Anton Paar

DMA 35 supports Winter Services for safe Travels

Relevant for: Road assistance centers in cold climate countries

Also in harsh winter weather conditions, people in cars, railways, planes and other means of transportation, and also pedestrians are on the move to get to their final destination. Winter services such as salt application on roads and pathways help commuters to arrive safely.

1 Ice and Snow: a familiar sight in cold climate countries

Also in the winter time, when the roads might be slippery, people have to commute to fulfill their daily tasks, whether by car, train or foot which asks for action to facilitate travels and enhance safety in difficult weather conditions.

Basically, two means of treatment apply: spreading of sand or similar (e.g. ashes or gravel) and the winter maintenance of roads and pathways with salts. While gravel has a blunting effect and causes lots of dust which is an undesired side action especially in densely populated areas, moist salt remains on the road longer and is therefore the more convenient option.

Excess salt may cause damage to metallic road constructions and bridges and has also an environmental impact. Care has to be taken to keep the amount of the applied salt as low as possible and as high as necessary.

2 Salt or brine?

Salt as a thawing agent has been enjoying increased importance due to growing motorization, but spreading of solid salt does not always show the desired result because solid salt can be quickly blown away by wind as well as fast moving vehicles. This is why salt is not always applied as solid salt, but also as moistened salt or as brine in defined concentrations to minimize losses and improve efficiency.

Here, a reliable instrument for fast and precise concentration measurement is in demand, the portable DMA 35 density meter (compare **Figure 1**) offers itself as most suitable solution.

Road salt is suitable for melting snow and ice on transport routes. Commercial road salt mainly consists if sodium chloride (NaCl) and can also contain varying amounts of other constituents, e.g. calcium and magnesium sulfate. There also exist other thawing agents, mainly inorganic calcium and magnesium salts such as calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) and potassium chloride (KCl).

If the weather forecast predicts snow, applying a mixture of salt and brine before snow, rain or frost arrive helps to prevent the formation of ice on the road surface. For this preventive activity, very small amounts of salt are sufficient. Verifying the brine concentration can be carried out with the portable density meter DMA 35 fast and on the spot.

Fig. 1 The portable DMA 35 density meter

3 DMA 35: a great performer in cold weather

The density of a solution is a reliable indicator for the concentration of a binary solution. As brine only contains very small amounts of additional components, also the brine's concentration can be determined reliably by means of density measurement. The fact that the density at measuring temperature is automatically expressed as the density at a reference temperature (usually 20 °C),

fluctuations of the ambient temperature will not affect the result, no matter whether DMA 35 was held at ambient temperature or at room temperature.

4 Samples and results

4.1 General remarks

The most common brine solutions are calcium chloride and sodium chloride. Three salt solutions each were prepared containing 15 % w/w, 20 % w/w and 25 % w/w salt as these concentrations are close to the concentrations of brines used for road defrosting. The solutions were measured five times each with the respective custom function for DMA 35.

4.2 Temperature influence on the density value

Three possibilities were considered:

- both DMA 35 stored indoors, and brine solution in a tank indoors at room temperature,
- DMA 35 stored indoors at room temperature, brine solution stored outside at cold ambient temperature, and
- both DMA 35 and brine solution stored outdoors at cold ambient temperature.

To verify these three possibilities under laboratory conditions, samples and instrument were stored in the refrigerator overnight.

The results were always expressed as density referred to a standard temperature of 20 °C. Five subsequent measurements were carried out, **Tables 1 to 3** summarize the results.

Table 1: DMA 35 and samples at room temperature (22.6 °C)

		$CaCl_2$ solution	**NaCl solution**
	Measurement number	Density [g/mL] at 20 °C”	Density [g/mL] at 20 °C”
15 % w/w	1	1.1275	1.1072
	2	1.1273	1.1072
	3	1.1273	1.1072
	4	1.1273	1.1071
	5	1.1273	1.1072
	mean	1.1273	1.1072
	std deviation	8.94427E-05	4.47214E-05

Table 1: DMA 35 and samples at room temperature (22.6 °C)

		$CaCl_2$ solution	**NaCl solution**
	Measurement number	Density [g/mL] at 20 °C	Density [g/mL] at 20 °C
20 % w/w	1	1.1755	1.1464
	2	1.1755	1.1464
	3	1.1755	1.1463
	4	1.1754	1.1464
	5	1.1755	1.1464
	mean	1.1755	1.1464
	std deviation	4.47214E-05	4.47214E-05
25 % w/w	1	1.2260	1.1872
	2	1.2260	1.1872
	3	1.2260	1.1873
	4	1.2260	1.1872
	5	1.2259	1.1872
	mean	1.2260	1.1872
	std deviation	4.47214E-05	4.47214E-05

Table 2 summarizes the data recorded with cold samples ($CaCl_2$: 15 % w/w at 11.8 °C; 20 % w/w at 10.9 °C; 25 % w/w at 7.6 °C; NaCl: 15 % w/w at 1.0°C; 20 % w/w at 8.6 °C; 25 % w/w at 5.5 °C) and DMA 35 at room temperature.

Table 2: DMA 35 at room temperature, samples cold

		$CaCl_2$ solution	**NaCl solution**
	Measurement number	Density [g/mL] at 20 °C	Density [g/mL] at 20 °C
15 % w/w	1	1.1315	1.1160
	2	1.1316	1.1160
	3	1.1316	1.1159
	4	1.1315	1.1160
	5	1.1315	1.1159
	mean	1.1315	1.1160
	std deviation	5.47723E-05	5.47723E-05

Table 2: DMA 35 at room temperature, samples cold

		$CaCl_2$ solution	**NaCl solution**
	Measurement number	Density [g/mL] at 20 °C	Density [g/mL] at 20 °C
20 % w/w	1	1.1805	1.1531
	2	1.1804	1.1530
	3	1.1805	1.1530
	4	1.1806	1.1531
	5	1.1806	1.1530
	mean	1.1805	1.1530
	std deviation	8.3666E-05	5.47723E-05
25 % w/w	1	1.2332	1.1961
	2	1.2331	1.1962
	3	1.2333	1.1960
	4	1.2332	1.1961
	5	1.2331	1.1962
	mean	1.2332	1.1961
	std deviation	8.3666E-05	8.3666E-05

Table 3 summarizes the data recorded with cold samples ($CaCl_2$: 15 % w/w at 8.4 °C; 20 % w/w at 8.0 °C; 25 % w/w at 9.5 °C; NaCl: 15 % w/w at 6.9°C; 20 % w/w at 8.5 °C; 25 % w/w at 9.2 °C) and DMA 35 at cold temperature.

Table 3: DMA 35 cold, samples cold

		$CaCl_2$ solution	**NaCl solution**
	Measurement number	Density [g/mL] at 20 °C	Density [g/mL] at 20 °C
15 % w/w	1	1.1327	1.1134
	2	1.1326	1.1133
	3	1.1325	1.1135
	4	1.1324	1.1135
	5	1.1324	1.1135
	mean	1.1325	1.1134
	std deviation	0.000130384	8.94427E-05

Table 3: DMA 35 cold, samples cold

		$CaCl_2$ solution	**NaCl solution**
	Measurement number	Density [g/mL] at 20 °C	Density [g/mL] at 20 °C
20 % w/w	1	1.1816	1.1526
	2	1.1817	1.1529
	3	1.1815	1.1529
	4	1.1816	1.1529
	5	1.1815	1.1528
	mean	1.1816	1.1528
	std deviation	8.3666E-05	0.000130384
25 % w/w	1	1.2321	1.1938
	2	1.2321	1.1940
	3	1.2320	1.1939
	4	1.2320	1.1940
	5	1.2321	1.1940
	mean	1.2321	1.1939
	std deviation	5.47723E-05	8.94427E-05

5 Are you eager for a deeper insight?

Grit and solid salt are not suitable for any roads that are traveled on with higher speed. Here, the partial replacement of solid salt by brine is the better option, especially when applied preventively, as it can be distributed more easily and stays on the road longer. Investigations showed that the savings on applied salt can be up to 50 %.

For safe travels in harsh winter conditions the layer between tire and road surface should be moist so no ice or snow can stick to either surface. This can be achieved by applying a mixture of wet salt and brine before the snowfall (preventive spreading) as road salt will only be fully effective when dissolved: the salt layer stays on the road, no ice forms as salt lowers its melting point (the melting point of a NaCl brine can be as low as -21.1 °C), and small amounts of snow melt immediately.

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