NWSRG

NATIONAL WINTER SERVICE RESEARCH GROUP

SECTION FOUR

SALT STORAGE

In association with IHE

INSTITUTE OF HIGHWAY ENGINEERS

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CONTENTS

SECTION 4 - SALT STORAGE

ANNEXES

KEY

Red text are warnings or especially important information

Green text are particular recommendations or key advantages to consider

CHECK LIST:

How is salt moisture being managed to ensure it is being maintained within its optimum range?
Do current salt storage capacity and mutual aid arrangements provide adequate resilience?

SECTION FOUR
Salt Storage

4.1 INTRODUCTION

4.1.1. This section contains information on how salt should be stored and the options that are available to help maintain the salt in optimum condition.

4.1.2 The most economical treatment rates are available when salt is maintained within the optimum moisture content range and the production of fine particles through handling is minimised. Proper storage is essential to maintaining this good condition however the condition of the salt should always be adequately monitored.

4.1.3 Reviewing of current storage arrangements should be a priority when considering investment in winter service. Using salt in good condition underpins the savings that can be achieved from additional investment in new equipment and technologies.

4.1.4 The 'Treatments for Extreme Cold' section provides guidance on storage requirements for alternative de-icers to salt.

4.2 THE OPTIMUM CONDITION OF SALT FOR SPREADING

4.2.1 The moisture content of the salt will affect how it flows out of a spreader hopper. It will also have an effect on the size and size distribution of the salt grains. These both affect spread rate and how it is distributed across the paved surface. Significant changes in salt moisture content should be avoided within a store or stockpile to avoid increases in treatment rates or the need for spreader recalibration. It is also important that the type, grade and the moisture content of the salt is maintained as closely as possible to that of the salt used when calibrating the spreaders.

4.2.2 The moisture content of salt is given as a percentage value. This is the weight of water in the salt expressed as a percentage of the dry weight of salt. The higher the percentage value the wetter the salt.

4.2.3 BS 3247:2011 is the British Standard for salt used for highway winter maintenance. While this gives information on a "British Standard" for acceptable condition of the salt and also how to test it, these may not result in optimum condition for spreading.

4.2.4 BS 3247:2011 specifies the range of acceptable particle sizes and maximum moisture content on delivery of 4%. However, the best spreading performance (and possible reduction in spread rates as a result) will be obtained if kept within the recommended optimum ranges.

4.2.5 The optimum moisture content range for sodium chloride salt being utilised as a dry treatment is dependent upon fines content. Where the maximum fines content (<0.3mm particle size) is less than or equal to 7.5%, optimum moisture content is within the range 1.5% to 4%. Where the maximum fines content is above 7.5%, optimum moisture content is within the range 2% to 4%. Dry treatment with salt outside of the above ranges is likely to exhibit higher losses and may well require higher spread rates (see Section 8).

It should be noted that, for dry treatments, the fines and moisture content of salt may be outside of the optimum range even though it conforms to the relevant British Standard.

Optimum moisture content for sodium chloride salt being utilised as a pre-wetted treatment is less than 4%. Pre-wetted treatment with salt outside of this range may well require higher spread rates (see Section 8).

Optimum moisture content for treated sodium chloride salt is less than 4%. Treated salting with salt outside of this range may well require higher spread rates (see Section 8).

The optimum moisture content for different salt types and spreading technologies are summarised in Table 4.2.1:

TABLE 4.2.1 – OPTIMUM MOISTURE CONTENT FOR SALT TYPES AND SPREADING TECHNOLOGY GENERALLY USED IN THE UK		
Salt type	**Technology**	**Optimum range**
UK rock salt, Marine Salt and imported rock salt **Maximum fines content (<0.3mm particle size) is less than or equal to 7.5%**	Dry salting	1.5 to 4%
UK rock salt, Marine Salt and imported rock salt **Maximum fines content is above 7.5%**	Dry salting	2 to 4%
UK rock salt	Pre-wetted	Less than 4%*
UK rock salt	Treated	Less than 4%*

** A lower limit does not apply as the pre-wetting or treatment agent helps to prevent the loss of the finer particles during and after spreading*

4.3 ACTIONS WHEN SALT OUTSIDE THE OPTIMUM MOISTURE CONTENT RANGE

4.3.1 Where salt is outside the optimum moisture range, authorities must assess the suitability of the salt for effective treatments. There are a number of possible actions that can be taken. The decision to undertake any remedial action must be based on an authority's own assessment of the risks and any mitigating processes in place.

The potential effects of different salt moisture contents is summarised in Table 4.3.1

TABLE 4.3.1 – POTENTIAL EFFECT OF SALT MOISTURE CONTENT ON SPREADING SALT	
WETTER	• Tunnelling in the spreader hopper • Caking of salt stockpiles • Leaching from salt stockpiles • Poor salt distribution – areas of carriageway under or over salted
OPTIMUM	• **TARGET RANGE ✓** • Consistent spreading • Good distribution
DRIER	• Finer particles may be lost due to wind and vehicle draughts during and after spreading (particularly when the moisture content is less than 1% and especially when treating a dry road) • For pre-wetted and treated salt low moisture is not considered a problem

4.3.2 Whatever type of salt is being used, tunnelling (the formation of large voids resulting in salt not falling onto the distribution mechanism) can occur in the spreader hopper if the moisture content of the salt is too high, the highest risk for salt with greater than 4.5% salt moisture content.

4.3.3 Tunnelling must be avoided because it will result in uneven spreading and incorrect spread rate application to large areas of the road and may result in road sections being left untreated.

4.3.4. Salt used for making brine will not be subject to the problems associated with dry or pre-wet salting treatments but losses and environmental impacts from uncovered salt storage can remain a problem. The decision on required actions will depend on how far outside of the optimum range and difference from calibration level is the salt moisture.

Some of the potential actions that can be taken are summarised in Figure 4.3.2 below:

TABLE 4.3.2 – POTENTIAL ACTIONS WHEN SALT OUTSIDE OPTIMUM MOISTURE RANGE MOISTURE CONTENT	
Wet (>4.5%)	• Review spread rates and increase to account for poorer distribution • Consider moving wet salt away from the stockpile to dry (in a suitably contained area to minimise environmental impact) • When the moisture content reaches the optimum range, the salt can be mixed with drier salt in the stockpile or from new deliveries • Samples should be checked after mixing to confirm that the moisture content is in the optimum range
Wet (<4.5%)	• Review spread rates and increase to account for poorer distribution • Consider mixing with drier salt in the stockpile or from new deliveries • Samples should be checked after mixing to confirm that the moisture content is in the optimum range
Optimum	• **TARGET RANGE ✓**
Dry	• For dry salting, assume high losses after spreading • Consider mixing with salt of higher moisture content in the stockpile or from new deliveries

4.3.5 Reducing or increasing the moisture content of salt outside the optimum range to provide a consistent and homogenous stock is difficult, time consuming and costly.

Simply wetting salt without a "mixing" action is likely to increase problems and make the salt less effective or ineffective for treatments.

Using covered storage or barns will provide greater economies over time and the ability to deliver consistently economical and effective treatments.

Figure 4.3.1 – Salt leaching from an unprotected stockpile

4.4 OPTIMUM WAYS TO STORE SALT

4.4.1 The quality of storage facilities are important to help keep the salt in consistently good condition. Good storage is essential, in conjunction with good, properly calibrated spreaders, if lower spread rates are to be used. Storing salt in a barn or dome or other storage structure will allow optimum condition to be maintained most easily after delivery and will require less stock management.

Purpose built salt barn

Sheeted stockpile

The factors to consider when deciding on storage options are shown in Table 4.4.1 below:

TABLE 4.4.1 – STORAGE OPTION FACTORS

Storage method	Factors to consider			
	Relative cost of construction	Maintenance requirements	Control of salt Condition	Effect on spread rates
Salt barn	High	Low	Excellent	Generally Lower spread rates possible (<10g/m²)
Outside under cover	Low	Covering must be installed and regularly inspected	Good – IF good storage practices used	Lower spread rates will not normally be achievable unless the covers are well maintained and the area is properly drained
Outside unprotected	Low	Low*	Poor	Lower spread rates are generally not achievable (not less than 15g/m²) if salt is not maintained within optimum range

** Environmental and drainage aspects such as contaminated runoff must be managed in consultation with the local agency responsible for the environment*

4.4.2 Unprotected stockpile issues

There are many potential issues with storing salt in unprotected stockpiles. These include salt quality, usability, effectiveness of treatments and environmental impacts.

Where water enters a salt stockpile the moisture content is likely to vary significantly making accurate or even effective spreading virtually impossible and remedial measures to correct moisture content of salt stockpiles can be expensive and/or time consuming. Rain falling on an uprotected stockpile will also result in loss of salt from drainage of almost saturated solution. Research has shown that on large stockpiles of typical shape the loss per annum is of the order of 1/8 per cent of the initial weight of the pile for each inch of rainfall.

Where salt is used from an outside uncovered stockpile precautions should be taken to determine its moisture content and the consistency of that moisture content in the salt being used at a particular time.

There is a risk of the stockpile causing increased, unnecessary pollution and environmental damage through leaching or windblown salt particles. Unprotected stockpiles are likely to require additional works to be undertaken to counteract these increased risks, incurring additional associated costs.

UK indigenous rock salt contains insolubles that range from about 2.5 to 7% by weight. The insolubles are mostly marl. When stored outside, a thatch is typically formed on the surface of the stockpile from the marl and recrystallised salt as the sodium chloride at the surface is dissolved by precipitation. The thatch helps to prevent large amounts of water from entering the stockpile.

Other rock salts and marine salts can have a very low insoluble content and it can take longer for a thatch to form. When stored outside, the potential for water ingress is therefore greater with salts of higher purity.

Care is required to avoid overly disturbing or using the thatched salt when managing stockpiles or loading spreaders as this will likely affect proper spreading.

Where salt is used from an unprotected stockpile, the following considerations should be taken into account:

- Stockpiles should be left undisturbed to keep the thatch intact, apart from the working face. The thatch that forms on rock salt should not normally be used. The thatch from a stockpile of higher purity salt can be used if it is properly regraded.
- The stockpile should be profiled such that water runs off and does not pool on the surface and should be monitored for loss of sodium chloride content and spread rates adjusted as necessary.
- The thatch that forms on an exposed rock salt stockpile should not be used because it has a very low sodium chloride content and is likely to have a lower or higher moisture content (depending on weather conditions having been wet or dry) than the rest of the stockpile.
- If large particles from the thatch are spread, the discharge rate of salt from the spreader is likely to be affected, wastage may increase, and target spread rates may not be achieved. In addition, there is an increased risk of damage to vehicles
- Once a thatch has formed on an outdoor unprotected stockpile it should be disturbed as little as possible as it helps mitigate the effects of weather (both wet and drying). If the thatch is broken up, the ingress of water will increase until new thatch has formed
- Arrangements should be put in place for the proper disposal of thatch, unusable salt and other salt contaminated detritus removed from stockpiles. Disposal techniques can include crushing.
- External stockpiles should ideally take the form of an extended trapezium with the working face at one of the shorter ends in order to help limit the ingress of water to the stockpile and the condition of the salt at different parts of the stockpile should be checked regularly

4.5 SALT STORAGE QUANTITIES REQUIRED FOR RESILIENCE

4.5.1 Minimum salt stock levels should be agreed and documented for pre-season and all times throughout the full season.

4.5.2 Recommendations on winter resilience for English Local Highway Authorities were provided by The Quarmby Report of 2010, with the recommendation that Authorities should have sufficient pre-season stocks of salt for 12 days/48 runs (assuming each run at 20g/m²) It was further recommended in this report that:

- Authorities with capacities less than 12 days/48 runs should fill their storage; they should also carefully review their history of usage and mutual aid arrangements, opportunities with surrounding authorities, and consider whether there is a case for increasing storage capacity towards 48 runs.
- Authorities with capacities in excess of 12 days/48 runs should consider whether and to what extent they should stock at or above these levels, taking account of their own pattern of usage, their costs, and the levels of resilience in neighbouring authorities with whom they may have or could have mutual aid arrangements.

4.5.3 Authorities should consider these recommendations but make an assessment based on their local needs, priorities and finances. It is important to consider the number of days that will be needed from ordering through to delivery and build this in to the level of stocks held.

4.5.4 Key considerations will be:

- What extent of network will be treated? Is this the normally salted network or a smaller locally determined Minimum Winter Network
- Resilience of the supply chain and supply lead times throughout the season and during severe weather events, based on local history and distance from mines
- Production and transport limitations, close down periods, weather related delivery issues and spikes in demand can all cause breakdown in supply. The risk of these issues occurring will be at the time of greatest need of supply.

- The Christmas holiday period can extend the periods where new supplies are unavailable and self-sufficiency is critical to ensure services can be maintained

- Authorities should be aware of increased use of salt away from the precautionary network and public expectations of action in severe conditions increasing the demand on salt stocks

Guidance and examples of how authorities have implemented resilience standards are provided in the 'Planning' section of the NWSRG guidance.

4.6 STORAGE PROVISION AND PREPARING STORAGE AREAS

4.6.1 This section provides information on the various aspects of storage requirements that should be considered in planning and preparing for good quality salt storage. Annex 1 and 2 provide further detailed guidance.

4.6.2 The storage area must be large enough to contain the salt stockpile and provide room for vehicles to manoeuvre when unloading/ loading and maintaining the stockpile.

If changing to a different salt type, the effect on the storage area requirements or amount of salt that can be stored should be reviewed.

4.6.3 Different types of salt should be clearly segregated in storage to prevent loading of the wrong type of salt. An appropriate COSHH assessment should be carried out for each material.

4.6.4 For safety reasons the maximum stockpile height should not exceed the ability of the loader to push up salt from solid ground. All faces should be sloped to reduce the risk of collapse. Salt should be handled by machine even when taking samples.

4.6.5 For lower height barns or uneven ground conditions that do not permit the use of articulated lorries in tipped mode, delivery options can include the use of 'walking floor trailers' instead of traditional rigid tipper trucks.

4.6.6 **Stockpile risks**
Walking on stockpiles can be extremely dangerous and must never be allowed without adequate precautions and equipment for health and safety reasons. Apart from the potential for slips and falls, a 'swallow-hole' in the stockpile may entrap anyone walking on it.

All handling of salt, including collecting samples, or access to covers etc. should be carried out using mechanical access or loading equipment whenever possible. This equipment should be appropriate for the task and operated from outside of the stockpile.

Where walking on the stockpile is unavoidable, it must be subject to properly audited safe procedures which include the use of proper equipment and supervision. Lone working should be prohibited.

Salt stockpiles can become dangerous if the salt is piled too high. Vertical or very steep faces also present a danger due to the risk of collapse. The risk will increase dependent on the quality of the material and storage method.

Appropriate risk assessments should be undertaken and communicated to staff.

4.7 STORAGE AREA DRAINAGE AND ENVIRONMENTAL REQUIREMENTS

4.7.1 The effects of de-icers on environmental pollution are of concern to the UK governments generally as well as agencies, organisations and a proportion of the general public.

4.7.2 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 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. A review of PPGs is currently underway with a replacement series Guidance for Pollution Prevention (GPPs). GPPs provide environmental good practice guidance for the whole UK, and environmental regulatory guidance directly to Northern Ireland, Scotland and Wales only. For businesses in England, regulatory guidance is available from GOV.UK instead.

4.7.3 Winter service treatments are a significant contributor to pollution of groundwater and damage to the biosphere. Measures outlined in this guidance will help to mitigate environmental impacts by preventing unnecessary pollution and minimising the amount of salt needed to be spread.

4.7.4 Some additives to salt may have either or both detrimental and beneficial impacts on different environmental aspects and therefore recycling of drainage water (brown water recycling) should be considered.

4.7.5 Where pre-wetted salt is used, there may be a business case for the recycling of drainage water from stockpiles and the washing down of spreading equipment, as well as the collection of rainwater for brine production.

4.8 PRIORITISING SALT STORAGE WHEN COVERED STORAGE IS LIMITED

4.8.1 As maintaining salt in optimum condition is highly reliant on how it is stored, consideration should be given to prioritising storage methods where different types of facility are required for the amount of salt stocked.

4.8.2 When there is insufficient covered storage capacity for all salt stocks, the priority for storing under cover should be as follows:

- Highest priority:
  - o High purity/low insoluble content salt
    e.g. Marine salt

- Lowest priority:
  - o UK & imported rock salt

Note: To date, the NWSRG has not undertaken independent research to investigate in detail the effects of exposure on unprotected external storage of treated salts.

4.9 STORAGE OF STRATEGIC SALT STOCKS

4.9.1 Following salt shortages during severe winters, strategic stockpiles of salt to supplement local stocks in emergency conditions have been put in place. The management of such stockpiles, to ensure the integrity and usability of the salt, needs to be considered.

4.9.2 Recommendations for preparing and maintaining stockpiles given in this section apply equally to strategic stockpiles, however salt should not be stored outside undercover indefinitely unless it can be confirmed that the salt is in good condition. Strategic stocks of salt should be inspected regularly and samples taken to monitor the salt condition.

4.10 SPREADER LOADING

4.10.1 It is important that spreaders are loaded in such a way that maintains the salt condition resulting from good storage.

4.10.2 Ensure procedures are in place for safe methods of working which include loading thatch or aggregations (lumps) of salt. Where possible it is best to load salt from just above the base of the stockpile to avoid contamination However, care should be taken to avoid contamination of the salt with detritus when having to remove it from the base level of the stockpile.

4.10.3 When loading vehicles it should be ensured loads are not heaped unevenly, which can affect the centre of gravity of the vehicle and produce unsafe loads. Loaders should not be used to level salt in spreader hoppers and shunting of vehicles should not be used to distribute loads because of the risk of damage to vehicles.

4.10.4 Sheeting spreaders can be advantageous when treating in wet conditions. This will protect the salt from snow and rain and prevent it being lost from the hopper during spreading.

Spreader loading

Annexe 1

CALCULATING STORAGE SPACE DIMENSIONS

This section provides information on calculating the dimensions of storage facilities required to safely store the volume of salt required.

Calculating storage space dimensions – key facts
If too much salt is stored in an area it can be difficult to manage the salt stocks using the methods recommended in this guidance.

The amount of salt that can be stored in a given area will depend upon:

- the steepness of the stockpile slope determined by the salt's angle of repose
- the maximum safe and workable height of the salt stockpile
- the shape of the stockpile
- the space required for vehicle manoeuvring in barns and domes
- access and egress for vehicles when delivering and loading salt, including the door height should be sufficient that an articulated lorry can exit the barn with the tipper elevated as it draws out

Consideration should be given to segregated storage of mixed salt and sand within the barn.

Angle of repose

- Salt deposited from a height will naturally form a cone with sides that slope at the 'angle of repose' of the salt; that is the angle the surface of the pile makes with the ground
- The angle of repose is determined by the shape and size of the particles and will therefore vary from one type of salt to another and is also effected by moisture content
- This means that the salt is in a stable situation and is inherently safe in terms of collapse or flow. However, this storage method is not typical in the UK, where salt is typically "pushed up" into stockpiles. The range of angles of repose discussed in this section allows for these different storage methods

The angles of repose for commonly used salts are given below:

TABLE A1.1 – ANGLE OF REPOSE FOR COMMON DRY SALT TYPES

Salt type	Angle of repose (degrees)	Approximate height to width ratio of stockpile (h/w)
UK Rock Salt	40-44	0.90
Treated UK Rock Salt	36-40	0.78
Marine Salt	35-40	0.78

**The higher the angle of repose, the steeper the slope of the stockpile and the greater the amount of salt that can be stored in a stable condition in a given area, as shown below:*

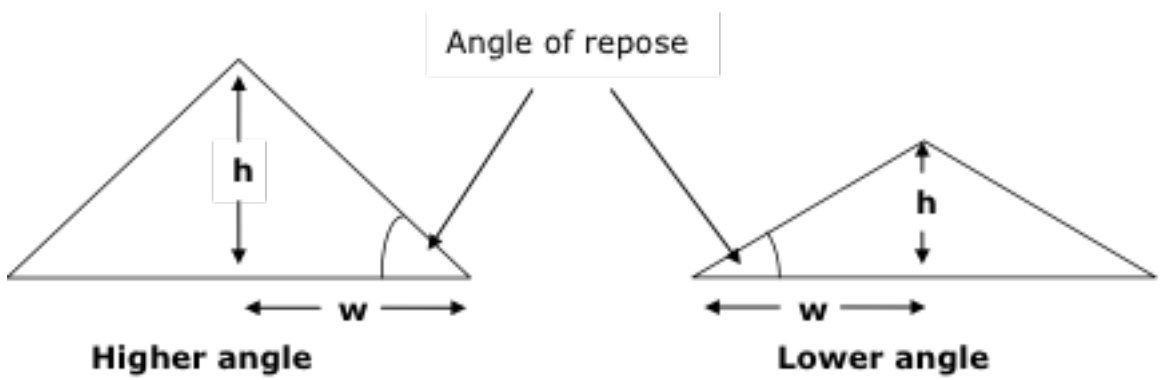
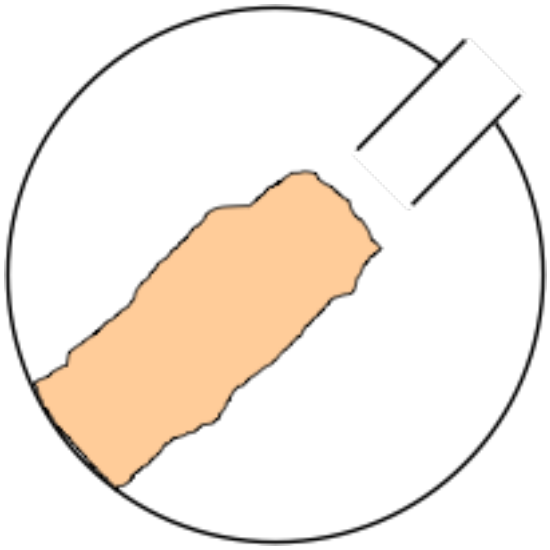


Figure A1.1 Angle of repose

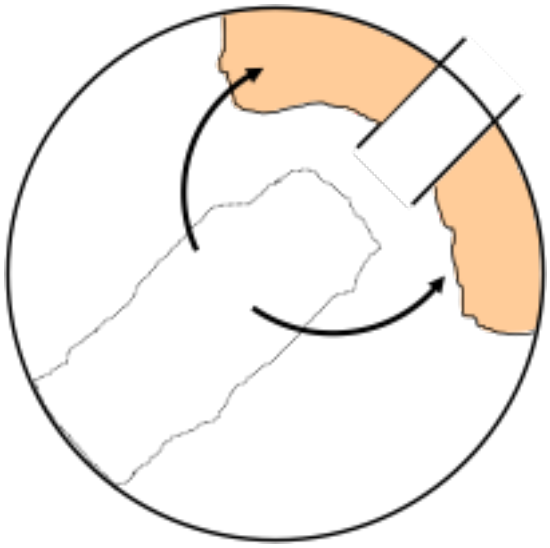
- Therefore, the required storage area will depend on the type and particle sizes of the salt and also the general shape of the stockpile

An example of a good unloading procedure when restocking a circular barn is outlined in the plan view below:

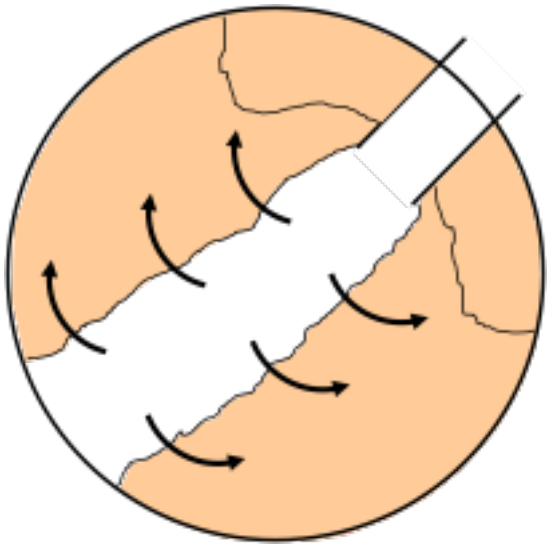
Step 1
Delivery vehicles reverse into the storage area and discharge the load along a central line



Step 2
Salt is moved so that it forms a heap against the retaining walls – the first loads are heaped against the walls adjacent to the entrance



Step 3
The salt continues to be heaped against the walls, working away from the entrance and leaving the central area clear for delivery and unloading



Step 4
Once the salt has been heaped all around the retaining walls, the central area can then be filled, so that the capacity of the storage facility is maximised

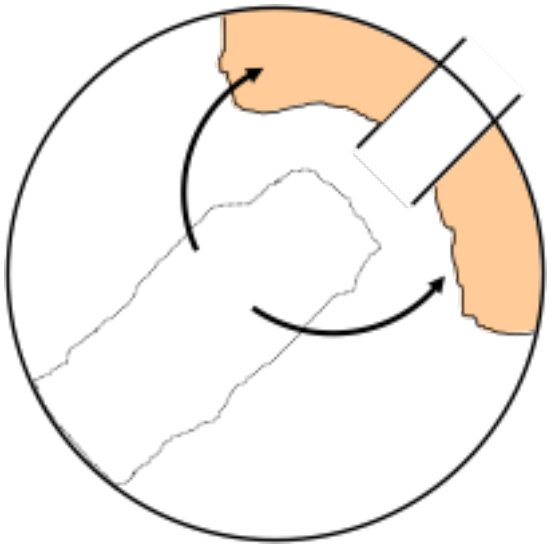


Figure A1.2 – Method for restocking a circular barn

Details of storage area requirements for a range of stockpile shapes and sizes and salt types are given in the following figures and tables:

CONICAL STOCKPILE	
Height	h
Diameter	D

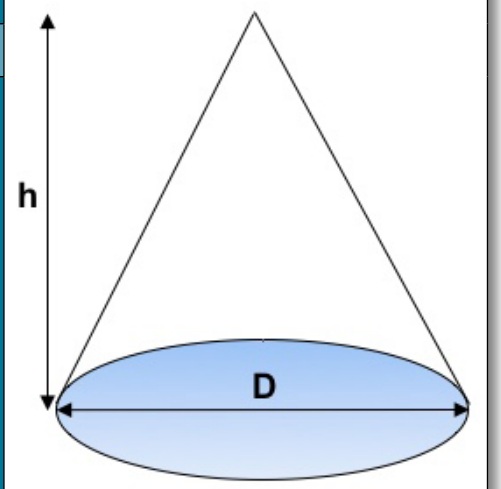


Figure A1.3 – Conical stockpile

TABLE A1.2 – SAMPLE VOLUMES AND WEIGHTS FOR CONICAL STOCKPILES					
6.3mm Rock zalt, Bulk density = 1200kg/m³, Angle of repose = 40°					
Height (m)	Floor Area (m²)	Diameter (m)	Stockpile Surface Area (m²)	Volume (m³)	Amount (tonnes)
3	40.2	7.2	52.4	40.2	48.2
z	54.7	8.3	71.4	63.8	76.5
4	71.4	9.5	93.2	95.2	114.2
4.5	90.4	10.7	117.9	135.5	162.6
5	111.5	11.9	145.6	185.9	223.1

TRAPEZOIDAL STOCKPILE	
Height	h
Base width	W1
Top width	W2
Length	L

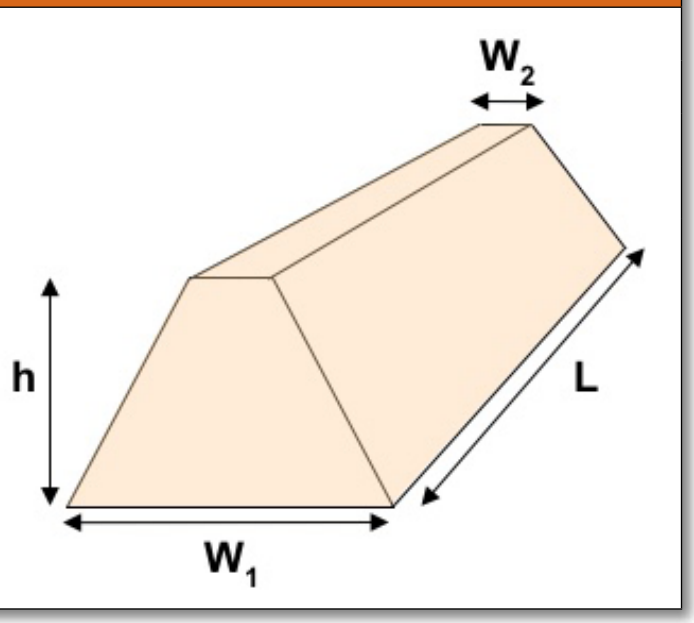


Figure A1.4 – Trapezoidal stockpile

TABLE A1.3 – SAMPLE VOLUMES AND WEIGHTS FOR TRAPEZOIDAL STOCKPILES							
6.3mm Rock Salt, Bulk density = 1200kg/m³, Angle of repose = 40°							
Height	Length (m)	W1 (m)	W2 (m)	Floor Area (m²)	Stockpile Surface Area (m²)	Volume (m³)	Amount (tonnes)
3	10	10	2.8	100	121.8	192.7	231.3
	20	10	2.8	200	243.7	385.5	462.6
	30	10	2.8	300	365.5	578.2	693.9
	40	10	2.8	400	487.4	771.0	925.2
	50	10	2.8	500	609.2	963.7	1156.5
	10	15	7.8	150	171.8	342.7	411.3
	20	15	7.8	300	343.7	685.5	822.6
	30	15	7.8	450	515.5	1028.2	1233.9
	40	15	7.8	600	687.4	1371.0	1645.2
	50	15	7.8	750	859.2	1713.7	2056.5
4	10	15	5.5	150	179.1	409.3	491.2
	20	15	5.5	300	358.2	818.6	982.4
	30	15	5.5	450	537.4	1228.0	1473.5
	40	15	5.5	600	716.5	1637.3	1964.7
	50	15	5.5	750	895.6	2046.6	2455.9
5	10	15	3.1	150	186.4	452.1	542.5
	20	15	3.1	300	372.8	904.1	1084.9
	30	15	3.1	450	559.2	1356.2	1627.4
	40	15	3.1	600	745.6	1808.2	2169.9
	50	15	3.1	750	932.0	2260.3	2712.4

STORAGE AGAINST WALL	
Height	h
Base width	W1
Top width	W2
Length	L

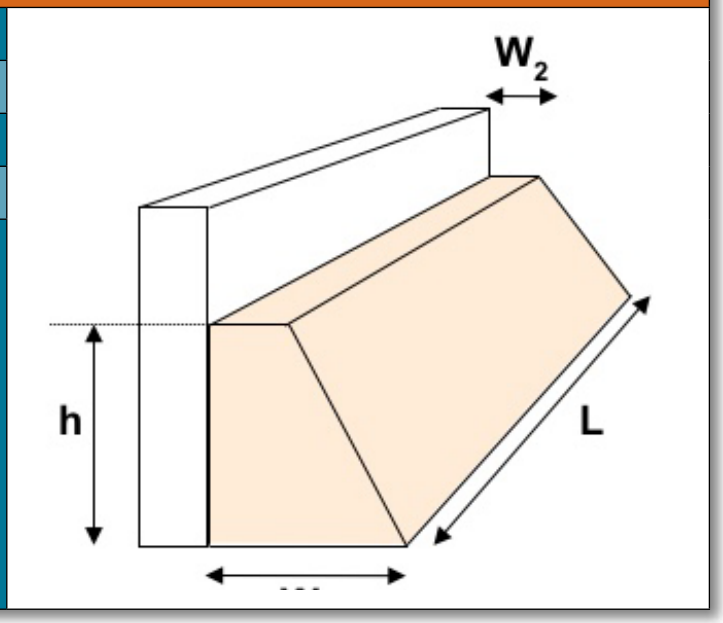


Figure A1.5 – Storage against wall

TABLE A1.4 – SAMPLE VOLUMES AND WEIGHTS FOR STORAGE AGAINST WALL							
6.3mm Rock Salt, Bulk density = 1200kg/m³, Angle of repose = 40°							
Height	Length (m)	W1 (m)	W2 (m)	Floor Area (m²)	Stockpile Surface Area (m²)	Volume (m³)	Amount (tonnes)
3	10.0	10.0	6.4	100.2	111.2	247.1	296.5
	20.0	10.0	6.4	200.5	222.3	494.2	593.1
	30.0	10.0	6.4	300.7	333.5	741.3	889.6
	40.0	10.0	6.4	401.0	444.7	988.5	1186.1
	50.0	10.0	6.4	501.2	555.8	1235.6	1482.7
	10.0	15.0	11.4	150.2	161.2	397.1	476.5
	20.0	15.0	11.4	300.5	322.3	794.2	953.1
	30.0	15.0	11.4	450.7	483.5	1191.3	1429.6
	40.0	15.0	11.4	601.0	644.7	1588.5	1906.1
	50.0	15.0	11.4	751.2	805.8	1985.6	2382.7
4	10.0	10.0	5.3	100.3	114.9	306.0	367.2
	20.0	10.0	5.3	200.7	229.8	612.0	734.3
	30.0	10.0	5.3	301.0	344.7	917.9	1101.5
	40.0	10.0	5.3	401.3	459.6	1223.9	1468.7
	50.0	10.0	5.3	501.6	574.4	1529.9	1835.9
5	10.0	10.0	4.1	100.4	118.6	353.1	423.7
	20.0	10.0	4.1	200.8	237.2	706.2	847.4
	30.0	10.0	4.1	301.2	355.8	1059.3	1271.1
	40.0	10.0	4.1	401.6	474.4	1412.4	1694.8
	50.0	10.0	4.1	502.1	593.1	1765.5	2118.6

Annexe 2

CONSTRUCTION REQUIREMENTS FOR SALT STORAGE FACILITIES

Construction requirements for salt storage facilities

- Planning for new, upgraded and refurbished storage facilities should be carried out in accordance with this guidance
- All planning, building and environmental regulations, appertaining to the facility, should be followed
- All buildings and storage structures must meet UK building design codes and be constructed of materials not subject to corrosion
- All of the walls within a barn must be designed to withstand the maximum possible loads caused from salt stored against them and the dynamic forces from loading the salt
- Salt stockpiles should be kept on a concrete (preferred) or bituminous base sloped to allow water to drain away
- Adequate drainage must be provided which meets environmental requirements/agreements
- Salt stockpiles can be formed by enclosing the stockpile on three sides with retaining walls
- Storage facility construction should be designed and specified by competent persons
- Storage facilities should be constructed and completed construction approved by competent persons
- The storage and loading area should have an impermeable floor or base constructed from concrete (preferably) or a layer of adequate bituminous paving. This prevents the ingress of water from the ground into the stockpile and also prevents salt water from the stockpile seeping into the ground
- An impermeable floor will help to prevent contamination of the salt, in particular when removing the salt from the stockpile during loading of spreaders

- To maximise the use of the available space and to contain the salt, retaining walls can be formed to contain the stockpile.
- Retaining walls for external stockpiles should ideally be impervious to water, mainly to prevent water entering but also they will help to maintain a more stable moisture content in dry conditions
- Retaining walls may also provide additional protection as well as support and anchorage for external stockpile covers
- All buildings and storage structures must be designed and built to meet UK building design codes. All construction materials should be durable in a salt laden environment e.g. timber, high grade concrete (C50).
- Where salt is stored directly against the walls of a building or other retaining structure, these must be designed to withstand the loads from the static pressure of the salt and the dynamic forces caused when loading, etc.

DECIDING ON THE POSITION AND ORIENTATION OF SALT STORAGE

The position and orientation of salt storage facilities can be optimised to help maintain the salt in good condition and minimise the effects of wet or windy weather.

Optimising position and orientation of salt storage facilities – recommendations
Where possible optimise the position and orientation of salt storage facilities to help maintain optimum salt condition

To minimise weather ingress, openings should be located to minimise exposure to the prevailing wind and weather. This helps:

- Prevent excess or unnecessary moisture entering the stockpile
- Prevent unnecessary drying of the stockpile by wind and draughts
- Minimise the requirements for anchoring coverings to external stockpiles
- Minimise the possibility of coverings being disrupted or damaged by wind

Where openings face the prevailing weather, doors should be installed.

External covered stockpiles are best oriented so that the long side of the stockpile is parallel with prevailing winds to minimise the length exposed to the full force of the wind (unless highest wind speeds are experienced from a different direction).

The conditions of temperature, humidity and air circulation should be kept as consistent as possible within any storage structure.

The condition of salt in a barn will typically remain fairly constant, but salt stored near an open door may have different moisture content to the rest of the stockpile.

Salt in enclosed or covered stockpiles may be wetter if exposed to precipitation through open doors or defective coverings but may also dry out more rapidly due to sun and wind.

Where practicable, the door/opening to an enclosed structure should be located to minimise exposure to the prevailing wind and weather. In the UK, prevailing winds are generally from the southwest and therefore, doors/openings would typically be best placed on the north east to southeast portion of the building. Local factors should be taken into consideration however, and it is recognised that such an arrangement is not always practicable.

The surrounding ground/paving should be designed so water is drained away from the entrance or a drainage channel is provided to prevent water from entering.

External covered stockpiles are best oriented so that:

- The long sides of rectangular piles are parallel to the prevailing wind so minimising the length of covering directly exposed to the oncoming wind direction
- Water drains away from the stockpile or protection is provided from water entering the base of the stockpile by drainage channels or a dwarf wall
- Loading is carried out on the low ground level side of the stockpile so water drains away from the loading area

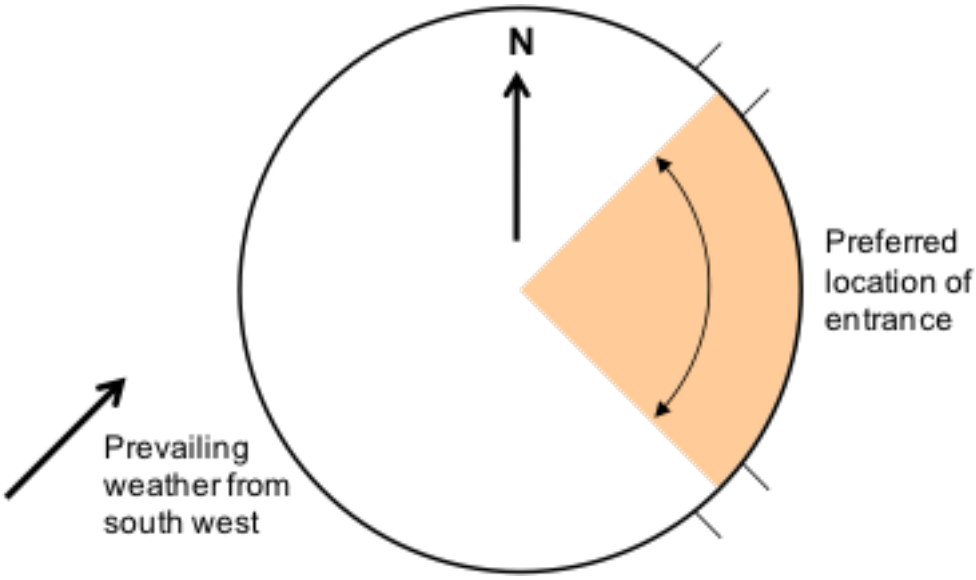


Figure A2.1 Preferred location of entrance to a circular barn

COVERING OUTDOOR STOCKPILES

Where salt cannot be stored in a barn or dome then the next best method of storage is to provide covering of external stockpiles to minimise either unnecessary wetting or drying of the salt.

Covering outdoor stockpiles - recommendations

- Outdoor stockpiles should be covered to protect the salt from rain and wind
- The covers should be positioned to prevent precipitation from reaching any part of the stockpile, including the base
- Covers should be handled carefully to prevent them being damaged and they must be secured against the wind
- Covers should be inspected on a regular basis, especially after high winds, heavy rain or snowfall, and any damage must be repaired
- Sheeting should be arranged to allow access to the working face, while still providing cover to the remainder of the stockpile
- Stockpiles are positioned to minimise disruption of covers by prevailing winds
- Careful consideration needs to be made to the material and methods you use for weighting, options include use of ground weighting or roped bags.

Effect of covers to stockpiles after water enters - warning

If water enters either a covered or an uncovered stockpile the condition of the stockpile will deteriorate rapidly. Any Covering is likely to prevent subsequent drying in fine weather. For this reason it is particularly important that water is prevented from entering a covered stockpile.

- See 4.3 for action that can be taken when salt becomes wet.

Precipitation on a salt stockpile clearly increases the moisture content and will frequently result in uneven moisture content.

Covering the stockpile will protect the salt, help keep the condition consistent and minimise any losses.

Salt stored outside is best covered with waterproof sheeting to protect against rain and wind. Commercially available sheeting systems designed specifically for salt stockpiles are recommended

Unprotected stockpiles should be avoided because salt and anti-caking agents are lost through leaching, and the moisture content of the salt cannot be maintained at optimum levels

There is a far greater risk of swallow holes forming in unprotected stockpiles

Figure A2.2 – Example of waterproof sheeting

- Covers may be prone to deterioration through long exposure to the elements, e.g. ultra-violet radiation, and this should be considered when making purchasing decisions
- Damage to covers should be repaired promptly to prevent the ingress of water, which would have a detrimental effect on salt condition
- Significant water ingress can lead to the development of 'swallow holes' which can be a hazard to people working on the stockpile and the stockpile stability
- Walking on the stockpile should be avoided and only undertaken when absolutely necessary with adequate safety precautions and equipment in place
- Salt at the working face of the stockpile is exposed to the elements. However, it is usually impractical to cover the working face of a stockpile during frequent use and therefore it is good practice to minimize the size of the working face
- Outdoor stockpiles should ideally take the form of an extended pyramid or trapezium with the working face at one end

Annexe 3

HOW AND WHEN TO CHECK SALT CONDITION

As the condition of salt, particularly in regard to moisture content, is critical to effective and economical treatments, it is extremely important to regularly monitor the salt condition.

Checking salt condition – recommendations

- Authorities should regularly check the salt condition, by testing samples taken from existing stockpiles as well as new deliveries
- A regime of testing should be developed in consultation with the salt supplier
- Simple checks on moisture content can be carried out locally at reduced cost but should be supplemented and verified by UKAS accredited laboratory tests analysed according to the British Standard BS 3247:2011
- Independent testing should be compared with certificates provided by suppliers
- BS 3247:2011 provides information for the testing of salt moisture content, grading and certain chemical properties. For consistent, accurate results, these tests are best carried out by UKAS accredited laboratories or properly equipped internal facilities using trained persons
- There are other, simpler methods that can be used to measure salt moisture content. These tests can be used for comparative purposes to check how the moisture content is changing throughout a season. If the simple checks indicate a change in salt moisture, it is recommended that samples are then sent for testing by an accredited laboratory for confirmation.
- Checks should be made on new deliveries of salt. It is recommended that a testing regime is developed in consultation with the supplier, based on the consistency of the salt being supplied.
- Checks should also be carried out regularly on the condition of salt in stockpiles.

An example of frequencies of sampling for different storage options are shown in the table below, but authorities should develop their own programme of testing based on local experience:

TABLE 4.16.1 – SALT TESTING FREQUENCY	
Storage type	**Frequency of testing (per month)**
Outside unprotected	2
Outside covered	1
Barn	1

If incorporated as a routine procedure, sampling and testing the salt condition will be a quick and easy process and will provide useful long-term information.

Procedure - Salt condition sampling to BS3247:2011
The aim of sampling is to obtain a bulk sample that is representative of the average properties of the batch. European Standard BS EN 932-1:1996 specifies methods for obtaining samples of aggregates from deliveries and stocks.

For safety reasons, the sample should not be taken by hand from the stockpile but by using equipment normally used to load spreaders.

It is recommended that two bucket loads are first removed from the same location and height. A third bucket load should then be removed and a sample (of about 2kg) taken from this bucket. In this way the sample will be representative of salt that would be loaded into a spreader.

When sampling from stockpiles in barns, it is recommended that samples are taken from the working face and other areas of the stockpile. For external stockpiles, salt should only be taken from the working face to avoid disturbing the cover or thatch.

Further guidance on sampling

For each sample:
- Assign a unique reference number
- Note on a plan of the stockpile where each sample was taken

The samples should be placed in an airtight container labelled with the sample reference number and sent for analysis, preferably at a UKAS accredited laboratory, and tested to BS3247:2011.

Procedure - Local testing salt moisture content
Samples should be taken from the stockpile in the same way as for testing to BS 3247:2011.

Although the preferred method for measuring the moisture content is in accordance with BS 3247, a reasonable estimate for continual monitoring can be obtained by:
1. Weighing a sample of salt (before drying)
2. Drying the sample in a fan oven at 70°C
3. Weighing the dry sample
4. Calculating the difference in weight
5.The moisture content (%) can be obtained using:
100 x (wet weight – dry weight) ÷ (dry weight)

Example

If a sample weighs 500g (wet) and 478.5g (dry) the moisture content would be 100 x (500 – 478.5) ÷ 478.5 = 4.5%

Annexe 4

CHECKLIST FOR STORING AND MAINTAINING SALT STOCKS

The following checklist should assist authorities to store and maintain salt stocks in good condition. It is recommended that this – or a similar checklist – is incorporated within the Operational Winter Service Plans of individual authorities.

TABLE A4.1 - CHECKLIST FOR SALT STORAGE

Storage areas	✓ ✘
The storage space requirements been reviewed on the basis of current recommendations	
All bases of stockpiles are sloped to promote water to drain away	
Drainage is in accordance with environmental guidelines and approved by the relevant authority	
All buildings and storage structures must meet UK building design codes and constructed of materials not subject to corrosion	
There is suitable access and egress for spreaders and delivery lorries with adequate space for safely manoeuvring the vehicles and loading equipment	
All outdoor stocks are covered	

Management of salt stocks	✓ ✘
The stockpiles are regularly tested for quality, including chloride content, moisture content and grading	
Procedures are in place for situations where the quality of the salt falls outside of allowable tolerances and particularly optimum moisture content	
Procedures are in place relating to the safe and proper working of the stockpile (e.g. loading and stock rotation)	
There is an effective stock management system in place that enables stock rotation without excessive handling	
There are adequate re-stocking arrangements in place with suppliers	
Regular checks are made of the integrity of coverings on external stockpiles	

Health and safety	✓ ✘
Policies and procedures for safe handling of materials by mechanical means are in place	
Policies to prevent walking on stockpiles without proper equipment and safeguards are in place	
Policies to prevent single working are in place	
The maximum stockpile height is specified in procedures	
All the faces of stockpiles are sloped to prevent collapse	
An appropriate risk assessment is in place for each site and process	
An appropriate COSHH assessment is in place for each material	

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