DRS511 road sensor for

Safe Winter Driving

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Figure 1. The DRS511 road and runway sensor. The new feature is the optical detection of water, ice and snow on the road surface. In addition, it measures conductivity, electrochemical polarizability, surface capacitance (black ice), surface temperature and ground temperature.

Vaisala's ROSA road weather stations provide real-time, accurate information on road weather and surface conditions. This allows road maintenance personnel to take a proactive approach to salt spreading and the removal of snow and ice. It also allows the installation of various traffic control applications and warnings. The key component of ROSA is Vaisala's new DRS511 road sensor, with much improved capabilities for the measurement of water layer thickness and the detection of ice and snow.

Vaisala has designed and manufactured road weather stations since the early 1980's. During that time weather station platforms and road sensors have developed a lot. The last major change came in 1994, when the ROSA road weather station and the DRS50 road sensor were introduced.

The DRS511 observes the state of the road surface

Now, Vaisala is launching a new pavement sensor, the DRS511, which builds on and further develops the good features of the earlier DRS50 model. Like the DRS50, the new sensor is a robust, multi-sensor block operating on the thermally passive principle; i.e.

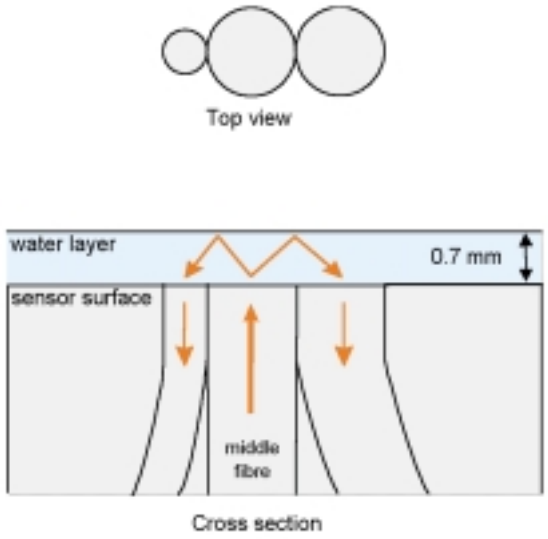


Figure 2. The principle of the optical "eye" of the DRS511. The middle optical fibre emits invisible infrared light from the sensor surface upwards, while the other two fibres measure the amount of reflected light. The eye is able to measure the water layer thickness and detect the presence of snow and ice.

The DRS511 road sensor in brief

- A road sensor which incorporates optical measurement
- Improved measurement of water layer thickness
- Direct detection of snow and ice on the road surface
- More accurate observation of road conditions than before
- Fully compatible with existing ROSA hardware
- Conserves all the measurement capabilities of the DRS50

Road surface states reported by ROSA

Dry
Moist
Moist and chemical
Wet
Wet and chemical
Frosty
Snowy
Icy

Warnings and alarms reported by ROSA

Ice alarm
Ice warning
Frost warning
Rain warning

no cooling or heating is used in the measuring process. Again, like its predecessor, the DRS511 measures surface conductivity, electrochemical polarizability, surface capacitance (black ice), surface temperature and ground temperature. But the DRS511 has an important added feature – optical coverage detection.

The detection of ice or snow on the road is of vital importance to a road weather station – as is the necessity to know the salt concentration on the road, since this determines the depression of the freezing point, and enables the appropriate preventive actions to be taken. The measurement of water layer thickness and the detection of ice or snow on the road surface has been improved in the DRS511 by integrating an optical sensor into the road sensor. More accurate water layer thickness measurement leads to the more accurate allocation of salt and depression of the freezing temperature.

The DRS511 observes the coverage on the road surface through an optical "eye". Located in the middle of the sensor surface, the eye consists of a construction of optical fibres. The construction is a derivative of a typical optical distance sensor (see Figure 2). The eye measures the water layer thickness and detects the presence of snow and ice.

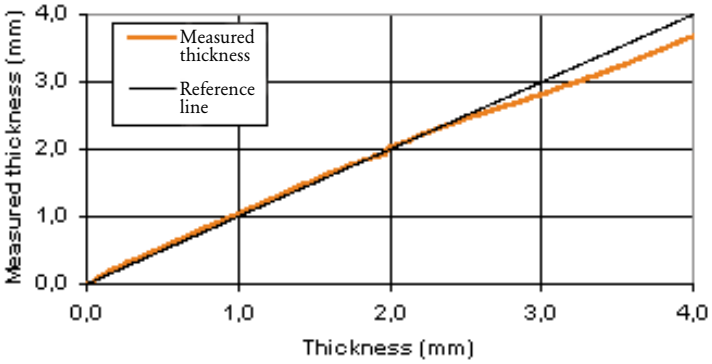


Figure 3. Water layer thickness measured by the DRS511 in laboratory conditions.

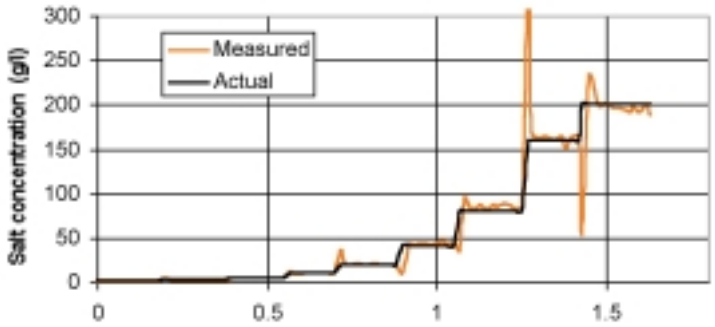
It is important to note that the sensor detects snow directly on the road surface. Hence, the ROSA road weather station can detect whether snow remains on the road when it is snowing.

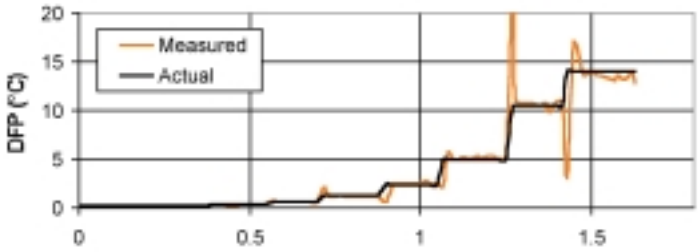
Optical measurements

By comparing the optical measurement results with the other measurements of the sensor, it is possible to accurately determine the freezing temperature and the risk of ice formation. The measurements are analyzed in the ROSA station by improved analyzer firmware which utilizes a patented method to deal with the optical data.

In laboratory conditions the sensor is capable of reaching a measurement range of up to 4 mm and an accuracy of 0.1 mm in the range 0.0 to 1.0 mm (see Figure 3). An accuracy of more than 10 per cent is reachable for salt concentration and depression of the freezing point (DFP).

In a real road environment, traffic causes additional noise in the measurements, which decreases the DFP accuracy from the laboratory value. In addition, the local uneven distribution of salt – especially across the road and just after spreading – causes ambiguities compared to an average from a larger area of road surface. Nevertheless, field tests show a significant increase in the accuracy of road surface condition analysis.





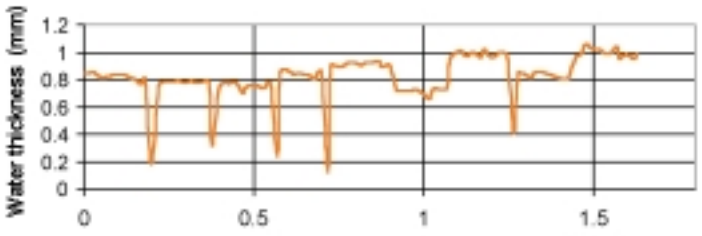


Figure 4. Salt concentration, depression of freezing point, and water layer thickness as a function of time in a laboratory experiment measured at 0 °C.

Sensor accuracy tested

How well does the DRS511 perform when installed into a real highway? To get an independent answer, we organized a field test with the Finnish National Road Administration (Finnra). The purpose of the test was to compare the road surface conditions measured by the ROSA against human observations in the same section of highway. The trial was carried out in Finnra's road weather station at Utti in southeastern Finland during the winter of 1998/99. The station was equipped with two DRS511 sensors, whose observations were compared with almost 300 observations made by the staff of Finnra in various weather conditions.

In 86 per cent of all cases, the road state measured by the DRS511 sensors was the same as, or did not significantly disagree with, the observed road state. This already very good figure increased to 91 per cent when more careful attention was paid to the sensors' location. One of the sensors was located in the wheel track and the other near the centre line, outside the wheel track. Thus, one of the sensors normally saw more snow on the road, while the snow in the other's location was cleared by traffic.

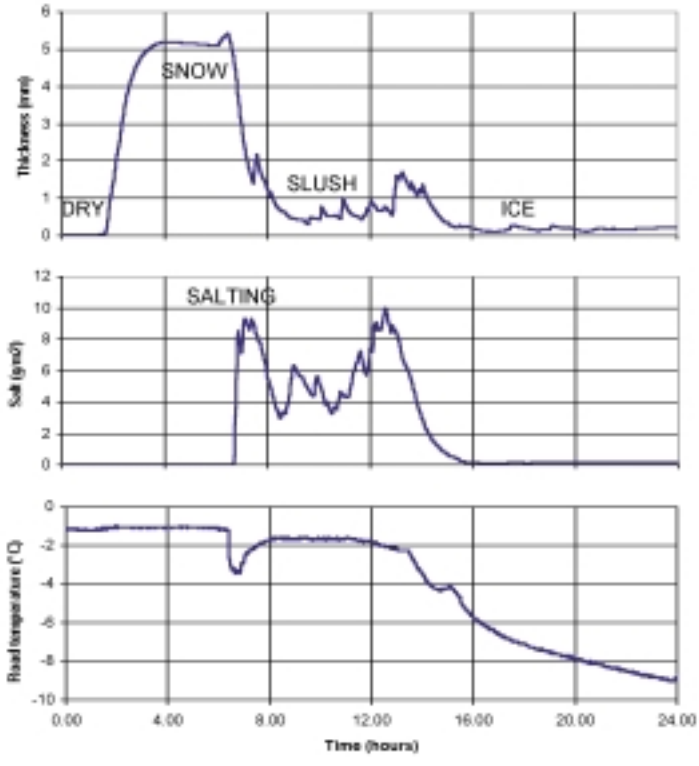


Figure 5. Thickness data from a highway during a day in January 1999. The observed road conditions are marked in the figure. Salt amount and road temperature curves clarify the situation.

Promising test results

These test results show that, with the ROSA station, road maintenance personnel will get much more accurate road condition information. The more accurate measurement of water layer thickness can be used for warnings of possible aquaplaning. The results also suggest that the DRS511 is reliable enough to be used with certain traffic control applications, such as variable message signs and automatic weather-controlled speed limit systems.

The new DRS511 pavement sensor can be used in existing ROSA systems simply by updating the ROSA firmware. No other hardware upgrades in the ROSA weather station platform are needed. This enables full backwards compatibility, and emphasizes the role played by the new DRS511 road sensor in the development continuum of Vaisala's road weather sensors and stations. ■

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