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Development of a RetroOptisk ice Indicator

English summary

1. Introduction

Supported by Vindforsk and FOI (the Swedish Defence Research Institute) HoloOptics has developed an optronic ice indicator using retrooptical metrology.

The retrooptical ice indicator comprises of a modulated detector and a synchronized IR emitter, one probe, and a support structure a base plate and cables.

The emitter-detector and control electronics is mounted in a weather safe casing. The emitter-detector will work properly in all lighting conditions, including direct sun light. The emitter-detector is heated at all times. Heating power approx. 1 W or 500 W/m^2.

The probe is a reflector that is reflecting the radiation from the emitter back to the detector if not covered with ice. Two different types of probes exist. Type A detects clear ice and heavy rime ice. Type B detects al types of rime ice.

If 95-98% of the probe is covered with ice, of the type which it is sensitive; the indicator will indicate the presence of ice. If then, the part of the probe free of ice is increased to approx. 25 % the indication will stop.

One indicator (Ice2) has an internally controlled probe heating. The probe heating is turned on and off without time delay. Heating power is approx. 3W or 1,6 kW/m^2.

Three indicators were tested in a climate camber at KTH (The Royal Institute of Technology in Stockholm).

From December 2003 to April 2004 four indicators was tested at a wind power station in Suorva in northern Lapland and four at KTH Suorva is situated 100 km north of the polar circle.

2. Presentation of the prototypes

In total eight prototype indicators were made numbered Ice1 to Ice8

Main specification of the prototype indicators is shown in table 1.

Name	Probe Type	Probe Heating	Probe insulation	Probe Facing	Test Site	Notes
Ice1	B	No	Yes	Upwind	Suorva	
Ice2	A	Yes	Yes	Upwind	Chamber and Suorva	
Ice3	B	No	No	Upwind	Chamber and Suorva	
Ice4	A	No	No	Upwind	Chamber and Suorva	
Ice5	B	No	No	North	Royal Institute of Technology	
Ice6	A	No	No	North	Royal Institute of Technology	
Ice7	A	No	No	Upward	Royal Institute of Technology	
Ice8	A	No	No	South	Royal Institute of Technology	

Table 1 Main specification of the prototype indicators

Probes mounted directly on the aluminium structure are indicated as not insulated. Figure 1 shows the prototype indicators.

Figure 1 Installed Ice indicators in Suorva

In the figure 1 Ice1 is closest to the camera.

3. Climate chamber tests

Three indicators were tested in a climate camber at KTH (The Royal Institute of Technology in Stockholm). In the tests very fast actions are used to enhance the effect.

To create light rime ice the indicators was cooled to – 10°C and then taken out to an environment with an air temperature of +23°C and 80 % humidity. Rime ice is created on the probes. Ice3 and Ice4 with not insulated probes are indicating. After a period of time the ice is melted and the water flown off. The indication is stopped. As Ice2 does not indicate its probe heating is not turned on.

Indicating time is long for Ice4. It is explained by the fact that its structure will make take longer time for the melted water to blow off. Ice2 with an insulated probe is not indication. The freed ice-formation energy will prevent ice to form on more than 95% of the probe. For the non-insulated probes the freed energy will quickly be absorbed by the aluminium structure.

To create heavy rime ice the indicators was cooled to –23 °C and then taken out to an environment with an air temperature of +23 °C and 95 % humidity. Heavy rime ice is created on the probes. All indicators are indicating. The probe heating on Ice2 is turned. After a period of time the ice is melted and the water flown off. The indication is stopped. The probe heating on Ice2 is turned off.

Indicating time is short for Ice2 as the probe heating will quickly melt the ice. As before the longest indicating time is recorded by Ice4.

To create simulated clear ice the indicators was cooled to – 23°C. The probes was then sprinkled with water with a temperature of +1 °C. The water is frozen on to the probe. After 90 sec, as Ice2 stopped indicating the indicators are taken out to an environment with air temperature of +23 °C and 30 % humidity. After a period of time the ice is melted and the water flown off.

Indicating time is short for Ice2 as the probe heating will quickly melt the ice. Ice3 with a probe of type B is not indicating. As before the longest indicating time is recorded by Ice4.

The test result is shown in figure 2.

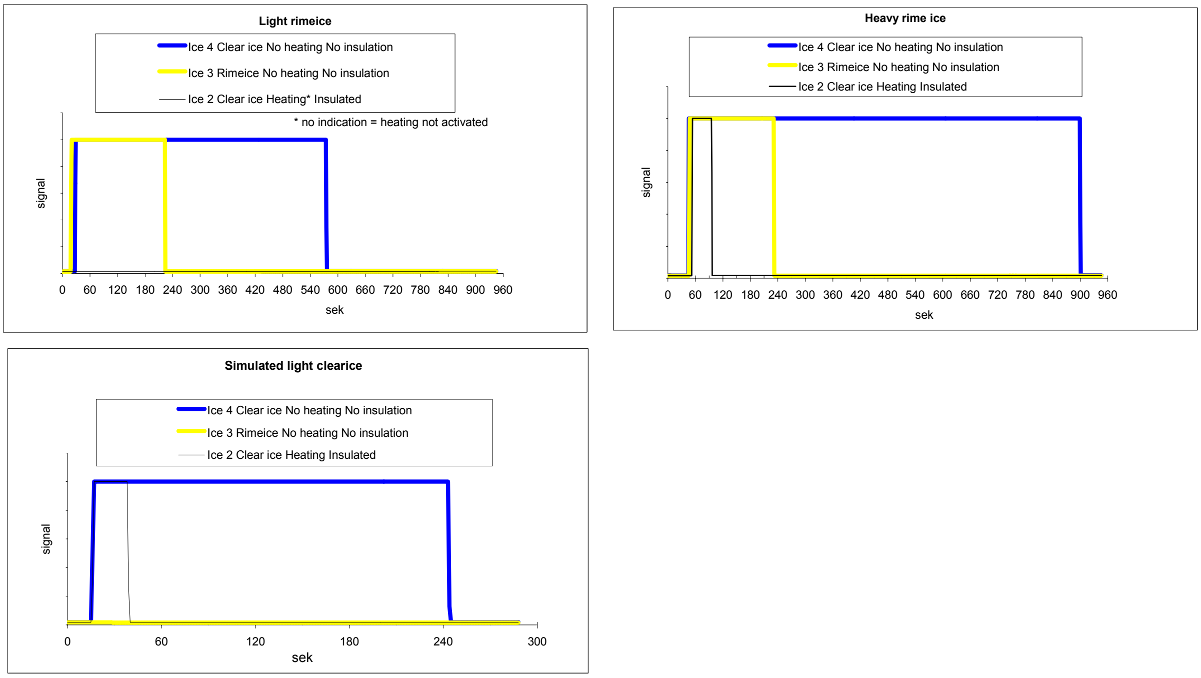

Figure 2 Climate chamber test results

Figure 2 shows that the retro optical ice indicator can indicate clear ice and differentiate between clear ice and rime ice.

4. Field tests

Field tests was made at two places Suorva wind power station and at Royal Institute of Technology (KTH)

-Suorva wind power plant

At the wind power plant in Suorva four indicators was installed, called Ice1-Ice4. The indicators are installed at the roof of the hub, 40 m above the ground. This installation ensures that the probes of the indicator are always facing upwind.

Air temperature, visibility and humidity were registrated by a nearby weather station.

Figure 3 Installation at the Suorva wind power plant. Air temperature is approx. – 25°C

After 1 800 h the alignment of Ice1 and Ice2 was failing due to some external force.

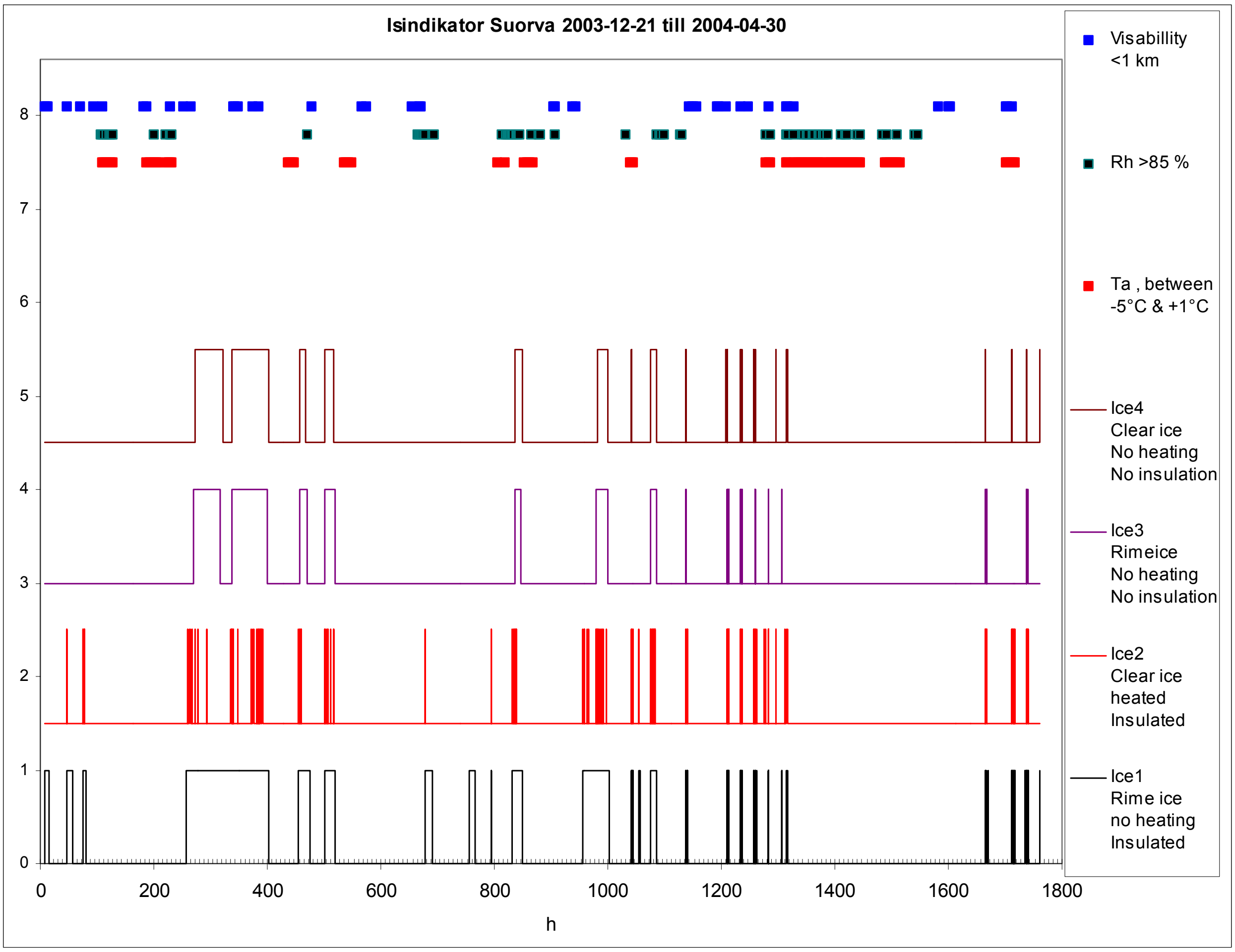

Figure 4 Indications from Ice1-4 and the nearby weather station

The indications are shown in figure 4. Between 1300 and 1700 h the logger was not working

Analysen av mätningarna från Suorva försvåras av att det inte finns några väderdata med avseende på isbildning i området. När is förekommer finns ingen möjlighet att avgöra vilken typ av is som bildats.

- Royal Institute of Technology (KTH)

At the Royal Institute of Technology four indicators was installed. See chapter 2.

Apart from the indicators the air temperature and humidity was registered.

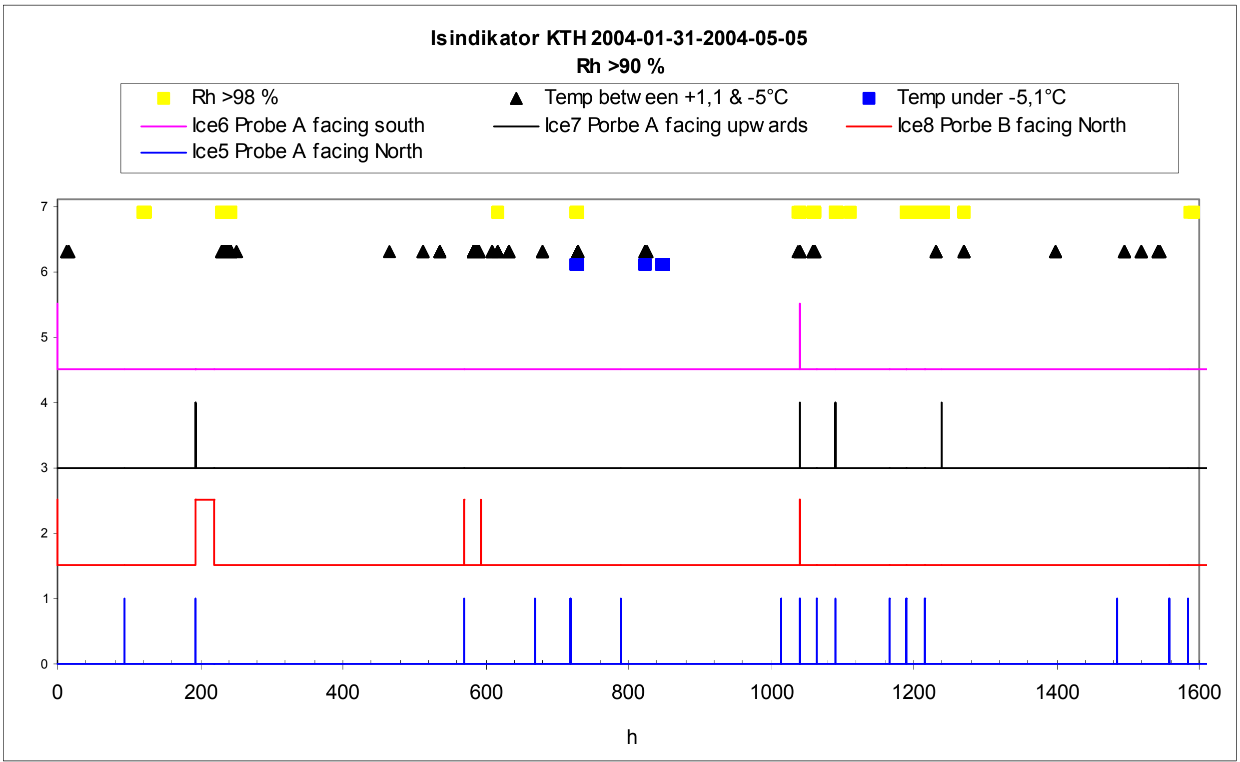

Figure 5 Indications at KTH

A check against the local weather stations shows that the risk for icing was high on the times indicated by Ice5.

At the location, north and south winds are the only possibly. Ice5 is facing north and Ice6 is facing south. Both indicate clear ice and heavy rime ice. Ice 5 is indicating approximately 16 times and Ice 6 only once. This shows the importers of install the probe upwind.

Installation of the probe facing upwards, as in Ice7 decreases the sensibility and increases the risk of false indication due to dirt on the probe. The other indicators were not affected by dirt.

5. Conclusions

All tests shows that an ice indicator using the retro optical metrology:

Can indicate clear ice

Can discriminate between clear ice and rime ice

If mounted on a correct place, and a service visit once a year the problems due to soot etc on the probe is acceptable.

All indicators and sensors will give false indications under some specific conditions In normal rain the probe drain will ensure its proper function. In heavy rain the probe may saturate, resulting in a false indication. If complemented with an air thermometer this source of false indication is eliminated.

6. Future development

The results of the testing have resulted in the development of the T23 Clear Ice Indicator beta version. It will be tested during the 2004-2005 winter at several locations

The T23 Clear Ice indicator will be further development. Developments planed are:

Continually supervision
An automatic self-test and a system for continuous health monitoring of the T23 Clear Ice Indicator will further increase the reliability. The self-test will indicate if the performance is degraded, although the indicator is still working. The continuous health monitoring will show if the indicator is indicating ice in spite of the probe is not covered with ice.

Increased intrinsic resistance against false indications

The indicator will include equipment for the setting of the power of the probe heating and its delay time.

Standby function.

The indicator will include equipment for the measurement of the ambient temperature and moisture etc.

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Appendix.

T23 Clear Ice Indicator Beta version