**General Literature Search for ORIL Research Idea Submission (November 2014-2015)**

**Snow and Ice Control for Local Highways**

Robert Sterling

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Prepared by

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Library Administrator

[zona.kahkonen.keppler@dot.state.oh.us](http://www.riverkeeper.org/campaigns/safeguard/gas-drilling/the-facts-about-new-york-and-fracking-waste/)

Ohio Department of Transportation

Snow and Ice Control for Local Highways

*Prepared for*

*Ohio’s Research Initiative for Locals (ORIL)*

*November 2014*

*Prepared by*

*Zona Kahkonen Keppler*

*Transportation Literature Searches are prepared for ODOT staff to identify completed research and other authoritative information in an area of interest. The citations below are representative, rather than exhaustive of available English-language studies and other pertinent information on the topic. Primary online resources for the literature search TRID Online, TRB‘s Research in Progress (RiP), and Practice-Ready Papers databases, WorldCat, the National Transportation Library (NTL) catalog, and other academic, engineering and scientific databases as available.*

***Keywords (singly/combinations****): urea, carbamide, salt, salts, road salt, rock salt, sodium chloride, deicers, snow and ice control, winter maintenance, anti-icing, ice control, brine*

***Citations:*** *Links to online copies of cited literature are provided when available. If you are interested in full reports/articles lacking a web link, please contact me and I will obtain the full report/article if possible.*

***Research idea:*** *Local agencies, i.e. counties and townships, are experiencing difficulties in obtaining road slat for snow and ice control. Cost and availability are issues, as is the corrosiveness of salt on vehicles, pavements, and bridge decks.*

*The Harrison County Engineer’s Office has been advised that urea may be a viable substitute for road salt, and has been used with some success. It has been suggested that gas processing plants under construction in Southeastern Ohio might be possible sources of manufactured urea.*

*Urea, as well as other alternatives to rock salt would like to be considered as possible options to use for snow and ice control.*

***Summary:*** *The usage of urea (carbamide) as a snow and ice control substance was searched in all available databases yielding eight research reports. Urea has been used as a deicer for airports, although runoff is reportedly an environmental concern. Many states are attempting to discover a viable alternative to the use of road salt. Though few full research reports are scarce, some salt alternatives in the experimental state (as reported in the news media) have been listed at the end of this search.*

**Possibilities for the Use of Chemicals Materials Alternative to Chlorides for Decreasing Road Slipperiness in Winter**

Having assessed in various aspects the study materials (salts), used for road maintenance in a cold period of the year, and taking a special consideration of the impact of these materials (salts) on the environment as well as their price, it could be stated that the most acceptable alternative for Lithuania is the already used sodium and calcium chloride salts. A large disadvantage of two materials (sodium chloride and calcium chloride) is that chloride ions strongly increase the speed of corrosion reactions of metals. Larger concentrations of chlorides aggravate vegetation processes and, thus, cause damage to roadside plants. Having assessed all the materials (salts) according to their chemical and physical properties and also according to their price and availability from technological point of view in the production, at present the following compounds could be distinguished: **carbamide** and calcium magnesium nitrates. When using calcium nitrate fewer chlorides get into the environment and the environment is less corrosive in regard to metals, however, here another problem occurs. If too large concentrations get into the environment, nitrates can cause pollution of ground water and soil. In future, having expanded the production of calcium and magnesium nitrates, it will be possible to start producing certain mixtures, e.g. **carbamide** with those nitrates or the mixture of **carbamide**, calcium, magnesium nitrates and calcium chloride, and, thus, to reduce a direct use of chlorides.

Laurinavicius, Alfredas

Mazeika, Romas

Vaiskunaite, Rasa

Brimas, Gintautas

Milasius, Sarunas

pp 274-282

2011

Baltic Journal of Road and Bridge Engineering

Volume: 6
Issue Number: 4
Publisher: Vilnius Gediminas Technical University

**Assessing the Impact of Pavement De-icing Products on Aircraft and Airfield Infrastructure**

[http://www.coe.montana.edu/me/faculty/Shi/AirportDeicers.pdf](http://www.riverkeeper.org/campaigns/safeguard/gas-drilling/the-facts-about-new-york-and-fracking-waste/)

In the mid-1990s, airports worldwide started to introduce new types of alkali-metal-salt based pavement deicing products (PDPs) to mitigate the environmental concerns of the previously used **urea** and glycol-based PDPs. While improvements to the operational and environmental quality of airport winter maintenance activities were seen, a significant number of field reports began to surface regarding the unintended consequences of these new PDPs, including the catalytic oxidation of carbon-carbon brakes, cadmium corrosion, PDP interaction with aircraft deicing and anti-icing fluids, asphalt and concrete deterioration, and the corrosion to airfield electrical infrastructure and ground support equipment. The Airport Cooperative Research Program therefore began research to collect data on PDP usage and review the damage associated with these new PDPs. This paper summarizes that research effort.

Friedman, Paul L.

Shi, Xianming

pp 223-237

2009

[Journal of Airport Management](http://trid.trb.org/results.aspx?q=&serial=%22Journal%20of%20Airport%20Management%22)

Volume: 3
Issue Number: 3
Publisher: Henry Stewart Publications

**Aquatic Toxicity of Airfield-Pavement Deicer Materials and Implications for Airport Runoff**

[http://pubs.acs.org/doi/pdfplus/10.1021/es8017732](http://www.theguardian.com/sustainable-business/alternatives-salt-battling-ice-cheese-beets-ash)

Concentrations of airfield-pavement deicer materials (PDM) in a study of airport runoff often exceeded levels of concern regarding aquatic toxicity. Toxicity tests on Vibrio fischeri, Pimephales promelas, Ceriodaphnia dubia, and Pseudokirchneriella subcapitata (commonly known as Selenastrum capricornutum) were performed with potassium acetate (K-Ac) PDM, sodium formate (Na-For) PDM, and with freezing-point depressants (K-Ac and Na-For). Results indicate that toxicity in PDM is driven by the freezing-point depressants in all tests except the Vibrio fisheri test for Na-For PDM which is influenced by an additive. Acute toxicity end points for different organisms ranged from 298 to 6560 mg/L (as acetate) for K-Ac PDM and from 1780 to 4130 mg/L (as formate) for Na-For PDM. Chronic toxicity end points ranged from 19.9 to 336 mg/L (as acetate) for K-Ac PDM and from 584 to 1670 mg/L (as formate) for Na-For PDM. Sample results from outfalls at General Mitchell International Airport in Milwaukee, WI (GMIA) indicated that 40% of samples had concentrations greater than the aquatic-life benchmark for K-Ac PDM. K-Ac has replaced **urea** during the 1990s as the most widely used PDM at GMIA and in the United States. Results of ammonia samples from airport outfalls during periods when **urea-based** PDM was used at GMIA indicated that 41% of samples had concentrations exceeding the U.S. Environmental Protection Agency (USEPA) 1-h water-quality criterion. The USEPA 1-h water-quality criterion for chloride was exceeded in 68% of samples collected in the receiving stream, a result of road-salt runoff from urban influence near the airport. Results demonstrate that PDM must be considered to comprehensively evaluate the impact of chemical deicers on aquatic toxicity in water containing airport runoff.

Corsi, S. R.

Geis, S. W.

Bowman, G.

Failey, G. G.

Rutter, T. D.

pp. 40-46

2009

[Environmental Science & Technology](http://edition.cnn.com/2014/02/05/us/winter-snow-salt-shortage/?q=&serial=%22Environmental%20Science%20&%20Technology%22)

Volume: 43
Issue Number: 1
Publisher: American Chemical Society

**Use of Geosynthetics in Deicing Facilities at the Cleveland Airport**

[**h**ttp://geosyntheticsmagaz.../0607gs\_digitaledition.pdf](http://www.npr.org/templates/story/story.php)

This article discusses the use of geosynthetic materials, specifically plastic-laminated clay liners (GCL), aggregate-filled cellular confinement systems, nonwoven geotextiles, and high-density polyethylene (DHPE) pipe- in the construction of Cleveland-Hopkins International Airport’s (CLE) new deicing facility. One immediate cause of concern that stimulated improved deicing methods came from the Ohio Environmental Protection Agency (OEPA), which criticized GCL for its deicing runoff (from fluids such as ethylene glycol, propylene glycol, and **urea**) into the nearby Abram and Silver creeks. The GCL used was needlepunch-reinforced sodium bentonite encapsulated between both woven and unwoven textiles and was implemented as a hydraulic barrier layer for the pavement of the deicing area. The project is an example of mediating between environmental protection and minimizing functionality loss due to delays.

Petno, Daniel

Athanassopoulos, Chris

pp. 16-23

[Geosynthetics](http://www.coe.montana.edu/me/faculty/Shi/AirportDeicers.pdf?q=&serial=%22Geosynthetics%22)

Volume: 25
Issue Number: 3
Publisher: Industrial Fabrics Association International

**The Effect of Deicing Chemicals on Turfgrass**

[http://www.ossian.com/pdf/IowaTurfStudy-full.pdf](http://pubs.acs.org/doi/pdfplus/10.1021/es8017732)

Runoff from deicing products applied to paved surfaces may result in turf grass injury. The purpose of this study was to assess the level of damage caused by several common deicer products. The study was conducted on an established stand of common Kentucky bluegrass (Poa pratensis L.) at the Iowa State University Research Station north of Ames, Iowa. Treatments containing 30 percent **urea** + 70 percent calcium chloride, 50 percent **urea** + 50 percent calcium chloride, 67 percent **urea** + 33 percent calcium chloride, potassium chloride, **urea**, rock salt, Safe Step (50 percent rock salt + 50 percent potassium chloride), magnesium chloride, and calcium chloride pellets were evaluated. It was found that **urea** at rates greater than 610 grams/square meter/year, and rock salt greater than 2440 grams/square meter/year can cause severe vegetation loss and poor re-establishment of turf from seeding.

Minner, D. D.

Bingaman, B. R.

Gall, J. A.

p. 529-537

1998

[Xth PIARC International Winter Road Congress](http://trid.trb.org/results.aspx?q=&datein=all&serial=%22Xth%20PIARC%20International%20Winter%20Road%20Congress%22)

Location: Lulea, Sweden
Date: 1998-3-16 to 1998-3-19
Sponsors: Permanent International Association of Road Congresses

**Liquid Glycol and Formanide Urea Based Ice Control Chemicals**

This document reports on field effectiveness evaluations of commercial and military specification liquid ice control chemicals as runway and taxiway anti-icing and deicing agents. The formulations tested were approved as being non-deleterious to aircraft metals and plastics. The chemicals evaluated weredetermined to be less effective as deicersthan **urea** for temperatures above 15 degrees Fahrenheit, and more effective below. Deicing effectiveness was variable. Chemical effectiveness as anti-icers was more predictable. The chemicals proved effective in preventing ice formulation up to a water: chemical dilution ratio of 8:1. Based on investigations requested and/or sponsored by the Controlling Office, the chemicals should not be applied to non-air entrained Portland cement concretes, nor should they be used without consideration of their effects on the environment. Results reported by other investigators indicate that care should be exercised to insure against excessive traction losses due to the application of liquid ice control chemicals.

54 p.

Rice, R.R.

Air Force Civil Engineering Center

Tyndall AFB, FL 32401 United States

1974

**Effects of Runway Deicers on Pavement Materials and Mixes: Comparison with Road Salt**



This paper presents a study aimed at comparing the destructive effect of newly introduced deicing chemicals, such as potassium acetate and sodium formate**, with urea and ordinary road salts** on the durability of pavement construction aggregates and asphalt concrete when subjected to freeze-thaw cycles while submerged in solutions of different concentrations. The destructive effect of each deicer on aggregates was fixed in terms of percent weight loss due to breakdown. For pavement samples, it was quantified by weight and density loss, change in mechanical properties, variation in the penetration of recovered asphalt, and variation in the gradation of recovered aggregates. Test results showed that for all deicers, the critical concentration causing the greatest damage to the aggregate was in the 1-2% range, and for all deicers the quartzite aggregate suffered more damage than the limestone. It was also found that road salt produced comparable damage to that caused by other deicers to quartzite, while the damage was markedly less for limestone aggregates. In the case of asphalt concrete samples, it was found that conditioning asphalt samples using freeze-thaw cycles in the presence of a deicer solution caused a decrease in the indirect tensile strength and modulus of elasticity and an increase in the penetration values of the recovered asphalt cement. **Test results also showed that the maximum damage was caused by urea, while the damage due to the other deicers was comparable to that of distilled water.**

p. 385-391

Hassan, Y.

El Halim, A.O.A.

Razaqur, A. G.

Bekheet, W.

Farha, M. H.

Journal of Transportation Engineering
Volume: 128
Issue Number: 4
Publisher: American Society of Civil Engineers

2002

**Current Deicing Practices and Alternative Deicing Materials**

<http://www.michigan.gov/documents/ch2-deice_51438_7.pdf>

**Urea** currently is not in use as a road deicer except in the State of Washington, but it is used on airport runways because it is less corrosive than road salt to aluminum airplane bodies. Urea is an organic compound, which degrades by hydrolysis to ammonia and then is converted to nitrate by soil microorganisms.

Although urea itself has relatively low toxicity insofar as terrestrial and aquatic life are concerned, ammonia and nitrate do pose environmental problems.” The toxicity of ammonia to aquatic life is relatively high. One study finds that when exposed to as little as l-10 ppm of ammonia, 50 percent of the aquatic biota present will die.

The other by-product of urea, nitrate, is basically a fertilizer and potentially can contaminate drinking water supplies. High nitrate levels also stimulate algal growth in aquatic systems and accelerate eutrophication. In addition, nitrate levels above 1Oppm in drinking water impair the ability of humans to transport oxygen in the blood; this is especially the case with infants and can result in methoglobinemia, or “blue baby syndrome.”

**Additional Options for Snow and Ice Control**

**Environmental Impacts of Oil and Gas Brine Applications for Dust and Ice Control in New York**

Research in Progress Project 36734

[http://www.utrc2.org/rese...-impacts-oil-and-gas-brine](http://www.ossian.com/pdf/IowaTurfStudy-full.pdf)

Transportation agencies are required to treat roads for dust and ice control to ensure adequate safety for travelers. This is commonly achieved through application of solid and liquid chemicals. These materials can be conventional rock salt, **brine from rock salt, natural brine, or oil and gas brine**. Due to the high cost of treating roads for the removal of snow and ice, in states with active oil and gas wells such as New York, the potential for using this brine to control dust or ice on roads is currently being explored. Environmental concerns exist over the use of conventional oil and gas brines due to their potential high total dissolved solids and metals concentrations. They can also be elevated in organic compounds and can contain certain chemical additives. In 2012, New York State production of natural gas was 26.4 billion cubic feet while oil production was 394,507 barrels. It has been estimated that 30 percent of the brine produced alongside the oil and gas is disposed of via road spreading. Although unconventional natural gas drilling in the Marcellus Shale in New York State is currently not permitted, the extraction of Marcellus Shale gas is allowed in other states (e.g., Pennsylvania) where the associated unconventional brine is used for road spreading. If conventional or unconventional oil and gas brine is applied to roadways for dust or ice control, there is the potential for runoff to impact receiving water or roadside soil. The environmental impact of the leaching of chemical components from soil impacted with oil and gas brine applied for transportation purposes is unknown. The objective of this work is to determine the potential for chemicals found in oil and gas brine to leach from soil to groundwater. Leaching studies will be conducted to compare conventional oil and gas brine and unconventional oil and gas brine. A literature review will be conducted to determine the volume and chemical characteristics of brine applied to roadways for dust or ice control. The chemicals of concern will be identified and the leaching potential of these chemicals will be determined through toxicity characteristic leaching (TCLP) tests and synthetic precipitation leaching (SPLP) tests. This work will provide local and national transportation agencies with important data regarding the environmental impacts of oil and gas brine applications.

Research and Innovative Technology Administration

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Principal Investigator: Wilson, Jessica

Start date: 2014-08-01

End date: 2015-10-31

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**Bio-based Renewable Additives for Anti-Icing Applications**

Center for Environmentally Sustainable Transportation in Cold Climates

Research in Progress Project 37223

Relative to de-icing and sanding, anti-icing leads to improved level of service (LOS), reduced need for chemicals, and associated cost savings and safety and mobility benefits. Yet, the anti-icers available on the market are plagued by growing concerns over their corrosion to metals (chlorides), impact on concrete and asphalt (acetates), toxicity to the aquatic resources (agro-based products), etc. Agencies are constantly seeking for alternatives that maximize the benefits of acetates and agro-based products while minimizing their drawbacks. Meanwhile, research is needed for value-added utilization of **desugared beet molasses and glycerol**, which are the principal by-product of beet sugar refining and biodiesel production, respectively. The objective of this project is to develop innovative anti-icing formulations for snow and ice control on highways, using **beet sugar refining by-products, glycerol, and other bio-based additives** for freezing-point suppression, performance enhancement, and corrosion inhibition. This project will produce at least one paper for presentation at the Transportation Research Board (TRB) annual meeting and publication in a peer-reviewed journal. One patent application will be filed out of this project. Building on the success of this research, field operational tests will be conducted as part of a follow-up study. The team will work closely with transportation agencies to field test the new "green" anti-icers. The project fits under the Center for Environmentally Sustainable Transportation in Cold Climates (CESTiCC) research thrust of "reducing environmental impacts during construction, operations and preservation through effective design, management and preservation strategies". It also meets the United States Department of Transportation (USDOT) strategic goal in environmental sustainability as it helps "advance environmentally sustainable policies and investments that reduce harmful emissions from transportation sources". Development of alternative anti-icing products serves the public interest, as such research is expected to generate significant cost savings for the DOTs and other maintenance agencies, traveler benefits in terms of improved safety and mobility, and societal benefits in reducing the amount of chlorides into the environment. The use of alternative products will greatly reduce corrosion and environmental impacts from winter roadway operations. This work provides maintenance agencies with more options in their snow and ice control toolbox for sustainable winter road service. The exploration of bio-based renewable additives for anti-icing applications would also add value to agricultural by-products and stimulate the local economy (e.g., the $50+ million Montana beet sugar industry).

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Start date: 20140915

End date: 20151215

**Snow and Ice Control at Extreme Temperatures**

[http://on.dot.wi.gov/wisd.../tsrsnowremovcoldtemps.pdf](http://on.dot.wi.gov/wisdotresearch/database/tsrs/tsrsnowremovcoldtemps.pdf)

Using salt to clear snow and ice from roadways is effective at temperatures of about 10 F or higher. At lower temperatures, higher volumes of salt are required, and its use becomes less cost-effective. When the temperature gets extremely low, state agencies tend to plow the roads, rely on abrasives, and/or use high volumes of salt. In more urban areas with high traffic volumes, abrasives are less effective and other strategies can result in overuse of salt, equipment, and manpower. The Clear Roads winter maintenance pooled fund is interested in identifying additional strategies for maintaining roads in extreme temperatures, including preventing blowing and drifting. As a member state in the Clear Roads pooled fund, Wisconsin DOT asked for a review of existing research and other states’ practices in this area as a precursor to a full-scale research project. As expected, most state and provincial DOTs are using traditional methods to prevent and remove snow and ice at very low temperatures. In addition to a review of current research, six winter maintenance professionals at state and provincial DOTs with cold climates were represented, including Maine, Ontario, Alberta and Manitoba. The most innovative strategy in use among these agencies is the **hot-water sand spreader being tested by the Ontario Ministry of Transportation.** Originally developed in Europe, the spreader delivers sand that is pre-wetted with hot water (about 200 F). This technology is designed to keep sand on the road for much longer than conventional sand spreading techniques. **Norway has also tested the use of hot water** as a pre-wetting agent for salt, and one article about this research noted that testing was planned to assess how this technique affects the temperature limits of salt application. Other strategies identified that may be less common include constructing snow ridges rather than snow fences to control blowing and drifting; and for areas where snow storage is required, use of an in-traffic loading technique that minimizes lane closures.

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Madison, WI 53714 USA

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Madison, WI 53707-7986 USA

Wisconsin Department of Transportation

Research and Library Services, 4802 Sheboygan Avenue
Madison, WI 53707 USA

8p.

2011

**Background on the hot-water sand spreader**

The **hot-water sand spreader** was developed in Europe and used successfully there, and has been tested in recent years by the Ontario Ministry of Transportation. The spreader discharges sand mixed with water that has been heated to 95 C [203 F], a technique that is designed to cause the sand to stay on the road for an extended time. Max Perchanok of Ontario MTO reports that his agency’s initial assessments of the technology were favorable, but that in the winter of 2010-2011, the agency carried out traction monitoring that did not demonstrate much improvement over conventional sanding. Perchanok noted that the road does continue to appear brown where the sand was deposited, and said staff theorized that the sand could be staining the snow but not staying in place. Perchanok still thinks the hot-water sander concept is sound, and he isn’t sure yet what his agency’s next step will be. The agency is exploring using the same grade of sand that has achieved successful results in the sander in Europe, and is evaluating the methodology of the traction monitoring performed this year.

The sander is manufactured in Sweden by Falköping, and is distributed in Ontario by Gin-Cor Industries see [http://www.gincor.com/index.php?page=test-2](http://geosyntheticsmagazine.com/repository/2/2675/0607gs_digitaledition.pdf?page=test-2)

Additional information on the hot-water sander:

**Product brochure:**

[www.friggeraker.se/gb/userfiles/images/FRIGG\_LTFV\_GB\_100210\_LR.pdf](http://www.nytimes.com/2013/12/24/us/wisconsin-finds-another-role-for-cheese-de-icing-roads.html)

**Making Sand Last: MTO Tests Hot-Water Sander**

Ontario MTO *Road Talk,* Summer 2008.

[www.mto.gov.on.ca/english/transtek/roadtalk/rt14-2/#a5](http://www.mto.gov.on.ca/english/transtek/roadtalk/rt14-2/#a5)

**Sustainable Winter Sanding with Pre-wetting**

Max Perchanok, et. al

2010 Annual Conference of the Transportation Association of Canada

[www.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2010/docs/m1/perchanok.pdf](http://trid.trb.org/results.aspx)

**Implementation of New Sanding Method in Norway**

Torgeir Vaa

*Transportation Research Circular EC063,*

*Sixth International Symposium on Snow Removal and Ice Control Technology,* pages 473-486, June

2004

http://onlinepubs.trb.org/onlinepubs/circulars/ec063.pdf

An in-depth description of Norway’s first several years using the hot-water sander and refining its development.

**Winter Friction Project in Norway**

Jon Dahlen, Torgeir Vaa

*Transportation Research Record: Journal of the Transportation Research Board,* No. 1741, pages 34-41, 2001

[http://trid.trb.org/view.aspx?id=688954](http://trid.trb.org/results.aspx?id=688954)

The initial development of the hot-water sander as part of Norway’s Winter Friction

Project in the late 1990s.

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**Calcium Magnesium Acetate as Lower-Production Cost: Production of CMA Deicer from Cheese Whey**

[http://ntl.bts.gov/lib/21000/21900/21927/PB99148991.pdf](http://www.utrc2.org/research/projects/environmental-impacts-oil-and-gas-brine)

Also:

**Say 'cheese!'**

<http://www.pwmag.com/deicing-and-antiicing/city-officials-say-cheese-in-snowfighting-effort_o.aspx>

p72

Spinner, Jenni

2014

Public Works
Volume: 145
Issue Number: 1
Publisher: Hanley Wood

**Chloride Cocktail: Department in Illinois Finds Good Results Mixing Their Own Deicer/Anti-Icer**

http://www.roadsbridges.com/Chloride-Cocktail-article7214

UC Berkeley Transportation Library

Though it has not previously been popular on a large scale, liquid use in anti-icing operations is becoming a fixture in some communities, especially those in Iowa. Among the first is the McHenry County Division of Transportation (MCDOT) which began to switch between brine and liquid calcium chloride for anti-icing operations depending on the temperature conditions. Switching between the two proved inefficient and thus MCDOT set out to find a new mixture of brine and liquid calcium chloride that would be suitable for all conditions. **A successful mixture was found that included 85 percent brine, 10 percent De-ice, and 5 percent calcium chloride.** MCDOT has decided to integrate use of the new mix with its local weather service's maintenance decision support system (MDSS).

pp 50-52

DeVries, R Mark

Hodne, Bret

2006

Roads & Bridges
Volume: 44
Issue Number: 8
Publisher: Scranton Gillette Communications

[**Strategies for Snow and Ice Control at Extreme Temperatures: A Review of Current Practices**](http://www.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2010/docs/m1/perchanok.pdf#search="alternative rock salt")



Prepared for the TRB 2014 Annual Meeting and Transportation Research Record 39 Sponsoring committee: Surface Transportation Weather (AH010)

‘*This study includes results from survey sent to US DOTs. The survey was conducted 121 through the SNOW-ICE listserv, Survey Monkey and a LinkedIn group. The survey was 122 distributed on June 5, 2012 and responses were collected until July 11, 2012. The respondents 123 primarily work for Department of Transportation (DOT) group (not exclusively) at the 124 headquarters or district/region/station level, representing 23 states and four countries.’*

Extremely cold winter storms (below about 10°F) bring about different considerations for taking care of roads than warmer winter storms, where granular salt and salt brine are cost-effective measures of melting snow and ice when used in combination with other operations (e.g., plowing). At temperatures lower than about 10°F, either extremely large quantities of salt are needed or no amount of salt can melt snow or ice pack. Chemical usage is of a widely used technique with various modifications (using deicers in daylight hours only, mixing salt with MgCl2, CaCl2, and/or agriculture by-products, and using high application rates) during extreme cold conditions. Additionally, plowing is still the ubiquitous and popular snow removal techniques in extreme cold conditions. Despite their environmental and hidden costs (air pollution, sedimentation, spring cleanup & disposal), abrasives are frequently used during extreme temperatures to provide temporary traction in low traffic volume and rural roads. In spite of high cost, pavement treatments offer the benefit of reducing chemical usage and associated environmental toll, enhancing agency preparedness, and quicker recovery to bare pavement. Weather forecasting system need to be better utilized in predicting the cold weather temperatures for better preparedness. Innovative strategies continue to be tested at severe temperatures, but agencies are reluctant to use due to its higher cost especially at places of uncommon extreme cold conditions. More research needs to be done to combine innovative strategies with traditional strategies keeping cost reduction as a main factor.

**Strange Brew**

[http://www.pwmag.com/flooring/strange-brew.aspx](file:///E%3A/TRB_2014_Compendium_Data_Only/papers/14-4014.pdf)

Made from **rum and vodka byproducts**, Magic Minus Zero (Sears Ecological Applications Company, Rome, New York) contains no alcohol. Road departments, mostly in the Northeastern states, have been using the liquid deicer for several years. The substance can be applied directly to pavement before a snowstorm, or sprayed onto rock salt to neutralize the salt's corrosive nature and double the salt's impact. It melts snow and ice in temperatures to -35° F.

The liquid, which is formulated from the leftovers of rum-making, is such an effective additive that Pat Doherty, Director of Public Works (Pingree Grove, Illinois), said the town has used 40 percent less salt as it could have under similar weather conditions.

**Vodka Leftovers Can Help Make Driving Safer by Removing Highway Snow**

[https://time.com/3601722/vodka-road-salt-highway-snow/](http://www.gincor.com/index.php)

**Against the use of Urea:**

* New Jersey prohibits sale and use as a deicer; for years,
* Vermont state airports used a **urea-based** deicer, since salt corrodes aircraft. But the **urea** was also harming groundwater and has since been discontinued.

Material Safety Data Sheet (MSDS) Urea

[http://meltsnow.com/development2010/wp-content/uploads/2010/08/UREA\_MSDS\_MSWS.pdf](http://trid.trb.org/view.aspx)

According to MeltSnow.com, ‘like any deicer used in excess, products with **urea** can burn vegetation and cause damage. Also called **carbamide, urea** is often used in areas where chlorides cannot be tolerated at all, such as on elevated walkways and in airports. While it works extremely well as a fertilizer ingredient, it is only moderately effective as an ice melter. As the old saying goes, as an ice melt chemical it’s better than nothing – but not by much. Our experience is that urea provides as much traction from not melting as it does provide melting of snow and ice.’

[http://meltsnow.com/products/urea-and-kcl/](http://ntl.bts.gov/lib/21000/21900/21927/PB99148991.pdf)

Avoid Products that Contain **Urea. Urea** has been recommended as a safer alternative, reasoning that it does not contain chlorides and, as a form of nitrogen, will help fertilize your yard when it washes off. However, **urea-based** deicing products are a poor choice as it is fairly expensive and performs poorly when temperatures drop below 20 degrees F. The application rate for urea during a single deicing is ten times greater than that needed to fertilize the same area of your yard, and ultimately, very little of the urea will actually get onto your lawn, but will end up washing into the street and storm drain and eventually to the nearest lake or stream. Given that nitrogen is a problem for surface water resources, it doesn’t make sense to use nitrogen-based products for de-icing. From <http://renewtherock.com/road-salt-and-de-icers/>

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**Salt Alternatives in the News**

Hamilton County, Ohio: **mixes its salt with gritty, non-toxic ash** left over from coal-fired power plants.

[http://online.wsj.com/news/articles/SB123084701287847257](http://www.pwmag.com/flooring/strange-brew.aspx)

Allen County, Ohio: **sand and stone mixed with salt** at ratio of 3:1 (ratio 2:1 last year).

Putnam County, Ohio: is having a company **treat stone with liquid calcium chloride.**

Auglaize County, Ohio: uses sand sprayed with **beet juice**. Salt is good down to 20 degrees, then beet juice is used which is good when temps fall below zero. Apply ay 6 gallons per 1.5 miles of roadway. They have reduced their salt use down by 20% with this method.

Tennessee: has used a substance called Magic Salt which is made from **potato juice** and is biodegradable and noncorrosive. (In same article they mention **beet syrup, tomatoes** and a **corn-based product**

Ankeny, Iowa (a Des Moines suburb), sprinkled **garlic salt mixed with road salt** on its streets last month after a local spice maker gave the town nine tons destined for a landfill.

[http://www.npr.org/templates/story/story.php?storyId=98529510](http://onlinepubs.trb.org/onlinepubs/circulars/ec063.pdf?storyId=98529510)

Washington State: uses **desugared molasses: a mix consisting of molasses from a local supplier, calcium chloride and brine** donated by a local dairy company

[http://online.wsj.com/news/articles/SB123084701287847257](http://meltsnow.com/development2010/wp-content/uploads/2010/08/UREA_MSDS_MSWS.pdf)

Wisconsin (Polk County): officials and a local company, F&A Dairy Products, came up with a mutually beneficial solution for **cheese brine**, a by-product of making mozzarella and provolone. Local governments save on salt costs by using the brine to deice their roads, and the cheese company saves on disposal costs. Currently, local counties use all of the brine that F&A produces. Salt soaked in cheese brine has a lower freezing point (-21F) than regular salt brine (-6F).

[http://www.nytimes.com/2013/12/24/us/wisconsin-finds-another-role-for-cheese-de-icing-roads.html?\_r=0](http://meltsnow.com/products/urea-and-kcl/?_r=0)

The City of Milwaukee in Wisconsin's Department of Public Works is also experimenting with **cheese brine** to de-ice roads. Cheese brine is blended with rock salt (at a ratio of approximately eight gallons of cheese brine to every one ton of rock salt) and then spread on roads in the Bay View section of the city, in order to test the results. Data on amount of precipitation, time and day of solution application, as well as temperature, pavement conditions, among others, will be recorded, and results will be shared in the spring of 2014.

[http://www.pwmag.com/deicing-and-antii...owfighting-effort\_o.aspx?dfpzone=general](http://www.pwmag.com/deicing-and-antiicing/city-officials-say-cheese-in-snowfighting-effort_o.aspx?dfpzone=general)

 In New York State: **wastewater from hydraulic fracturing** (fracking) of natural gas production has been approved to be spread on the roads of 23 municipalities in seven western counties, according to [http://www.riverkeeper.org/campaigns/safeguard/gas-drilling/the-facts-about-new-york-and-fracking-waste/](http://online.wsj.com/news/articles/SB123084701287847257)

With the required approval, production brine from conventional, low-volume fracking in New York State is currently allowed to be spread on roads for de-icing, dust control, and road stabilization purposes. If not properly controlled, this waste can run off into adjoining property and ultimately could contaminate rivers, streams, and underground aquifers that feed local drinking water supplies. Government entities, as well as private companies, that wish to use production brine for road spreading must get permission from the New York State Department of Environmental Conservation (NYSDEC) to use the brine by applying for a Beneficial Use Determination (BUD).

[http://www.riverkeeper.org/campaigns/safeguard/gas-drilling/the-facts-about-new-york-and-fracking-waste/#sthash.yiXYdvq6.dpuf](http://www.friggeraker.se/gb/userfiles/images/FRIGG_LTFV_GB_100210_LR.pdf#sthash.yiXYdvq6.dpuf)

In Pennsylvania, according to state records **natural gas brine** from the state’s conventional, low-volume wells has also been used for road spreading in New York State. According to the Pennsylvania Department of Environmental Protection (PADEP), in 2011, 2012, and 2013 production brine from conventional, low-volume fracking in Pennsylvania was sent to Allegany and Chautauqua Counties for road spreading.

In the Netherlands, scientists are working with regional partners and technology firms to create a de-icing salt made from biomass sources – **roadside grasses or kitchen waste**.

The biomass produces an organic salt called calcium magnesium acetate (CMA). CMA also can be produced from fossil fuels, but Dutch scientists have developed a way to take biomass and use certain bacteria to convert sugars into acetate, the basis for CMA de-icers, and hydrogen. Pieternel Claassen, lead researcher at Wageningen UR Food and Bio-based Research, hopes to produce green salt on a larger scale by 2020, pending more research funding.

<http://www.labmanager.com/news/2012/12/de-icing-salt-made-from-grass-or-kitchen-waste?fw1pk=2#.VGpJdzYo6ic>

Burning logs to keep warm produces a lot of **ashes**. Today's EPA-certified wood stoves and fireplace inserts are cleaner and more energy efficient than traditional wood-burning fireplaces, which use more wood, produce dust and emit harmful toxins. **Ashes** from wood stoves or fireplaces can be strewn across sidewalks and driveways to increase traction on slippery ice. The best part is that **ashes** are environmentally friendly and will blow onto or dissolve into local soil, acting as a fertilizer. **Ashes** also can be composted or saved as fertilizer for spring planting in the garden.

[http://www.theguardian.com/sustainable-business/alternatives-salt-battling-ice-cheese-beets-ash](http://online.wsj.com/news/articles/SB123084701287847257)

In Bergen County, New Jersey, officials in the past have used a mixture of salt and water that resembles **pickle juice** and costs significantly less than salt, former county Public Works Director Joe Crifasi told CNN affiliate WCBS in 2011, which was also an exceptionally snowy winter.

Other alternatives to salt have included liquid from byproducts, including **beer waste** and **beet juice**, according to a study by the Cary Institute of Ecosystem Studies, a New York state-based environmental group.

[http://edition.cnn.com/2014/02/05/us/winter-snow-salt-shortage/](https://time.com/3601722/vodka-road-salt-highway-snow/)