

Guidelines for Winter Road Maintenance

Edition 2025 | Translation 2026

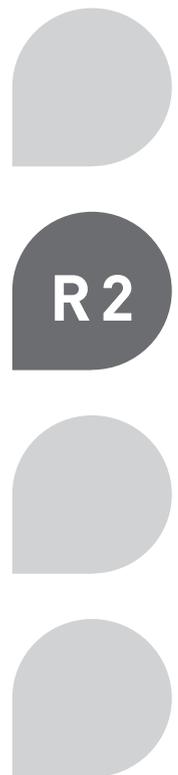


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Working Group: Traffic Management Committee: Winter Road Maintenance

Chairman:

Dr.-Ing. Horst Hanke, Saarbrücken

Members of committee:

Dipl.-Ing. Horst Badelt, Bergisch Gladbach
Dipl.-Ing. (FH) Siegfried Beck, Nuremberg
Dipl.-Ing. Sebastian Brand, Berlin
Dipl.-Ing. Drazan Bunoza, Mendig
Prof. Dr.-Ing. Thorsten Cypra, Saarbrücken
Dr.-Ing. Heinz Dirnhofer, Munich
Dipl.-Ing. (FH) Mike Fensterseifer, Koblenz
Dipl.-Ing. Monika Ferreira Penas, Gelsenkirchen
Dr. rer. nat. Franz Götzfried, Bad Wimpfen
Mandy Hesse, Hanover
Dipl.-Ing. Stefan Höfler, Sankt Pölten
Yvonne Krause, Berlin
Dipl.-Ing. Frank Laufenberg, Bonn
Dipl.-Kfm. Stefan Ludewig, Cologne
Dipl.-Ing. Angela Neubauer-Sturm, Munich
Marco Paulus, Beeskow
Dr.-Ing. Rupert Pfeiffer, Wiesbaden
Dipl.-Ing. Karen Scharnigg, Bergisch Gladbach
Roland Sommer, Marktredwitz
Dipl.-Ing. Karsten Süße, Dresden
Tobias Wehinger, MBA, Bräunlingen
Markus Weikinat, Dipl.-Ing., Stuttgart
Dr.-Ing. Matthias Zimmermann, Karlsruhe

Members of the task group:

Dr.-Ing. Horst Hanke, Saarbrücken (Head)
Dipl.-Ing. (FH) Siegfried Beck, Bayreuth
Prof. Dr.-Ing. Thorsten Cypra, Saarbrücken
MR Dr.-Ing. Heinz Dirnhofer, Munich
Dr. rer. nat. Franz Götzfried, Bad Wimpfen
Dipl.-Ing. Angela Neubauer-Sturm, Munich
Dipl.-Ing. Karen Scharnigg, Bergisch Gladbach
Tobias Wehinger, MBA, Bräunlingen

Preliminary remark:

The “Guidelines for Winter Road Maintenance”, edition 2025, translation 2026 were developed by the Winter Road Maintenance Working Committee (chaired by Dr.-Ing. Horst Hanke, Saarbrücken), which is also the Technical Committee for Winter Road Maintenance of the Association of Municipal Companies (VKU), within a working group. It replaces the information sheet of the same name, edition 2020.

The guidelines describe the legal, technical and organisational principles of winter road maintenance and provides recommendations for its organisation and implementation.

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0 Preface

These guidelines for winter road maintenance provide recommendations for those responsible for winter road maintenance on practical implementation, from preparation and execution to documentation. They include information on the use of personnel, vehicles, machinery, equipment and gritting materials. They apply both outside and inside built-up areas, and refer to roads including cycle and pedestrian facilities, pedestrian crossings, car parks and rest areas.

1 Basics of winter road maintenance

1.1 Objective of winter road maintenance

In the Federal Republic of Germany, the majority of passenger and goods transport is carried out on roads. A significant proportion of local public transport also uses roads. A functional road network is of vital importance for both individual citizens and the economy, especially as an increasing proportion of goods transport is time-sensitive (“just in time”) and travels by road.

Winter road conditions have a significant impact on traffic safety and traffic flow, ranging from reduced traction to impassability. The resulting economic losses due to accidents, lost time, lack of accessibility or production losses can be very high.

Winter road maintenance should, as far as possible, prevent ice from forming, remove any ice that does form or minimise its impact on traffic. It thus makes a significant contribution to road safety and the economy. In order to combat ice efficiently, effective organisation and good operational planning are required in addition to the technical requirements and appropriate equipment.

1.2 Legal basis

The Federal Highway Act and the road and street cleaning laws of the federal states contain regulations for winter road maintenance. In addition, requirements arise primarily from the duty to maintain traffic safety under the German Civil Code (BGB), according to which anyone who opens a public road and creates or allows a dangerous situation to persist there must take reasonable precautions to avert the resulting dangers. This also applies to public roads and means that snow and ice on traffic routes must be cleared to the best of one’s ability in winter.

The content and scope of these regulations and requirements differ for roads outside and within built-up areas. Detailed requirements are not regulated by law. The requirements to be met in individual cases in order to fulfil the obligation to clear snow and grit are specified in detail and further developed by case law.

The provision of winter services to the best of one’s ability and the fulfilment of traffic safety obligations must be ensured above all through effective organisation of winter services. Deployment must be planned in good time and the necessary conditions must be created. All winter services, including organisation and preparation, must be documented in a comprehensible manner. This is the only way to prove later that traffic safety obligations have been fulfilled.

The following section describes the legal requirements for winter road maintenance services arising from the legal situation and established case law. These are primarily relevant in terms of criminal and liability law. In practical winter road maintenance, it is often sensible and effective to go beyond these purely legal requirements in order to ensure smooth traffic flow, road safety and the cost-effectiveness of winter road maintenance services.

1.2.1 Roads outside built-up areas

According to Section 3 (3) of the Federal Highway Act (FStrG) and analogous provisions in most state road laws, roads must be cleared and gritted to the best of one's ability in winter when they are slippery. This does not imply a general obligation to clear and grit roads, i.e. an obligation to clear all roads of snow everywhere and at all times and to grit them when they are slippery.

However, according to case law, the general duty to maintain traffic safety under the German Civil Code (BGB) gives rise to a duty to grit "particularly dangerous spots" on roads if they are important for traffic. In principle, all federal highways, state roads and district roads can be considered important for traffic. According to case law, such road sections are particularly dangerous if, due to their special layout or certain conditions that are not or not immediately recognisable, they suggest the possibility of an accident even if road users exercise the necessary care in traffic and are unable to negotiate the road section even with such care. These can include, for example, tight bends, narrowings of the carriageway, intersections, junctions in combination with longitudinal gradients or roads with an increased, unexpected tendency to become slippery (especially bridges). The resulting obligation to grit only applies once the hazardous situation has arisen and only during the day (see section 1.2.3). The courts also consider the hazardous situation to already exist if slippery conditions are to be expected with a probability bordering on certainty; i.e. in the event of expected freezing wet conditions, a preventive obligation to grit may apply.

Cycle paths are to be treated in the same way as roads with regard to the obligation to grit, i.e. there is an obligation to grit on cycle paths that are important for traffic and have dangerous spots. Cycle paths that fulfil an important transport function for everyday traffic, even in winter, are considered important for traffic, in particular cycle highways. However, cycling on slippery surfaces can generally be classified as dangerous, so that there is a duty to grit all cycle paths that are important for traffic. On the other hand, there is generally no duty to grit footpaths outside built-up areas.

1.2.2 Roads within built-up areas

The obligation to provide winter road maintenance services for towns and municipalities is based on the state road laws or street cleaning laws of the federal states and on the general duty to maintain traffic safety. Local authorities may, by ordinance or statute, transfer some of these obligations to residents within reasonable limits and impose further regulations, which must, however, always remain within the framework of the law. The legal obligations for clearing and gritting vary greatly. Even within built-up areas, winter maintenance must be carried out by an effective organisation and documented.

In built-up areas, the local authority is generally responsible for street cleaning. In winter, this may result in a snow clearance obligation in individual cases. Snow clearance does not have to be carried out everywhere at the same time and may be given lower priority than gritting. Local authorities must draw up clearance plans in which the areas to be cleared are assigned specific priority levels.

Within built-up areas, gritting is only mandatory on roads in places that are both dangerous and important for traffic. The importance of a road section for traffic is determined primarily by its connecting function (classified roads, main roads) or by special traffic (e.g. regular bus services).

Dangerous road sections are those which, due to their special location or certain conditions that are not readily apparent, suggest the possibility of an accident even if road users exer-

cise the care generally required in traffic. These can include sharp bends, narrowings of the carriageway, intersections, junctions in combination with longitudinal gradients or roads with an increased tendency to become slippery (especially bridges).

Cycle paths are to be treated in the same way as roads with regard to the obligation to grit, i.e. there is an obligation to grit on cycle paths that are important for traffic and have dangerous spots. However, cycling on slippery surfaces can generally be classified as dangerous, which means that there is an obligation to grit all cycle paths that are important for traffic.

Pavements and pedestrian crossings must generally be gritted in icy conditions, regardless of the level of danger and importance of the road.

The obligation to grit only applies when a hazardous situation arises and only during the day. The courts also consider a hazardous situation to exist when icy conditions are to be expected with a high degree of certainty; i.e. in the event of expected freezing wet conditions, a preventive obligation to grit may apply.

1.2.3 Performing the obligation to clear and grit roads inside and outside built-up areas

Road sections and cycle paths for which there is a duty to clear and grit must be included in a clearing and gritting plan. This plan must specify the order in which the sections are to be cleared according to their urgency.

Effective gritting materials must be used in accordance with the winter conditions. The effectiveness and limits of use of gritting materials are described in section 3.

The time frame for the obligation to clear and grit is determined by traffic requirements. Traffic routes are generally only to be cleared and gritted for normal daytime traffic. In the morning, work should start in good time so that the main rush hour before general daytime traffic is protected. In the evening, the obligation to clear and grit ends when general daytime traffic ceases. During the rest of the time, there is generally no obligation to clear snow and grit.

Posting signs indicating “limited winter service” does not reduce the obligation to clear snow and grit and is therefore irrelevant in terms of liability law. It is merely intended as a reminder to road users that the legal obligations are interpreted strictly.

If winter services are contracted out to private companies, the party responsible for winter services has a monitoring obligation.

Local authorities may, within the limits of what is reasonable, transfer their snow clearance and gritting duties within built-up areas to residents by means of regulations or by-laws. As a rule, this is done in accordance with state laws for pavements, shared footpaths and cycle paths or footpaths at the edge of the carriageway, and, where applicable, for pedestrian crossings and cycle paths. In the case of pavements, only the width necessary for pedestrian traffic needs to be maintained, not the entire width of the pavement. As owners of land adjacent to roads, local authorities have the same obligations as other residents. If the responsibility is transferred to residents, the local authority is responsible for monitoring compliance. Further explanations can be found in the FGSV’s “Working paper on the transfer of winter maintenance obligations to residents”.

1.3 Requirements for winter maintenance

1.3.1 Requirements for the level of service in built-up areas and outside built-up areas

From the point of view of traffic importance, economic efficiency and technical feasibility of winter road maintenance, it is recommended that all road authorities go beyond the legal requirements and set their own framework for winter road maintenance as a requirement level and make this known to all parties involved in order to create clarity. This requirement level must at least meet the legal requirements and should serve as a voluntary benchmark for winter service deployment planning; it does not constitute a legal entitlement for road users.

1.3.2 Requirements for classified roads outside built-up areas

For classified roads outside built-up areas, the Federal Ministry of Transport, in cooperation with the road construction authorities of the federal states, has laid down the “winter maintenance requirement level” in its performance specifications for road maintenance on federal trunk roads (see Table 1); this has also been adopted by the federal states for roads under state law.

This requirement level meets the legal requirements and in some cases exceeds them. It serves as a guideline for the organisation of winter road maintenance, but does not establish any legal entitlement for road users.

The statements regarding the time period and quality are to be understood as targets towards which the organisational measures within the scope of winter road maintenance should be geared. In order to ensure the quality level, winter road maintenance should begin

Table 1: Winter maintenance requirements for roads outside built-up areas (according to the performance specifications for road maintenance on federal highways, version 2023)

Requirement level for winter road maintenance					
Road with Traffic function		Period of Quality level	Quality level depending on weather conditions		
			Snowfall, black ice, Black ice	Heavy, prolonged snowfall	Heavy snow drifts, Avalanches, freezing rain
1	Federal motorways (BAB) and other sections of road that fulfil an important transport function in connection with the BAB network.	24 hours a day	Passability of continuous carriageways, ramps at junctions and intersections; rest areas and hard shoulders must be usable.	At least one lane in each direction must be passable, including important ramps at junctions and intersections and access roads to managed rest areas, if necessary with snow chains; The usability of unmanaged rest areas is no longer guaranteed.	Passability is no longer guaranteed
2	Important roads for interurban traffic, roads with heavy commuter traffic, roads with regular bus services	06:00 to 22:00 daily	Passability	Passability, in the case of multi-lane carriageways, passability of at least one lane in each direction; if necessary, with snow chains	
3	Other roads for interurban traffic	According to local traffic requirements	Passability	Passability, if necessary with snow chains	
4	Sidewalks, cycle paths, multi-purpose lanes	In accordance with local traffic requirements	Accessibility, walkability	Accessibility and walkability are no longer guaranteed	
5	Other traffic areas along important and other roads in lines 2 and 3	In accordance with local traffic requirements	Usability	Usability is no longer guaranteed	
<p>Explanations</p> <p>“Passability” means that obstructions due to residual snow or, depending on the duration of winter maintenance, a closed snow cover must be expected in some places. Similarly, black ice or ice cannot be ruled out in some places.</p> <p>“Walkability” requires that a strip be kept free of snow and ice or gritted to allow two pedestrians to pass each other with caution (approx. 1.5 m).</p> <p>“Usability” of rest areas and paved side lanes means that the access roads and lanes of rest areas and the paved side lanes can be used with driving adapted to the given obstructions and that vehicles can be parked.</p> <p>“In accordance with local traffic requirements” means that winter maintenance is carried out at times when special traffic conditions so require. In individual cases, this may also mean that no winter maintenance is carried out.</p>					

early enough in the morning so that it can be completed before the start of the time periods specified in the requirements. Outside the specified times, the passability of the roads cannot be guaranteed. Winter services may be intensified beyond the requirement level within the limits of the available resources, provided that this is technically feasible in individual cases and appropriate for economic reasons (e.g. snow clearance during the night, even outside the federal motorways, to prevent the snow from being compacted by traffic and sticking to the road surface, or preventive gritting at night).

Work to restore the visibility, legibility and functionality of traffic signs and traffic facilities, as well as clearing sight lines, shall be carried out after snow clearance and gritting operations. Temporary impairments must be accepted.

The traffic function of the requirement level to which the individual road sections are assigned should be reviewed at regular intervals. If there are changes to the assignment, the clearing and gritting plans must be adjusted as necessary.

For cycle paths, the requirements in the requirement level have so far only been defined in general terms (“in accordance with traffic requirements”). According to case law, it can be assumed that there is a duty to grit important cycle routes during general daytime traffic. The provisions of the requirement level are to be understood accordingly.

1.4 Components of winter road maintenance

In addition to the main tasks of winter maintenance, clearing (mechanical removal of snow) and gritting (combating winter slipperiness), extensive preparatory and follow-up work is required to achieve the specified objectives, some of which must be carried out outside the winter period. This includes, in particular:

- Regulation of responsibilities and accountability
- Training of personnel (including third-party personnel)
- Disposition of third-party contracts and assignments
- Deployment planning
- Preventive snow protection
- Road condition and weather information service
- Provision of an efficient fleet of vehicles and machinery
- Stockpiling of gritting materials
- Deployment documentation.

2 Measures for snow protection and mechanical snow removal

2.1 Definition of snow

Snow is a solid precipitation consisting of small ice crystals.

With increasing moisture and density, snow is referred to as powder snow, wet snow (sticky snow) or slush. Slush is a mixture of water and snow.

2.2 Protection against snow deposits

2.2.1 Snow drifts

Snow drifts occur during snowfall in combination with wind or after a snowfall when dry, loose snow is picked up and carried by the wind. The snow carried by the wind is deposited where the wind speed and thus the drag force decreases (e.g. on hedges, fences, incisions, embankment edges, engineering structures, noise barriers).

Precautions against snow drifts on roads can be taken by designing the road to take account of the topographical features. Sections that are particularly at risk should be avoided when planning the route or mitigated by the design of the road space (e.g. location of the carriageway on an embankment, widening of incisions, snow protection planting).

If snow protection planting (e.g. hedges) is carried out, it should be planted parallel to the road in a width of approximately 6 m (three rows) and at a distance of 12 to 15 times the height of the hedge.

Otherwise, the risk of snow drifts can be prevented by erecting snow fences. As snow fences usually have to be erected outside the road property, the consent of the property owner should be obtained in autumn before they are erected. For federal highways, Section 11 of the Federal Highway Act (FStrG) also allows snow fences to be erected without the consent of the property owner. Snow fences should be erected at right angles to the main wind direction in good time in autumn and removed again in spring.

The fences are usually 1.15 m to 2.25 m high. The distance between the snow fences and the road should be 12 to 15 times the height of the fence. The length of the snow fences is limited to 80 to 100 m due to the risk of collapse in gusty winds. These sections should overlap by at least 10 m. If the fences are not effective, several rows of fences can be erected one behind the other. The distance between the rows of fences should be 10 times the height of the fence. The dimensions of the snow fences therefore depend on the local conditions.

The best results are achieved when half of the snow fence is open to allow air to flow through. To prevent the snow fence from blowing over prematurely, we recommend leaving a gap of around 30 cm between the bottom of the snow fence and the ground.

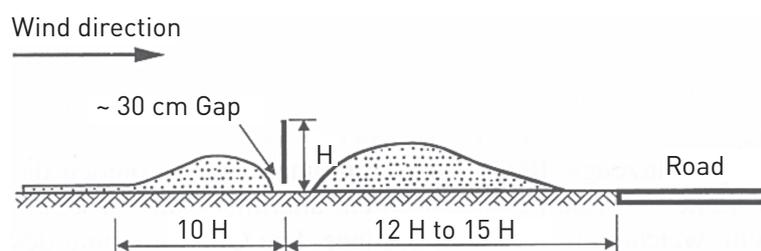


Figure 1: Snow accumulation with correctly installed fence

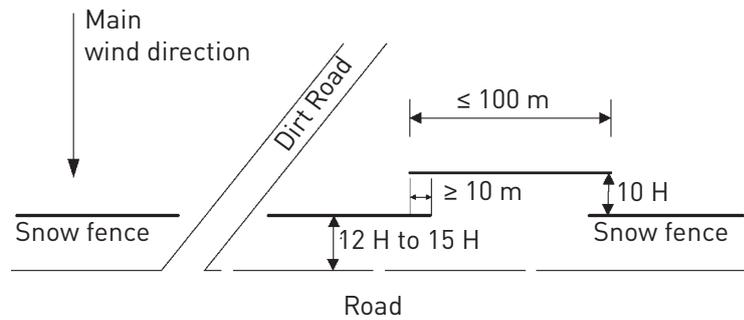


Figure 2: Arrangement of snow fences when the main wind direction is perpendicular to the road ($H =$ fence height)

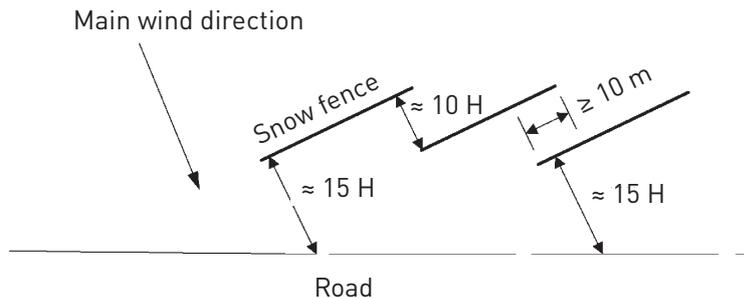


Figure 3: Arrangement of snow fences when the main wind direction is at an angle to the road ($H =$ fence height)

2.2.2 Avalanches

Avalanches can occur when large quantities of snow, sometimes mixed with debris and vegetation, suddenly slide down steep slopes.

In the event of acute avalanche danger, the road section must be closed for safety reasons.

Avalanche risk on roads is prevented by measures on the slopes, such as protective forestation and avalanche barriers, or by enclosing the road with galleries and tunnels. Avalanche blasting can be used to trigger avalanches in a controlled manner when there is a risk of avalanches, in order to eliminate the danger to road users.

2.2.3 Snow and ice glare due to industrial emissions

In addition to natural snowfall, snow-like precipitation (industrial snow) can also be caused by water vapour emissions from industrial plants. This is particularly critical when the weather conditions do not otherwise indicate precipitation, as the precipitation then occurs suddenly, unexpectedly and only locally. Industrial snow usually occurs during inversion weather conditions, with little air movement and low frost. This anthropogenic weather phenomenon usually only occurs on a small scale and cannot be predicted by weather services. Depending on the degree of pollution from industrial emissions, industrial snow can also be contaminated with pollutants.

Industrial snow is usually finer-grained than natural snow because it forms close to the ground and the ice crystals therefore do not have enough time to fully develop. As the small snow crystals sink slowly to the ground, they can cause slippery roads and reduce visibility.

In addition, water vapour from industrial plants can condense as moisture on surrounding roads and freeze immediately at certain temperatures. This creates a dense and very slippery layer of ice. Since this precipitation depends on both the specific industrial emissions and the microclimatic conditions, the location of roads at risk of becoming slippery can change quickly and cannot be predicted.

Snow and ice caused by industrial emissions can significantly impair traffic. However, the people responsible for winter road maintenance in the area are familiar with the road sections that are particularly affected by this. These areas should be given special attention when planning and carrying out winter road maintenance. Preventive gritting is advisable on road sections where ice is likely to form due to industrial emissions. On road sections where industrial snow is to be expected, clearing and/or gritting may also be necessary even if other roads in the vicinity do not need to be treated. In addition, it is recommended that appropriate warning signs be erected on road sections known to be affected. Road sections that are susceptible to such phenomena should be monitored particularly closely in appropriate weather conditions.

2.3 Mechanical snow removal

2.3.1 Basic

There are various methods for mechanical snow clearance from roads:

- Clear fresh snow with snow ploughs,
- Sweeping fresh snow with brooms,
- Milling and/or throwing high snow drifts and snow deposits and, if necessary, removing and depositing them.

Clearing and sweeping can be combined in a single operation.

The aim should be to remove as much snow as possible from traffic areas mechanically in order to minimise the use of de-icing agents. Clearing snow early, even when snow depths are low, reduces the risk of snow becoming compacted on the road surface under traffic.

The additional use of de-icing agents during clearing while snow is still falling is advisable in order to keep the snow clearable and prevent the formation of compacted snow.

In snowy areas, snow markers are put up before winter so that drivers of winter service vehicles can see the edge of the road, obstacles at the side, manholes and the like, thereby avoiding damage. Snow markers are posts with a diameter of about 5 cm, which are marked in a conspicuous colour. Snow markers are not traffic signs under the Road Traffic Regulations, but are only aids for operational services. Snow markers are placed at the edge of the road approximately 50 cm outside the area to be cleared, in the direction of the road and in accordance with visibility conditions. The length of the posts depends on the expected snow depth. As snow markers are an obstacle to other maintenance work (e.g. mowing), they are erected before each winter service period and removed again afterwards.

Kerbs should always be lowered at the ends to facilitate winter maintenance operations.

2.3.2 Snow clearance with snow ploughs

2.3.2.1 Requirements for snow ploughs

A snow plough is a machine connected to the carrier vehicle by means of a so-called mounting plate, which mechanically clears snow from the road surface.

The requirements for the snow ploughs used depend on the local winter service situation (clearing and passage widths, snow quantities and types).

The basic requirements for snow ploughs and their dimensions are specified in the DIN EN 15583 series of standards. Additional recommendations are set out in the notes on the procurement and use of vehicles and equipment in road maintenance, Part 2 Snow ploughs (H BEFG-2).

Front snow ploughs are mainly used as single-sided snow ploughs. They consist of a straight, rotatable snow blade that can be swivelled to the left or right, depending on where the snow is to be cleared. According to the current state of the art, single-sided snow ploughs are used on roads with a plough width of up to 5.50 m, some with extendable or fold-out elements.

The front snow plough is raised, lowered and swivelled hydraulically or electrically. The so-called parallelogram ensures that the plough remains horizontal when raised or lowered.

During clearing, the plough can be hydraulically loaded (“aggressive clearing”) or unloaded depending on the clearing task; the “floating position” refers to the state without loading or unloading, i.e. the snow plough rests on the road with its own weight. Aggressive clearing is used to remove as much snow as possible, but requires a lot of energy and lower clearing speeds, and also leads to high wear and tear. Clearing with plough relief or in floating position is particularly recommended for slush or loose snow and when a thin layer of snow is to remain on the road surface (“white clearing” = clearing while maintaining a layer of snow without gritting or with gritting using dulling gritting materials).

Single-sided snow ploughs are designed either as single-blade ploughs or multi-blade ploughs.

Multi-blade ploughs consist of independent blade segments. They adapt better to the road surface and avoid protruding obstacles thanks to a hook-in system. There are designs of multi-blade ploughs in which a blade element can be folded in or retracted telescopically to change the clearing and passage width.

Single-blade ploughs are suitable for use on flat road surfaces and are usually equipped with overrun protection. The simple design without overrun protection is mainly used for simpler clearing tasks on cycle paths and footpaths.

Wedge snow ploughs have two slanted snow blades that are connected at the front in a wedge shape. Because they throw the cleared snow to the right and left, wedge snow ploughs are used to clear relatively narrow roadways or single-lane roads, especially when there is a lot of snow.

Additional folding discharge barriers on the side of the snow plough can be used to carry the snow for a short distance before depositing it to the side (e.g. at bus stops, intersections, level crossings).

Side snow ploughs are mounted on the side of the vehicle. They are used in combination with front snow ploughs to clear large widths with one vehicle, especially on motorways. Such plough combinations can achieve a clearing width of up to 7.50 m.

Snow ploughs are equipped with various scraping blades to adapt to the operating conditions, which are preferably attached to the plough blade with clamping devices. Steel blades made of highly wear-resistant steel and combination blades (steel and rubber, with corundum or carbide inserts if necessary) are suitable for all types of snow and also enable aggressive clearing. Combination blades are characterised by smoother running and greater wear resistance than steel blades. Solid rubber or solid plastic blades are suitable for wet snow or slush.

The throwing height and range of ploughs depends on the angle of the scraper blade, the driving speed, the shape of the blade and the height of the plough. Ploughs with a raised right blade are suitable for throwing snow over long distances. The flatter the plough lies on the road, the more aggressively it clears.

Snow ploughs should kick up as little snow as possible. Attaching snow deflectors to the plough reduces the driver’s visibility during clearing.

The safety markings required for snow ploughs (in particular lighting, warning flags, retro-reflective warning markings and reflectors) in accordance with the Road Traffic Licensing

Regulations are provided in accordance with the “Information Sheet for Winter Service Vehicles” issued by the Federal Ministry of Transport.

2.3.2.2 Snow clearance practice

Roadways are generally cleared towards the right-hand edge of the road. The plough should be driven as far to the left as possible so that no snow remains in the middle of the road (on single-lane roads) or on the left-hand edge of the road (on dual carriageways). If there is still snow remaining on the right-hand edge of the road, this strip is cleared in a further pass.

On multi-lane roads, several snow clearance vehicles are usually deployed in quick succession. On motorways, it is advisable to use extra-wide front snow ploughs, possibly in combination with side snow ploughs.

Figure 4 shows schematic diagrams of possible examples of staggered clearing of multi-lane carriageways. Other solutions are possible.

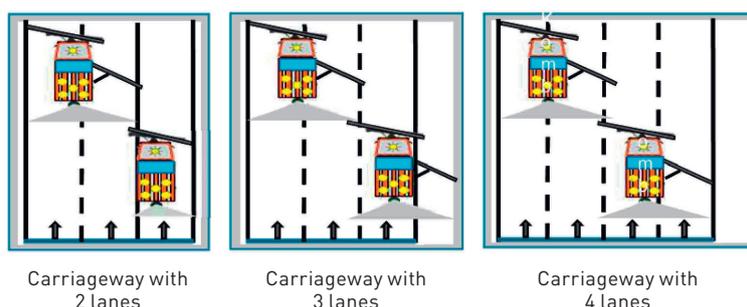


Figure 4: Examples of staggered clearing and spreading and spraying operations on multi-lane carriageways

In heavy snowfall, consider cancelling the staggered clearing operation in order to clear only one lane, but with shorter cycle times.

On bridges, snow should be cleared in such a way that it remains on the right-hand side of the carriageway and on the bridge deck as far as possible. If necessary, snow guards should be installed in the area of the guardrail.

At level crossings, the railway company is responsible for clearing the road in the area of the railway track. In order to avoid the formation of snow drifts on level crossings as far as possible, snow brought along should be deposited to the side before level crossings and the plough should be raised slowly before the level crossing. Other regulations, in particular the suspension of gritting, must be agreed with the railway company.

By swivelling the plough perpendicular to the vehicle axle, the snow can also be moved along the edge of the carriageway over short distances (e.g. at stops or junctions).

Work areas on the carriageways should be cleared before the onset of winter if possible. In the case of unavoidable winter construction sites, the available width in all sections must be adjusted to the minimum passage width of the ploughs.

2.3.3 Snow clearance with sweepers

Compared to snow plough blades, sweepers are better suited to uneven road surfaces, e.g. paved surfaces or ruts. They also remove residual snow that would otherwise remain in the depressions and become compacted.

However, the use of sweepers (usually as rotating front sweepers) is limited to loose, soft or wet snow at low snow depths and only allows a low forward speed, as otherwise the snow cannot be transported to the side. The use of sweepers is a suitable alternative, especially for

footpaths and cycle paths, as the clearing widths are small and the working speeds are generally relatively low. This allows a better clearing result to be achieved, with the result that the amount of gritting material can be reduced.

2.4 Removal of large amounts of snow with snow clearance machines

Snow deposits at the roadside should be removed if

- they form dangerous ramps in front of protective barriers, which could cause vehicles that leave the road to be thrown over bridges or into embankments,
- they lead to lane or pavement narrowings that significantly impede or endanger traffic,
- a hard shoulder is no longer usable,
- the visibility of approaching vehicles at intersections is significantly reduced,
- melt water can get onto the road and endanger traffic.

Snow removal machines (snow blower, snow cutter and snow cutter-blower) are primarily suitable for loosening and removing large amounts of snow and snow deposits. Wheel loaders, excavators or loaders from the agricultural sector can also be used to remove smaller snow deposits.

Snow removal machines loosen and transport snow using mechanically driven rotating parts. The clearing mechanism is driven by its own drive unit or via the PTO (power take-off) shaft of the carrier vehicle.

Snow blowers are primarily suitable for moving large quantities of fine-grained snow. The front-mounted snow blower consists of two counter-rotating impellers and is used for clearing high snow drifts (road clearing). A side snow blower, on the other hand, has only one throwing wheel and is equipped with a wide feed plough. It is mainly used for clearing snow from the edges and for loading snow deposits. The snow is thrown in the desired direction via adjustable and/or rotatable chutes.

Snow cutter are suitable for deposited and compacted snow. They have a lower clearing capacity than snow blower. The front-mounted snow blower has a milling drum whose axis is arranged transversely to the direction of travel and covers the entire clearing width. The snow is ejected via chimneys that can be adjusted in inclination and/or rotated. Side blowers are equipped with a feed plough.

A snow cutter - blower has a milling drum for loosening the snow and a throwing wheel for ejecting it.

When milling or throwing, particular care must be taken to ensure that the snow is not thrown onto houses, roads, railway tracks, etc. below. Where space permits, the snow should be deposited directly to the side on meadows, fields, etc. Where this is not possible (usually in built-up areas, in front of noise barriers and in some cases on bridges), the snow must be loaded and transported away. In the latter case, after being loosened and conveyed, the snow is loaded onto transport vehicles (trucks), transported away and deposited in suitable snow dumping areas until it melts.

Due to the contamination of the snow with dirt and pollutants, the cleared snow must not be deposited in particularly sensitive areas such as drinking water protection areas, smaller standing bodies of water or natural wetlands. Point source discharges or seepage should be avoided as far as possible.

Snow clearance machines are available in various sizes, ranging from self-propelled machines to large machines with their own drive unit in the carrier vehicle, front-mounted machines driven by PTO shafts and small hand-guided machines.

The basic properties and requirements for snow removal machines are contained in the European standard DIN EN 15906.

2.5 Manual snow clearance

In many cases, individual clearing tasks can only be carried out manually or must be supported manually, such as

- clearing pavements, kerbs, bus stop areas, access to emergency telephones, pedestrian crossings, stairs and narrow paths,
- clearing manholes, drains, hydrants and traffic signs,
- the removal of large accumulations of snow on bridge caps and large signs that could fall onto traffic routes below, and
- creating drainage slots in the kerb to ensure that meltwater can drain away.

In addition to brooms and snow shovels, various attachments for hand-held small machines are also used, such as mounted sweepers, clearing blades or snow blowers.

3 Measures against winter slipperiness

3.1 Winter road conditions

Winter road conditions have a significant impact on traffic safety and flow.

Winter slipperiness is the slipperiness of road surfaces caused by winter weather conditions, accompanied by a reduction in the grip between the wheels and the road surface. Depending on how it develops, the following types are distinguished:

- Snow
Slippery conditions caused by snow becoming compacted or frozen, or by slush or snow residue freezing.
- Hoarfrost
Slippery conditions caused by the freezing of moisture in the air on the traffic surface.
- Black Ice
Slipperiness caused by the freezing of existing moisture (also known as “freezing wetness”).
- Freezing Rain
Homogeneous layer of ice formed by freezing rain (temperature of the drops below 0 °C) or by rain on a supercooled road surface.

The following factors are decisive for the formation of winter slipperiness (see Figure 5):

- Temperature and condition of the road surface
- Type, quantity and temperature of precipitation
- Moisture content and temperature of the air

Altitude, embankment/cutting location, road structure, surroundings, cloud cover, radiation and wind conditions influence the above factors and thus have an indirect effect on the formation of slippery conditions.

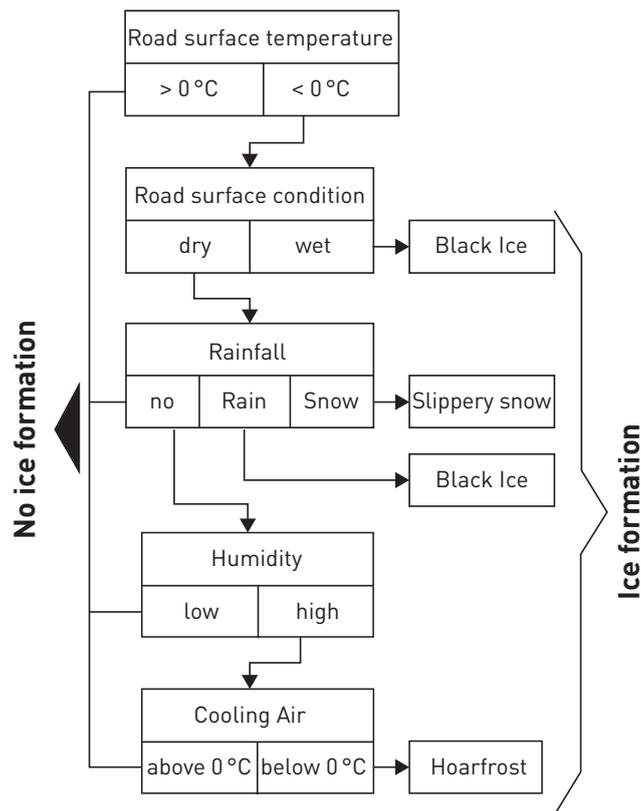


Figure 5: Formation of winter slipperiness

3.2 Gritting materials

3.2.1 General

De-icing agents or gritting materials can be used to combat winter slipperiness. De-icing agents increase the coefficient of friction on winter slippery road surfaces by physical and chemical means, while gritting materials do so by mechanical means.

The requirements for de-icing agents are specified in the European standards of the 16811 series, which must be observed when purchasing these substances for winter road maintenance. The series is divided into the following parts:

- DIN EN 16811 Part 1: Sodium chloride – Requirements and test methods
- DIN EN 16811 Part 2: Calcium and magnesium chloride – Requirements and test methods
- DIN CEN/TS 16811 Part 3: Other solid and liquid de-icing agents – Requirements and test methods

The European standards contain limit values, test methods and specifications, in particular for the proportion of active substance, grain size distribution, moisture content, heavy metal content and other chemical additives.

Additional information and recommendations for the procurement of gritting materials, their requirements and quality assurance can be found in the “Notes on the procurement of de-icing and gritting materials for winter road maintenance” (H BeStreu).

Information on the properties of gritting materials is also contained in H BeStreu. The decisive properties of these materials are their heavy metal content, grain size distribution, strength and shape.

3.2.2 De-icing agents

3.2.2.1 Types

De-icing agents dissolve in combination with the water molecules in snow and ice, lowering the freezing point of the solution and thus causing the snow or ice on the road surface to melt or preventing existing moisture from freezing. This results in a wet road surface. Figure 6 shows the relationship between the concentration of the salt solution and the freezing temperature for the three most common de-icing agents.

The following chlorides are particularly suitable as de-icing agents:

- Sodium chloride (NaCl)
- Calcium chloride (CaCl₂)
- Magnesium chloride (MgCl₂)

NaCl is the most commonly used and cheapest de-icing agent. It is obtained as rock salt, evaporated salt or sea salt and is available in large quantities as a natural substance. Sodium chloride can also be produced as a by-product of industrial processes. For use in winter road maintenance, the latter must also meet the requirements of DIN EN 16811-1.

CaCl₂ and MgCl₂ are usually obtained as by-products of industrial processes.

Other de-icing agents, e.g. alcohol-based de-icing agents, technical urea, calcium magnesium acetate (CMA), sodium and potassium formate, potassium carbonate, etc., are sometimes very expensive, flammable, hazardous to water and have a lower de-icing effect than the three chlorides mentioned above. In addition, they are not readily available, often have to be transported over long distances and require significantly more energy. They therefore have a poorer ecological balance than the chlorides mentioned above. Such de-icing agents are not recommended for use on roads. Before using such substances, the requirements of DIN EN 16811-3 must be checked.

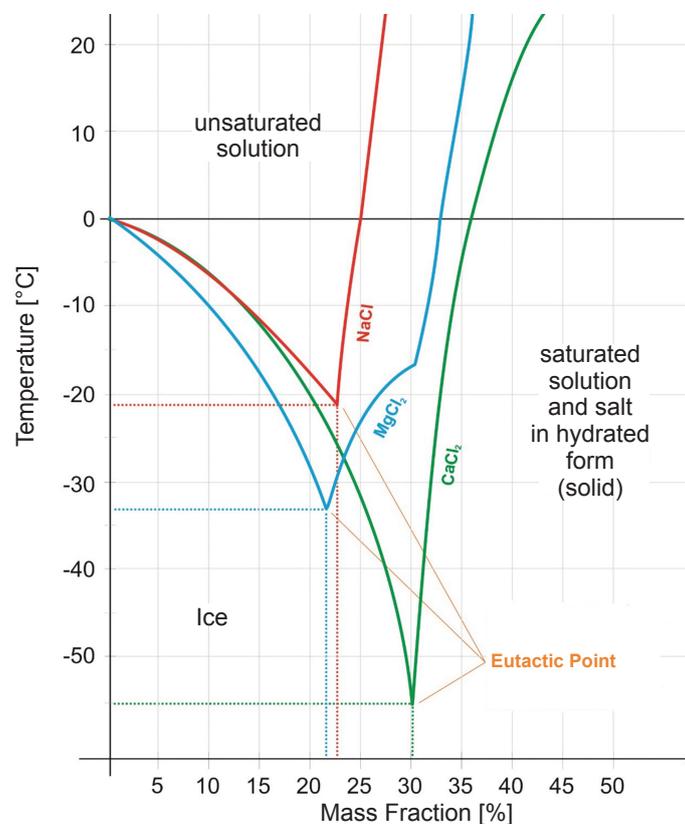


Figure 6: Freezing and solubility curves of sodium, calcium and magnesium chloride in water

Between the curve branches (freezing and solubility curves) of the salts in Figure 6, the salt solutions produced or forming on the road surface do not freeze. In principle, this area can be used for winter maintenance with de-icing materials. To the left of the eutectic points, below the curves, ice freezes from the salt solutions. To the right of the eutectic points, salt crystallises from the supersaturated salt solutions. Below the eutectic points, ice and solid salts are present. The eutectic point is the theoretically lowest possible temperature of a solution of salt in water before frozen water and salt crystals are present alongside the saturated solution. The practical limit for the use of salt in winter road maintenance is already reached above the eutectic point, as a saturated solution cannot be achieved on the road in practice.

3.2.2.2 Dry salt

To avoid losses during spreading, to ensure good spreading and to optimise effectiveness and retention on the road, it is necessary to moisten the dry salt ("pre-wetted salt") or apply it entirely in liquid form as a de-icing solution. The application of pure dry salt is no longer state of the art and is not recommended on roads.

3.2.2.3 Moist salt

Salt (NaCl) should always be moistened before application to prevent loss due to wind and to ensure even distribution and longer adhesion of the de-icing agent to the road surface. This means that a smaller quantity can be used to achieve a better and faster effect. The use of pre-wetted salt is therefore generally recommended over dry salt for ecological, economic and traffic reasons. The pre-wetted salt technique is usually carried out using the pre-wetted salt 30 ("FS30") method. With FS30, the dry salt is moistened with a salt solution on the spreader during the spreading process. Dry salt and solution are mixed in a ratio of 70:30 by weight. The salt solution is carried in a tank separate from the dry salt on the spreader vehicle.

Sodium chloride, calcium chloride or magnesium chloride solutions can be used for moistening. Certain salt concentrations are required for storing the solutions in the maintenance depot and for producing pre-wetted salt on the gritting vehicle. This ensures that no salts crystallise from the solutions at excessive concentrations, which could cause operational disruptions due to clogged pipes and valves. It also prevents solutions with too low a concentration from freezing at low temperatures.

The following application concentrations are optimal for use:

Sodium chloride solution	22 % by mass
Calcium chloride solution	20 to 25 % by mass
Magnesium chloride solution	17.5 % by mass.

A tolerance of ± 1 % should be applied in each case.

If solutions with higher concentrations are supplied, they must be diluted with water to the application concentration before use (see also Figure 6).

Depending on the application, it is also possible to deviate from the standard FS30 pre-wetted salt. For example, a lower solution content is sufficient in the event of snowfall, while a higher solution content is advantageous in the event of black ice or for preventive gritting.

Moist salt should always be applied in all weather conditions (even in falling snow).

When using moist salt for preventive gritting, it should be noted that the dry substance is quickly thrown out of the wheel tracks by traffic after application and thus becomes ineffective. Preventive gritting with moist salt should therefore only be carried out immediately before the expected formation of slippery conditions.

Brine are even better suited for preventive spreading, as the loss rate is significantly lower when applied to dry road surfaces or when the road surface is only slightly damp.

3.2.2.4 De-icing solutions

Due to their more even distribution compared to pre-wetted salt and their longer retention time on the road surface, pure salt solutions ("FS100") are more suitable for preventive gritting and for spreading small amounts of de-icing agent on both roads and cycle paths. This is possible at not too low road temperatures (down to about -6 °C) without significant precipitation or temperature drops. In addition, preventive gritting before snowfall or freezing rain can prevent snow or ice from sticking to the road surface.

FS100 therefore offers considerable advantages in terms of road safety, economy, environmental protection and work organisation in the above-mentioned applications and should therefore be used in preference in these cases.

Application is usually carried out using special spray nozzle designs or spray bars. For use with spreading widths of up to 8 m and speeds of up to 60 km/h, there are also special spreader distributors that can apply both FS30 and FS100.

The application of CaCl_2 and MgCl_2 as pure solutions is also suitable for preventive de-icing. However, it should be noted that when spreading higher densities of CaCl_2 and MgCl_2 solutions without a simultaneous solid salt content, there is a risk that slippery road conditions may occur under certain meteorological conditions, especially at very low air humidity, due to the formation of hydrates. This product should therefore be used with particular caution.

Further information on the use of salt solution in winter service (FS100) can be found in the "Notes on the practical use of FS100 in winter service" (H FS100).

Pure de-icing solutions are also used in de-icing spray systems (see section 3.5.2). For de-icing spray systems, the use of brine is recommended for the reasons mentioned above.

3.2.2.5 Required spreading densities

Choosing the right dosage of salt for de-icing in winter service is very difficult. Since the physical relationships involved in the melting effect are complex, practical recommendations for spreading density have been developed in tabular form. The tables provide recommendations for winter service and reference values for spreading density depending on the various de-icing situations and the expected temperature.

De-icing with de-icing agents works by lowering the freezing point; i.e. a sufficiently high concentration of salt must be applied to the road surface so that the freezing point of the salt solution is lower than the road surface temperature. This means that the amount of salt required depends both on the amount of liquid on the road surface (possibly also in the form of ice or snow) and on the expected temperature.

For curative gritting (gritting when slippery conditions already exist), approximately twice the amount required for preventive gritting is necessary. This has been proven in extensive practical and laboratory tests and is primarily related to the time required for the thawing process (i.e. also the residence time of the salt) and the heat balance during the thawing of ice with NaCl, during which heat energy is extracted from the environment (a so-called endothermic process).

The winter service measures and associated spreading densities recommended depending on weather and road conditions and the expected temperature are shown in the table in Figure 7.

Conditions to be combated	Situation and effects	Recommended winter maintenance measures	Reference value spreading density [g/m ²] with expected road temperature				Remarks
			to -3°C	to -6°C	to -10°C	below -10°C	
Hoarfrost	<ul style="list-style-type: none"> falling temperatures, slightly below 0°C high humidity, possibly locally no precipitation <p>Moisture in the air settles, possibly only locally, as frost on traffic surfaces, usually only in the early hours of the morning</p>	Preventive spreading in appropriate weather conditions <ul style="list-style-type: none"> preferably with brine (liquid spreading) otherwise with pre-wetted salt as immediately as possible before the expected formation of hoarfrost <p>If preventive measures were not possible, de-icing</p> <ul style="list-style-type: none"> with brine (liquid spreading) with pre-wetted salt 	15 10	20 10	.* 15		<p>Pre-wetted salt as FS30</p> <p>Liquid spreading as FS100 with NaCl solution (at least 20%)</p> <p>*FS100 (brine) only down to -6°C</p> <p>Hoarfrost below -10°C generally not to be expected</p>
Black ice (freezing moisture)	<ul style="list-style-type: none"> damp road surface (no spray plumes, dark road surface) temperature falls below 0°C, possibly locally <p>Existing moisture freezes over to form slippery ice, possibly only selectively or with a local time delay</p>	Preventive spreading in appropriate weather conditions <ul style="list-style-type: none"> preferably with brine (liquid spreading) otherwise with pre-wetted salt as immediately as possible before the expected formation of light black ice <p>If preventive measures were not possible, remove ice with pre-wetted salt</p>	20 10	30 15	.* 25	.* 30	
Black ice (freezing wetness)	<ul style="list-style-type: none"> wet road surface (clear spray marks) temperature falls below 0°C, possibly locally <p>Existing moisture freezes over to form slippery ice, possibly only selectively or with a local time delay</p>	Preventive spreading in appropriate weather conditions <ul style="list-style-type: none"> preferably with brine (liquid spreading) otherwise with pre-wetted salt as immediately as possible before the expected formation of black ice <p>If preventive measures were not possible, remove ice with pre-wetted salt</p>	35 20	55* 30	.* 40	.* 50*	+ For spreading densities above 40 g/m ² , the pumping capacities of the spreaders are generally not sufficient to spread these at high speeds and larger spreading widths. Lower speeds or several cumulative spreading operations may be required to spread larger quantities.
Freezing rain (black ice)	<ul style="list-style-type: none"> dry road surface road temperature below 0°C (frozen road and ground) warming of the air with rain around 0°C <p>Rain freezes to form black ice as soon as it hits the road</p>	Preventive spreading prevents the ice from sticking to the road surface <ul style="list-style-type: none"> preferably with brine (liquid spreading) otherwise with pre-wetted salt immediately before the expected ice formation <p>Subsequent removal of ice is generally not advisable as too large quantities are required; thawing of ice only possible with very low precipitation (light drizzle). Ice thaws by itself over time due to warm air and rain.</p>	40 40	40 40	.* 40	Generally, not to be expected	In the case of freezing rain, the formation of ice can only be delayed, but not completely prevented, by preventive gritting.
Snowfall (packed snow)	<ul style="list-style-type: none"> announced snowfall dry road surface temperature below 0°C <p>The fallen snow remains on the roadway and is driven over by traffic</p>	<ol style="list-style-type: none"> Preventive spreading (before snowfall or at the onset of snowfall) prevents snow from sticking to the road surface <ul style="list-style-type: none"> with brine or with pre-wetted salt During snowfall, spread the falling snow to keep it clearable <ul style="list-style-type: none"> with brine (only for broom clearing) with pre-wetted salt After the end of the snowfall, aggressively clear the snow and spread to thaw the snow residue <ul style="list-style-type: none"> with brine (only for broom clearing) with pre-wetted salt <p>Spreading quantity depends on the amount of snow remaining after clearing and previous spreading operations</p>	30 15	35 20	.* 20	.* 20	<p>Preventive application during snowfall or spreading in the falling snow can delay the formation of ice and prevent the snow from freezing to the carriageway, but cannot replace curative spreading.</p> <p>Curative control of slippery snow with brine (FS100) is only possible if the snow is cleared cleanly, as otherwise the snow cover will not thaw sufficiently. As a rule, it is possible to clear snow from cycle paths and footpaths.</p>

Figure 7: Reference values spreading density

The reference values contained in the table are to be regarded as guidelines and must be adapted to the respective local conditions and circumstances. The information provided in the last column ("Remarks") must be observed. In particular, it should be noted that liquid spreading can only be used in snowfall or snowy conditions if the road is swept clean at the same time (usually possible on footpaths and cycle paths).

The values in the table are based on the use of a 22 ± 1 % sodium chloride solution, both for pre-wetted salt and liquid spreading.

If calcium or magnesium chloride solution is used for pre-wetted salt, the values in the table must still be applied accordingly, as there are no significant differences in dew formation in the temperature ranges shown in the table.

The situation is similar for liquid spreading: in the range down to -6 °C, in which the table recommends the use of liquid spreading, there are no significant differences in the de-icing performance of the various types of salt solution. The values can be used for solutions containing calcium or magnesium chloride at the recommended concentrations.

Further explanations and information on the table can be found in the working paper “Practical recommendations for effective clearing and gritting in winter road maintenance”.

3.2.2.6 Winter maintenance on porous asphalt

With a void content of at least 22 % in the pavement and a coarse grain structure on the surface, porous asphalt pavements have a different structure to dense pavements. Based on experience and results, the pavement properties of porous asphalt pavements require special observation during winter maintenance and a different application of de-icing salt:

Due to the increased cooling of the pavements and the limited ability of salt to be stored on the surface, 1.5 to 2 times the spreading density required for dense road pavements is necessary in most cases. This should be used as a guideline for winter maintenance, taking into account local experience and conditions.

FS100 should be used in preference for preventive applications on dry road surfaces, as the solution wets the surface of the porous asphalt much more completely than pre-wetted salt. For preventive applications on wet roads, liquid spreading (FS100) or simultaneous application of FS30 and FS100 (combined spreading) is preferable to the previously standard FS 30 spreading.

During heavy precipitation with a visible film of water or snow on the surface, the use of liquid spreading is not advisable, i.e. only FS30 should be used.

Further information and specific recommendations on the spreading densities to be used can be found in the working paper “Winter service on roads with asphalt surface layers made of porous asphalt” (AP WD OPA). These instructions must be observed.

3.2.3 Abrasive

Abrasive materials become interlocked with the surface of the skim layer due to the effects of traffic. This can slightly increase the coefficient of friction on winter roads for a certain period of time, depending on the road condition, gritting density and traffic load/speed. Abrasives are virtually ineffective on ice and black ice.

As the abrasives are thrown to the side of the road by vehicles after a short time, repeated spreading is often necessary depending on the volume of traffic.

Natural material in the form of sand or grit are mainly used as de-icing agents. These are preferable to crushed (granulated) slag and other by-products from various industrial processes.

To achieve a roughness effect, a spreading quantity of at least 100 g/m² is required. A quantity of approximately 150 g/m² is recommended as the standard spreading density.

The effect of abrasive is particularly low on cycle paths, and there is a risk of the rolling grit effect. They are therefore not suitable for use here.

The effectiveness of de-icing agent is better the higher the proportion of granular spreading material, i.e. the more angular the grains are. The use of de-icing agents requires that they

are delivered dry and stored dry so that they remain spreadable (for more details, see H BEStreu). Abrasives must be collected again after the end of the slippery period and either recycled or disposed of.

3.2.4 Mixtures of gritting materials

Mixtures of de-icing and abrasive agents are generally not recommended. Due to the high spreading densities required for abrasive agents and the need for frequent re-spreading, more de-icing agents end up on the traffic areas than with pure salt spreading, whereas at lower temperatures too little de-icing agent is applied. It is not possible to adjust the spreading quantity to the temperature and amount of water. When applying de-icing agents, it is generally not advisable to add dulling agents.

3.2.5 Effects on traffic

The friction between the wheel and the road surface is characterised by the coefficient of friction. The coefficients of friction of a road surface successfully treated with salt correspond to those of a wet road surface. Abrasives increase the friction of winter-smooth road surfaces only slightly, even when large quantities are applied, and then only temporarily (Figure 8).

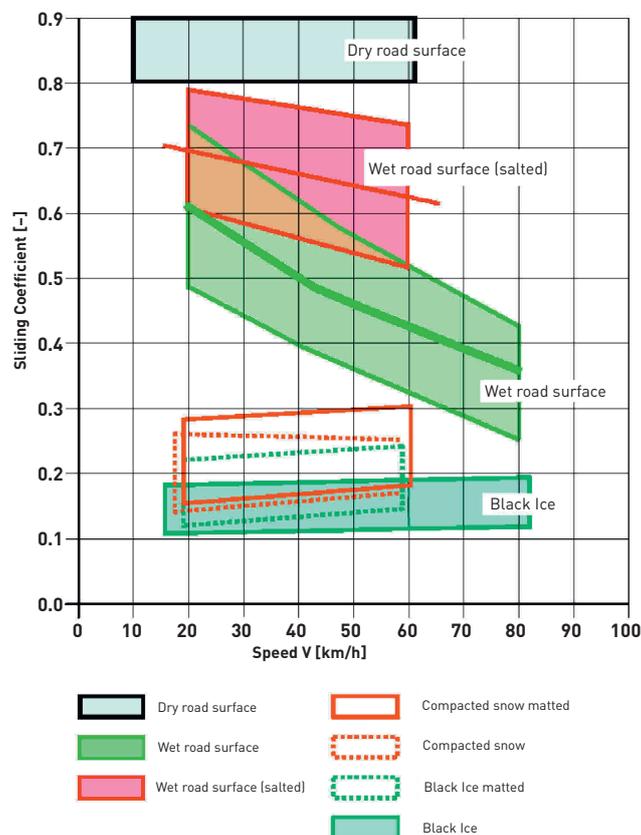


Figure 8: Friction coefficients for different road conditions

The use of de-icing agents on motorways and rural roads reduces the high accident rates on slippery road surfaces and helps to prevent traffic jams. The operating costs for winter road maintenance are more than offset by the economic benefits in terms of traffic flow and road safety (time, accident and operating costs for road users).

When using abrasives, the accident rate remains higher than when using de-icing agents. Abrasive materials remaining on the road surface after the period of slippery conditions can impair the road safety of two-wheeled vehicle users.

In municipalities, a reduction in the accident rate and severity of accidents can be observed on main roads and uphill sections after salt has been spread, while grit has no positive effect on road safety (accident rate, accident severity). On roads with low traffic volumes, the complete absence of gritting materials has proven to be generally unproblematic in terms of traffic. The effect of de-icing agents is often overestimated by road users.

The faster the winter road maintenance service responds to the formation of slippery conditions, the more positive the effects on traffic are. If these conditions can be predicted with sufficient certainty, preventive gritting is particularly effective in terms of its impact on traffic.

3.2.6 Effects of de-icing agents on environment

If used improperly or without adequate protection, de-icing agents can cause damage to roads, structures, vehicles or environment:

- Corrosion of vehicle bodies and components if corrosion protection is missing or defective. The corrosiveness of different salts varies depending on the metal.
- Damage to structures: Unprotected reinforcement in reinforced concrete and steel structures, damage to unprotected concrete. Magnesium-containing de-icing agents are aggressive to concrete.
- Contact damage to vegetation in the immediate vicinity of roadsides.
- Damage to plants and parts of plants as a result of changes in the nutrient balance of trees and shrubs.
- Damage to fish and fish food sources due to temporary accumulation of chlorides in natural bodies of water near roads.

Modern winter road maintenance with preventive gritting and pre-wetted or liquid spreading, as well as targeted application and better adhesion of gritting materials to the road surface, significantly reduces the amount of gritting required. As a result, consequential damage such as that described above is now minimised.

The chlorides used in winter road maintenance are classified as Water Hazard Class I.

The salt used can partially form fine salt dust due to the effects of road traffic and recrystallisation during drying. However, this has no adverse effects on health.

3.2.7 Effects of abrasive spreading on environment

Abrasive spreading do not generally have any chemical effects on the road and local environment. However, they are thrown beyond the edges of the road by traffic onto adjacent areas. The use of abrasive materials can have the following adverse effects:

- Clogging of drainage systems
- Contamination of agricultural land
- Contamination and elevation of green areas and verges
- Damage to parked and moving vehicles
- Impairment due to dust formation (fine dust formation)
- Significantly higher energy requirements for production, application, recovery, disposal or treatment

In the case of abrasive materials, the formation of fine dust due to traffic and during reapplication must be taken into account. The crushing of abrasive materials on the road can increase fine dust pollution during the winter months.

Collected gritting materials are contaminated by traffic-related and other pollutants and must be recycled or disposed of. Only gritting materials made from natural stone are suit-

able for recycling. Various treatment processes are available (dry treatment or washing and screening), but all involve considerable effort and further environmental pollution. Even after treatment, reuse as a gritting material is not possible because it does not meet the requirements of H BeStreu regarding grain distribution and grain shape; recycling is only possible in earthworks, road construction and landfill.

The use of abrasive materials on road surfaces is fundamentally questionable due to their limited and temporary effect, high environmental impact and the requirement to avoid waste, and cannot be recommended.

3.2.8 Life cycle assessments

The life cycle assessment tool provides a sound basis for making decisions on the selection of gritting materials from an environmental perspective. It assesses all the environmental impacts of gritting materials throughout their entire life cycle, from extraction to disposal.

According to the life cycle assessments available to date, both salt and grit are considered harmful to the environment, and measures to reduce both gritting materials are still necessary. In terms of the amount required to grit a defined road surface, the ecological impact of grit is higher than that of salt, although pre-wetted salt and, in particular, brine have a significantly better ecological balance than dry salt.

In the life cycle assessments, sodium chloride is clearly superior to other de-icing agents; natural stones are superior to other materials when it comes to de-icing agents.

According to the life cycle assessments carried out, the use of de-icing agents on pavements should be limited to snowy conditions. Sodium chloride, in the form of salt solution or pre-wetted salt, should always be used on roadways, including cycle paths.

It has also been shown that energy consumption and emissions during the manufacture and transport of gritting materials and during the operation of winter service vehicles have a significant impact on the environmental impact of winter road maintenance. It is recommended that gritting materials manufactured in an energy-intensive manner be avoided. When transporting gritting materials, the transport distance and the means of transport are decisive for the impact.

3.3 Spreader

3.3.1 Characteristics and types of spreader

Spreaders are used to spread gritting materials evenly on traffic areas. They essentially consist of a hopper, a gritting material conveyor and a gritting material distributor, as well as a control panel with control software. The spreading density, width and strip position can be set on the control panel.

Spreaders can be mounted on the vehicle, placed on the flatbed, attached to the flatbed or carried as a trailer. Spreading discs are generally used as spreader distributors.

Pre-wetted salt spreaders require additional tanks for salt solutions, including a pump and a wetting device. The dry salt is wetted on the spreading disc immediately before application.

Spreaders for spreading FS100 have tanks and special metering devices. The spreading is usually carried out via special spray nozzles or spray bars.

Combined spreaders that can spread both pre-wetted salt and brine have a solid container, tanks for brine and both spreading discs and spray nozzles for application. Alternatively, it is also possible to spread both pre-wetted salt and liquid salt using a specially designed spreading disc, eliminating the need for spray nozzles; this is currently possible for spreading widths of up to 8 m and speeds of up to 60 km/h.

The drive can be provided by the machine's own combustion engine, a wheel hub drive or vehicle hydraulics (in accordance with DIN EN 15431: Winter and road service area maintenance equipments – Power system and related controls – Interchangeability and performance requirements).

3.3.2 Requirements for spreaders

The requirements for spreaders are specified in:

- DIN EN 15597-1 “Winter maintenance equipment – Spreading and Spraying – Part 1: General requirements and definitions”
This standard contains information on the description of a spreader, general requirements for the design of a spreader, including its control system, and requirements for dosing accuracy and its testing.
- DIN EN 15597-2 regulates the requirements for the distribution of spreading material and its testing.
- DIN EN 17106-1 and 17106-3-2 contain safety requirements for spreading machines.

Recommendations for the procurement, testing and use of spreading machines are contained in the “Notes on the procurement and use of vehicles and equipment in road maintenance, Part Spreading machines” (H BEFG-3), which should be observed.

3.3.3 Adjustment of sprraders

Correct distribution of spreading material depends on the correct adjustment and calibration of the spreading machine. The adjustment and calibration must be adapted to the spreading material used (grain size, moisture content) and any changes due to daily use must be corrected. Factory settings of the spreading machines are only sufficient in very rare cases. Correct adjustment can be achieved by making changes to the mechanics and the control software.

In addition to the type testing of a spreader type, which must be carried out by the manufacturer, an acceptance test must therefore be carried out by the customer on delivery with the respective spreading material used for each spreading device. Furthermore, an inspection should be carried out at least once a year (before the start of winter). The H BEFG-3 contains information on this, which must be observed.

3.3.4 Additional equipment for spreaders

With the aid of mounted infrared sensors, the road surface temperature can be measured continuously from the spreading vehicle. This is not only helpful for documenting the road surface temperature during inspection runs and operations and for supporting the driving personnel, but can also facilitate winter service operations in certain weather conditions (especially in the case of frost and black ice) if the measured values are directly integrated into the dosing control system. Use when temperatures are expected to drop (especially for preventive gritting) should be carried out with care, as the sensor only records the current temperature and the gritting density is then dosed accordingly. If such systems are used, the instructions in the working paper “Temperature-controlled gritting material dosing” must be observed to avoid incorrect dosing. The working paper provides recommendations for the use of such systems and their limitations, specifications for their programming, and specifications for the installation and use of temperature sensors.

More advanced sensor technology for measuring road surface conditions or water film thickness is already available today. However, due to the currently high measurement uncertainties and low representativeness of the measured values, it is not recommended for calculating the spreading density.

Alternatively, it is also possible to store data on road widths and particular slippery conditions (e.g. bridges) in the gritting plans or geographically and thus carry out automated GPS-based control of the gritting machine.

3.4 Grit storage

3.4.1 Storage capacity

When calculating storage capacity, it is important to ensure that sufficient quantities of gritting materials are available at all times during the winter.

This means that supply contracts should be concluded with gritting material suppliers, stipulating maximum delivery times and minimum daily delivery quantities. Depending on this delivery time and a time buffer for the first reorder and to ensure security of supply, the period for which the storage capacity must be sufficient is then determined. This period and the assumption of continuous full use during this time (several full uses per day) then result in the required storage capacity, which is calculated from the number of cycles multiplied by the amount of salt per cycle.

Extensive and prolonged snowfall can lead to bottlenecks in the delivery of gritting materials. To ensure the supply of gritting materials under these conditions, larger quantities of gritting materials should be kept in stock. This can also be done at storage sites outside a building yard or maintenance depot. The recommended storage quantities per square metre vary depending on the region. Your own storage quantities can be reduced if you have binding contracts with a supplier for subsequent deliveries. In such cases, the supplier should be able to provide evidence of appropriate storage facilities.

Based on theoretical calculations and studies, the Federal Ministry of Transport has developed and published guideline values for storage quantities depending on the geographical and climatic location (Guidelines for the dimensioning of road salt storage facilities, TAUSALA).

The total capacity for brine should be at least sufficient to cover several days of full use, taking into account delivery or production times. Details and specifications can be found in the "Guidelines for the procurement and operation of brine systems for winter road maintenance" (H SolA).

For a better overview of stocks and to ensure that replenishments are ordered in good time, warehouses and silos can be equipped with automatic stock recording and reporting systems. If the storage facilities are shared by several people, this also facilitates mutual billing.

3.4.2 Grit storage in the network

In addition to storage in the central building yard or maintenance depot, additional decentralised gritting material storage facilities may be useful. Their necessity and locations are determined by the operational planning. For the various applications, it must be checked whether and where the vehicles need to be reloaded during operation. If these reloading points are not located near the central gritting material storage facility, the establishment of reloading stations should be considered. Alternatively, it should be examined whether the need for reloading can be avoided or moved closer to the central storage facility by changing routes or increasing loading capacity.

Decentralised support centres can also be used to station your own vehicles and/or deploy rented vehicles from there.

Support points are particularly economical if they serve several vehicles or even several master craftsman districts for reloading. In this respect, locations on the border between two or more districts and locations at special altitudes are often suitable.

3.4.3 Storage of road salt

Solid gritting materials can be stored in salt barns or in high silos. The best storage option depends on the space available and an economic assessment. The analysis should include not only the construction and operating costs of the storage facility itself, but also the costs of the spreading material and their storage, as well as the operational and economic costs of winter service operations and, if applicable, supply security. A combination of barns and silo storage is also possible.

Gritting materials must be stored in a dry place. For indoor storage, a maximum moisture content of 2 % is permissible, while for silo storage, this must not exceed 0.6 % (dry salt in accordance with DIN EN 16811-1).

When storing de-icing materials, ensure that the de-icing material storage facilities are adequately protected against corrosion.

Information on the dimensioning of de-icing agent storage facilities, the correct choice of storage type for optimised loading, and the design and material of the storage facilities can be found in the "Information on the storage and loading of gritting materials for winter road maintenance" (H LaStreu).

Containers may be set up on roads, squares, particularly hazardous locations (grades), pavements and pedestrian crossings for the storage of gritting materials for local use by road users. A container capacity of 0.5 m³ to 1 m³ is recommended.

3.4.4 Storage and production of brine

If pre-wetted salt and/or brine is used, a facility for storing, preparing or producing brine is required.

Brine can be produced from dry salt and water, or a concentrated salt solution can be purchased and diluted immediately after delivery. At bases or where solution consumption is low, it may also be more economical to purchase the solution ready for use or to transport it from the central location to the base, so that only one tank is required there.

To minimise refuelling times, the salt solution or mixing systems should have a sufficient water supply and high pump capacity. Furthermore, the hoses and tank nozzles should have a sufficient diameter.

It is recommended to set up the solution tanks near the dry salt loading stations so that loading can take place at the same time. Combination systems consisting of silos and solution tanks offer great advantages here, whereby several loading points next to each other are also advantageous depending on the number of vehicles to be serviced regularly.

Further recommendations and specifications can be found in the "Guidelines for the procurement and operation of brine systems for winter service" (H SolA).

3.4.5 Grit loading equipment

Powerful equipment is required for loading the gritting vehicles and for storing and transferring the gritting materials. Wheel loaders, telescopic loaders or stationary systems (e.g. gantry cranes) are recommended.

Wheel loaders must have sufficient unloading height to be able to load mounted spreaders without any problems. They can also be used for storing and transferring gritting materials in the hall.

A loading device is not required for high silos, as the vehicles drive under the silo and are loaded directly from there (see H LaStreu).

3.5 Special measures

3.5.1 Road heating

Traffic areas can also be kept free of ice and snow by means of heating. Systems developed to date (surface or storage heating) use fossil or electrical energy sources, district heating or geothermal energy with the aid of heat exchanger systems. Heat storage systems are less economical than direct heat utilisation (geothermal energy).

Due to the high construction costs (investment in the use of geothermal energy) and very high operating costs (energy costs for direct heating), the use of heated traffic areas is limited to special cases (e.g. steep ramps to car parks, tunnel ramps, bridges or special footpaths).

Heating can be economical if, on sections of road with a high risk of slipperiness (e.g. river or valley bridges), the heating achieves conditions that correspond to those of the surrounding road sections. Special winter maintenance is then no longer necessary for the particularly hazardous section.

3.5.2 De-icing agent spraying systems

De-icing agent spraying systems (TMS) use a stationary hydraulic system with spray nozzles to apply a brine to the road surface. Spraying can be triggered automatically by sensors (see section 5.3.3) or manually as required. TMS can react immediately and more quickly than gritting services to forming ice and are therefore particularly suitable for use at locations with a high risk of ice (bridges). Due to the high investment costs, they are mainly used on heavily used and important roads where traffic is severely disrupted or comes to a road blocking in icy conditions. Application criteria and detailed questions regarding the planning and implementation of TMS are compiled in the "Information sheet for the planning, construction and operation of de-icing spraying systems (TMS)". According to this, a detailed economic feasibility study must be carried out in each individual case. The economic efficiency of such systems decreases with increasing use of preventive gritting.

4 Vehicles for winter maintenance

In winter service, trucks, equipment carriers and tractors are used as carrier or towing vehicles for spreaders, snow ploughs, sweepers and snow removal machines. The machines can be used individually or in combination.

The requirements for winter maintenance vehicles are specified in:

- DIN 30701: Municipal vehicles; general requirements
- DIN 30707-2: Machines for winter maintenance – Part 2: Requirements for winter maintenance vehicles with snow ploughs

When purchasing vehicles, it must be ensured that, in combination with the intended attachments and superstructures, the permissible axle loads, in particular the permissible front axle load of the vehicle, are observed in addition to the permissible total weight when fully loaded.

For use on footpaths and cycle paths, in addition to the permissible total weight, the specific surface pressure of the tyres or the tyre pressure and the vehicle dimensions may also be of influence.

The required drive power depends mainly on:

- the total weight of the loaded spreader and its power requirement, if this has to be covered by the vehicle's drive motor
- the clearing width, the type and weight of the clearing device and the desired clearing speed
- the weight of the snow clearing machine and its power requirement, if this has to be covered by the vehicle's drive motor
- the gradients to be negotiated during operation

Four-wheel drive combined with differential locks enables optimum power transmission to the road. In addition, throw-on snow chains (skid chains), which can be engaged when necessary, can be useful.

Winter service vehicles and machines used in road traffic must be marked in accordance with the "Information sheet for winter service vehicles" issued by the Federal Ministry of Transport.

According to this, the marking must include:

- Red-white-red warning markings
- Equipment with yellow flashing lights
- Paintwork in a conspicuous colour (usually RAL 2011); vehicles that are rented when required are exempt from this requirement.

The following additional equipment is recommended for winter service vehicles:

- Voice radio or mobile phone
- Up to two additional work lights to improve visibility in the clearing area and two additional direction indicators on the long sides of the vehicle
- Devices for monitoring the gritting process and the area behind the vehicle (camera, additional headlights)
- Heated windscreen and heated exterior mirrors
- Tachograph or on-board computer that records the use of clearing and gritting machines

The following standards must be observed for the attachment and installation of winter service machines:

- DIN EN 15432 "Winter and road service area equipments – Mechanical interface on vehicles for front-mounted machines – Interchangeability" regulates the standardisation of front mounting plates
- DIN EN 15431 "Winter and road service area equipments – Power transmission and control of attachments – Interchangeability and requirements" regulates the drive of winter service machines (hydraulic, PTO or electrical connection)
- DIN EN 15430-1 "Winter and road service area equipments – Data acquisition and transmission – Part 1: Data acquisition in the vehicle" regulates the data interfaces between the vehicle (control panel) and the machines

Further recommendations on drive systems and interfaces can be found in the "Notes on the procurement and use of vehicles and equipment in road maintenance, Part 1: Vehicle-equipment interfaces" (H BEFG-1).

5 Organisation of winter road maintenance

5.1 Operational planning

5.1.1 Necessity of deployment planning

Winter service is only partially predictable in terms of necessity, timing and scope. However, if winter service is required, it must be carried out quickly and smoothly. To ensure this, comprehensive and detailed operational planning is required in good time before the start of winter or the start of operations. Operational planning also serves the purpose of ensuring that winter services are carried out economically and that legal proof of performance is provided to the best of our ability.

The following specifications, usually in the form of plans, are required for operational planning:

- Priority plans
These regulate the division of the road network into priority levels and specify where which gritting materials are to be used in normal operations. They do not have to be drawn up as separate plans, but can also be an integral part of the clearing and gritting plans.
- Clearing and gritting plans
regulate which vehicles plough and grit which routes (or which convoys clear which routes and areas), whereby the order and route should be specified.
- Standby plans (staff deployment plans)
These plans regulate the time period (according to the level of requirements) during which winter services are to be carried out, specify on a daily or weekly basis which personnel are on call or standby at what times, and regulate the alarm system. As a rule, vehicles are also assigned to the personnel.

In addition to winter service on roadways, it is advisable to draw up deployment plans for cycle paths, pedestrian crossings, tram and bus stops, pavements, car parks and public spaces. For cycle paths, the results of the research project “Sustainable promotion of cycling in winter through optimised winter maintenance (WinRad)” should also be taken into account.

It may be helpful to draw up special plans for different scenarios or weather conditions. Examples of special plans include deployment plans for gritting operations on particularly critical sections of road (bridges, uphill and downhill sections, etc.), plans for main arterial roads in towns and municipalities, night-time deployment plans or inspection route plans.

It may also be advisable to make provisions for special winter service and weather situations (e.g. prolonged heavy snowfall).

5.1.2 Priority ranking

In the event of widespread snow or ice, it is not possible to service all routes at the same time. Therefore, traffic areas of particular importance or with particular traffic hazards should be given priority. The road and path network to be maintained must therefore be classified into priority levels according to its traffic importance and the need for early safety measures.

In built-up areas and outside built-up areas, the following criteria are decisive for determining the priority level of a particular section of road:

- Connecting function of the road
Outside built-up areas: motorways, federal, state and district roads
In built-up areas: classified roads, main roads, collector roads, residential roads

- Traffic volume
expressed as average daily traffic (ADT)
- Special traffic
Public transport routes, school bus routes, emergency services (access roads to hospitals, fire stations, etc.), access roads to industrial and commercial areas
- Particularly critical sections
Uphill and downhill sections; dangerous bends, narrow sections, intersections and junctions; locations with a particular risk of slippery conditions (bridges, forest and shaded sections, areas with industrial snow hazards, sections with porous asphalt)

It is also advisable to prioritise car parks, cycle paths, pedestrian crossings and pavements based on traffic importance and the location of danger spots.

When determining the order of priority, it may be advisable to consult with local authorities, the police or transport companies.

Guidance on assessing urgency and drawing up clearance and gritting plans is provided in the “Guidelines for drawing up optimised clearance and gritting plans for winter road maintenance”.

5.1.3 Use of gritting material on roads outside built-up areas

On roads outside built-up areas (including cycle paths), salt (NaCl) should always be used as a gritting material for safety reasons; this should be applied as pre-wetted salt or as brine.

The spreading of abrasives is only suitable for very lightly trafficked, high-altitude roads in snowy areas where a continuous snow cover can be maintained for a long period of time. The effectiveness of abrasives must be checked at regular intervals and the spreading repeated as necessary (re-spreading due to the abrasives being thrown off the road surface).

The use of gritting materials outside built-up areas is only advisable in exceptional cases (particularly low traffic volumes without any particular danger spots or traffic).

5.1.4 Use of gritting material in built-up areas

Within built-up areas, gritting materials are used in accordance with the “differentiated winter service” method. Differentiation means that the same strategy is not used on all roads and in all weather conditions. Instead, the use of gritting materials is differentiated according to the traffic importance of the roads, their layout and the specific local conditions.

Salt is necessary on all roads where, for reasons of traffic safety and traffic flow, a higher level of traction between vehicles and the road surface must be achieved. These are routes with particularly high traffic importance, traffic volumes and special traffic or special hazard locations. As a rule, this corresponds to roads with a statutory gritting obligation (traffic-significant roads with special danger spots). In principle, pre-wetted salt or brine spreading should be used here.

Care must be taken to ensure that a continuous gritting network is created and that gritting boundaries are located at points that are plausible for road users; this also applies to gritting boundaries with neighbouring districts or other road maintenance authorities.

On all other roads and car parks where salt spreading is not necessary, the use of gritting materials should generally be avoided, i.e. clearing should only be carried out when necessary. In very special cases (freezing rain, black ice, extreme frost), gritting may also be advisable on these traffic areas; in these cases, de-icing agents should be used.

The spreading of abrasive gritting materials on roadways should also be avoided in built-up areas. The use of abrasive gritting materials is also only suitable here for very lightly traf-

ficked, high-altitude routes in snowy areas where a continuous snow cover can be maintained for a long period of time. The abrasive gritting must be checked at regular intervals and repeated if necessary (re-gritting due to the gritting material being thrown off the road surface).

Salt should be used on cycle paths where gritting is mandatory (roads with significant traffic). Pre-wetted salt or brine should always be used for this purpose.

The use of de-icing agents is recommended on pedestrian crossings to combat slipperiness there in the long term.

There is a general gritting obligation on pavements in built-up areas. In snowy conditions, this can usually be fulfilled with de-icing agents. De-icing agents are also required here at particularly hazardous locations (stairs, slopes) or in special weather conditions (black ice, frost, freezing rain).

5.1.5 Clearing and gritting plans

Clearing and gritting plans (for spreading and spraying) must be drawn up to regulate the winter service operation. These plans specify which vehicles are to be used and which routes they are to clear or grit in which order; as a rule, the route must be specified in detail, including access routes, turning points and empty runs during the operation. The route can be specified to the driving personnel in graphical form on a site plan and/or as a list. Alternatively or in addition to this, route guidance via an on-board computer is also possible.

The clearing and gritting plans should generally be drawn up separately for clearing and gritting, for the most common regular operations. In addition, operational plans for frequently occurring special operations (e.g. "minor winter service", hazardous locations, high altitudes) may be useful in individual cases.

It also makes sense to separate clearing and gritting because, when clearing, each lane must be serviced individually due to the clearing width, whereas when gritting, the entire continuous carriageway can be gritted asymmetrically in one go. Asymmetrical gritting has the advantage that all routes can be cleared more quickly and shorter deployment times are possible. In addition, it ensures that the gritting material is distributed evenly across the road without gaps or overlaps.

The clearing and gritting plans must be updated regularly in good time before the start of winter; they should be systematically reviewed and revised at longer intervals. The clearing and gritting plans should be systematically revised in the event of major changes. The "Guidelines for the preparation of optimised clearing and gritting plans for winter road maintenance" published by the Federal Ministry of Transport can serve as guidance and assistance.

In doing so, the specifications (network specifications, operating specifications and traffic specifications) must be systematically compiled, empty runs during operations must be minimised and the servicing of routes must be optimised according to their urgency. Care should be taken to coordinate winter services across districts, including with other road authorities. The establishment of operational detours can also shorten turnaround times and minimise empty runs, especially on motorways and dual carriageways.

When drawing up clearing and gritting plans, the resulting distances for gritting routes (or clearing routes) and for empty runs (including arrival and departure routes) must be determined. Based on the distances to be covered, the time required for the route must be estimated and compared with a specified maximum turnaround time.

The cycle time is the time within which a winter service vehicle has cleared and gritted or only gritted the route assigned to it, returned to the starting point and is ready for the next

assignment (i.e. reloaded). After the cycle time has elapsed, a follow-up assignment must be immediately feasible. The turnaround times are based on the specified requirement level and may vary for clearing and gritting.

The Federal Ministry of Transport has specified the following cycle times for curative operations on federal trunk roads in the service specifications for road operations on federal trunk roads, which have been adopted by the federal states for the roads within their jurisdiction:

Gritting operations

Motorways and federal roads that are connected to the motorway network the motorway network traffic function	2 hours
Other important roads for inter-regional traffic	3 hours

Area operations

Motorways and federal roads that, in conjunction the motorway network traffic function	3 hours
including continuous carriageways within	2 hours
Other important roads for interurban traffic	3 hours

These values can also serve as a guide for local authorities, including for cycle paths.

These circulation times do not apply to preventive operations with brine; the operation must simply be completed before the expected formation of ice.

If no own evaluations of driving speeds in practical use are available, the following average speeds can be used to estimate the time required for winter maintenance operations:

Municipal winter service:	20 km/h for area operations and gritting operations
Roads outside built-up areas:	35 km/h for gritting operations 25 to 30 km/h for clearing operations
Motorways:	50 to 60 km/h for gritting operations 35 to 40 km/h for clearing operations

These values are approximate average speeds for the entire operation, including all empty runs and lost time, i.e. they should be regarded as travel times. High proportions of empty runs increase average speeds, while extreme conditions (steep gradients, heavy snowfall, bottlenecks, traffic jams, many town crossings) can reduce them. Pure reloading times (at the depot or base) must be added to the cycle time.

For cycle paths, the achievable average speeds depend on the condition of the infrastructure and the vehicles used; the maximum speed achievable here is 20 km/h.

5.2 Staff deployment plans

Staff deployment plans must be drawn up, agreed and communicated to staff in good time before the start of winter. Standby times, deployment times and alarm routes and procedures must be specified. The specific standby arrangements are then made at short notice in winter. If additional personnel are required from other areas, their availability must be arranged in good time and they must be instructed accordingly. This also applies to support personnel who are not directly involved in winter service but are necessary for its functioning (e.g. workshop personnel).

The maximum working hours and minimum rest periods specified in the Working Hours Act must be observed; these may only be exceeded or fallen short of in justified exceptional cases in practical application.

5.3 Work before the start of winter

5.3.1 Drawing up and reviewing deployment plans

Work schedules must be drawn up in good time before the start of winter, i.e. clearing and gritting plans should be reviewed and updated if necessary, standby plans should be drawn up and discussed with those responsible. It may be advisable to inform third parties (e.g. police stations) of these plans. The coordination of gritting limits and cross-district operational planning with neighbouring districts and other building authorities should be regularly reviewed and documented.

Changes due to long-term work sites, road closures or traffic restrictions must also be taken into account in the plans if necessary.

New or amended clearing and gritting plans should be checked and tested with a fully equipped emergency vehicle before the start of winter; the same is recommended for new drivers so that they can familiarise themselves with their plans. This will help to avoid difficulties during the first winter service operation.

When using external vehicles for winter service, contracts must be concluded in good time and appropriate arrangements made (briefing, alerting, deployment plans).

A “mass test” can also be used to check the entire organisation and procedures, in which a complete operation is simulated before the start of winter.

5.3.2 Preparation of vehicles and machinery

One of the most important preparatory measures for the proper performance of winter service is the care and maintenance of vehicles and machinery.

A functional check of all vehicles and machines, including those used by external companies, must be carried out in good time before the start of winter, including a trial installation (e.g. snow ploughs). It is particularly important to check the gritting machines for dosing accuracy and the spreading pattern. Each machine must be inspected before the start of winter (see section 3.3.3 and H BEFG-3). This inspection should be repeated during the winter (e.g. in periods without winter service), and in any case if functional defects are suspected or if other gritting materials or grit sizes are used.

5.3.3 Gritting material storage

Gritting materials for winter road maintenance must be procured and stored in good time; this also applies to salt solution and the storage of gritting materials at depots, as well as the installation and refilling of gritting containers along the route. The condition of the gritting materials stored in the halls and the functionality of the gritting silos, salt solution systems and equipment for loading the vehicles must be checked before the start of winter.

In order to ensure the timely delivery of gritting materials and salt solution during winter service when required, supply contracts must be concluded with appropriate companies in good time before the start of winter.

5.3.4 Training and instruction of personnel

Effective, economical and environmentally friendly winter road maintenance requires competent personnel, including the personnel of external contractors. This requires regular training of personnel. In addition to reviewing familiar regulations, procedures and organisational guidelines before the start of winter, it is also important to teach new techniques and findings for winter road maintenance. All levels involved in the provision of winter services

should be trained. Due to the different tasks involved, training courses for staff should focus on different areas, with practical instruction and exercises being particularly important for winter service personnel in addition to theoretical training elements.

The following topics are particularly important for training:

- Weather forecasts and weather observations, relationships between weather conditions and winter road maintenance
- Basics of winter service, ice formation and the use of gritting materials
- Areas of application and effectiveness of FS30 and FS100, correct dosage of gritting materials
- Measures for the economical use of gritting materials
- Deployment plans, deployment procedures and records
- Vehicles and machines, machine operation including practical exercises
- Experiences from last winter (statistics, special features, summary)
- Innovations for the coming winter (new machines, plans, regulations, findings, etc.)
- Information on particularly critical sections of road (e.g. porous asphalt surfaces, bridges particularly prone to slippery conditions)
- Information on occupational safety

Drivers assigned to winter service vehicles (including substitutes) must have sufficient driving experience to be able to drive the vehicles safely in winter conditions. If necessary, driver training should be provided before the start of winter.

Further information and suggestions on the organisation, preparation and implementation of training courses for winter service personnel can be found in VKS Information No. 62 "Training for winter service".

5.3.5 Public relations

In addition to all the technical preparations that ensure the proper and smooth running of winter service, public relations work should not be neglected. In addition to information about the nature and implementation of winter service and its limitations, information about appropriate driving behaviour for road users in winter is particularly important for road safety.

The following objectives apply to public relations work in winter service:

- Explaining responsibilities,
- Explaining winter service obligations and also "non-obligations", i.e. not all roads and traffic areas are given priority or are serviced at all, especially municipal roads (categorisation, urgency).
- Describing the activities, difficulties, conflicts, competing interests and approaches to resolving them, as well as the limitations of winter service.
- Informing citizens about their obligations,
- Promoting the use of appropriate equipment and careful driving in winter.

In addition to press releases (shortly before or at the start of winter service operations), other media and working materials such as radio and television interviews, internet presentations, winter service leaflets, posters, videos or films should also be used to inform the public about winter service. The possibilities offered by social media should be exploited. Press releases prepared before winter and containing all the important information can also be used during the winter to respond to enquiries.

The success of public relations work should be monitored on an ongoing basis to check the extent to which the information is reaching its target audience. Further information on this can be found in the VKU internet information sheet “Public relations for winter road maintenance”.

5.3.6 Raising awareness among road users

According to the provisions of the Road Traffic Regulations (StVO), road users must adapt their equipment to winter conditions. This can be supported by those responsible for winter road maintenance by disseminating reports and forecasts on winter conditions via the media.

Just like their equipment, road users must also adapt their driving style to winter conditions. Timely traffic and road condition reports and forecasts can also be helpful here, as can signage at locations that are prone to particularly slippery conditions or unexpected slipperiness in winter or that are particularly difficult to drive on.

5.3.7 Supporting measures by traffic authorities

On particularly critical and snow-prone routes, temporary snow chain requirements may be imposed. However, there should also be stopping areas where chains can be fitted and removed.

At particularly critical points, especially on longer uphill stretches in snowy areas, a temporary restriction on truck traffic should be considered. It is conceivable to stop truck traffic or all traffic for a short time until the critical stretch has been cleared and gritted. However, this requires adequate storage space. Another measure could be route-specific truck bans, in which case an efficient alternative route must be available.

Such measures must be coordinated with the traffic authorities and the police at an early stage and require good logistical preparation and implementation.

A temporary ban on trucks overtaking in snow and black ice generally applies to trucks over 7.5 tonnes in accordance with road traffic regulations. A lane closure for trucks over 7.5 tonnes may also be imposed on the left-hand lane(s) on specific routes.

5.3.8 Other preparations

Traffic signs indicating particularly critical locations (sign 101 StVO with additional signs for snow and ice) must be set up in good time before winter.

In snowy areas, snow signs should be set up at the edge of the road in good time at locations where large amounts of snow can obscure the course of the road. It is also recommended that road drains be marked with snow signs.

Snow fences must be set up in good time at locations at risk of snow drifts and the necessary agreements must be concluded with the property owners.

5.4 Road condition and weather information

5.4.1 Weather conditions and developments

For effective and economical winter road maintenance, knowledge of the current weather conditions and their further development, as well as the road conditions, is crucial for making appropriate decisions on the deployment and control of winter road maintenance.

The actual large-scale and small-scale monitoring of weather conditions is the responsibility of the meteorological services. Close cooperation between the authorities responsible for winter service and the weather services is therefore important.

The following forecast products and data from meteorological systems are available to those responsible for winter road maintenance:

- Own measuring stations (road weather stations (RWIS), meteorological weather stations),
- Road weather forecasts from meteorological services,
- Road weather warnings,
- Precipitation radar images and their expected development in the future,
- Satellite images.

The following data can also be used:

- Data from mobile measuring vehicles or emergency vehicles,
- RWIS data from neighbouring districts or building authorities,
- Information exchange with the meteorological service,
- Exchange of information with other winter service organisations (neighbouring maintenance depots/building yards), police stations and airports.

5.4.2 Road condition monitoring

The most important sources of information for monitoring road conditions are road weather stations. Video cameras are also useful for visual observation of road conditions. In addition to these technical aids, on-site checks are also useful in certain situations. The scope and type of inspection trips should be tailored to the availability and quality of the technical information available.

Road weather stations are fixed installations with devices for recording, transmitting, storing and displaying current weather and road condition parameters. The parameters are recorded at one or more measuring points using sensors on and next to the road.

The measurement results from road weather stations serve as a decision-making aid for the targeted implementation of winter road maintenance by road maintenance departments/building yards and also provide a basis for forecasts of possible ice formation by meteorological services as part of a road condition and weather information system.

The measuring points are usually installed at locations within the maintenance network that are particularly prone to slippery conditions or are characteristic of winter weather. An analysis of the local microclimate is useful for determining the position. Requirements for road weather stations and recommendations for the positioning of measuring points and the arrangement of sensors in the road cross-section are laid down in the “Guidelines for the planning, installation and operation of road condition and weather information systems” (H PEB SWIS) and DIN EN 15518-3 “Requirements for stationary sensors”. The requirements for data transmission are regulated by the “Technical Delivery Conditions for Road Stations (TLS)”.

5.4.3 Road condition and weather information systems

The European standard DIN EN 15518-1 describes all components of road condition and weather information systems (SWIS). Possible specifications for road condition and weather forecasts are contained in DIN EN 15518-2.

A road condition and weather information system (RWIS) links the measuring points (road weather stations) installed on roads for road condition and environmental data and makes them available to meteorological services. RWIS covers detailed short-term (up to 24 hours) to medium- and long-term road condition and weather forecasts (longer than one week), some with a high degree of spatial and temporal differentiation. The short-term forecasts

should be updated continuously by the meteorological services (at least every 6 hours). These forecasts are a good decision-making aid for winter road maintenance and should therefore be used. Details about SWIS can be found in the H PEB SWIS.

In order to optimally meet winter traffic requirements while improving and rationalising winter road maintenance, the comprehensive and cross-border use of a road condition and weather information system (RWIS) is necessary. The use of RWIS enables faster and more targeted, and in particular preventive, winter service operations, which are in the interests of road safety and performance and also protect the environment through the use of appropriate gritting quantities.

In addition, the reduction in inspection trips and the proper planning and alerting of standby personnel optimise the organisation of winter road maintenance services, resulting in significant savings.

5.4.4 Road Weather stations

To supplement the forecasts provided by weather services, weather stations can be set up in the municipal building yard or maintenance depot, free of obstacles and able to record environmental data without interference, to monitor weather conditions. Road Weather stations should record at least the following parameters:

- Air temperature
- relative humidity
- Precipitation

These measurement results should also be documented so that weather conditions can be traced at a later date.

5.4.5 Mobile data collection

In addition to stationary data collection, mobile data collection with moving vehicles is also possible. Especially when vehicles with infrared sensors are used to adjust the spreading quantities to the road surface temperature, it makes sense to transfer this temperature data online to the control centre and archive it. This provides an up-to-date overview of the condition of the network and supports operational planning. In addition, the archived data can be evaluated later and used for network-related temperature forecasts.

Since any necessary inspection trips should always be carried out with a loaded gritting vehicle, these can then also serve as measurement trips.

The temperature profiles can be used to identify particular cold spots and existing temperature differences in the network. In conjunction with your own winter service experience, this can be used to derive recommendations for the locations of road weather station measuring points or route-specific ice forecasts. The profiles can also be used to support operational control by specifying route points that require particular attention or monitoring during operations. Special gritting densities can then be included in the deployment plans for these points. Today, it is also technically feasible to transmit this information directly to the gritting vehicles during deployment.

Individual trips in a few different weather conditions (thermal mapping) do not provide the detailed information on the various weather conditions that is possible with continuous thermal recording.

5.5 Operation management

5.5.1 Operations management

The person responsible for organising and carrying out local winter road maintenance can delegate the task of operations management to a subordinate person as operations manager, either permanently or for specific times (e.g. at night or on weekends). Operations management can be divided into areas or sectors (e.g. roads, pedestrian areas), especially in municipalities.

The tasks, competences and responsibilities of the operations management should be set out in writing.

- The operations management generally has the following tasks:
- Monitoring and assessing the weather situation and weather developments,
- Monitoring and assessing the condition of traffic areas,
- Triggering the operation by alerting personnel and external companies,
- Determining the nature of the operation (operation plan and scope of the operation)
- Specifications for the spreading density to be applied,
- Monitoring of winter service operation,
- Ensuring random checks on site,
- Contact person for the police and third parties,
- Intervention in special events (e.g. vehicle breakdown), coordination of special operations, allocation of vehicles and personnel in such cases,
- Documentation of winter service operations and the measures taken by the operations management (see the above points or section 5.4.2).

If inspection trips are necessary at critical points to check the road conditions, these inspections should be carried out with a gritting vehicle so that gritting can be carried out immediately on site if necessary.

The ongoing monitoring of the stock levels of gritting materials and brine and the timely reordering of these materials should be regulated.

5.5.2 Practical deployment procedure

Curative winter service should begin as soon as possible after the formation of slippery conditions or when snowfall begins. Preventive gritting is recommended when, based on the road condition and weather forecast, slippery conditions are highly likely and can be predicted relatively accurately, i.e. in the event of expected black ice, hoarfrost or freezing rain. Preventive gritting can prevent this slippery conditions and should generally be carried out using brine. If pre-wetted salt is used for this purpose, gritting should be carried out as shortly as possible before the expected formation of slippery conditions.

In the event of snowfall, clearance must begin even when snow depths are low. This means that vehicles with ploughs attached must be deployed as soon as snowfall is forecast, even if only gritting is initially planned. In the event of persistent snowfall, gritting is necessary in the falling snow, as gritting in the snow keeps it clearable (see section 2.1).

The necessary spreading density for salt spreading depends primarily on the expected temperature and the road conditions (see section 3.2.2.5, Figure 8). Consequently, the spreading density cannot be specified in absolute terms for all operations or for an operation covering the entire network. The operations management specifies the standard spreading density for the respective application; the actual spreading density can then be varied by the driving per-

sonnel on site depending on the situation. Vehicles with road surface temperature measurement and automatic spreading density adjustment can provide support in certain weather conditions.

Furthermore, care must be taken to ensure that the driving personnel continuously adjust the spreading width and position to the road surface during operation so that the spreading is neither too narrow nor too wide. Spreading too widely not only leads to unnecessary consumption of gritting material, but also causes the gritting material to be thrown where it should not go (roadside vegetation, skidding against parked vehicles). However, spreading too narrowly can cause parts of the road to remain slippery and create a hazard. When spreading, the entire width of the carriageway should always be covered at the same time, both on two-way carriageways (asymmetrical spreading) and on dual carriageways. With spreading data recording and satellite navigation, it is possible to program spreading plans with spreading widths and positions and control them automatically while driving.

5.5.3 Operational data recording

5.5.3.1 Necessity of data collection

In winter service, traceable documentation of all operations is essential. The reasons for this are:

- Proof of the effectiveness of the organisation and the winter service activities carried out from a liability perspective (see section 1.2)
- Proof of the quantities of grit used and their necessity
- Basis for subsequent review and improvement of deployment plans,
- Analysis and evaluation of operations and their processes,
- Proof and review of the cost-effectiveness of winter service,
- Billing basis for external companies used,
- Billing basis with other construction authorities,
- Basis for winter service statistics for internal purposes and, if necessary, for accountability reports to higher authorities.

5.5.3.2 Scope of data collection

The following data should be recorded by the driving personnel of a winter service vehicle or the driver of a convoy, unless this has already been recorded centrally:

- Date of deployment,
- Vehicle number or registration number,
- Operational district/route, Journey according to schedule or deviations from schedule,
- Mileage/kilometres driven,
- Weather conditions and road conditions,
- Type of gritting material (FS30/FS100, salt/de-icing agent), total amount of material spread, reloads,
- Set spreading densities,
- Set spreading widths,
- Information on clearing (yes/no, device),
- Most important times with respective locations during the journey and
- Special incidents.

The following data should also be recorded by the operations management:

- General data on weather, air temperature, road conditions and how these developed
- Checks carried out and their findings
- General operational data for the entire operation (start, end, operational plan, gritting density if applicable)
- Alerts and start of operations for individual vehicles/work groups
- Information from third parties and to third parties (e.g. telephone calls with the police, public transport control centres, other units involved in winter road maintenance)
- All essential specifications and decisions made

5.5.3.3 Type of data collection

In principle, all this data can be recorded manually. However, thanks to modern information technology, a large proportion of the data can now be recorded automatically, which can significantly reduce the workload of drivers and operations managers. This also ensures a high level of accuracy and reliability in data collection.

The following automated recordings are possible:

- Recording of weather developments and forecasts via the RWIS system
- Documentation of current weather data and road conditions via weather stations, road weather stations and, if necessary, via emergency vehicles
- Documentation of data collected from the vehicle via on-board computers, whereby the position of the vehicle can be documented via satellite navigation systems. The on-board unit can also be used for navigation via pre-programmed gritting plans.

Information and recommendations on automated data collection can be found in VKS Information No. 47 “Automatic data collection in winter road maintenance – recommendations”.

5.5.4 Winter maintenance centres

In addition to the usual organisation of local operations centres (workshops, municipal building yards, etc.), it is possible to collect and distribute data and information and, if necessary, coordinate across districts by setting up higher-level winter service centres.

However, a central office cannot have the necessary detailed knowledge of local and micro-climatic conditions for all road networks. Due to the large amount of data and information, this winter service centre cannot control or monitor local winter services. Above all, it can significantly reduce the need for master workshops to monitor weather and road conditions themselves and can support local operations management, but it cannot replace it.

Winter service centres collate data from all road weather stations in the region as well as all weather and RWIS information. Specially trained personnel interpret and analyse the collected data. The centre is in constant contact with local operations centres, provides weather information and, if necessary, road condition data, alerts them when operations are required, coordinates interregional operations if necessary and, conversely, receives information from local operations centres about ongoing winter service operations.

Further information can be found in the working paper “Setup and operation of winter service centres”.

5.5.5 Winter maintenance management systems

The establishment of winter maintenance management systems is becoming increasingly important.

The purpose of such systems is to utilise and integrate all available and useful technical options in winter road maintenance in order to support and optimise operational organisation and control by means of IT-supported forecasts and calculations. At the same time, documentation and billing can also be supported.

5.6 Winter maintenance in tunnels

Winter maintenance is considerably more difficult in tunnel portals.

Snow clearance is difficult in that there is often little space available in front of the portals for snow to be deposited due to trough sections or structural restrictions, and the safety equipment at the portals must be kept clear (accessibility of emergency walkways, visibility of guidance systems, usability of central reservations, access to portal control cabinets, keeping access routes to staging areas and operating buildings clear, and ensuring that barriers are in working order).

Therefore, when planning tunnels and their facilities in the portal areas, sufficient space must be provided for snow storage, especially in snowy locations.

It is often unavoidable that snow is carried into the tunnel by the snow clearance vehicles themselves, by moving traffic or by wind. Snow must therefore be cleared and gritted right into the tunnel.

In addition, shading and hypothermia caused by cold air currents in the portal areas can lead to dangerous icy conditions more quickly than on the open road. These areas are already critical for traffic because icy conditions can occur suddenly and unexpectedly for road users when exiting the tunnel.

For the reasons mentioned above, the portal areas require special treatment during winter maintenance. They must be checked particularly carefully for possible ice formation and then treated early, preferably preventively. Road weather stations and, if necessary, de-icing spray systems can support winter maintenance in this regard. In individual cases, road heating in the portal areas may be advisable, especially in urban areas where the tunnel ramps have relatively steep gradients and can therefore cause problems in icy conditions.

Furthermore, when planning winter road maintenance operations, rescue routes and access routes for emergency services to the tunnel must be taken into account so that they remain passable and usable at all times, even in winter.

Further information on the operation of road tunnels is contained in the leaflet on the maintenance and operation of road tunnels.

6 Cost-effectiveness of winter road maintenance

The economic efficiency of winter road maintenance can be assessed on two levels: operational efficiency, which is determined by the direct operating costs of winter road maintenance, and economic efficiency for the general public (economic efficiency), which takes into account not only the direct operating costs but also the economic effects and follow-up costs; the latter are not quantifiable in all cases, particularly in terms of environmental impacts.

The operating costs consist of:

- Costs of gritting materials (procurement, storage and loading)
- Follow-up costs of spreading abrasive materials (recovery and disposal or treatment)
- Costs of vehicles and machinery (procurement/depreciation, maintenance, operating costs)
- Personnel costs (deployment and standby, training) including ancillary personnel costs
- Costs of preparatory measures and winter service management
- Costs for the use of external companies
- Costs of fixed winter service equipment (road weather stations, de-icing spray systems, road heating systems) including regular maintenance and inspection

The following costs and effects must be taken into account in the national accounts:

- Operating costs of winter service (see above)
- Change in vehicle operating costs for road users after dispersion through avoidance of congestion, fuel savings, time savings due to higher travel speeds
- Savings in accident costs and accident-related costs
- Impact on the economy: avoidance of production losses in the economy as a result of delays to employees or production goods to be delivered by road, loss of revenue in the transport industry
- Costs of environmental pollution caused by the production and transport of gritting materials, damage to plants, water, soil, vehicles and buildings, and changes in pollutant emissions from traffic and commercial vehicles

The costs of environmental pollution cannot be quantified across the board, especially since the effects of winter road maintenance are often very difficult to separate from other forms of environmental pollution (e.g. pollutants).

The economic savings resulting from winter road maintenance have been demonstrated in various studies and compared with the operational costs of winter road maintenance. These studies show that the use of road salt results in significant economic gains on motorways, all non-urban roads and trafficked urban roads. Minimising the time between the onset of slippery conditions and the spreading of salt leads to significant savings in operating costs for traffic and accident costs, so that early and effective use, especially as a preventive measure, makes economic sense.

Technical regulations

FGSV publications

- Structure and operation of winter service centres; working paper, 2007 edition
- Information sheet for the planning, construction and operation of de-icing spray systems, 2009 edition
- Working paper "Notes on the transfer of winter service duties to residents", 2015 edition
- Temperature-controlled gritting material dosing – Recommendations and information on technical requirements and gritting material dosing; working paper, 2015 edition
- Notes on the procurement of de-icing and de-icing agents for winter road maintenance (H BeStreu), 2017 edition
- Notes on the planning, installation and operation of road condition and weather information systems (H PEB SWIS), 2019 edition
- Notes on the storage and loading of gritting materials for winter road maintenance (H LaStreu), 2020 edition
- Notes on the procurement and operation of brine systems for winter road maintenance (H SolA), 2021 edition
- Winter service on roads with asphalt surface layers made of porous asphalt (AP WD OPA), working paper, 2022 edition
- Notes on the procurement and use of vehicles and equipment in road operations (H BEFG):
 - Part 1: Vehicle-equipment interfaces, 2017 edition
 - Part 2: Snow ploughs, 2020 edition
 - Part 3: Gritting machines, 2022 edition
- Guidelines for the practical application of FS100 in winter road maintenance (H FS100), 2024 edition
- Practical recommendations for effective clearing and gritting in winter road maintenance, with supplementary information and explanations; working paper, 2024 edition

Information documents from the VKU/VKS

- Winter service on cycle paths/winter service on pedestrian crossings, VKS Information 35; 1998 edition
- Automatic data collection in winter road maintenance – recommendations, VKS Information 47; 2001 edition
- Differentiated winter road maintenance in municipal areas, VKS Information 52; 2003 edition
- Training for winter road maintenance, VKS Information 62; 2005 edition
- Effective winter service in municipal areas, VKS Information 79; 2013 edition
- Winter road maintenance for cyclists, VKS Information 99, 2020 edition
- Public relations in winter road maintenance, VKU Internet Information 2023

Publications of the Federal Ministry of Transport

- Information sheet for winter service vehicles, Federal Ministry of Transport, Building and Urban Development, letter StV 13/36.25.60-04 dated 7 October 1996, VkB1. Issue 20, 1996, No. 184. pp. 528-529

- Guidelines for the dimensioning of road salt storage facilities (TAUSALA guidelines), 2019 edition
- Performance specifications for road maintenance on federal highways, Part 5 Winter service, 2023 edition
- Research on Road Construction and Road Traffic Engineering, Issue 461: Development of guidelines for the preparation of optimised clearing and gritting plans for winter road maintenance (Durth, W. and Hanke, H., 1986)
- Research on Road Construction and Road Traffic Engineering, Issue 548: Optimisation of operational planning for winter road maintenance in cities and municipalities (Durth, W. and Hanke, H., 1987)

Publications of the Federal Highway Research Institute (BAST)

Booklet V379: Sustainable promotion of cycling in winter through optimised winter road maintenance (WinRad)

DIN standards

- | | |
|--------------|--|
| DIN EN 15144 | Winter service equipment – Terminology – Terms relating to winter service |
| DIN EN 15430 | Winter and road service area maintenance equipments – Power system and related controls –
Part 1: Data acquisition in the vehicle
Part 2: Protocol for data transfer between the information provider server and the client user server |
| DIN EN 15431 | Winter and road service area maintenance equipments – Drive and control systems for attachments – Interchangeability and performance |
| DIN EN 15432 | Winter and road service area maintenance equipments – Mechanical interface on vehicles for front-mounted equipments – Interchangeability
Part 1: Fixed front mounting plates
Part 2: Interchangeability on lifting systems |
| DIN EN 15518 | Winter maintenance equipment – Road weather information systems
Part 1: General definitions and components
Part 2: Road weather – Recommended observation and forecasting
Part 3: Requirements for measured values from fixed installations
Part 4: Test procedures for stationary installations |
| DIN EN 15583 | Winter maintenance equipment – Snow ploughs
Part 1: Product description and requirements
Part 2: Test methods and requirements |
| DIN EN 15597 | Winter maintenance equipment – Spreading and Spraying machines
Part 1: General requirements and specifications for Spreading and Spraying machines
Part 2: Requirements for the distribution of spreading material and their testing |
| DIN EN 15906 | Winter maintenance equipment – Snow removal machines with rotating tools – Specification and clearing performance |
| DIN EN 16330 | Winter maintenance and road maintenance equipment – Power system and related controls – Power hydraulic system and electric interfaces |

- DIN EN 16811 Winter maintenance equipment – De-icing agents
 Part 1: Sodium chloride – Requirements and test methods
 Part 2: Calcium and magnesium chloride – Requirements and test methods
 Part 3: Other solid and liquid de-icing agents – Requirements and test methods
- DIN EN 17106 Road maintenance machinery – Safety
 Part 1: Basic safety requirements
 Part 3-1: Safety requirements for snow throwers with rotating tools
 Part 3-2: Specific requirements for spreaders
- DIN EN 17443 Winter maintenance equipments – Brine production systems – Requirements and test methods
- DIN 30701 Municipal vehicles – General requirements
- DIN 30707 Machines for winter road maintenance
 Part 1: Requirements for motor vehicles for spreading equipment larger than 1.5 m³
 Part 2: Requirements for winter service vehicles with snow ploughs
 Part 3: Data sheet for vehicles and equipment
- DIN 30710 Safety marking of vehicles and equipment
- DIN SPEC 1108 Services in waste and recyclables logistics, street cleaning and winter service
 Part 1: Terms
 Part 2: Requirements for operations and personnel
 Part 5: Winter services

Remarks on the system of technical publications of the FGSV

R stands for regulations:

These publications either specify the technical design or realization (R1) or give recommendations on the technical design or realization (R2).

W stands for information documents:

These publications represent the current state-of-the-art knowledge and define how a technical issue shall be practicably dealt with or has already been successfully dealt with.

Category R1 indicates 1st category regulations:

R1-publications contain the contractual basis (Additional Technical Conditions of Contract and Directives, Technical Delivery Forms and Technical Testing Regulations) as well as guidelines. They are always coordinated within the FGSV. R1-publications – in particular if agreed on as integral part of the contract – have a high binding force.

Category R2 indicates 2nd category regulations:

R2-publications contain information sheets and recommendations. They are always coordinated within the FGSV. Their application as state-of-the-art technology is recommended by the FGSV.

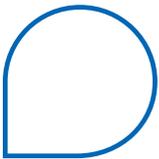
Category W1 indicates 1st category documents of knowledge:

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Tel. +49 (0) 22 36 / 38 46 30

info@fgsv-verlag.de · www.fgsv-verlag.de

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