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Magnesium Chloride Toilet Vault Treatment: A Means To Inhibit Freezing in Outdoor Toilet Vaults

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INTRODUCTION

Toilet vaults in colder climates are prone to freezing in the winter, which is often the period of their heaviest use. Throughout the Forest Service, U.S. Department of Agriculture, and other agencies, sweet smelling toilets (SSTs) are widely used. These toilets have a lined containment vault, which stores 500 to 1,000 gallons of waste. The SST has a large vent stack that draws a draft through the toilet riser and up to the outside where the odor is less noticeable. While the toilet's design goal is to reduce odor, the draft through the vault draws in outside air and that accelerates freezing of the vault contents. Freezing of the waste can form a stalagmite that actually blocks the toilet riser, rendering the toilet unusable and

unsanitary. Once the toilet riser is blocked, the only practical way to make it usable again is to have it steam cleaned and pumped. The cost of cleaning and pumping each toilet vault is typically more than \$500, and it may need to be repeated several times each season.

PURPOSE AND SCOPE

The San Dimas Technology & Development Center (SDTDC) was asked to address the frozen waste issue. The project's goal was to develop a system or technique that will prevent—or at least inhibit—stalagmite formation in the vaults. If the contents can be kept in a fluid condition, the waste will spread evenly throughout the vault and not form a frozen cone. Naturally, any method selected



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needs to be economically feasible and competitive with the current practice of steam cleaning and pumping.

DISCUSSION

Small, portable outhouses and recreational-vehicle commodes often use a liquid antifreeze chemical to prevent freezing and reduce odor, but the cost of these products when applied to a vault toilet is too high to compete with the current practice. Volatile compounds like methanol could be added periodically to keep the waste fluid but storage, handling, and safety concerns rule them out. We (SDTDC staff) considered propane- and oil-fueled heaters and concluded that safety concerns were too risky, and the cost of fuel to maintain the vault temperature above freezing was too high to compete with cleaning and pumping. We also considered submersible fish pond and livestock watering trough heaters. They may be appropriate for some locations, but not where there is minimal solar radiation and no grid power available. We considered small windmills, but the price is high and some locations do not get enough wind during the winter to make adequate power. We could not find any self-starting portable generator sized appropriately for a single or dual vault, although if four or more vaults were very close to each other, it could be economical to power several submersible heaters with a small generator. We would still need to enclose the generator and provide venting for exhaust and adequate fuel for long-term operation. With all economic and safety issues considered, chemical treatment with common road salts looked like the most practical way to start testing. Magnesium chloride (MgCl₂) offers the lowest freezing point of the salts that are generally used by State and municipal road maintenance agencies. MgCl₂ dissolves readily in water, and it is generally accepted by municipal and local wastewater treatment facilities. However, before using it, consult the local authority and the product Material Safety Data Sheet.

Figure 1 compares the freezing points of MgCl₂ and sodium chloride (NaCl) in solution with water.

Note: The eutectic point for NaCl is 2.00 pounds per gallon and for MgCl₂ it is 2.25 pounds per gallon. The freezing point will rise with the addition of more salt beyond these points.

Concentration (lb/gallon)	Rock Salt(NaCl) Freezing Point Degrees F [C]	Magnesium Chloride (MgCl ₂) Freezing Point
0.0	32 [0]	32 [0]
0.5	26 [-3]	26 [-3]
1.0	19 [-7]	18 [-8]
1.5	11 [-12]	0 [-18]
2.0	0 [-18]	-20 [-29]

Figure 1—Freezing points.

TEST LOCATION

The Chugach National Forest in Region 10 (Alaska) has many recreational sites that get heavy use during the winter season. The maritime climate that prevails through much of the forest makes it ideal for winter recreational activities, since it receives abundant snowfall yet the temperatures are more moderate than the interior areas of the State. Turnagain Pass recreational area is very popular with both snowmobile and nonmotorized sports enthusiasts. The area is divided by a major road, and the motorized activities are limited to one side. Each side has two duplex vault toilets, and there is no grid power available.

INITIAL TESTS

During the 2004-2005 winter season, we tried a MgCl₂ brine solution in two of the vaults, but—due to a design problem on the vault cleanout hatch—the vaults filled with water and froze before more salt could be added. Consequently, these toilets were closed for the rest of the winter. Temperature dataloggers were placed in two of the vaults that did not have flooding problems. One datalogger was in a control (unmodified) vault and the other was placed in a vault that had the vent stack capped off. We wanted to measure the temperature difference caused by the draft, and were able to get some data during the 2004-2005 winter. A nearby weather station also provided ambient temperature data, and the results are shown in figure 2.

Figure 2 shows the vented vault temperature changes (vault 1) were more volatile and, in some cases, they dropped as much as 15 degrees Fahrenheit below the unvented vault (vault 2).

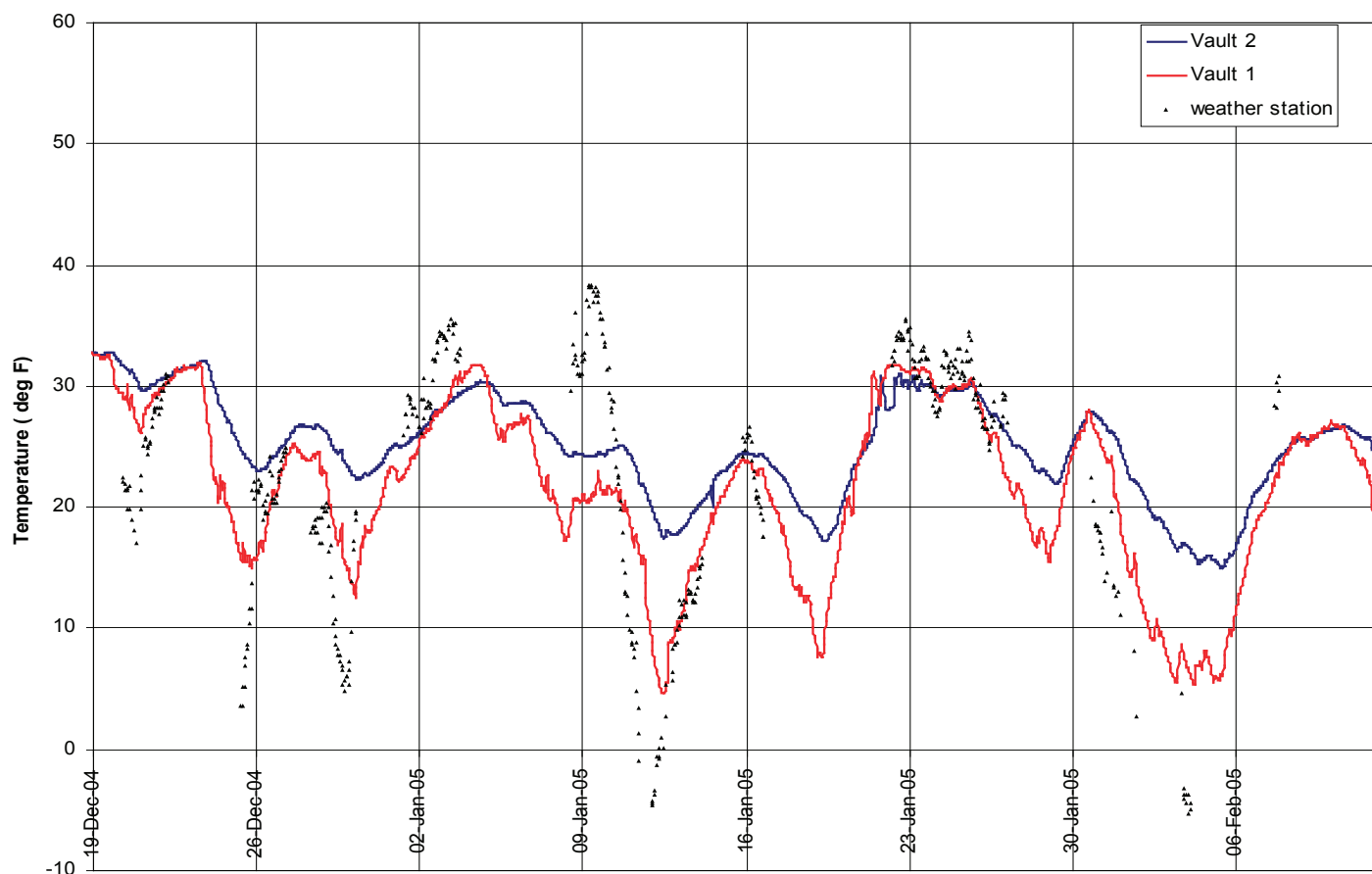


Figure 2—Temperature logs.

However, capping the vent brought odor into the stall, and the author personally thought it was unbearable for timespans greater than his ability to hold his breath.

2005-2006 TEST

In two of the vaults, the cleanouts were modified with a riser to prevent the flooding that occurred the prior year, and testing resumed during the 2005-2006 winter season. Due to the odor problem associated with blocking the vent, we did not block the vents on either vault. Also, we decided to try adding $MgCl_2$ directly to the waste instead of adding it as brine. Generally, there is some residual liquid in the vault even after it is pumped, so the $MgCl_2$ was simply dumped in through the toilet riser as needed to maintain a fluid state. Only one vault was treated with $MgCl_2$ and the adjacent vault served as the control.

The vault treated with $MgCl_2$ remained fluid all season, and it had enough capacity that it did not need to be pumped. The adjacent control vault did have freezing problems, and waste built up below the riser to the point where service was necessary. Only 200 pounds (four bags) of $MgCl_2$ were required to maintain one vault all winter. The results from this test only gave us one reference datum, but in this case, $MgCl_2$ appeared to offer a viable, economical solution to the problem and warranted further study.

2006-2007 TEST

We expanded our experiment to include seven of the eight vaults at Turnagain Pass. We put data sheets in the closets of each duplex stall and stocked them with $MgCl_2$ bags. Our intent was to record the amount of $MgCl_2$ added, and the intervals. We did not add any liquid to the vaults,

and there was very little residual liquid in them when we added the first dose of one bag per stall in the first week of November 2006. Subsequently, two bags were added to each stall the following week and another bag was added during the last week of November, for a total of four bags per stall. Since the vaults were almost completely empty, there was not enough liquid to dissolve the $MgCl_2$ and adding more chemical did not help. The maintenance crew did not want to compromise capacity by adding liquid, since they felt that would force them to pump the vaults before the season was over.

Magnesium chloride needs a fluid medium to be effective at thawing solid waste. You should use about 2 pounds of $MgCl_2$ per gallon of water to keep the freezing point down around -20 degrees Fahrenheit (-29 degrees Celsius), but concentrations greater than 2.25 pounds per gallon will start to increase the freezing point. Since the salt did not seem to be very helpful when the content of the vault was already frozen, the maintenance crew did not add any more $MgCl_2$ after November 26, 2006.

ECONOMICS

A full pallet of $MgCl_2$ (49 bags) costs about \$2,200 delivered to Anchorage, AK. A pallet can be purchased from the manufacturer in Salt Lake City, UT, for about \$780 plus shipping. Shipment via contract carrier on a Government bill of lading to destinations within the contiguous United States should cost less. Including shipping to Anchorage, AK, the $MgCl_2$ treatment cost approximately \$182 per vault for an entire season. Compared to \$500 per vault for steaming and pumping, we believe that the salt treatment will be less costly.

CONCLUSIONS

$MgCl_2$ can be effective at preventing toilet vault contents from freezing. However, at the start of winter season precharge the vault with about 10 inches of water below the riser and add 1 to 2 pounds of $MgCl_2$ per gallon, depending on winter temperatures. Depending on average temperatures and increasing liquid level in the vault, use figure 1 to determine how much additional $MgCl_2$ to add during the winter season.

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For additional information on magnesium chloride toilet vault treatment, contact Brenda Land or Joe Fleming at SDTDC. Phone: 909-599-1267. E-mail: bland@fs.fed.us or jdfleming@fs.fed.us

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