Calcium Chloride vs. Magnesium Chloride

Dampness in Dust Control Applications

1) Introduction

a) In dust control applications, solutions of $CaCl_2$ and $MgCl_2$ often compete against each other. However there is no clear consensus regarding the concentrations and application rates for the two products that deliver equivalent performance. Although application guidelines are available from independent sources, (Table 1, for example), the guidance is quite broad and not very helpful when making situation-specific comparisons.

Table 1.

Independent Source	Product	Application Rate	Concentration
Bolander, P., *Dust Palliative Selection and Application Guide*, USDA Forest Service, November 1999	$CaCl_2$	0.90 – 1.60 l/m^2 0.20 – 0.35 gal/yd^2	35% - 38%
	$MgCl_2$	1.40 – 2.30 l/m^2 0.30 – 0.50 gal/yd^2	28% - 35%

b) Recommendations from suppliers vary in a similar fashion. As a result, it is difficult for customers to know how to best compare these two products when making purchasing decisions for any given situation.

c) In an attempt to clarify the relative effectiveness of these two products, this paper applies an objective basis for comparison recommended 40 years ago to products commercially available today.

2) Objective Basis for Comparison

a) In his 1972 project titled, A Comparison Between Calcium Chloride and Magnesium Chloride as Dust-Binding Agents on Gravel Roads, Janeric Reyier summarizes a basis for comparison as follows:

> *"When we compare the effectiveness of salts as dust palliatives we must take into consideration two factors. First, whether the salts have the capacity to form a solution at the prevailing temperature and humidity, and second, what volume of solution is formed under these conditions with the same starting quantities."* [a]

b) Reyier's summary is sensible since the dust control performance of $CaCl_2$ and $MgCl_2$ is based on the ability to provide moisture cohesion to the road surface, (i.e. keep it damp). Therefore, this paper will apply Reyier's comparison factors to current application scenarios in the United States.

3) Reyier Factor #1: Compare the capacity to form a solution at the prevailing relative humidity and temperature

a) The first step in this comparison is to gather the prevailing relative humidity and temperature data for the regions of interest. Figures 1 and 2 show monthly averages for relative humidity and temperature during dust control season for three regions in the United States. [b]

Figure 1

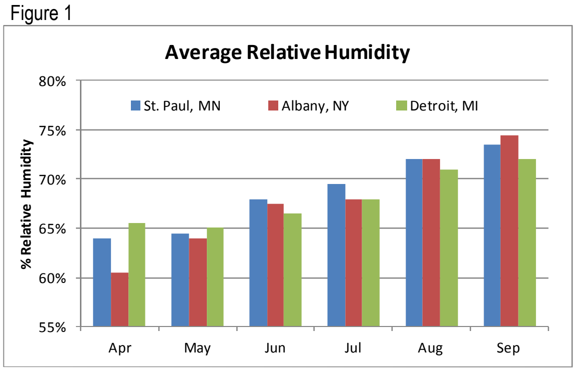
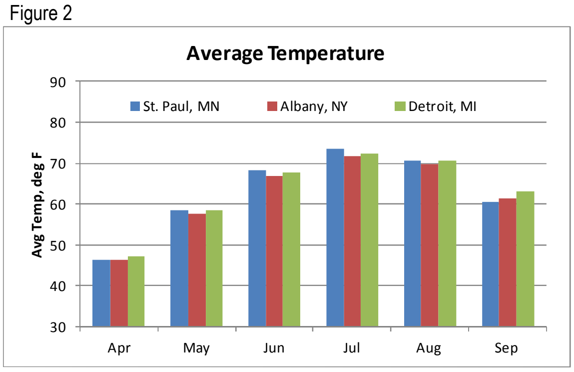


Figure 2



b) The next step is to determine if these hygroscopic salts exist as a solid or liquid under these weather conditions. Reyier's report provides the humidity and temperature conditions where $CaCl_2$ and $MgCl_2$ transition between solid and liquid phases. The phase boundaries are shown in Figure 3; the blue line for the $CaCl_2$ phase boundary and the red line for the $MgCl_2$ phase boundary. When relative humidity and temperature points fall above the phase boundary line, the product at equilibrium will be in the liquid phase.

c) The green triangles in Figure 3 represent the prevailing relative humidity and temperature conditions from Figures 1 and 2. It is easy to see that these weather conditions fall well into the liquid phase zone for both $CaCl_2$ and $MgCl_2$. Therefore, the data indicates that both products have the capacity to form solutions under these conditions.

d) It is important to note that it is not known how well Reyier's physical property data represents the properties of today's commercial products. However, the accuracy of his data is considered adequate for this purpose, because none of the average weather conditions fall close to the phase boundary conditions. In other words, there is room for error without affecting the bottom line conclusion that both products have the capacity to form solutions under these conditions. This is consistent with current real-world observations.

4) Reyier Factor #2: Volume of solution formed under these conditions with the same starting quantities

a) Understanding how solution volume changes in response to different humidity conditions is important, because the volume of solution in the road determines how thoroughly the fines are bonded by moisture cohesion. Once $CaCl_2$ or $MgCl_2$ solutions are applied to a gravel road surface, the solution volume begins to change as it seeks equilibrium with the moisture content of the air. If relative humidity is high, the solution volume grows, increasing the liquid coverage of fines and improving dust control. If relative humidity is low, the opposite response occurs.

b) The solution volume in the road also depends on the initial concentration of the product applied; the more concentrated the product, the greater the moisture absorption and resulting solution volume under different relative humidity conditions.

c) It is important to understand that the relationship between solution volume and relative humidity is essentially independent of temperature when conditions are in the liquid phase zone. The primary effect of temperature is built into the relative humidity measurement, so it does not need to be considered separately.

d) The effect of impurities and other variables associated with today's commercial $CaCl_2$ and $MgCl_2$ products makes it unlikely that a calculation based on published physical property data would be an accurate reflection of solution volume versus relative humidity performance. Therefore, a simple lab experiment was conducted to measure the solution volume response of commercially available 34% $CaCl_2$, 35% $CaCl_2$ and 30% $MgCl_2$ solutions at two different relative humidity levels.

i) The specific gravity of each solution was measured and equal weights were placed in shallow plastic dishes. The dishes were placed in a sealed chamber at constant relative humidity and allowed to reach equilibrium, after which weight and specific gravity of each solution was again measured. Using these measurements, solution volumes were calculated before and after reaching equilibrium. Normalizing the data to an equal starting volume basis allowed the moisture-absorbing performance of the products to be compared as shown in Figure 4.

Figure 3

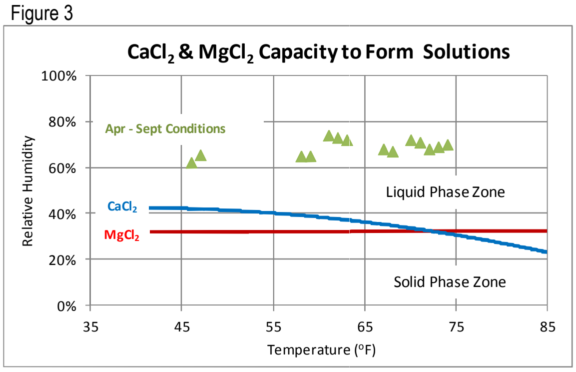
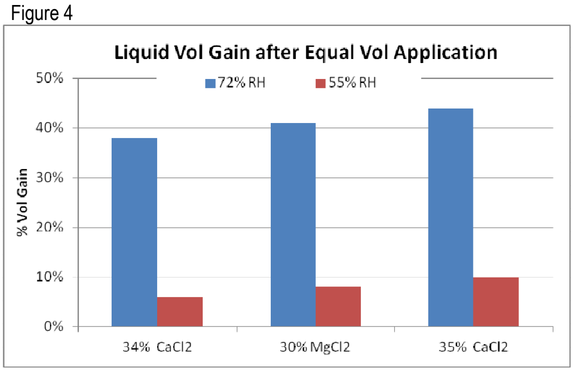


Figure 4



5) Summary

a) Based on Reyier's two factors for comparing the effectiveness of hygroscopic salts used in dust control, it has been determined that 30% $MgCl_2$ and 34.5% $CaCl_2$ would be expected to be similarly effective when applied in equal volumes under the prevailing conditions in the north central and northeastern United States.

b) While Reyier's approach is technically solid, his study did not address the issue of retention when comparing the effectiveness of $CaCl_2$ and $MgCl_2$. With all conditions being equal, a product that remains in the road longer is more preferable. A higher retention yields extended dust control and reduces application frequency. The fact that $CaCl_2$ is a larger, heavier molecule may give it greater retention than the smaller, lighter MgCl2 molecule. This topic represents an opportunity for future study.

6) References

a) Reyier, J., *A Comparison between Calcium Chloride and Magnesium Chloride as Dust-binding Agents on Gravel Roads*; Examination Project, The Institute for Road-building, Royal Technical College, Stockholm, 1972

b) http://www.cityrating.com

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