

# 2

## ***CURRENT DEICING PRACTICES AND ALTERNATIVE DEICING MATERIALS***

This chapter describes current MDOT deicing practices and materials (primarily road salt and sand) and presents information on several materials thought to merit study as potential alternatives to the extensive use of road salt: CMA (calcium magnesium acetate), calcium chloride, CG-90 Surface Saver, Verglimit, CMS-B, and sand. Although certain of these materials, particularly sand, currently are used by the MDOT to some extent, their properties and effects must be fully known and understood if their use may be expanded. Three additional materials—ethylene glycol, urea, and methanol—were dropped from consideration; the rationales for their exclusion are presented.

### ***CURRENT DEICING MATERIALS AND PRACTICES***

In the 21 counties in which the MDOT maintains the state trunk lines, operations are run from 30 locations; in the remaining 62 counties, trunklines are maintained by contractors to the MDOT. Road salt is the predominant deicing chemical used by the MDOT; sand is the abrasive exclusively used. Calcium chloride and CMA also are used, but in far smaller volume than road salt; these chemicals and sand are discussed below. The MDOT uses 260 trucks to plow snow and to spread the deicers and sand. To predict and monitor road conditions, various sophisticated technologies are used, including pavement condition sensors that monitor surface temperatures, moisture, and chemical concentrations on road surfaces. Deicing materials are used to a much higher degree in the four-county metropolitan Detroit district than in the rest of the state; this is not only because of the area's large number of roadways, but also because many are below ground level.

#### ***Sodium Chloride (Road/Rock Salt)***

Road salt breaks down snow and ice, causing them to melt. Its use by the MDOT increased in the 1950s and 1960s, and, with variations due to weather conditions, has remained relatively constant since the 1970s. (See Exhibit 2.1 for the amount of road salt used by the MDOT in the last ten years, by district.) Factors affecting application within a district include the number of roads, average daily traffic (ADT), road type, and weather conditions. The minimum effective temperature for road salt is 12°F/-9°C.

In the 1960s the MDOT began controlling the spread of road salt by equipping its trucks with flow valves and calibration systems. In 1986 an MDOT task force evaluated the department's use of the material, and its report, *Reducing Salt Usage on State Trunklines in Michigan*, listed specific steps that could be taken to reduce the amount of road salt used. Despite the implementation of the

**Exhibit 2.1: Tons of Road Salt Used per Winter on County and Municipal Roads  
under the Jurisdiction of the MDOT  
(in thousands)**

District	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
1	25.2	24.7	27.4	20.4	27.7	32.6	30.6	31.1	31.0
2	15.9	19.0	18.8	15.1	20.2	20.1	19.2	18.0	23.7
3	31.3	24.7	27.0	17.3	25.6	29.1	38.8	32.9	41.6
4	26.7	26.2	31.0	21.5	34.0	39.3	46.2	33.0	41.4
5	53.6	49.3	70.7	30.1	50.8	52.2	65.7	42.5	63.8
6	39.4	46.1	58.4	37.4	48.7	46.0	61.1	51.9	51.9
7	44.7	44.5	51.8	23.8	42.6	40.1	61.3	43.9	50.5
8	46.0	43.1	53.4	27.9	40.0	36.4	55.3	42.9	45.2
Metropolitan Detroit	143.4	143.9	139.0	79.4	112.1	104.1	157.1	132.6	130.7
TOTAL	417.2	421.6	477.4	272.9	401.7	399.9	535.3	429.0	480.0

SOURCE: Michigan Department of Transportation.

recommendations and the use of controlling devices, there has been no overall reduction in road salt use.’

Road salt costs \$20-40 per ton.

### *Road Salt Storage*

Deicing chemicals can contaminate soil, surface water, and groundwater. Road salt was at one time stored uncontained and without protection from precipitation; road salt contamination has been identified at at least 62 salt storage facilities operated by the MDOT, municipalities, or county authorities.’ Most MDOT road salt now is stored in sheds constructed for that specific purpose. Additionally, efforts are made to ensure that trucks are loaded in a contained area, which reduces the amount of road salt released to areas adjacent to storage facilities. The MDNR Waste Management Division recently surveyed 122 agencies that store or use salt or brine for road deicing. Of the 14 MDOT facilities surveyed, some were not in compliance with one or more storage requirements; that is, they had failed to develop a pollution incident prevention plan, had not obtained a permit for surface water or groundwater discharge, did not properly contain floor drain/truck wash water, and/or they store salt/sand on impervious pads. However, it is the MDOT's goal to achieve compliance with all MDNR salt storage requirements.<sup>3</sup>

The MDOT provides to contracting counties and local governments funds to construct containers for road salt; the amount of funding depends on the five-year average percentage of stored road salt used by the localities on state roads. For example, if, over five years, 50 percent of the road salt stored in a locality’s facility is used on state trunk lines, the department provides 50 percent of the cost of constructing containment facilities. (At facilities not under the jurisdiction of the MDOT, containment varies widely.)

## *Other Deicing Materials in Use*

The MDOT uses a small quantity of calcium chloride, predominantly to add to sand piles to prevent freezing at low temperatures. Also, calcium chloride sometimes is mixed with sand to facilitate its flow through spreaders at low temperatures. CMA is used on a limited basis, principally on the Zilwaukee Bridge.

In the past, MDOT road salt suppliers used various additives to enhance the road salt's performance. Chromium was added as a corrosion inhibitor, but this practice has been discontinued because some forms of chromium can be a toxic heavy metal.<sup>4</sup> Sodium ferrocyanide and ferric ferrocyanide were added to road salt to prevent "caking." Neither currently is used by the MDOT because under very specific conditions these compounds can generate cyanide, a poison.

## **ALTERNATIVE DEICING MATERIALS**

Alternatives to road salt have been developed and tested throughout the United States in an attempt to increase deicing effectiveness and eliminate the negative environmental and corrosive effects of road salt. The deicers require varying methods of application, their costs differ, they perform differently, and they have varying environmental, human health, and corrosivity effects.

### *Materials and Products Evaluated*

The general characteristics, performance, effects on human health/use, effective temperatures, and cost of five chemical deicing alternatives and sand are described below. Environmental and corrosive effects are touched on but covered in more depth in chapters 3 and 4.

### *Calcium Magnesium Acetate (CMA)*

Calcium magnesium acetate works by interfering with the bond between snow particles and the road surface; in contrast, road salt chemically breaks down snow and ice as it moves downward from the surface. The performance, corrosivity, and environmental impacts have been reviewed more extensively for CMA than for any deicing material other than road salt.

CMA users in California, Colorado, Massachusetts, Michigan, Nebraska, Nevada, Ontario, and West Virginia were surveyed by the federal Transportation Research Board (TRB) to determine its performance in tests. In general, CMA is described as an acceptable deicer but when applied during or after a storm, it is found to be slower acting than road salt, frequently taking 15 to 30 minutes longer to induce melting; CMA's effectiveness diminishes in temperatures below 23°F/-5°C, in freezing rain, drier snowstorms, and light vehicle traffic zones.<sup>5</sup>

Theoretically, the weight ratio of CMA to road salt needed to obtain equal deicing capability is 1.7: 1. Early experiments with CMA in Michigan found that 2.6 times as much CMA as road salt is required to attain reasonably dry pavement;<sup>6</sup> more recent experience, on the Zilwaukee Bridge, shows a 1: 1 ratio to be satisfactory. (One factor affecting the change in the application ratio is the significant improvement in recent years of the product's physical properties.) Experience in Ontario finds 1.19: 1

to be satisfactory. CMA's deicing capability lasts longer than road salt's; residual CMA on roadways can last up to two weeks, creating a carry-over effect for subsequent storms.' While initial application rates are higher than with road salt, subsequent applications tend to be fewer.<sup>8</sup>

CMA can be applied using existing MDOT spreading equipment. Field tests show that when wet, CMA sometimes clogs spreading equipment and sticks to truck beds. By weight, less CMA than road salt can be stored in existing sheds.<sup>9</sup>

Research findings to date indicate that CMA likely has few negative environmental effects and is relatively nontoxic to humans. Because it is biodegradable and exhibits poor mobility in soils, it is less likely than road salt to reach groundwater. Although preliminary environmental evaluations suggest that CMA may have the potential to extract heavy metals from roadside soils, further testing on this point is needed. CMA exhibits negligible adverse effect on common roadside vegetation and apparently is safe for use near most aquatic environments. Further monitoring and study are needed to determine the effect of heavy CMA treatments and associated biochemical oxygen demand (BOD)—which depletes oxygen in water bodies—on small, poorly flushed ponds and streams. The acetate in CMA currently is formed by the reaction of acetic acid (derived from natural gas) with dolomite lime, but efforts are under way to produce acetic acid from other sources, such as municipal and other wastes. If successful, the new sources may introduce substances to CMA that alter its known environmental effects or create new ones.<sup>10</sup>

Laboratory and human evidence indicate that CMA's toxicity level is comparable to that of road salt: skin and eye irritation potential is low. It is recommended that people wear long-sleeved shirts, trousers, and safety glasses when handling and applying the material and a dust respirator if airborne particulates are present."

The primary benefit of CMA is its noncorrosive properties, which reduce the effects on motor vehicles, bridges, and roadways. Corrosivity experiments conducted in Michigan indicate that metals exposed to CMA experience one-third to one-ninth the corrosion of those exposed to road salt.<sup>12</sup> Research by the TRB indicates that corrosion damage to automobiles, exposed metal and steel on bridges, and reinforced concrete on bridge decks and roadways is significantly less from CMA than from road salt. Since 1988 the MDOT has used CMA on the Zilwaukee Bridge and adjacent approaches to control ice and prevent corrosion. Approximately 200400 tons of CMA are used annually by the MDOT.<sup>13</sup>

CMA costs \$650–675 per ton. The high price is due primarily to the cost of acetic acid. New methods of producing acetic acid could decrease the price significantly. Tests are being conducted to produce lower-cost acetic acid from corn, agricultural residues, industrial waste, wood waste, and municipal waste.

### *Calcium Chloride*

Calcium chloride is *hygroscopic* (can absorb and retain water) and produces an *exothermic* (heat-producing) reaction when mixed with water. It is applied in liquid or pellet form and causes widespread surface melting.

In a study by the TRB in 1988, calcium chloride deiced twice as fast as road salt and also outperformed potassium chloride (discussed below). Calcium chloride was able to penetrate ice at all tested temperatures at approximately twice the rate of road salt.<sup>14</sup> Another study, however, indicates that after 30 minutes the performance of calcium chloride and road salt equalizes. When used as a wetting agent for road salt, chloride increases the performance of the salt. It also can be mixed with sand to prevent the sand's freezing and clogging spreaders at low temperatures (this is the principal use to which the MDOT currently puts calcium chloride).<sup>15</sup> Calcium chloride can perform to temperatures as low as -20°F/-29°C.

Environmental effects of calcium chloride are similar to that of road salt, although chloride as a component of calcium chloride is more toxic to aquatic biota than is chloride as a component of salt. In humans, chloride causes skin burns, severe tearing, and respiratory irritation; handlers should wear respirators, rubber gloves, and protective clothing. Studies find that calcium chloride corrodes steel faster than normal weathering processes but slower than road salt. It should be stored indoors, away from moisture, in containers made of noncorrosive materials.<sup>16</sup>

If used in liquid form, calcium chloride may be applied using existing MDOT snow-removal equipment modified to hold tanks and dispersion units.<sup>17</sup> The total amount of calcium chloride used by the MDOT during the winter of 1989-90 was 95 1 tons, at a cost of approximately \$205 per ton.<sup>18</sup>

## CG-90 Surface Saver

CG-90, CG-90 Surface Saver, and CG-90 Surface Saver Liquid are corrosion-inhibiting road salt products produced by Cargill. Such corrosion-inhibiting salts often are combinations of sodium chloride and magnesium chloride with a coating containing a corrosion-inhibiting chemical, i.e., zinc, phosphorous, or sulfate, which forms a film on exposed metal surfaces and acts as a barrier to the oxygen necessary for corrosion to occur. Only CG-90 Surface Saver is evaluated in this report because it has a lower corrosion rate than CG-90 and is produced in pellet form, which is preferred for widespread deicing.

Like road salt, CG-90 Surface Saver is applied directly on ice or snow immediately after plowing. Studies by Cargill find CG-90 Surface Saver effective down to 1°F/-17°. Laboratory tests indicate that CG-90 Surface Saver deices 1.5 times faster than road salt.<sup>19</sup> An additional benefit is that CG-90 Surface Saver helps prevent road surface scaling (this is discussed in more detail in chapter 3). Cargill indicates that CG-90 Surface Saver protects against corrosion better than water, calcium chloride, and road salt. (CMA was not included in Cargill's corrosion comparisons.) Field tests of the CG-90 products have focused on CG-90, the older of the three Cargill products. Tests conducted in the State of Washington find that to temperatures down to 12°F/-11°C, CG-90 is faster acting and easier to handle than urea. The Minnesota DOT has used CG-90 on a large new structure, the Richard Bong Bridge, for three consecutive winters and reports an absence of corrosion.<sup>20</sup> Moreover, the department finds that there may be some residual corrosion prevention when road salt with no additives later is applied. A concern is that as the road salt becomes dilute and breaks down to chloride, sodium, and magnesium, some of these components eventually may act as corrosive agents.

The environmental effects of CG-90 Surface Saver are similar to that of road salt because it is composed largely of sodium and magnesium chlorides. The small quantity of phosphorous in the coating acts as a stimulant to plant growth and may accelerate eutrophication in small water bodies high in nutrients. *Eutrophication* is the process whereby a water body's oxygen supply gradually is reduced, causing organisms requiring higher levels of dissolved oxygen to be displaced by organisms tolerant of low levels.

Because CG-90 Surface Saver is mostly road salt, the same handling precautions are required. The manufacturer cautions that inhaling the product can cause mild irritation of the nose and throat, as can dust on exposed skin.

CG-90 Surface Saver costs \$185 per ton.

### *Verglimit*

Verglimit is a patented bituminous concrete pavement that contains calcium chloride pellets encapsulated in linseed oil and caustic soda. The pellets remain inactive until the roadway surface wears under traffic. As the pavement wears, the exposed particles dissolve by attracting and absorbing moisture from the air, creating minute pores in the pavement. When a pore becomes full, the spillover dampens surrounding pavement. These many damp spots create a surface on which it is very difficult for ice or packed snow to adhere. As humidity decreases after a winter storm, water in the solution evaporates, leaving the liquid calcium chloride in the pore for the next storm." There are strict specifications for mixing and laying Verglimit; for example, after laydown, to make the roadway safe for use, the exposed calcium chloride and linseed oil must be rinsed from the asphalt surface for several days.

Verglimit is intended for use in such areas prone to icing as bridge decks, steep grades, sharp curves, heavily shaded roads, and roads adjacent to water. Verglimit serves as a preliminary deicing agent until maintenance crews can apply another material, resulting in the decreased use of the supplemental deicer. Because Verglimit absorbs water, problems with effectiveness occur below 27°F/-3°C, although tests in New Jersey find the material effective at 24°F/-4°C.

Verglimit has been used in Europe since 1974, North America since 1976, and Japan since 1978. It is used in many places in the United States, including California, Maine, Massachusetts, New Jersey, New York, and Ohio. These states report that the Verglimit lasts almost as long as asphalt and wears roughly the same.<sup>22</sup> Additionally, dry traction on Verglimit is about the same as on asphalt. Friction tests show the two to be comparable, although Verglimit has a slightly lower friction rating.

The deicing abilities of Verglimit are satisfactory. Tests in New Jersey and Ottawa find that Verglimit does not melt much snow after snowfall but prevents ice and snow from binding to the road surface, enabling traffic to break up the ice. Tests in New Jersey find that heavy traffic—at least 5,000 ADT—is necessary to initiate the full deicing potential of Verglimit; road surfaces seem to be more slippery when traffic is lighter.

Verglimit poses little environmental threat. Its only mobile component is calcium chloride, which as it does not come to the surface until the voids in the pavement are full of moisture-reaches the environment in a very weak, diluted form. Furthermore, harm from road salt is reduced to the extent that the need for salting is reduced on the roadway. Tests conducted by the Department of Public Works in Allentown, Pennsylvania, find that snow and ice slush on Verglimit contain about 2,000 parts per million (ppm) of calcium chloride; tests taken during rain storms indicate little or no calcium chloride present in the water on the roadway.

Verglimit is less corrosive than road salt. The product is designed so that calcium chloride does not appear on the road surface at low relative humidities. At higher relative humidities (90–95 percent), calcium chloride appears in patches or spots in the pores between the aggregates, and traffic does not come into contact with it. When there is rain, calcium chloride spills onto the surface but is greatly diluted and partly washed away. For example, at a surface abrasion rate of 0.5 millimeters per year, the quantity released per summer day is 0.07 gram per square meter, and one millimeter of precipitation forms a concentration of 0.007 percent. This concentration does not promote corrosion any more than does plain water.<sup>23</sup>

The price of Verglimit varies, but it generally costs \$109-145 per ton, about 33 times the cost of asphalt. Although using the deicer trebles road installation cost, the extra expense possibly is offset by reductions in road salt use, highway infrastructure corrosion, motor vehicle corrosion, and traffic accidents.

### *CMS-B*

CMS-B, also known as Motech, is a by-product of sugar beet processing that has newly been discovered for its deicing capabilities. CMS-B currently is being tested by an Indiana county road commission.

Savannah Foods and Industries, Inc., owns five sugar beet processing plants in Michigan and two in Ohio. Sugar beets are processed into sugar and various by-products at each plant. During processing, the beets are pulped, and water is used to extract various sugar compounds. All of the molasses by-product from the Michigan and Ohio plants is collected and processed at a single plant in Fremont, Ohio; recently, a new process has been developed that improves efficiency. The new process leaves a residue (CMS-B) in the form of a liquid with 27 percent solids. Of that 27 percent, 10 percent is potassium chloride. There also is a small amount of sodium chloride in the solution.

RDE, Inc., of Crystal Lake, Illinois, was contracted to develop marketable products for the residue solution. In efforts to create a dry product from the solution, it was discovered that CMS-B is hygroscopic (can absorb water). Furthermore, it can be applied as a deicing solution that is effective to -10°F/-23°C. As mentioned, some MDOT districts spray calcium chloride on road salt to enhance the road salt's deicing properties, and although RDE has not experimented with CMS-B in this manner, it has added the product to sand with good result.

Experiments have not yet been conducted to evaluate the environmental effects of CMS-B, but because potassium chloride is the predominant component, the chloride ion's effects on vegetation

and aquatic biota will be a factor. Insofar as human health is concerned, potassium chloride is an irritant to eyes, skin, and the gastrointestinal tract; chemical-proof goggles, gloves, and impervious clothing should be worn when handling it.

As of March 1993 RDE was moving quickly toward marketing CMS-B as a deicing material. An estimated 60,000 tons of the material will be available annually from Savannah Foods. The cost is approximately \$.40–.50/gallon. Because CMS-B is a developing product, it cannot yet be fully evaluated and compared to other deicing materials, but it is one to watch for future consideration.

## Sand

The MDOT currently uses sand principally as an abrasive on low traffic volume roadways and at low temperatures when the melting action of road salt is poor, but it must be mixed with road salt or calcium chloride to prevent its freezing into lumps and clogging spreading equipment. In applying sand, the maintenance truck plows the loose snow/ice from the pavement and spreads the sand mixture on the remaining packed snow/ice to increase traction. The effectiveness of sand as an abrasive is reduced by continued traffic pressing the sand into the packed snow or new snowfall covering the sand layer. On bare road surfaces, however, too much sand may increase the potential for vehicle skidding. Sand accumulates along curbed roadways and on soil adjacent to roadways after application, requiring collection. It also can enter drainage systems in areas with sewers and contribute to catch basins becoming clogged. Sand itself is not a corrosive agent, although it may have a wearing effect on the protective coatings of vehicles. Sand that has been ground into fine particles and become airborne can aggravate respiratory problems.

Sand costs approximately \$5 per ton.

### *Materials Eliminated from Consideration*

After preliminary analysis and consultation with the advisory board, ethylene glycol, urea, and methanol were dropped from the list of deicing materials considered appropriate for use by the MDOT because of their poor performance, environmental and human health effects, and/or high cost. A brief description of each material follows to facilitate understanding why it was excluded.

#### *Ethylene Glycol*

Ethylene glycol breaks down when exposed to aerobic microbes; the higher the temperature, the more active the microbes and the more rapid the breakdown. Therefore, although this fast breakdown rate means ethylene glycol does not accumulate in the environment, it does create extremely high levels of biochemical oxygen demand, which depletes oxygen in water bodies: At 69°F/20°C, levels of five-day BODs have been reported as high as 800,000 ppm.<sup>24</sup> By comparison, the typical levels for raw sewage and treated domestic waste water are 220 ppm and 20 ppm, respectively. In surface water runoff following deicing with ethylene glycol, BOD can be expected at levels of 500–5,000 ppm.<sup>25</sup>

Ethylene glycol BOD concerns are compounded by the fact that the material breaks down very slowly at temperatures below freezing, when aerobic microbes are inactive, and thus is diluted very slowly



when groundwater and surface water are frozen. This causes pulses of relatively high levels of the chemical during thaws. The intermittent release of high concentrations of the chemical is more harmful than a continuous release of lower concentration.

Existing road deicing equipment would have to be modified to accommodate the small tanks and spray bars necessary to apply ethylene glycol.

Airtight storage of the material is required. Ethylene glycol is considered a moderate irritant to the skin, eyes, and mucus membranes, and safety glasses and gloves must be worn when handling the material. It can be fatal if ingested. Another adverse aspect of the material is that it contains trace levels of 1,4-dioxane, an animal carcinogen. This chemical is regulated as a potential human carcinogen, having induced tumors in research animals. Although it is present in *technical* grade ethylene glycol, which is used for antifreeze, at levels of 1-22 ppm, it is not detectable in *polyester* grade, which is a purer class of ethylene glycol and is the grade used most in Michigan (primarily as an aircraft deicer) today.<sup>26</sup>

### *Urea*

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 1-10 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 10 ppm 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.”

### *Methanol*

Methanol as a deicing liquid penetrates packed snow more quickly than road salt and is more effective at lower temperatures, but it volatilizes (turns into a gas) quickly and must be reapplied more often than road salt. When evaporating, the breakdown products of methanol can affect ambient (surrounding) air quality by releasing vapors that can contribute to ozone pollution in Earth’s lower atmosphere.<sup>28</sup> Methanol is a liquid and must be stored in an enclosed container, but the vapors released when the containers are opened and the material is being handled can pose health risks to workers. Protective gloves, impervious clothing and a self-contained breathing apparatus are necessary when handling methanol. In addition, specialized application equipment is required. Finally, the cost of methanol is approximately 5.5 times that of road salt.

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