts (track belts). A track lacing joins the ends of these belts so that they form an endless loop.

Without its tracks, the snow groomer can be neither propelled by its engine, nor braked if it is in motion!

The track cleats can be made of steel, aluminum or rubber. The track cleats are at right angles to the track belts. Each track cleat has a guide bow (tire guide) set at about the midway point of the cleat. These tire guides are designed to keep the tracks on the vehicle and give the vehicle stability. The tension wheel, all running wheels and the drive sprocket run inside this set of track guides.

The teeth of the drive sprocket grip between the tire guides. The rotary action of the drive sprockets propels the vehicle. The grip of the tracks is further improved by the installation of special elements. This also increases the vehicle's stability. Mounted in a defined configuration on the track cleats, these elements significantly help increase the grip of the tracks in a wide range of operating conditions.

The tracks are designed for operation on snow and ice!
If the vehicle has to be moved on a very thin blanket of snow or on ground that is completely clear of snow, it is imperative for the operator to be very careful. Broken track cleats and/or track belts can be the result if the operator fails to exercise sufficient care when driving.

The tracks are tensioned by their tension wheels. A slack track can skip teeth on the drive sprocket. This situation is clearly audible and perceptible and is known as "track skip". It is the snow-groomer operator's responsibility to check the tracks at the start and end of every shift to make sure that they are correctly tensioned, undamaged and not worn.

An all-season track or summer track has track cleats that consist of a steel core with a vulcanized rubber cladding. The cleat's contact surface has a herringbone structure for traction on asphalt, dirt, mud and snow. All-season tracks are used for various summertime operations, but also in ski areas in the fall and winter (if there is not much snow).

All-season tracks do NOT have the same performance characteristics (grip) as winter tracks. The track is narrower, resulting in a change in the vehicle's susceptibility to tilt. Extra caution is necessary for uphill, downhill and crosshill passes on wet and snow-covered surfaces!

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3. Safety instructions

3.1 Requirements and tasks of a snow-groomer operators

Only persons who have received the appropriate training and are tasked to do so are permitted to operate snow groomers. The operator must be at least 18 years of age. The operator must be physically able and mentally attentive in order to operate the vehicle. The operator should be familiar with the snow conditions and safe practices for operation of the equipment. The operator must know the topography of the area in which the vehicle is to be operated, and must be aware of the dangerous and risky areas.

The ideal snow-groomer operator is:

- Aware of the responsibility involved in operating the vehicle entrusted to them and in undertaking the associated tasks.
- Prepared to engage in communication with supervisors and mechanics regarding unusual occurrences during the shift and irregularities in the condition of the vehicle.
- Willing to learn, so as to recognize good and poor slope quality.
- Flexible, so as to learn from their own mistakes and from the mistakes of others.
- Thoroughly familiar with procedures for working in mountainous terrain.
- Prepared to work at night and to be alone in the cockpit for most of the time.

The snow-groomer operator operates the snow groomer and is responsible for the preparation and upkeep of the slope areas.

The area of responsibility also includes the following:

- Ensuring own safety and the safety of persons in the danger zone and in the vicinity of the vehicle.
- Safe execution of all work-related tasks and the daily checks of the vehicle.
- Keeping the vehicle clean, inside and outside.
- Exercising responsibility in relation to the equipment and the environment.
- Minimizing downtime by practicing professionalism in all vehicle operations.

Before operating a snow groomer, the snow-groomer operator must acquire a thorough familiarity with the vehicle. Getting to know the vehicle is the first step toward becoming a professional snow-groomer operator.

The vehicle is only as good as the operator behind the controls.

The professional operator uses the operator's manual as a source of information and interacts with trainers and experienced operators in order to benefit from their experience.
The snow-groomer operator bears full responsibility for the vehicle. A check of the vehicle before and after the shift is obligatory.

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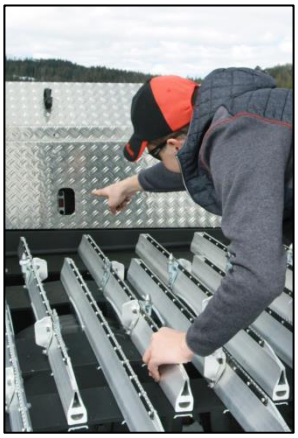
3.2 Daily checks before start-up

A regular maintenance ensures the reliability of the snow grooming vehicles. The objective of a regular maintenance should be to prevent breakdowns and failures during the season while extending the service life and thus lowering the operating costs.

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,
- The operability of the protection devices,
- The levels of all fluids and the fuel level,
- For leaks,
- Visual inspection of the tracks and running gear,
- The tires and their pressure,
- The security of the auxiliary equipment and the cable winch,
- The lighting system and warning systems,
- The proper function of the telecommunication equipment,
- The cleanliness of the windows and the rear-view mirrors,
- The presence of ice and snow on the vehicle and on the auxiliaries;



Communication between operators is obligatory whenever a change of vehicle or shift takes place. It is essential to tell the relief operator whether the vehicle was in full working order or whether problems were encountered. If uncertainties arise regarding the maintenance and care of the vehicle, the service technician is the correct person to contact.
To facilitate the inspection on the next morning, the machine should be cleared of snow and ice after the working shift and stored in a heated garage, if possible.

3.3 Drugs and alcohol

The use of drugs or alcohol by a snow-groomer operator during work is prohibited. It is wholly unacceptable for an operator to report for work under the influence of drugs or alcohol.

An altered condition induced by drugs or alcohol would have grave effects on the operator's own safety and on the safety of others and would therefore be a serious danger for everyone. Drugs and alcohol influence also a person's concentration, physical coordination, vigilance and judgment. These symptoms constitute significant safety problems, particularly in the context of the use and operation of machines and safety systems.

By law, it is prohibited to operate machinery when under the influence of drugs or alcohol!

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3.4 Danger zones of snow groomers

The danger zone for a snow groomer is the 360 degree circle around the vehicle.

The areas where vision is restricted (blind spots) are particularly important in this respect. The operator has to keep the snow groomer's entire danger zone under observation at all times

The snow-groomer operator must in particular:

- watch out for persons and vehicles in the danger zone,
- make sure that eye contact with everyone in the vicinity of the snow groomer has been established before the vehicle is set in motion,
- watch out for maintenance personnel and/or ski-area workers who could be in the vicinity of the danger zone,
- slow down whenever there are persons close to or inside the danger zone,
- make sure that the tiller shaft is always switched off while passing people;

Normally, it is prohibited to move a snow groomer on ski slopes open to the public. In an emergency situation, before moving onto the slope that is open to the public it is essential to obtain clearance in advance from the supervisor and request an escort to warn the slope users of the danger.

The beacon lights have to remain switched on at all times from when the diesel engine is started until it is shut down. When the vehicle is on slopes open to the public, the lighting and the acoustic warning systems have to be switched on as well.

Eye contact with persons in the vicinity is essential, so that intentions can be mutually recognized. If eye contact cannot be established the vehicle has to be brought to a standstill and the horn sounded to warn people of its presence.

A person approaching a snow groomer must always establish eye contact with the vehicle operator. Under no circumstances is it permissible for anyone to touch the vehicle before eye contact has been established and the parking brake has definitely been applied.

For snow groomers that are equipped with cable winch and are currently performing work in winch operation, the hazardous area(s) also include the space between the vehicle and the anchor point. Since horizontal and vertical cable deflections can occur at any time during winch operation, these areas that are affected by the cable deflection must also be observed.

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3.5 Entering the cab

Entry is from the front by stepping up on the caterpillar track, which is used as a ladder – caution, danger of slipping!

Once the driver's door has been opened, the "3-point contact" procedure for preparing to enter the cab has to be used:

- Firm grip with one hand on the grab handle on the inside door handle
- Firm grip with the other hand on the grab handle on the A-pillar of the cab or the steering wheel
- One foot firmly planted on the track cleat as a ladder

After sitting down on the driver's seat, buckle the seat belt!

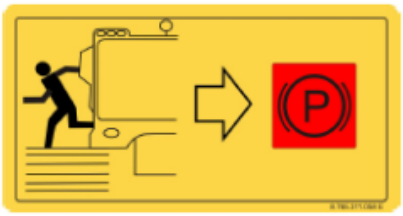
3.6 Leaving the cockpit

The vehicle should be parked in a designated area or well clear of the skiing area open to the public. Never park or stop the vehicle where visibility is poor or where the vehicle could cause obstruction!

It is important to proceed as follows:

- Reduce engine speed to idle speed.
- Do not shut down the engine immediately after full-load operation; allow the engine to continue idling for approximately 2 minutes; otherwise there is a risk of damaging the turbo charger!
- Do not operate the engine inside enclosed spaces – Risk of inhalation of toxic gases!

Before leaving the cockpit:



- Lower front and rear attachments
- Switch off the tiller
- Set the direction-of-travel switch to "Neutral" or move the steering levers to the neutral position
- Apply the parking brake
- Shut down the engine
- Remove the ignition key
- Lock the cab

When the shift is over the logbook has to be filled in and anomalies, if any, reported to the maintenance personnel. The procedure for leaving the cab is the same 3-point contact routine as for entering, and the same caution has to be exercised. Snow and ice on the auxiliaries, the load platform and the running gear should be removed at the end of the shift.

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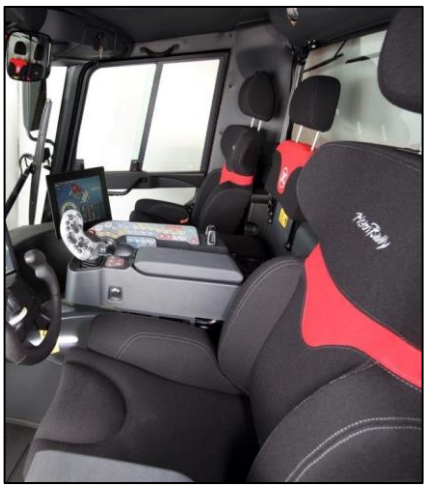
3.7 Transporting persons

As a general rule it is not permitted to transport persons not involved in operations on snow groomers!

- The snow-groomer operator bears full responsibility for persons and/or goods transported in or on the vehicle.
- The load platform is designed ONLY for transporting goods.
- If the seating arrangements are appropriate, no more than 2 passengers are allowed inside the cab.
- The operator must assist the passengers to enter and exit the vehicle.
- The passengers must buckle their seat belts and secure all loose objects.
- Each passenger has to be told when they can exit the vehicle.



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4. Operation of a snow grooming vehicle

The vehicle is slowed either by reducing engine speed (operation with throttle pedal) or by moving the steering levers toward the neutral position (operation with fixed engine speed).
The vehicle comes to a stop when engine speed drops below pull away speed. Because it is a hydraulic system, on a gradient the vehicle will roll slowly downhill. In order to hold the vehicle at a complete standstill, the operator now has to apply the parking brake.

4.1 Steering options

4.1.1 Semi-circular steering wheel

Driving a snow groomer fitted with a semi-circular steering wheel is similar to driving an ordinary car. Turning the steering wheel to the left causes the vehicle to move to the left. Turning the steering wheel to the right causes the vehicle to move to the right.

The direction-of-travel switch is used to engage either forward or reverse gear.

Once the parking brake has been released, the throttle pedal is depressed gently to ease the throttle open, so that the vehicle slowly pulls away.

The hydrostatic drive reacts aggressively, so steering movements have to be correspondingly sensitive.

4.1.2 Steering levers (sticks)

The steering levers are operated with the left hand.

There are 2 different techniques for controlling a snow groomer with steering levers:

4.1.2.1 Control with fixed engine speed (set by the engine potentiometer)

In this variant, driving speed is usually determined by the position of the steering levers:

- Steering levers must be in the neutral position (centered).
- Use the engine potentiometer to set the desired engine speed.
- Release the brake and slowly ease the steering levers forward.

Driving forward:
Slowly push both steering levers forward. The further forward the steering levers are pushed, the faster the vehicle moves. Moving the steering levers back toward the center position slows the vehicle.

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Reversing:
Slowly pull both steering levers to the rear. The further back the steering levers are pulled, the faster the vehicle moves. Moving the steering levers back toward the center position decelerates the vehicle.

Turning left:
Both steering levers are moved at the same time; the left lever is eased slightly back and the right lever is eased slightly forward.

Turning right:
Both steering levers are moved at the same time; the right lever is eased slightly back and the left lever is eased slightly forward.

4.1.2.2 Control with variable engine speed (set by the throttle pedal)

In this variant, driving speed is usually determined by the position of the throttle pedal:

- Steering levers must be in the neutral position (centered), engine rpm is set on idle.
- Release the brake and ease the steering levers fully forward.
- By pressing the throttle pedal, carefully increase engine speed.

Driving forward:
Move both steering levers all the way forward. Now use the throttle pedal to control engine speed. The higher the engine speed the faster the vehicle moves; the lower the engine speed the more the vehicle decelerates.

Reversing:
Move both steering levers all the way back. Use the throttle pedal to control engine speed. The higher the engine speed the faster the vehicle moves; the lower the engine speed the more the vehicle decelerates.

Turning left:
Move the left steering lever slightly from the front limit stop position back toward the center position and when the steering maneuver is finished, return it to the front limit stop position

Turning right:
Move the right steering lever slightly from the front limit stop position back toward the center position and when the steering maneuver is finished, return it to the front limit stop position.

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4.2 All-way blade

The blade can execute twelve different movements. With these movements snow can be shifted in various directions, so as to pre-process the contact surface for the caterpillar tracks and the tiller.

The center part is the main component of the blade and must give it the necessary stability. The center part is connected directly to the quick-change system of the vehicle's front sub-frame.

The right and the left blade wing is operated hydraulically. Its opening and closing action offers various ways to control the movement of the snow.

The purpose of the toothed rail is to slice the snow off the slope surface.

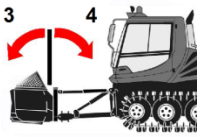
4.2.1 Blade functions

Lift - lower

The snow-groomer operator lowers the blade until the toothed rail touches the surface of the snow. The position and the setting of the blade depend on the specifics of the terrain and the work to be done.

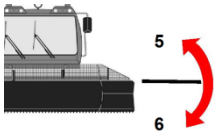
Roll forward – backward

As soon as the toothed rail is in contact with the surface of the snow, the roll function is used to control the aggressiveness of the blade's bite into the snow. Rolling forward makes the blade more aggressive, rolling backward reduces the aggressiveness of the blade's bite. The roll function is usually referred to as the "cutting angle".



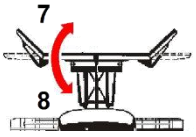
Tilt right – left

The change of inclination enables the blade to be adapted to the cross-section of the slope, keeping the blade in constant contact with the surface of the snow. Constant contact of the blade over its entire width ensures a better contact surface for the caterpillar tracks and the tiller, and helps produce a smooth slope without cavities, hollows and holes.



Swivel right – left

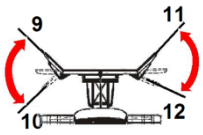
The blade can be swiveled to the left or right of its center position. By swiveling the blade in this way the operator is able to shift the snow from one side of the vehicle to the other while on the move. The two side wings are used together with the swivel function to make the snow slip more easily across the surface of the blade and prepare the contact surface for the caterpillar tracks and the tiller.



Elaborated by:
Florian Profanter

Blade wings: open – close

The blade wings are foldable extensions of the center part. With the wings closed, the blade is referred to as a "U-blade". From this starting position, the operator can "open" the wings by movement in the negative direction to a certain point past the line of the center part. This function in combination with swing enables the operator to shift or distribute large quantities of snow to both sides of the vehicle's line of progress as it works its way along the lane.



4.2.2 Front implement carrier

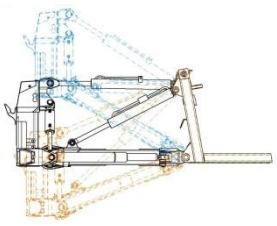
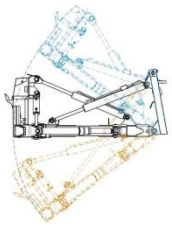
The front implement carrier is located between the blade and the main frame. The hydraulic cylinders, hoses and some of the valve blocks for controlling the blade functions are mounted on the front implement carrier. The quick-change system connects the blade to the front implement carrier.

Hydraulic components mounted on the front implement carrier are:

2 lifting cylinders:	lift and lower
1 roll cylinder:	roll forward - backward
2 tilt cylinders:	tilt left - right
2 swivel cylinders:	swivel left – right

The roll cylinder controls the blade's cutting angle. This is one of the most important functions for operation of the blade and the operator has to adjust it constantly as the vehicle moves along its lane. It determines how deeply the blade bites into the snow cover and how much snow is moved.

There are two types of front implement-carrier geometry:

Parallel guided blade:	**Radially guided blade:**
The roll cylinder is mounted on the vehicle frame. When the blade is lifted and lowered, the cutting angle remains unchanged. 	The roll cylinder is mounted on the push frame in the front implement carrier. When the blade is lifted and lowered, the cutting angle changes as well. 

Even small changes in cutting angle have a significant effect on the blade's aggressiveness!

Good hand-eye coordination is essential for operating the blade.
The snow-groomer operator needs a very good feel for the vehicle and the equipment in order to operate the blade with maximum effectiveness. Changes in terrain, which affect the machine's various angles of inclination, are transmitted via the driver's seat to the operator. The driver has to feel even the tiniest change in order to react accordingly with the blade. The combination of good hand-eye coordination and the feel for the vehicle is what makes an outstanding snow-groomer operator.

Elaborated by:
Florian Profanter

4.3 Tiller

The tiller of the snow groomer is generally known as the tool for creating a prepared surface for winter sports. The design of the rear implement carrier in combination with the Flex tiller enables the operator to change sharp slope contours into smooth transitions.

The **tiller frame** is the main structure and therefore the load-bearing part of the tiller.

Each **tiller box**, one on the left and one on the right, houses a tiller shaft. The snow processed and pulverized by the tiller shaft then passes out of the tiller boxes toward the rear and the finishers.

The **snow guard** prevents chunks of snow thrown up by the caterpillar tracks from being tossed over the tiller and onto the prepared slope behind the vehicle.

The **contact bar** consists of individual elements that are interconnected much like those of a windshield wiper system. The contact bar lies on the finisher and by exerting pressure it compacts the snow processed by the tiller shaft..

The prepared snow of the slope is given its typical corduroy-pattern finish by the grooves cast into the underside of the **finisher**. This final step in the preparation process seals the surface.

The **side finishers** are responsible for a smooth and gentle transition between the individual lanes in which the slope is prepared.

The **hydraulic side finishers** are mounted at the outside ends of the tiller and are operated hydraulically by the vehicle operator.

The tiller is driven by either one or two hydraulic motors, which are usually mounted at the two outside ends. The operating speed of the tiller shaft can be varied continuously between 0 and 1500 rpm.
Both tiller shafts have numerous **tiller teeth**. The tiller teeth are responsible for processing the snow and for pulverizing chunks of snow and ice. It is vital to prevent the tiller teeth from making contact with boulders, stones or dirt. Otherwise the result could be accelerated wear and/or damage to the tiller shafts and the hydraulic motors. The snow-groomer operator has a decisive influence on the durability of the tiller teeth and the tiller shaft.

4.3.1 Tiller settings

The snow-groomer operator needs a good understanding of the various possibilities for adjustment of the tiller in order to make full and correct use of them.

Activation of the tiller:
In order for it to work, the tiller has to be lowered onto the snow surface and activated

Elaborated by:
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Horizontal floating position/deadweight:
Only the tiller's own weight is applied to the surface of the snow.

Contact pressure:
Using the contact pressure function, the operator can hydraulically increase the weight of the tiller and consequently the down-pressure acting on the snow.

Counter pressure:
Using the counter pressure function, the operator can hydraulically reduce the weight of the tiller and consequently the down-pressure acting on the snow to below the deadweight of the tiller.

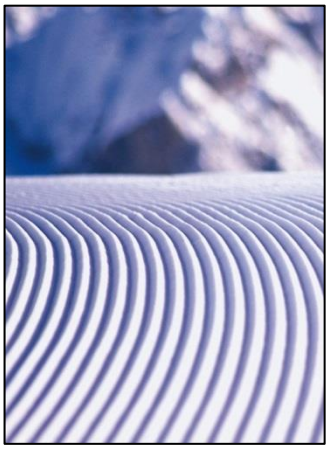
Tiller depth:
The tiller depth function enables the operator to set the depth to which the tiller teeth bite into the slope surface.

Tiller rpm:
Tiller speed can be increased or decreased by means of a potentiometer.

The operator is responsible for constantly adjusting the tiller to suit the current snow and slope conditions, firstly in order to ensure an optimum slope surface and secondly to keep the vehicle operating at the highest possible level of efficiency. Depending on the vehicle, the tiller can draw as much as 180 horsepower from the engine.

With the rear sub-frame, the possibilities for active and passive swiveling of the tiller are as follows:

Rigid position:
The rear implement carrier can be locked either centered or in any position within the swivel radius.



Horizontal floating position:
With the horizontal floating position activated, the rear implement carrier moves freely within the swivel radius and the tiller tracks behind the vehicle like a trailer.

Horizontal swing:
The tiller can be swung hydraulically to the left or right by the operator. This function is used primarily for steering assistance, but also for stabilizing the vehicle.

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4.3.2 Rear implement carrier

The rear implement carrier is secured to the back end of the vehicle frame and is the connection to the tiller.

The main components of the rear implement carrier are:

Main frame:
The main frame is connected to the vehicle frame at 3 points. All the cylinders for lifting, lowering and swinging the tiller are mounted on the main frame, and generally the cylinder for adjusting cutting depth is as well.

Quick hitch:
Mounted on the main frame, it is the connector piece to the tiller.

Functions of the rear implement carrier:

- Lifting / lowering the tiller,
- Swinging the tiller,
- Applying the downward contact pressure or the upward counter pressure,
- Adjusting the cutting angle (virtually all machines),
- Free tracking of the tiller (with sideways floating position activated);

4.4 Cable winch

The cable winch is an auxiliary designed to be mounted on the snow groomer behind the cab. The weight can be as high as 2500 kg (5510 lbs). The cable winch assists the vehicle to climb on uphill passes and secures it on downhill passes. Tractive force can be up to 4.6 metric tons (5.1 tons) and the cable can be up to 1450 meters (1586 yards) in length.

The winch body houses the winch drum with the winch cable, a reduction gear assembly with hydraulic motors and the cable reeling system. When switched off, the winch can be slewed through 360 ° by the operator. When in work mode, the winch slews freely on the slewing ring, so it is always facing in the direction of the winch cable.

There is a safety hook at the free end of the winch cable. The safety hook has to be attached to a secure attachment point (winch anchor point) at the top end of the gradient. The cantilever arm carries the winch cable from the cable drum over the top of the cab and always stays in line with the unreeled winch cable.

Elaborated by:
Florian Profanter

Only experienced operators should operate vehicles equipped with cable winches, on account of the added complexity!

- The weight and position of the winch shift the snow groomer's center of gravity up and to the rear.
- The operator has to take into account the extra weight of the winch on the vehicle, the changed center of gravity, and also the changed dimensions of the vehicle (overall vehicle height).
- Seated in the cockpit, the driver can adjust the tractive force of the winch continuously from 0 – 100 %.
- Tractive force is set and constantly adjusted to suit the work being done and the local conditions prevailing at any given time.
- The snow-groomer operator has to know exactly where the winch cable is running (enlarged danger zone) and be aware of the associated hazards!

Elaborated by:
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5. Environment

5.1 Environmental awareness in work practices

The snow-groomer operator has a very big influence on the vehicle's environmental impact.

The most important points are:

- Minimization of fuel consumption by working economically,
- Minimization of the diesel engine's idling times by controlling non-productive time,
- Reduction of the carbon footprint by professionalism at work

5.1.1 Reducing fuel consumption

Indicators for reduction in fuel consumption::

Operation of the diesel engine in the green zone of the rpm range	Over-high engine speeds increase fuel consumption and reduce torque.
Efficient use of the blade	Always use the blade in the way that gets the best torque and the best traction from the vehicle.
Control of tiller speed	Constantly adapt tiller speed to the prevailing snow conditions.
Adaptation of tiller depth	Constantly adapt tiller depth to the prevailing slope and snow conditions.
Correct contact pressure	Excessively high contact pressure increases the load on the vehicle and leads to higher fuel consumption.

5.1.2 Reducing idling time

Reducing the engine's idling time reduces emissions, saves fuel and extends the service life of the engine and the vehicle. All too frequently, the vehicle's engine is allowed to idle unnecessarily.

The vehicle's engine can and should be shut down after the recommended idle time of 2 - 5 minutes!

In an 8-hour shift, total idling time should not be more than 6 - 8 % (approximately 25 minutes) for standard vehicles or 10 - 12 % (approximately 40 minutes) for vehicles equipped with winches.

Elaborated by:
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Reducing idling time is the easiest way of reducing the environmental impact of slope preparation and lowering total operating costs.
It is the responsibility of every operator to be environmentally aware and to work and act accordingly.

The sustainability of slope preparation depends on the operators!

5.2 Environmental protection

Any machine is susceptible to malfunctions and consequently leakage and loss of fluids. Their color makes them very noticeable in the white snow.

The fluids that might leak from a snow groomer are:

Fluid	Color
Hydraulic oil	red, green, light brown, transparent
Transmission oil	brown
Engine oil	black, brown
Diesel fuel	various colors
Coolant	blue, green, red
Windscreen wash fluid	various colors

It is the operator's responsibility to be aware of the environment and, if there is any leakage or spillage, to initiate immediate and appropriate counter-measures.

A snow groomer's hydraulic system contains approximately 70 liters (17 gallons) of hydraulic oil and operates at high pressure.

Medium-pressure system (movements of blade and tiller)		**High-pressure system** (Drive for the tracks, tiller and cable winch)	
Pressure in the hydraulic hoses	**up to 250 bar (3,600 psi)**	Pressure in the hydraulic hoses	**up to 510 bar (7,400 psi)**
Oil flow rate	**up to app. 84 l/min (22 gal/min)**	Oil flow rate	**up to app. 280 l/min (75 gal/min)**

If a high pressure hose bursts, a large quantity of hydraulic oil is pumped out of the snow groomer in a matter of seconds.

If a fault of this kind occurs, the vehicle has to be shut down instantly, because in the time it takes to notice and react to the acoustic/visual alarm the hydraulic oil tank could already have emptied.

Elaborated by:
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Indicators for a leak in the hydraulic system are:

- traces of hydraulic oil on the snow surface,
- typical odor of hydraulic oil is perceptible,
- visual/acoustic alarms show/sound;

What to do if there is a leak in the hydraulic system?

- Immediately shut down the vehicle and locate the leak!
- Leak in the **medium-pressure system**:
  Under supervisor instruction it is permissible to move the vehicle, but without the function affected by the leak being used.
- Leak in the **high-pressure system**:
  It is NOT permissible to attempt to move the vehicle, the problem has to be identified and rectified on the spot. On account of the lack of lubrication, any attempt to keep the vehicle running can result in total failure of the hydraulic system!

Escaped hydraulic oil has to be collected and disposed of as hazardous waste in accordance with the applicable regulations – Risk of soil and groundwater contamination!

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