NWSRG

NATIONAL WINTER SERVICE RESEARCH GROUP

SECTION TEN

TREATMENTS FOR EXTREME COLD

In association with IHE

INSTITUTE OF HIGHWAY ENGINEERS

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CONTENTS

SECTION TEN
Treatments for Extreme Cold

10.1 INTRODUCTION

10.1.1 In this section we will consider extreme cold conditions when more generally available treatments are less effective.

10.1.2 The spreading of sodium chloride without suitable additives are considered to be less effective at or below -5°C at the time of spreading in low humidity conditions (below 100% relative humidity) and at or below -7°C in normal UK winter humidity conditions (at or above 100% relative humidity).

10.1.3 Based on research, the NWSRG consider that -15°C is the lowest practically effective temperature for salt as a de-icer on the road surface. Guidance is provided in this section for the use of alternative de-icers to (or with) salt in extreme cold conditions, including:

- Types of de-icer available
- Storage requirements
- Spreading equipment requirements
- Spread rates and treatment strategies
- Environmental and infrastructure considerations

This guidance is based on operational experience and a review of the available research and literature. However, due to the limited operational experience with these alternative materials in the UK, it is recommended that service providers should carefully monitor their use.

10.2 MUTUAL AID AND RESOURCE SHARING

10.2.1 Due to the cost of providing suitable facilities and equipment for the use of alternative de-icers as well as the cost of the de-icers themselves, consideration may be given to mutual aid and resource sharing within the winter plans of service providers.

10.2.2 However, plans need to be considered very carefully to ensure that an effective, timely service can be delivered in the likely operating conditions and demands on resource which will be present during extreme cold conditions.

10.3 DEFINITION OF EXTREME COLD

10.3.1 For the purposes of this guidance, "extreme cold" refers to weather conditions when **spreading** salt (sodium chloride) alone is not effective for precautionary treatments and/or post treatments.

10.3.2 There are two conditions:

- a) When the combination of temperature and humidity result in salt dissolving too slowly to be effective when it is spread.
- b) When the temperatures are so low that salt is no longer effective in melting or preventing ice forming

10.3.3 Based on research the NWSRG consider -7°C (or -5°C in low humidity conditions) as the lowest practical effective temperature for spreading dry or pre-wetted salt. When precautionary treatments are made below this temperature it is considered that the salt will not enter solution sufficiently rapidly for them to be practical. This is further affected by the humidity. The spread rate can be increased to raise the amount of salt in solution, but when little water is present (e.g. in dry, low humidity conditions), there will be circumstances when this will also be ineffective. Furthermore, increasing the spread rate will have detrimental economical, environmental and resilience implications.

10.4 CONSIDERATION OF ALTERNATIVE DE-ICERS

10.4.1 The guidance given in the Spread Rates section of the NWSRG guide (or other specific guidance that is used by the service provider) should be followed for treatments when the salt can enter solution before the minimum of the air or road surface temperatures are at or below -7°C or -5°C in low humidity conditions. This is typically when treatments can be made earlier in the day and completed at least 2 hours before the temperatures falls below -7°C (or -5°C in low humidity conditions)

10.4.2 While salt can be used to melt ice or compacted snow at temperatures down to -15°C, a lot of salt is required and alternative de-icers should be considered as they are more effective, likely to be more economical while less damaging environmentally and improve resilience

10.4.3 For practical and effective winter service, alternative de-icers should be considered for precautionary treatments when spreading at:

- Temperatures at or below -7°C or
- Temperatures at or below -5°C in low humidity conditions

10.4.4 Alternative de-icers may be used to reduce or eliminate the need to use abrasives.

10.5 SUITABLE ALTERNATIVE DE-ICERS FOR EXTREME COLD

10.5.1 Alternatives de-icers that can be used in extreme cold include:

- Magnesium Chloride
- Calcium Chloride
- Sodium chloride brine mixed with ABP type de-icers
- ABP Liquid (solutions)
- Potassium Acetate
- Calcium Magnesium Acetate
- Ethylene Glycol
- Propylene Glycol

While these de-icers provide benefits over sodium chloride in terms of effective operating temperature, they also may have disadvantages in terms of cost, corrosion, environmental impact and smell. Only those alternatives which are practically effective have been considered.

10.6 ALTERNATIVE DE-ICER TYPES

10.6.1 Guidance is provided in this section on the use of alternative de-icers for both precautionary treatments and post treatments on snow and ice in extreme cold conditions and has been included for the equivalent amounts of salt needed (dry or pre-wetted with sodium chloride brine) under the same extreme cold temperature conditions as the alternative de-icers ***where appropriate***, however their use is not recommended.

10.6.2 The use of salt alone is not recommended as although salt does not become completely ineffective at extreme cold temperatures (down to -15°C or so,) for practical purposes its effectiveness is reduced at these very cold temperatures, even if high spread rates are utilised. Therefore, as temperatures fall below the thresholds for 'extreme cold' conditions, the use of salt alone becomes progressively less economical and practical, as well as leading to increased environmental impacts.

DE-ICER (AS REFERRED TO IN GUIDANCE)	COMPOSITION
Magnesium chloride brine	32% concentration magnesium chloride brine
Calcium chloride brine	28% concentration calcium chloride brine
Brine with ABP - **Sodium chloride brine with ABP**	A blend of 23% concentration sodium chloride brine and ABP *20% sodium chloride, 10% ABP, 70% water*
Brine with ABP - **Sodium chloride and calcium chloride brine with ABP**	A blend of 23% concentration sodium chloride brine, 28% concentration calcium chloride brine and ABP *20% sodium chloride, 1.5% calcium chloride, 10% ABP, 68.5% water*
ABP Liquid	A blend of 32% concentration magnesium chloride brine and ABP *26% magnesium chloride, 13% ABP, 61% water*
Brine with ABP - **Sodium chloride brine with ABP Liquid**	A blend of sodium chloride brine (23% concentration) and ABP Liquid *16% sodium chloride, 10% magnesium chloride, 4% ABP, 72% water*
Sodium chloride brine	20% – 23% concentration sodium chloride brine, used in pre-wetted salting. Use is not recommended in extreme cold temperatures (see below)
Dry rock salt	High spread rates are required and use is not recommended in extreme cold temperatures (see below)

10.7 FACTORS TO BE CONSIDERED WHEN CHOOSING AN ALTERNATIVE DE-ICER

10.7.1 The factors to consider when choosing an alternative de-icer should include:

- Performance for precautionary and reactive treatments
- Local road conditions and temperatures
- How the de-icer can be safely stored How the de-icer can be spread effectively
- Cost (including purchase/storage/spreading/impacts/etc.) Ease of operational mobilisation
- Potential impacts on service levels if alternative de-icers are not used
- Availability
- Environmental impact
- Corrosion of infrastructure and vehicles
- Requirements for cleaning out existing plant e.g. brine from spreader saddle tanks, before using the alternative de-icers

10.8 BENEFITS OF ALTERNATIVE DE-ICERS

10.8.1 The alternative de-icers listed above provide benefits in two ways:

They can lower the freezing point of water further than salt, melt more ice than salt and melt ice more rapidly than salt.

When used with salt, hygroscopic de-icers (e.g. magnesium and calcium chloride) attract moisture and can facilitate the dissolution of salt. This is particularly helpful for precautionary treatments, but this also helps the salt dissolve more quickly when treatments are made to remove existing ice and compacted snow.

When applied in longitudinal lines along a road, alternative de-icers in liquid form are better able to penetrate existing ice and compacted snow, and provide a debonding layer, than salt. When used in this way, the liquid should have sufficient viscosity to prevent flowing out over the surface after spreading. If the liquid simply melts the surface of a layer of ice or compacted snow (rather than penetrates it), this can potentially create a more dangerous slippery surface that is also liable to refreeze, depending on the weather conditions.

10.9 EFFECTIVE USE OF ALTERNATIVE DE-ICERS

10.9.1 The most cost effective way to treat roads in winter conditions is to make precautionary treatments before snow or ice are present:

- To prevent ice forming in frost conditions
- To form a debonding layer on the road surface before snowfall or freezing rain. This will delay the bonding of snow and ice to help the dispersal by traffic or by ploughing.

10.9.2 Alternative de-icers should be used as liquids on their own or in combination with salt.

10.9.3 For precautionary treatments, the liquid de-icers are best spread as the wetting agent in pre-wetted salt.

10.9.4 For post treatments on layers of ice or compacted snow, liquid de-icers can be spread in longitudinal lines or used to pre-wet salt.

10.10 APPROPRIATE TREATMENTS USING ALTERNATIVE DE-ICERS

10.10.1 **Precautionary treatment.** The most cost effective way to treat roads in winter conditions is to make precautionary treatments, i.e. treatments before snow or ice are present:

- To prevent ice formation in frost conditions
- To increase the time period before snowfall or freezing rain bonds to the road surface and, therefore, facilitate their dispersal by trafficking and/or removal by ploughing

Alternative de-icers are most efficiently used for precautionary treatments in extreme cold conditions to increase the rate of dissolution of salt such that enough de-icer is in solution when required.

Guidance for precautionary treatments has been developed for effective treatments with the recommended alternative de-icers when used in conjunction with salt **(see Q8.20).**

10.10.2 **Post treating existing snow and ice.** It is not practical to use de-icers to fully melt layers of ice or compacted snow thicker than 1mm or uncompacted snow thicker than 10mm, dependent on the temperature. This is because large quantities of de-icer are required to melt all but these thin layers even at temperatures near to freezing.

The main objective of applying de-icers to all but thin layers of ice, snow or compacted snow should be to penetrate them, undercut them and debond them from the road surface so they are more easily removed by ploughing or dispersed by traffic.

Guidance for treating snow and ice has been developed giving effective treatments with the alternative de-icers when used in conjunction with salt and with the ABP Liquids, on their own, spread in longitudinal lines. These treatments will be more effective than either salt pre-wetted with brine or dry salt on thin and thick layers of ice and compacted snow.

10.11 ARRANGEMENTS FOR STORING ALTERNATIVE LIQUID MATERIALS

10.11.1 Alternative liquid de-icers must be stored and handled correctly to:

- Maintain their condition and effectiveness
- Prevent damage to infrastructure
- Prevent impacts to the environment from leaks and spillages
- Minimise the risks to personnel handling them.

10.11.2 Important considerations when storing alternative liquid de-icers are:

- Deciding on the type of container and storage capacity required
- Requirements for storage containers, including materials that are resistant to corrosion by the de-icer
- Requirements for the storage area, e.g. containment measures to prevent leaks and spillages entering the environment and drainage requirements
- Monitoring and maintaining de-icer condition
- Handling and special health and safety requirements
- Additional equipment requirements to enable loading and unloading of liquids from spreaders
- Storage and disposal techniques for unused liquids

10.12 TYPES OF STORAGE CONTAINER

10.12.1 When choosing the type of container the following factors need to be considered:

- Total storage capacity
- Requirements for storage container construction
- Requirements for preparing the storage area

10.12.2 A range of storage tank types and capacities are available. Examples that are suitable for the storage of liquid de-icers include:

- **Intermediate Bulk Containers (IBCs).** De-icers can be delivered and then stored in this type of container. These containers typically have a capacity of around 1000 litres, have an external metal reinforcing cage and can be easily refilled from subsequent deliveries made by tanker.
- **Tank Containers or Vertical or Horizontal Storage tanks.** These tanks will allow a larger storage capacity in a single tank up to around 50,000 litres.

Vertical storage tanks (the large tanks shown are 50, 000 litre capacity)

The use of IBCs can be a convenient option for delivery and subsequent storage of the liquid de-icers. Storage will need to be in multiple IBCs to provide sufficient storage capacity. Storage in a single or multiple containers needs to be considered when preparing the storage area.

10.13 RECOMMENDATIONS FOR THE STORAGE OF ALTERNATIVE DE-ICERS

10.13.1 A severe weather plan (winter service plan) should be produced that identifies the network to be treated using the alternative de-icers in extreme cold conditions

10.13.2 Service providers should plan to provide sufficient de-icers to give the necessary resilience. However, the likelihood of extreme events occurring in their particular geographic areas should be considered.

10.13.3 Service providers should then calculate the amount of de-icer required to be stored, based on the route length to be treated, the spread rates required under different weather conditions and the number of treatments for which a reserve is considered necessary.

10.13.4 To determine the storage capacity required, service providers need to consider the length of network to be treated using the alternative de-icers. For example, service providers should consider whether or not the alternative treatments will be utilised in extreme conditions:

- on the entire precautionary treatment network
- on the strategic network alone
- on critical network links
- at identified cold spots
- on critical infrastructure
- at vulnerable locations
- at major transport hubs

10.13.5 Storage areas for liquid de-icers should be bunded or storage tanks have a secondary containment system to contain any leaks and spills and to aid any clean up.

10.13.6 The containment capacity of the bund should be large enough to hold at least 110% of the capacity of the largest tank or 25% of the total storage capacity if in multiple tanks, whichever is the greater.

10.13.7 Storage should be sited on an impermeable surface, to prevent any leakage soaking into the ground.

10.13.8 Drainage from the store or loading area must not be allowed to soak away and must not pass into the surface water system or to soakaways. Foul drainage cannot be used without the prior permission of the drainage service provider. Discharge to a sealed tank equipped with a level alarm could also be considered.

10.13.9 Liquids should not be stored where spillage could enter adjacent surface water or foul water drainage and the bunded area should not have any drains within it that lead to these systems unless prior permission of the drainage service provider has been granted.

10.13.10 Where practical, preference should be given to indoor and/or covered storage of liquids. This will assist in preventing rainwater from building up in any bunded area, reduce bunding requirements, offer greater protection to the storage containers and associated equipment and fittings and also shading from direct sunlight.

10.13.10 Indoor storage areas should be well ventilated.

10.13.11 Ensure all local and national environmental requirements are met.

10.13.12 De-icing agents can cause environmental damage if leaks or spillages occur which are allowed to enter drains or watercourses. Precautions should be taken when preparing the storage area and procedures put in place for correctly managing de-icers during storage to prevent the risk of pollution. Incident planning and incident response training should be held for relevant staff. Appropriate equipment to be used during an incident should be readily available and staff should be trained in its use.

10.13.13 The Environment Agency for England and Wales (EA), Scottish Environment Protection Agency (SEPA), and the Northern Ireland Environment Agency (NIEA) have jointly produced a range of guidance documents for storage of industrial liquids, based on relevant legislation and current good practice which should be consulted, including:

- Guidance on industrial and commercial pollution prevention: 'Pollution Prevention Pays', available from the EA website
- Pollution Prevention Technical Information note: 'Safe storage and use of de-icing products', available from the EA website.
- Pollution Prevention Guidelines (PPGs) available from the agency websites, containing guidance directly applicable to the storage of liquid de-icers include:

- *PPG1: General Guide to Pollution Prevention*
- *PPG21: Incident Response Planning*
- *PPG22: Dealing with Spills*
- *PPG26: Storage and handling of drums and intermediate bulk containers*
- *PPG2: Above Ground Oil Storage Tanks*

10.13.15 Information on constructing good quality bunds is contained within:

- *The Construction Industry Research and Information Association (CIRIA) Report 163, on the construction of bunds for oil storage tanks.*

10.13.16 Storage in multiple containers, e.g. 1000 litre IBCs, will reduce requirement for substantial bunding and may be a convenient method for storing alternative liquid de-icers. If the bunded area is uncovered, the volume of rainwater/precipitation must be considered which could cause the bunded area to overflow.

10.13.17 Alternatives to building a bunded area include:

- Secondary containment provided by storage tanks with secondary linings or integrated sumps.
- Storage units for holding multiple containers, which are vented and have an integrated sump for containing leaks and spills.

10.14 MONITORING AND MAINTAINING DE-ICER CONDITION IN STORAGE

10.14.1 Procedures should be put in place to properly maintain and monitor the de-icer condition, and to ensure the de-icers remain effective after storage i.e. that they remain adequately mixed and that solid particles do not settle out.

10.14.2 A reference measurement should be made of the de-icer condition for each new delivery and recorded for future monitoring.

10.14.3 De-icers should be regularly stirred or agitated and immediately before each use to reduce any settlement or crystallisation and ensure the liquid does not separate out into layers of different concentrations.

10.14.4. When not in regular use, de-icers should be stirred or agitated at least once every 3 months to help maintain the condition of the de-icer.

10.14.5 The suitability of different methods of stirring and agitation will depend on the de-icer and its method of storage. The most effective method(s) should be discussed with the supplier but is likely to include one or more of the following:

- Inserting an airline into the storage tank to agitate the liquid, in particular any sedimentation on the base of the storage tank.
- Recirculation of de-icer within the tank using a pump.
- Manually stirring using a paddle, where the storage tank can be opened sufficiently. It should be ensured that all health and safety precautions are taken when working adjacent to an open storage tank.
- Using an electric mixer, typically with impellers (propellers, paddles) mounted on a driven shaft. Mixers are available with folding impellers that can be inserted into and mounted on IBCs.

Before each use, a sample of the liquid should be tested, using the procedure explained below, to ensure it is correctly mixed. A reference measurement should be taken and recorded for each new delivery of de-icer, for comparison with subsequent measurements.

TABLE 10.1 PROCEDURE FOR TESTING LIQUID CONDITION – CHECKING THE LIQUID IS THOROUGHLY MIXED

- The liquid should first be stirred/agitated in the storage tank before sampling
- Ideally the sample should be taken directly from the storage tank and not from the delivery hose
- If taking the sample from the hose, enough de-icer should first be discharged to ensure the sample is from the de-icer within the tank and not from residual liquid within the hose
- The sample size should be at least 10 litres
- A suitable hydrometer or refractometer can be used to measure the liquid density
- A reference measurement should be taken and recorded for each new delivery of de-icer, for comparison with subsequent measurements. Each subsequent sample reading should be within 5% of the reference value
- If the reading is outside the 5% limit, the liquid should be restirred/agitated and resampled
- If still outside the 5% limit, further investigation should be made of causes of the difference

10.15 HEALTH AND SAFETY AND EQUIPMENT REQUIREMENTS FOR LOADING LIQUID DE-ICERS TO SPREADERS

10.15.1 All connections and fittings must be constructed of materials resistant to corrosion by the de-icer i.e. polypropylene, polyethylene, GRP, PVC or stainless steel.

10.15.2 All pipes, hoses and connections should be regularly checked for leaks and tight fitting.

10.15.3 In order to load and unload spreaders quickly, a pump of sufficient capacity will be needed to transfer liquid de-icer between the spreader and storage container. In determining the required pump capacity, consideration should be given to the number of spreaders that are to be loaded, the spreader capacity and the number of pumps available.

10.15.4 It is recommended that all wetted parts of the pump should be stainless steel or other suitable materials to provide resistance to corrosion by the de-icers.

10.16 CONSIDERATIONS FOR APPLYING PRE-WETTED SALT WITH ALTERNATIVE LIQUID WETTING AGENT

10.16.1 Service providers should ensure that spreaders:

- Should not be adversely affected by the de-icer
- Can be set up and calibrated to accurately deliver the proposed spread rates to the defined target areas at the operating temperatures

10.16.2 Have the capability to be set up for different salt types and pre-wetting agents

- Drivers (including reserves) should be fully competent in the use and operation of the spreaders
- Regular checks should be made when using the alternative de-icers to ensure they have no additional (as compared to salt) detrimental effect on the following equipment:
  - Spreader body, chassis, electrics and spinner
  - Brine tanks on spreader
  - Spreader brine pumps
  - Spray nozzles on spreader
  - Pumps and other equipment for transferring de-icers to spreaders from storage tank

10.16.3 Standard pre-wetted salt spreaders are suitable for the application of salt pre-wetted with the alternative liquid de-icers. The liquid de-icers can be loaded into the spreader saddle tanks to pre-wet the salt using the same mechanism as when pre-wetting salt with sodium chloride brine.

10.16.4. A ratio of 30% brine to 70% dry salt by weight is currently used when pre-wetting using sodium chloride brine and this ratio will be suitable for the alternative de-icers. Although a lower percentage of the liquid has been used in North America most pre-wet spreaders that are used in Europe are designed to spread 30% liquid and 70% dry salt.

10.16.5 All spreaders should be individually calibrated and set up for the de-icer being spread. The purpose of calibration is to ensure that each spreader in a fleet is spreading the de-icer uniformly over the target area, at the correct rate of application and with as little wastage as possible.

10.16.6 Driver training is important to ensure all drivers are fully competent in the use and operation of the spreaders with the alternative de-icers. Where reserve drivers are available as part of an authority's contingency plans, it is essential that they are trained to an equal standard of competence.

10.16.7 If the concentration of some alternative de-icers is too high or some alternative de-icers are mixed together or with salt brine, recrystallisation may occur that may affect the pumps and nozzles of the spreader. If the liquid discharge rate falls more than 10% below the target, or if irregular discharge is suspected, the operation of the nozzles and pumps should be checked.

10.16.8 The guidance in this document has been based on the information available. However, due to the limited operational experience with these alternative materials in the UK, it is recommended that service providers make regular checks to ensure there are no detrimental effects to their spreaders.

10.17 SPREADING EQUIPMENT CONSIDERATIONS FOR LIQUID ONLY TREATMENTS

10.17.1 Liquids should be spread using dedicated liquid spreaders or combination spreaders where available.

10.17.2 If authorities do not have liquid spreaders, modifications to spreaders or other maintenance vehicles, potentially including equipment for weed spraying or plant watering, should be investigated to provide an adequate and calibrated liquid spreading capability.

10.17.3 Liquid spreading equipment that can apply de-icer liquid in longitudinal lines no greater than approximately 100mm apart for treatments on ice and snow should be used.

10.17.4 Precautionary treatments using only liquids in extreme cold conditions are not generally recommended because very high spread rates are required. However, spreading for localised priority treatments may be acceptable on occasion.

10.17.5 For post treatments, on anything other than very thin snow (less than 10mm thick) or thin ice and compacted snow (less than 1mm thick), it is recommended that application of the liquid should be in longitudinal lines (not more than 100mm apart) along the carriageway rather than as a uniform distribution. This should allow optimum penetration and undercutting of ice and snow.

10.17.6 In order to provide an effective and safe treatment, the liquid should have sufficient viscosity to limit flowing out over the surface of existing ice or compacted snow after spreading. If the liquid just melts the surface (rather than penetrates into a layer of ice or compacted snow), this can leave a more dangerous slippery surface that is also potentially liable to refreeze, depending on the weather conditions.

10.17.7 **Liquid de-icers should not be spread 'uniformly' onto an existing layer of ice or compacted snow without penetrating into it. If they melt the surface and form a liquid film on top of the layer of ice or compacted snow this may well result in more dangerously slippery conditions.**

10.17.8 Possible options for providing a liquid spreading capability include the modification of existing pre-wet spreaders with the addition of a spray/dribble bar and associated pipe work. When liquid only application is required, liquid can be diverted to the bar. Spray bars are available with interchangeable nozzles, for application of a fan spray or application of liquid in lines.

10.17.9 Other practical options will include the modification of maintenance vehicles by the addition of a storage tank, pumps and spray/dribble bars.

Applying ABP Liquid in longitudinal lines on snow and ice

10.18 AVAILABLE OPTIONS WITHOUT PRE-WET OR LIQUID SPREADERS

10.18.1 **When using the alternative de-icers discussed in this guidance, it is strongly recommended that pre-wet or liquid spreaders are utilised. This section is presented to give guidance to service providers without these capabilities regarding spreading in extreme cold conditions. However, the treatments are likely to be both less economical and less effective than with pre-wetted or liquid spreading capability.**

10.18.2 The options presented in this section should only be considered as a last resort and not as an alternative option to using the preferred methods previously described

10.18.3 Salt wetted with alternative de-icer liquids before loading onto spreaders can be considered but **strictly** in accordance with the guidelines given below:

10.18.4 Increase the spread rate. This may help in some conditions when no other alternatives are available (see salt spread rates included in the treatment matrices below) but authorities should consider the probable limited effectiveness, cost, salt stock resilience and environmental implications.

10.18.5 In extreme cold or low humidity conditions, even at high spread rates salt may not be effective. Authorities must assess the risk and act appropriately. For example consider road closures or clearly warning drivers of unsafe conditions.

10.18.6 The local winter plan should include additional measures for extreme cold conditions beyond treatments. These should include:

- Provision of timely information and warnings to the public.
- Liaison with the police and other emergency services.
- Additional monitoring of route condition after treatment.

10.18.7 It is not considered practical to spread solid alternative de-icers on their own or mixed with salt (except in very limited amounts for highly localised priority treatments) because of the onerous requirements for storing and spreading of the solid de-icers:

- The hygroscopic nature of the recommended alternative de-icing materials mean they readily absorb water and must be kept dry, i.e. stored in sealed bags or containers.
- De-icers would need to be properly mixed with salt immediately before spreading, (and not sooner) in sufficient quantities for spreading.
- Any materials remaining after spreading would need to be disposed of.

10.18.8 In the USA, salt is sometimes wetted with alternative liquid materials, typically calcium chloride, before loading into spreaders. This can be achieved by:

- **Wetting of dry salt with alternative de-icers during loading:** Salt can be sprayed with the liquid as it is loaded into the hoppers of spreading vehicles e.g. each loader bucket of salt could be sprayed before loading. This is not recommended by the NWSRG but is considered to be a potentially practicable alternative of last resort.
- **Wetting of dry salt stockpiles with alternative de-icers:** This is a practice that is not recommended by the NWSRG or considered at all desirable for use in the UK.

This practice involves the alternative liquid de-icer being injected into salt stockpiles using special spray nozzles which penetrate the stockpile or the stockpile being sprayed and turned to mix. Stockpiles can only be wetted to a certain extent before liquid will start to leach off. Non-UK practitioners of this method have suggested that not more than 30 litres of liquid is added per 1,000kg of salt. It would be essential that wetted stockpiles are be covered and situated on impervious bases with adequate drainage arrangements to prevent environmental damage.

10.18.9 As noted above, the wetting of dry salt in stockpiles is not considered at all desirable for use in the UK and the wetting of otherwise dry salt during loading is not recommended. If either of these methods is employed, the resultant salt distribution on the road will be poorer than when spreading using a purpose built pre-wet spreader. These methods also increase the risk of 'tunnelling' within vehicle hoppers. Spreaders are unlikely to have been appropriately calibrated for otherwise dry salt that has been wetted with alternative de-icers.

10.18.10 However, during extreme conditions when the use of dry salt would be relatively ineffective, salt wetted during loading with alternative de-icer can be considered as a potentially practicable emergency option of last resort, rather than to continue using dry salt alone. The need to make dry salt applications more effective in these conditions is considered likely to override concerns regarding the uniformity of the resultant spread distribution, and the impact of the lack of uniformity may be overcome with repeat treatments. However, it is strongly recommended that, where these treatments are utilised, the treated routes are closely monitored to determine the effectiveness of the treatments. Suitable warnings should be issued to the public regarding potentially dangerous driving conditions, because the de-icers may not be fully effective.

10.19 MAINTAINING SPREADING EQUIPMENT WHEN USING ALTERNATIVE DE-ICERS

10.19.1 In order to minimise corrosion which may result from the use of alternative de-icers (and as with salt) Spreaders should be washed down after use, using high volumes of water with low pressure, taking care that washdown water is handled properly to prevent environmental impacts. Wash bay areas should not be connected to any surface water sewer or soakaway. Refer to the Environment Agency's Pollution Prevention Guideline PPG13 *Vehicle Washing and Cleaning* for further guidance.

10.19.2 Spreader tanks, pumps and hoses should be rinsed with water before changing the liquid. After rinsing, the brine pump should be operated for a short time to put the new de-icing liquid through the whole system and prevent freezing.

10.19.3 Spreader manufacturers should be consulted to confirm spreaders have adequate protection for mechanical and electrical components:

- Paint work and protective systems should be of an appropriate standard
- Additional protection measures such as wax based coats, plastic chassis canopies and gear box covers should be considered

10.19.4 The alternative liquid de-icers, as well as sodium chloride brine, can result in greater corrosion of spreading vehicles when compared to spreading dry salt only.

10.19.5 The viscous nature of some alternative liquid de-icers and the hygroscopic nature of some of the chemicals can also increase the retention of corrosive liquid de-icers on metal components and keep metal components wetter for longer.

10.20 PRECAUTIONARY TREATMENTS WHICH CAN BE UNDERTAKEN FOR EXTREME COLD CONDITIONS BEFORE FROST, SNOW OR FREEZING RAIN

10.20.1 This section should be read in conjunction with the NWSRG guidance sections on "Spread Rates" and "Treatments for Snow and Ice".

10.20.2 In order to improve stock resilience and reduce the impact of salt and alternative de-icers on vehicles, infrastructure and the environment, spread rates used should not exceed those recommended.

10.20.3 The guidance given in the "Spread Rates" section of the NWSRG Practical Guide should be used for treatments when the salt can enter solution before the road surface temperatures is at or below -7°C, i.e. typically when treatments are completed at least 2 hours before the temperature falls below -7°C. Spread rates are also given for low humidity conditions when temperatures are at or below -5°C

10.20.4 Spread rates for precautionary treatments made in extreme cold before frost are given in Matrix A1, A2 and A3.

10.20.5 Spread rates for precautionary treatments made in extreme cold before snow and freezing rain are given in Matrix B
Spread rates are given for:

- Dry rock salt pre-wetted with alternative liquid de-icers,
- Standard pre-wetted precautionary treatments with sodium chloride brine
- Rock salt wetted with alternative liquid de-icers before loading and spread from dry salt spreader
- Dry rock salt

10.20.6 Spread rates are given for 'Good' spreading capability (Matrix A1), 'Fair' spreading capability (Matrix A2) and 'Poor' spreading capability (Matrix A3). See Q5.7 of the NWSRG guidance section on 'Spreader Calibration' for how to assess the spreading capability.

10.20.7 Liquid only precautionary treatments in extreme cold require very high spread rates, which are uneconomical and potentially more environmentally damaging for spreading over large areas of the network.

10.20.8 Spread rates in the tables can be high (greater than 40 g/m^2) and may require more than one pass to achieve. Service providers should take account of this with regard to treatment response times.

10.21 WHAT ARE THE IMPORTANT CONSIDERATIONS WHEN TREATING EXISTING SNOW AND ICE

10.21.1 For treatments during snowfall and on snow and ice, it is generally impractical and costly to spread sufficient de-icer (salt and/or alternatives de-icer) to melt anything other than very thin layers of snow and ice. Therefore;

- Treatments to remove ice or snow should be considered only as a last resort when precautionary treatments have not been possible.
- Effective ploughing to as near the road surface as possible is essential, to either prevent build up of snow and slush or to remove as much material as possible from compacted layers.
- Ploughing to the road surface will minimise de-icer usage.

10.21.2 Ploughing should be down to (or very close to) the road surface. However, snow ploughs should be adjusted and/or operated to avoid risk of damage to the plough, the road surface, street furniture and level crossings, etc. Guidance on the use of ploughs is contained in:

- *Section of Well managed Highways Infrastructure and detailed practical guidance is given in:*
- *NWSRG guidance section on 'Treatments for Snow and Ice'*

10.22 TREATMENTS WHICH CAN BE MADE FOR SNOWFALL DURING EXTREME COLD CONDITIONS

10.22.1 This guidance should be read in conjunction with the NWSRG guidance section on 'Treatments for Snow and Ice'.

10.22.2 The combination of ploughing and de-icer treatments should be as in Matrix C.

10.22.3 Ploughing should start and, where necessary, be continuous to prevent a build-up of snow and slush – it is important to remove as much snow and slush as possible before temperatures drop to extreme cold conditions.

10.22.4 De-icer applied during snowfall is unlikely to be effective. De-icing should only take place after ploughing has removed uncompacted snow, slush and as much hard packed snow and ice as possible.

10.22.5 Salt should be spread after ploughing (to the ploughed lane only) to provide a new debonding layer to facilitate further ploughing of fresh snow and the break up and dispersal of compacted snow.

- On heavily trafficked roads it is preferable to prevent a build-up of more than 10mm depth of snow. The build-up should be no more than 50mm in depth where there is a risk of compaction by traffic.
- During and after snowfall, for efficiency and environmental reasons only the ploughed lane(s) should be treated if other lanes have still to be ploughed. The spread width settings should be adjusted accordingly.

10.22.6 Treatments are undertaken during snowfall to:

- Limit the accumulation of snow on the road surface, thereby reducing the amount of salt required for subsequent treatments – this is even more important where temperatures are expected to drop to extreme cold levels which make ploughing more difficult or impossible if solid ice forms. Also far more de-icer will be required for remedial treatments.
- Help the dispersal/clearing of the snow by traffic.
- Prevent snow from being compacted and bonding to the road surface.

10.23 TREATMENTS WHICH CAN BE MADE ON LYING SNOW AND EXISTING ICE DURING EXTREME COLD CONDITIONS

10.23.1 This guidance should be read in conjunction with the NWSRG guidance section on Treatments for Snow and Ice.

10.23.2 The combination of ploughing and de-icer treatments should be as in Matrix D.

10.23.3 Where spread rates are given for the application of liquid, this is only on the basis that application is from a dribble bar forming discrete longitudinal lines of de-icer no more than approximately 100mm apart across the carriageway.

10.23.4 Application of liquids in lines can also be in conjunction with dry salt spreading and can be carried out immediately before, after or at the same time as the dry salt application.

10.23.5 Solid de-icer with larger particle sizes will be more effective than a finely graded material, as the larger particles can penetrate further and more quickly into the layer before dissolving to reach the road surface and debond the layer.

10.23.6 The road condition should be monitored on all treated routes when ice, snow or compacted snow are present and abrasives should be applied at a rate of 20 to 40g/m^2, as outlined in Matrix D, if more dangerously slippery conditions occur. Ideally, de-icers should penetrate and bore into ice and compacted snow in order to reach the road surface and debond the layer.

10.23.7 The performance will be optimised if de-icers are concentrated (e.g. larger particle size or liquids applied in lines) so, when they have penetrated the layer down to the road surface, there is sufficient ice melting capability to spread out and debond the layer from the road surface.

10.23.8 Liquid de-icers should not be spread 'uniformly' to a layer of ice or compacted snow. If they melt the surface to form a liquid film on the layer of ice this may result in more dangerously slippery conditions. Also, there is a risk of refreezing when the concentration of the solution formed falls such that the air/road surface temperature is below its freezing point temperature.

10.23.9 Small particles of solid de-icer may have a similar effect as uniformly spread liquid de-icers by only melting the surface. When using solid de-icers they should have a low fines content whenever possible, i.e. with less than 20% by weight passing a 1mm sieve, and less than 10% passing a 600µm sieve.

10.23.10 The treatments in Matrix D are designed to facilitate the dispersal of ice, snow and compacted snow without the need to use abrasive. However, the road condition should be monitored on all treated routes when ice, snow or compacted snow are present and abrasives should be applied at a rate of 20 to 40g/m^2, as outlined in Matrix D, if more dangerously slippery conditions occur.

10.24 COSTS AND BENEFITS OF USING ALTERNATIVE DE-ICERS

10.24.1 Authorities should consider the following factors when determining the costs and benefits of using alternative de-icers:

- Delivering stated service levels and complying with policy and plans
- Reduced traffic disruption costs, if roads can be kept passable in severe weather
- Purchase costs of the de-icers and the quantities required in comparison to salt only
- Investment in new storage facilities
- Investment in new spreading equipment or adapting of existing vehicles
- Costs of any additional impacts of de-icers on infrastructure, vehicles or the environment
- Some indicative costs provided by the major suppliers are given below for comparative purposes:

TABLE 10.2	£/TONNE (2011 PRICES)	
DE-ICER TYPE	**10 X IBC**	**TANKER LOAD (APPROX. 210 TONNES)**
Magnesium chloride brine (32% concentration)	180	110
Calcium chloride brine (28% concentration)	260	115
Sodium chloride brine (23% concentration) with ABP	250	200

10.24.2 Although more expensive than salt, the alternative de-icers will primarily be used as the brine component in pre-wetted salt where they make up only 30% of the total material spread. The use of alternatives will also enable lower spread rates to be used in extreme cold conditions than when using only sodium chloride. More frequent repeat treatments will also likely be required using only salt.

10.24.5 An indicative cost/km, based on the de-icer purchase cost, is shown below for the following spreading conditions:

- *Precautionary treatment before frost*
- *Fair spreading capability*
- *Spread width = 7m*
- *RST at or below -7°C and above -10°C and dry or damp road conditions*

TABLE 10.3 DE-ICER TYPE	SPREAD RATE (G/M²)	£/TONNE OF DE-ICER (2011 PRICES)	£/KM* (% OF COST FOR INDIGENOUS ROCK SALT)
Rock salt pre-wetted with magnesium chloride brine (32% concentration)	21	Magnesium chloride brine: £110 Rock salt: £30	£7.9 (130%)
Rock salt pre-wetted with calcium chloride brine (210% concentration)	22	Calcium chloride brine: £115 Rock salt: £30	£8.5 (139%)
Rock salt pre-wetted with sodium chloride brine with ABP	20	Sodium chloride brine with ABP: £200 Rock salt: £30	£11.34 (186%)
Rock salt pre-wetted with sodium chloride brine (23% concentration)	27	Rock salt: £30 Sodium chloride brine: £12 (brine salt £45/tonne)	£4.6 (75%)
Dry rock salt	29	£30	£6.1 (100%)

** It should be noted these do not include costs for storage, upgrades to spreaders, calibration, extra handling costs, etc*

10.25 THE ENVIRONMENTAL IMPACTS OF USING ALTERNATIVE DE-ICERS

10.25.1 Authorities should obtain a full specification and Material Safety Data Sheet (MSDS) detailing the types and amounts of chemicals contained in any de-icer used.

10.25.2 Authorities should follow the guidance in this document to reduce the risk of any significant environmental impacts from storage and spreading of alternative de-icers. When proposing to use any de-icer other than rock salt, authorities should contact the relevant national environmental agency to agree their use, including advice on special restrictions due to potential impacts on environmentally sensitive locations.

10.25.3 Environmental and regulatory agencies have concerns over the environmental impacts of spreading all de-icers. Service providers should be aware that any de-icer, including salt, will have an environmental impact and should take all necessary precautions, as far as practically possible, to reduce the amount of de-icer entering the environment. Service providers need to comply with all relevant legislation and guidance. Therefore close liaison with the relevant environmental agencies is recommended at the earliest stage.

10.25.4 Before, during and after spreading, de-icers will reach the environment in a number of ways:

- Leakages and spills during storage.
- Directly from the back of the spreader to the verge during spreading.
- Spray of the de-icer solution from the road surface by traffic and wind.
- Run off of the de-icer from the road surface into the surrounding environment e.g. surface water, ground waters, soil and sensitive habitats.

10.25.5 Following the guidance in this document and from the relevant agencies will enable service providers to reduce the risk of serious environmental impacts from spreading de-icers, by using proper storage facilities and spreading in the most efficient manner.

10.25.6 In assessing the environmental impact of using alternative de-icers, consideration should be given to the amount being spread, the level of available dilution and the potential receptor e.g. surface water, ground water, soil or sensitive habitats.

10.25.7 All of the chloride-based de-icers being recommended in this guidance (sodium chloride, calcium chloride and magnesium chloride) will have the potential to increase the salinity of adjacent land and watercourses. Using the alternative de-icers as recommended in this guidance will enable lower spread rates in comparison to standard treatments with sodium chloride. For example, spread rates for pre-wetted precautionary treatments using alternative de-icers are less than 100% of spread rates for standard treatments with salt pre-wetted with sodium chloride brine. This will result in a reduction of the concentration of chlorides entering the environment when carrying out treatment in these conditions.

10.25.8 Environmental agencies have concerns over increases in Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in water courses receiving drainage from road surfaces after treatments with de-icers containing ABPs (and glycols and acetates although these are not recommended here). BOD is the amount of oxygen used by microorganisms (e.g. bacteria) when breaking down organic matter, such as ABPs, in the water. COD is a measure of the total amount of oxygen required for the chemical oxidation or decomposition of compounds in water. These can deplete the oxygen levels in the water and kill or harm fish and other aquatic organisms.

10.25.9 For treatments made using salt pre-wetted with alternative de-icers, as recommended in this guidance, the proportion of ABP contained in the de-icer will be the same as standard treatments made using ABP treated salt. i.e. the ABPs make up around 3% by weight of the de-icer. Therefore, treatments recommended in this guidance should not have significant additional impacts compared to standard treatments with sodium chloride or ABP treated salt.

10.25.10 When making remedial treatments by spreading liquid de-icers that contain ABPs on compacted ice and snow, larger amounts of ABP will be spread as opposed to precautionary treatments using mixtures of the de-icer with salt. Therefore, it should be stressed that this should only be carried out as a last resort in extreme conditions, which in themselves occur very rarely. The de-icers will also be highly diluted by the water from melted ice and snow.

10.25.1 It is important that service providers have full information regarding the composition of de-icers that are spread to the road network and consequently entering the environment. A specification should be available for the de-icers supplied providing details of the chemicals contained in the product and in what amounts, including the amount of ABPs.

10.26 WHAT ARE THE POSSIBLE IMPACTS ON INFRASTRUCTURE AND VEHICLES OF USING ALTERNATIVE DE-ICERS

10.26.1 Authorities should follow the guidance in this document to prevent any serious impacts from:

- Storage of alternative liquid de-icers
- Corrosion of spreading equipment

10.26.2 All liquid chloride based de-icers, including sodium chloride brine, can result in greater corrosion of the metal components of spreading vehicles and other infrastructure when compared to spreading dry salt only.

10.26.3 The viscous nature of some alternative liquid de-icers and the hygroscopic nature of the chemicals can also increase the retention of corrosive liquid de-icers on metal components and keep metal components wetter for longer.

10.26.4 A review of the literature has indicated that magnesium chloride may be more detrimental to concrete structures than the other de-icers.

10.26.5 As when considering the environmental impacts, when assessing the impact of using the alternative de-icers on infrastructure and spreading vehicles, consideration should be given to the amounts of de-icers being spread and the high level of dilution of the de-icer after spreading. Since these particular de-icers are primarily to be used as the pre-wetting agent in conjunction with rock salt, and on the few occasions in the winter season where the temperature is below -7°C at the time of spreading (-5°C in low humidity conditions), the overall impact on infrastructure and road users is likely to be low due to the amount being spread, infrequency of use and subsequent dilution after application.

10.26.6 There is limited information available on the effect of the alternative liquid de-icers on skid resistance. Previous research by Ulster University, on behalf of the NWSRG, and research by TRL on behalf of the HA has indicated that ABP treated salt does not result in a lower skid resistance. It should also be noted that relatively low quantities of the alternative de-icers are being recommended to be spread (and subsequently diluted after application) and the alternatives are not expected to be in frequent use. It is recommended that service providers monitor the use of alternative de-icers to see if there is any correlation between their use and skidding resistance. Any results from future research in this area will be included in later revisions of the guidance.

10.26.7 Areas of concern for service providers will be accidents and liability, corrosion of spreading equipment and corrosion from storage of the liquids. Following the guidance in this document will help to prevent any seriously detrimental effects.

MATRIX A1 (SEE NOTES 1 TO 6) FROST OR FORECAST FROST PRECAUTIONARY SPREAD RATES FOR GOOD SPREADING CAPABILITY (IN G/M²)						
DRY SALT COMPONENT (% BY WEIGHT OF DE-ICER) **BRINE COMPONENT (% BY WEIGHT OF DE-ICER)** **ROAD SURFACE TEMPERATURE (RST), ROAD SURFACE CONDITIONS.**	**ROCK SALT (70%)** **MAGNESIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **CALCIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **BRINE WITH ABP (30%)**	**ROCK SALT (70%)** **SODIUM CHLORIDE BRINE (30%)** **SEE NOTE 1**	**ROCK SALT (96%)** **4% LIQUID DE-ICER ADDED BEFORE LOADING**	**ROCK SALT (100%)** **NO PRE-WETTING** **SEE NOTE 1**
RST at or below -5°C above -7°C, and dry or damp road conditions **NOTE: Only for low relative humidity <80%**	11	11	10	13	14	14
RST at or below -5°C above -7°C, and wet road conditions **NOTE: Only for low relative humidity <100%**	18	19	17	21	22	22
RST at or below -7°C and above -10°C and dry or damp road conditions	16	17	16	21	20	22
RST at or below -7°C and above -10°C and wet road conditions	27	28	26	35	34	37
RST at or below -10°C and above -12°C and dry or damp road conditions	21	22	20	29	26	30
RST at or below -10°C and above -12°C and wet road conditions	35	36	34	49	43	50
RST at or below -12°C and dry or damp road conditions	27	29	27	41	33	41
RST at or below -12°C and wet road conditions	46	48	45	68	56	68

Notes:

1. Spread rates have been included for dry salt and salt pre-wetted with sodium chloride brine, however their use is not recommended because they may not become effective in the required time scales
2. Dry salt:brine should be in the ratio 70:30 by weight for pre-wetting
3. Spread rates for pre-wetted salting are the weight of dry salt and brine combined as shown in headings.
4. A follow-up treatment of 50% of the recommended spread rate should be considered in lightly trafficked areas at the lower end of temperature bands indicated.
5. To take account of residual salt during periods of sustained freezing, when surfaces are well drained and there is no melt water or ice present, rates of spread for treatments carried out within 6 hours of previous treatments may be 50% of the rates in the above table.
6. Higher spread rates may require more than one pass to achieve, and service providers should take account of this with regard to treatment response times.

MATRIX A2 (SEE NOTES 1 TO 6) FROST OR FORECAST FROST PRECAUTIONARY SPREAD RATES FOR FAIR SPREADING CAPABILITY (IN G/M²)						
DRY SALT COMPONENT (% BY WEIGHT OF DE-ICER) **BRINE COMPONENT (% BY WEIGHT OF DE-ICER)** **ROAD SURFACE TEMPERATURE (RST), ROAD SURFACE CONDITIONS.**	**ROCK SALT (70%)** **MAGNESIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **CALCIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **BRINE WITH ABP (30%)**	**ROCK SALT (70%)** **SODIUM CHLORIDE BRINE (30%)** **SEE NOTE 1**	**ROCK SALT (96%)** **4% LIQUID DE-ICER ADDED BEFORE LOADING**	**ROCK SALT (100%)** **NO PRE-WETTING** **SEE NOTE 1**
RST at or below -5°C above -7°C, and dry or damp road conditions **NOTE: Only for low relative humidity <80%**	14	14	13	16	18	18
RST at or below -5°C above -7°C, and wet road conditions **NOTE: Only for low relative humidity <80%**	23	24	22	27	30	30
RST at or below -7°C and above -10°C and dry or damp road conditions	21	22	20	27	27	29
RST at or below -7°C and above -10°C and wet road conditions	35	37	34	45	45	49
RST at or below -10°C and above -12°C and dry or damp road conditions	27	28	26	37	35	40
RST at or below -10°C and above -12°C and wet road conditions	45	47	44	62	58	67
RST at or below -12°C and dry or damp road conditions	35	38	35	53	45	55
RST at or below -12°C and wet road conditions	59	62	58	88	75	91

Notes:

1. Spread rates have been included for dry salt and salt pre-wetted with sodium chloride brine, however their use is not recommended because they may not become effective in the required time scales
2. Dry salt:brine should be in the ratio 70:30 by weight for pre-wetting
3. Spread rates for pre-wetted salting are the weight of dry salt and brine combined as shown in headings.
4. A follow-up treatment of 50% of the recommended spread rate should be considered in lightly trafficked areas at the lower end of temperature bands indicated.
5. To take account of residual salt during periods of sustained freezing, when surfaces are well drained and there is no melt water or ice present, rates of spread for treatments carried out within 6 hours of previous treatments may be 50% of the rates in the above table.
6. Higher spread rates may require more than one pass to achieve, and service providers should take account of this with regard to treatment response times.

MATRIX A3 (SEE NOTES 1 TO 6) FROST OR FORECAST FROST PRECAUTIONARY SPREAD RATES FOR POOR SPREADING CAPABILITY (IN G/M²)						
DRY SALT COMPONENT (% BY WEIGHT OF DE-ICER) **BRINE COMPONENT (% BY WEIGHT OF DE-ICER)** **ROAD SURFACE TEMPERATURE (RST), ROAD SURFACE CONDITIONS.**	**ROCK SALT (70%)** **MAGNESIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **CALCIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **BRINE WITH ABP (30%)**	**ROCK SALT (70%)** **SODIUM CHLORIDE BRINE (30%)** **SEE NOTE 1**	**ROCK SALT (96%)** **4% LIQUID DE-ICER ADDED BEFORE LOADING**	**ROCK SALT (100%)** **NO PRE-WETTING** **SEE NOTE 1**
RST at or below -5°C above -7°C, and dry or damp road conditions **NOTE: Only for low relative humidity <80%**	16	17	15	19	22	22
RST at or below -5°C above -7°C, and wet road conditions **NOTE: Only for low relative humidity <80%**	27	28	26	32	36	36
RST at or below -7°C and above -10°C and dry or damp road conditions	25	26	24	32	33	35
RST at or below -7°C and above -10°C and wet road conditions	41	43	40	53	54	59
RST at or below -10°C and above -12°C and dry or damp road conditions	31	33	31	43	42	48
RST at or below -10°C and above -12°C and wet road conditions	52	55	51	73	69	80
RST at or below -12°C and dry or damp road conditions	41	44	41	61	54	66
RST at or below -12°C and wet road conditions	69	73	68	102	90	110

Notes:

1. Spread rates have been included for dry salt and salt pre-wetted with sodium chloride brine, however their use is not recommended because they may not become effective in the required time scales
2. Dry salt:brine should be in the ratio 70:30 by weight for pre-wetting
3. Spread rates for pre-wetted salting are the weight of dry salt and brine combined as shown in headings.
4. A follow-up treatment of 50% of the recommended spread rate should be considered in lightly trafficked areas at the lower end of temperature bands indicated.
5. To take account of residual salt during periods of sustained freezing, when surfaces are well drained and there is no melt water or ice present, rates of spread for treatments carried out within 6 hours of previous treatments may be 50% of the rates in the above table.
6. Higher spread rates may require more than one pass to achieve, and service providers should take account of this with regard to treatment response times.

MATRIX B (SEE NOTES 1 TO 4) SNOW OR FREEZING RAIN PRECAUTIONARY SPREAD RATES (IN G/M²)						
DRY SALT COMPONENT (% BY WEIGHT OF DE-ICER) **BRINE COMPONENT (% BY WEIGHT OF DE-ICER)** **WEATHER CONDITIONS ROAD SURFACE TEMPERATURE**	**ROCK SALT (70%)** **MAGNESIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **CALCIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%)** **BRINE WITH ABP (30%)**	**ROCK SALT (70%)** **SODIUM CHLORIDE BRINE (30%)** **SEE NOTE 1**	**ROCK SALT (96%)** **4% LIQUID DE-ICER ADDED BEFORE LOADING**	**ROCK SALT (100%)** **NO PRE-WETTING** **SEE NOTE 1**
Snow forecast (RST at or below -5°C and above -7°C)	23	24	22	28	28	28
Snow forecast (RST at or below -7°C and above -10°C)	33	35	32	40	40	43
Snow forecast (RST at or below -10°C and above -12°C)	39	41	38	47	47	52
Snow forecast (RST at or below -12°C)	47	50	47	58	58	70

Notes:

1. Spread rates have been included for dry salt and salt pre-wetted with sodium chloride brine, however their use is not recommended because they may not become effective in the required time scales
2. Dry salt:brine should be in the ratio 70:30 by weight for pre-wetting
3. Treatments for moderate/heavy snow are as for light snow, plus a follow-up treatment at half the recommended spread rate when no treatments in previous six hours
4. Higher spread rates may require more than one pass to achieve, and service providers should take account of this with regard to treatment response times.

MATRIX D (SEE NOTES 1 TO 13) SPREAD RATES ON SNOW AND ICE (IN G/M²)							
DRY SALT COMPONENT (% BY WEIGHT OF DE-ICER) BRINE COMPONENT (% BY WEIGHT OF DE-ICER) LOWER OF AIR OR ROAD SURFACE TEMPERATURE:	**ABP Liquid**	**ROCK SALT (70%) MAGNESIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%) CALCIUM CHLORIDE BRINE (30%)**	**ROCK SALT (70%) BRINE WITH ABP (30%)**	**ROCK SALT (70%) SODIUM CHLORIDE BRINE (30%) SEE NOTE 1**	**ROCK SALT (96%) SODIUM CHLORIDE BRINE (30%)**	**ROCK SALT (100%) NO PRE-WETTING SEE NOTE 1**
At or below -5°C and above 7°C	24	28	29	27	34	28	28
At or below -7°C and above 10°C	24	40	42	38	48	40	43
At or below -10°C and above -12°C	30	46	49	46	56	47	52
Less than -12°C	36	56	61	56	76	58	70

Notes:

1. Spread rates have been included for dry salt and salt pre-wetted with sodium chloride brine, however their use is not recommended because they may not become effective in the required time scales
2. Dry salt:brine should be in the ratio 70:30 by weight for pre-wetting.
3. Operators should consider carrying out patrols in extreme cold to determine the effectiveness of treatments and when further follow up treatments are required.
4. If the surface melts and becomes slippery, an initial treatment of abrasives should be applied at a rate of 40g/m² and successive treatments at 20g/m² until an acceptable level of friction is restored. Care should be taken to make further applications where ice or snow melts again and refreezes later leaving abrasives beneath the ice surface and therefore ineffective.
5. Abrasives should ideally be 5-6mm and angular, but gradings down to 1-5mm should be reasonably effective. After abrasives have been used, drainage systems should be checked and cleared if necessary. Recovered material, which will be contaminated with road oil, must be disposed of safely.
6. A small amount of salt should be added to the abrasive to prevent freezing of the water within it. If the moisture content of the abrasive is 7%, 50kg of salt per tonne of abrasive is sufficient to prevent freezing if thoroughly mixed.
7. At temperatures below -7°C, treatments with dry salt or salt pre-wetted with only sodium chloride brine are likely to melt ice at a slower rate than salt pre-wetted with the alternative de-icers. To increase the rate of ice melting with dry salt or salt pre-wetted with only sodium chloride brine the recommended spread rates can be increased.
8. Higher spread rates may require more than one pass to achieve, and service providers should take account of this with regard to treatment response times.

Notes for treatment of thin layers of ice (not exceeding 1mm thick):

9. Consider follow-up treatments at 50% in light traffic when there are few vehicles to assist the dissolution of the salt e.g. certain slip roads

Notes for treatment of layers of compacted snow and ice more than 1mm thick:

10. Plough to remove as much material (e.g. slush, snow, compacted snow) as possible from the top of the compacted layer before applying de-icer.
11. When using solid de-icers they should have a low fines content whenever possible, i.e. with less than 20% by weight passing a 1mm sieve, and less than 10% passing a 600µm sieve.
12. If ice or compacted snow is thicker than about 10mm, it may not be possible to penetrate the layer, undercut it and debond it from the road surface. The critical thickness is dependent on the road surface temperature and de-icer concentration and particle size.
13. When it is not possible to remove compacted snow and ice because of their thickness, or de-icers are ineffective, abrasives should be used as follows until the conditions are more favourable for de-icing:

For initial treatment, spread:

- 40g/m² of abrasives only

For successive treatments, spread:

- 20g/m² of abrasives only

NATIONAL WINTER SERVICES RESEARCH GROUP
Website www.nwsrg.org
Email nwsrg@trl.co.uk