THE USE OF ADDITIVES ON ROCK SALT TO ENHANCE HIGHWAY DE-ICING PERFORMANCE

Dr Neil A. Rosenburgh[1], Mr Jason L.Bagley[2]

[1]Technical Development Manager, Specialty Products, Compass Minerals International Inc.
[2]Business Manager, Specialty Products, Compass Mineral International Inc.

[1]Salt Union Ltd, Bradford Road, Winsford, Cheshire CW7 2PE, UK
[2]9900 West 109th Street, Suite 600, Overland Park, KS 66210, USA

This paper discusses the use of additives on rock salt to enhance highway de-icing performance in the UK and North America. Additives are utilized for numerous reasons within the highway de-icing industry the advantages associated with using treated salt have been highlighted. The UK and North American climates differ greatly and therefore the need for alternative approaches have been discussed. Finally, a cost benefit analysis of treated rock salt versus rock salt for a region of the UK has been summarised.

INTRODUCTION

Sodium Chloride (rock salt) is accepted in the UK and North America as the most efficient and cost effective agent for the prevention (anti-icing) and removal of ice (de-icing).[1]

Many authorities became interested in the claims attributed to agricultural by-products (ABPs). Such products, derived from various processes, such as sugar and corn treatment, have been around for some time.

The concept originated in the USA where ABPs were experimented with as additives to rock salt. One such product, de-sugared molasses was patented for use in conjunction with various de-icers, including sodium chloride. The concept was introduced to the UK market where ABPs were promoted as a salt additive. The resulting treated salt was rigorously tested by independent research facilities [2] as well as local and national authorities to substantiate the claims of this new product.

Treated salt now accounts for more than 20% of overall sales in the UK but less than 5% of the North American highway salt market. The treated salt market share continues to grow in both regions as new users realise the potential benefits it can bring to their winter maintenance operations.

DISCUSSION

The majority of treated salt (Fig. 1) in the UK is a 6mm rock salt that has been premixed with an agricultural by-product (ABP) at 3% by weight liquid per tonne to rock salt. The additive is a derivative of the sugar production process with powerful anti-icing, de-icing and corrosion inhibition properties.

Fig. 1 UK Rock salt treated with molasses based additive

Within North America colder climatic conditions dictate the need for lower temperature de-icing agents. Rock salt stockpiles are prone to freezing and excessive clumping. The addition of magnesium chloride ($MgCl_2$) to rock salt helps to negate these effects. In North America, the $MgCl_2$ liquid blend is usually added at 3-4% by weight to the dry rock salt. Without the ABPs the liquid addition rate tends to be limited to 2-3% to prevent excessive leaching.

STORAGE & ICE MELTING PERFORMANCE

Storing salt undercover in domes, barns or specialist sheeting (Fig. 2) ensures product quality is maintained, [3] however, leaching of $MgCl_2$ from covered stockpiles can detract from the performance of the treated salt as well as providing a cumbersome clean up operation.

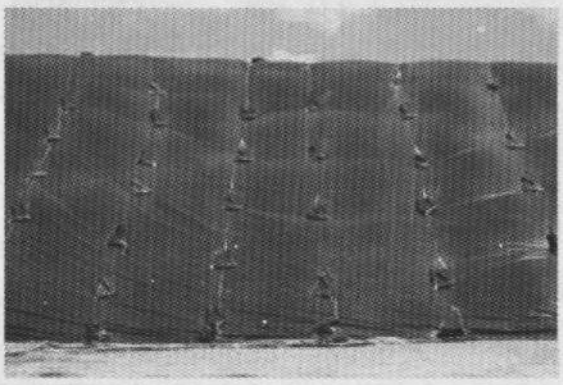

Fig. 2 Drystore sheeting system protecting strategic stockpile

ABPs can be readily blended with $MgCl_2$ to provide an ideal solution to the leaching problem. The ABP acts as a viscosity modifying agent allowing the $MgCl_2$ to adhere better to the rock salt as well as helping the salt adhere to the road. ABPs also synergistically lower the freezing point of $MgCl_2$ providing an even more powerful de-icing agent. With the addition of low temperature liquids, treated salt reduces the clumping and freezing normally associated with traditional rock salt, especially at cold temperatures. The resulting treated salt remains free flowing even down to -10°F.

Melting capacities (Table. 1) of treated rock salts produced using 4 different commercially available de-icers (Ad1-4) were determined by Compass Minerals technology group. The results showed increased performance compared to normal rock salt at varying temperatures and times.

5°F	Salt	Treated Salt (8 gal/ton on salt)				
		mean	Ad1	Ad2	Ad3	Ad4
Time	ml/g	ml/g	ml/g	ml/g	ml/g	ml/g
15	0.33	0.42	0.38	0.43	0.46	0.40
30	0.64	0.87	0.76	0.88	0.96	0.86
60	1.18	1.70	1.57	1.65	1.83	1.74

Table 1. Rock Salt and Treated Salt melting capacities (millilitres ice melted per gram de-icer used) at 5°F.

Treated salt can also greatly reduce the need for sand in a road maintenance plan. As temperatures fall, road crews abandon de-icing/anti-icing in favour of using sand to aid traction. With the lower effective working temperature of treated salt, road crews can delay, or eliminate this strategy switchover.

As some ABPs are colourless when blended with salt, dyes can be added to distinguish between treated and untreated salts (Fig. 3). This allows end users to easily identify the right tool for the right conditions (regular salt for warmer temperatures and treated salt for colder temperatures). Public awareness of the proper highway treatment is also increased as the product is more clearly visible on the road surface.

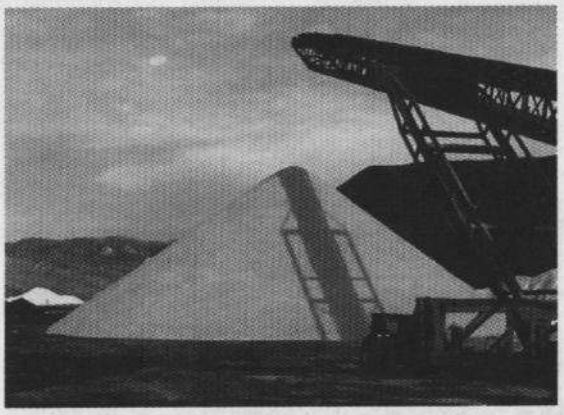

Fig. 3 US rock salt treated with corn syrup based additive and orange dye

SPREAD RATE & SPREAD PATTERN

Traditional rock salt generates a wasteful spread pattern (Fig. 4) where larger particles of material are lost to verges and finer particles of material are blown away by wind or vehicle draughts (Fig. 5).

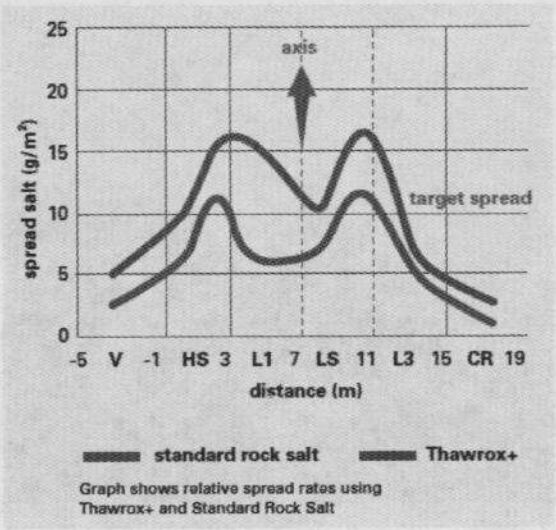

Fig. 4 Targeted spread on UK Motorway network:

V = Verge; HS = Hard Shoulder; L1/2/3 = Lane 1/2/3; CR = Central Reservation. (Thawrox+ = CMP UK treated salt)

Treated salt brings improved spreading performance and eliminates blocking; rock salt with higher moisture content due to prolonged storage is prone to blocking in the vehicle hopper potentially resulting in areas of the highway not being salted.

Treated salt is particularly effective because the additive helps to bind the rock salt, this reduces wind borne loss and bounce off and results in greater residual salt levels for longer term protection (Fig. 6).

Fig. 5 Standard rock salt can be blown off course

Fig. 6 Treated salt requires up to 30% less material to cover same target area

With reduced spreading, less salt is needed so spreading vehicles need to return to the depot less often. This means spreading routes can be lengthened and overall operational costs reduced.

COST BENEFIT ANALYSIS

Whilst treated salt is a premium product its use has a number of cost benefits than can outweigh any savings made by using traditional rock salt [4]. A cost benefit model has been independently developed in the UK which can demonstrate this (Table. 2).

North West England – Highways Agency Area 10			
		Rock Salt	Treated Salt
Total relevant operating costs	Made up from cost of raw materials, depot infrastructure, vehicles, maintenance	£970,044	£670,747
Total relevant other costs	Corrosion costs to vehicles and infrastructure	£12,879,421	£5,870,430
Total Benefits	These are the economic benefits of having roads free from ice, accident benefits and traffic flow benefits	£104,133,139	£104,133,139
Winter Gritting Budget	Represents a year on year cost saving to the winter gritting budget compared with conventional salt	n/a	£299,296
Authority Budget	The difference in cost to the wider area budget in comparison with the dry salt option	n/a	£626,470
Community as a whole	Realised from a combination of the reduction in operating cost, reduction in corrosion to vehicles and infrastructure	n/a	£7,008,991

Table. 2 Extract from Model summary for UK Highways Agency Area 10 (North West England)

The model allows highway authorities to see how treated salt can have a positive impact on winter services budgets, overall maintenance budgets and the community.

ANTI-CORROSION

Because of its anti-corrosive qualities, treated salt has longer term benefits. It helps to

lengthen the life expectancy of spreading vehicles (Fig. 7) and can reduce vehicle wash-down time.

Fig. 7 Spreading vehicle displaying typical corrosion problems

Treated salt can also have a positive effect on infrastructure, including streetlamps and road signs, thus reducing maintenance and capital costs over a longer period.

The corrosive nature of salt to rebar is the major driver behind corrosion reduction. Field trials undertaken by Salt Union Ltd (a Compass Minerals Company) in the UK where steel plates were mounted on spreading vehicle salt skirts (Fig. 8) visibly showed the reduction in corrosion with respect to traditional rock salt.

Fig. 8 Spreading vehicle with mild steel coupons attached to salt skirt

The exercise highlighted the aggressive nature of spreading pre-wetted salt (70% solid, 30% (23% NaCl brine), with pitting clearly visible on the panels. Treated salt showed reduced and uniform corrosion (Fig. 9).

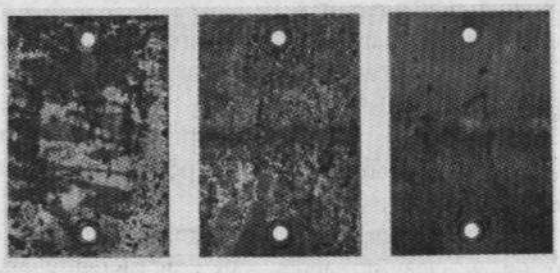

Fig.9 From Left to Right: Panels affixed to vehicle spreading: Pre-wet, Rock salt, Treated salt

Dramatic differences in corrosion were also observed by material scientists from Volkswagen Auto Group who performed a similar field test in Austria using pre-wetted

salt and additives [5] (Fig. 10 & 11).

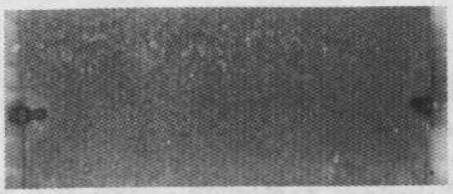

Fig. 10 70% solid NaCl, 30%(32% $CaCl_2$ brine)

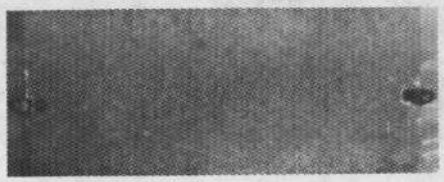

Fig. 11 70% solid NaCl, 26.25% (32% $CaCl_2$ brine), 3.75% (additive)

ENVIRONMENTAL

Treated salt is easily degradable after it has been applied to the roads. The additive is derived from ABPs, which makes it natural and environmentally friendly. It has a reduced chloride impact on the environment and has been approved for use by highways and environment agencies. The EPA in the US has recognized various treated salt additives under their "Design for the Environment" program because these additives allow reduction of overall salt usage, with the associated environmental benefits.

OPERATIONAL

Purchasing salt pre-treated means all the rock salt is thoroughly mixed with the additive and so preparation of de-icing materials is not required. This enables driver's hours to be fully optimized and keep operational labour costs down.

No extra training is required as treated salt makes use of existing spreading equipment. Treated salt unlike pre-wetting which requires additional infrastructure and maintenance of specialist equipment, simply utilises the existing spreading vehicles capability.

No hidden clean-up costs. Sand is regarded as an inexpensive commodity on the front side at application, but there is a growing realisation when factoring in clean-up and disposal costs.

Treated salt has been tested by a number of local authorities, highways agencies and maintenance contractors in the UK and throughout North America, many of whom claimed that treated salt has had a positive effect on their operations [6]. Engineers reported a greater adhesion to the road surface, a more even spread and a better flow of material in the hopper with little or no clogging to spinners and chutes.

CONCLUSION

In addition to the environmental and corrosion improvements associated with treated salt, highway de-icing performance and overall cost reductions continue to substantiate the use of this important tool.

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IODIZED SALT AND IDD ELIMINATION