Notes from HoloOptics

Testing T23β Clear-Ice Indicator™

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1. Introduction

Sandhaugen testfelt, Tromsö Norway is situated 400 km north of the polar circle close to the North Sea. From the beginning of December 2004 to May 2005 two T23 Clear-Ice Indicators™ beta version was used to indicate ice on a test platform, see figure 1.

In the beginning of Mars 2005 a third indicator was installed with approx. 30% higher probe heating capacity.

The installation and measurements is made in close cooperation with Norsk Miljökraft.

Sandhaugen testfelts position makes it very prone to icing as mild winds with high moisture content reach the mountains coast. If icing is calculated from air temperatures and relative humidity, icing conditions will exists under approx. 1/3 of the winter season.

Figure 1

2. T23 Clear-Ice Indicator™

The T23 Clear-Ice Indicator™ is a patented digital optronic ice-indicator that indicates the presence of atmospheric clear ice and/or rime ice. The indicator comprises of a head with an IR emitter and a photo detector and a probe. The probe is a changing its optical properties if it is covered with clear ice or rime ice.

The probe is mounted on an internally controlled probe heating. The probe heating is turned on when indicating. The probe heating is turned on without time delay.

After a period of time the ice is melted and the water is fallen off the probe. The indication will when stop and the probe heating is turned off.

The time it takes to melt the ice once the probe heating is on is dependent on many factors. Some are icing rate, air and surface temperature, melting power, wind speed and direction and type of ice.

As the probe is cooled ice may start to build up on the probe again. As the probe is covered with ice once more the indication and the heating is turned on.

This cycle is repeated for as long as ice is created on the probe surface, see figure 2.

The tested version of T23β Clear-Ice Indicator™ is a beta version with limited capacity.

3. Saturation

In severe icing conditions the icing rate is so higher that the probe heating melting capacity. This saturates the indicator.

The T23β Clear-Ice Indicator™ heating capacity is approx. 3 kg/m^2h of icing. This value is often exceeded at this location.

If saturated ice will start to build up on the probe. As atmospheric ice is no more present the ice on the probe will start to melt. The indication will stop only as the ice on the probe is melted. This may take several hours.

4. Test results

The test results are attributed to the T23β Clear-Ice Indicator™. The definitive version differs from the beta version in several ways. Most important is that the probe heating capacity is increased by a factor five.

Indications are compared with periods with high risk for icing. During periods where the air temperature is between –5 and +2 °C and the relative humidity (R_h) is more than 95% are classified as with high risk for icing. Temperature and R_h are measured every ten minutes.

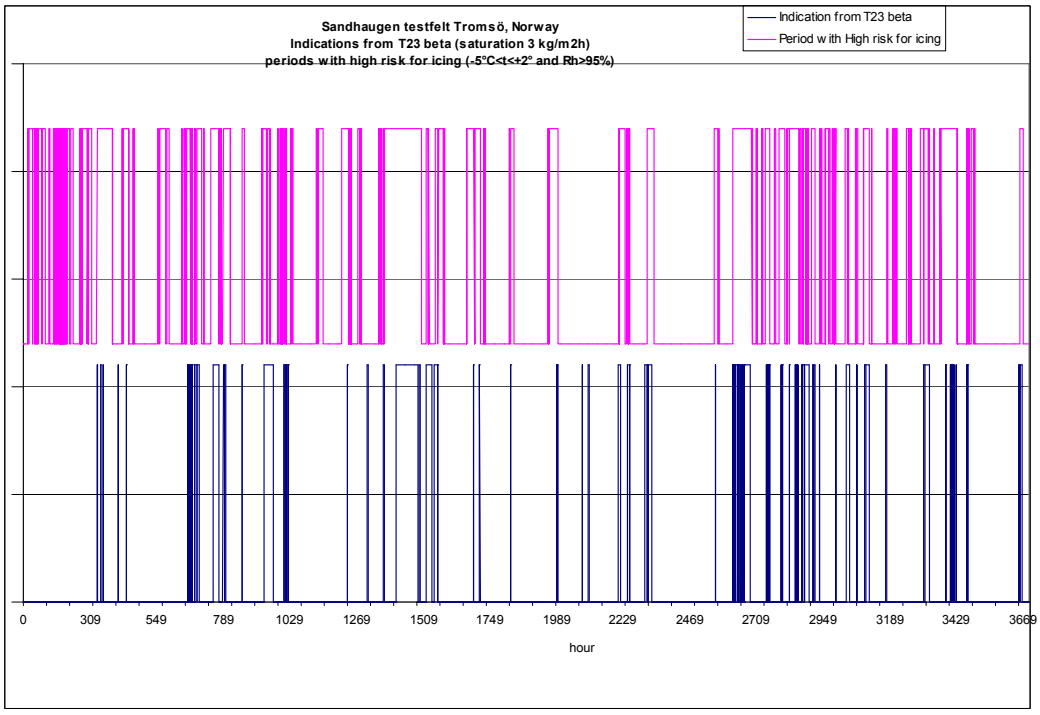


Figure 2 indications with T23β and periods classified as with high risk of icing

The two indicators used for the whole testing period made a total of 105 indications. During the time the third indicator with 30 % higher probe heating capacity was in use it indicted 82 times, but the original two indicated 46 times.

Some statistics from the measurements are shown in table 1.

	Dec 2004-May 2005		During T23β indications		During high risk for icing		T23β ind. & high risk	
	Temp	R_h	Temp	R_h	Temp	R_h	Temp	R_h
	°C	%	°C	%	°C	%	°C	%
Average	-3	88	-2	97	-2	98	-1	99
Max	+5	101	+3	101	+2	101	+2	101
Min	-13	32	-10	68	-5	95	-5	95

Table 1 main data for the test period

The typical relationship between T23β indication of ice and periods classified as with high risk for icing is shown in figure 4.

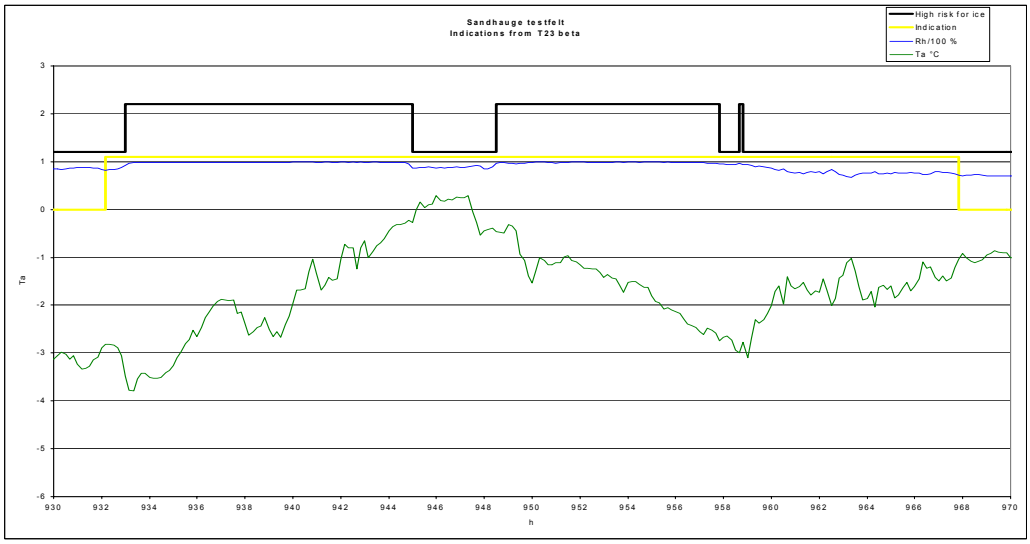


Figure 4 Indications of ice from T23β and periods with high risk for icing, example

Figure 4 shows that momentarily ice indications and high risk for icing may not be present at the same time. The ice indications may still be correct.

Total time for which indications exists is 3 691 hour from Dec 2004 to May 2005. During 1 178 hour the risk for icing was high according to the criteria used.

The installed T23β Clear-Ice Indicators™ beta was indicating during 406 hours. Of this 324 hours was during periods with high risk for icing.

If T23β is indicating ice during a period classified as with high risk for icing it is most probable that the indication is correct.

The 82 hours where the T23β was indicating ice at times not classified as with high risk of icing may be broken down as follows:

For 14,5 hours the indications of ice are embedded between two periods classified as with high risk for icing and the T23β is indicating ice, see figure 4 at 944-948 hour.

During this period icing condition may exists or the indicator may be saturated.

For 15 hours the indications of ice are preceding a period classified as with high risk for, see figure 4 at 932-933 hours

During this period icing condition may exists.

For 42 hours the indications of ice are preceding a period classified as with high risk, see figure 4 958-968 hours

During this period icing condition may exists or the indicator may be saturated.

For 5,5 hours the air temperature and humidity are close to the ones classified as with high risk for icing.

During this period icing condition may exists

For 4,5 hour the air temperatures are approx. –10°C and humidity 92-93 %

During this period icing condition may exists

For 0,5 hour the air temperatures are above +5°C and humidity 98-99 %

During this period rain is the probable cause of the indications.

The result is that between 95 and 99 % of all indications is due to icing.

5. Conclusions

The test shows that atmospheric ice is present at 95 to 99 % of all times T23β Clear-Ice Indicator™ is indication ice.

If indications at times where the air temperature is over +2°C this probability is even higher.

It is important that the probe heating capacity is higher then used in the beta version. In the definitive version this capacity is increased five times.

The definitive version of T23β Clear-Ice Indicator™ will be included with a health test system.

6. Icing Rate measurement

T23β Clear-Ice Indicator™ was never intended for measurements of the icing rate. If the indicator is not saturated it is possible to use it as an Icing rate sensor.

Figure 5 shows this for a period with low icing rate. This is used to make T26 Icing-Rate Sensor™.

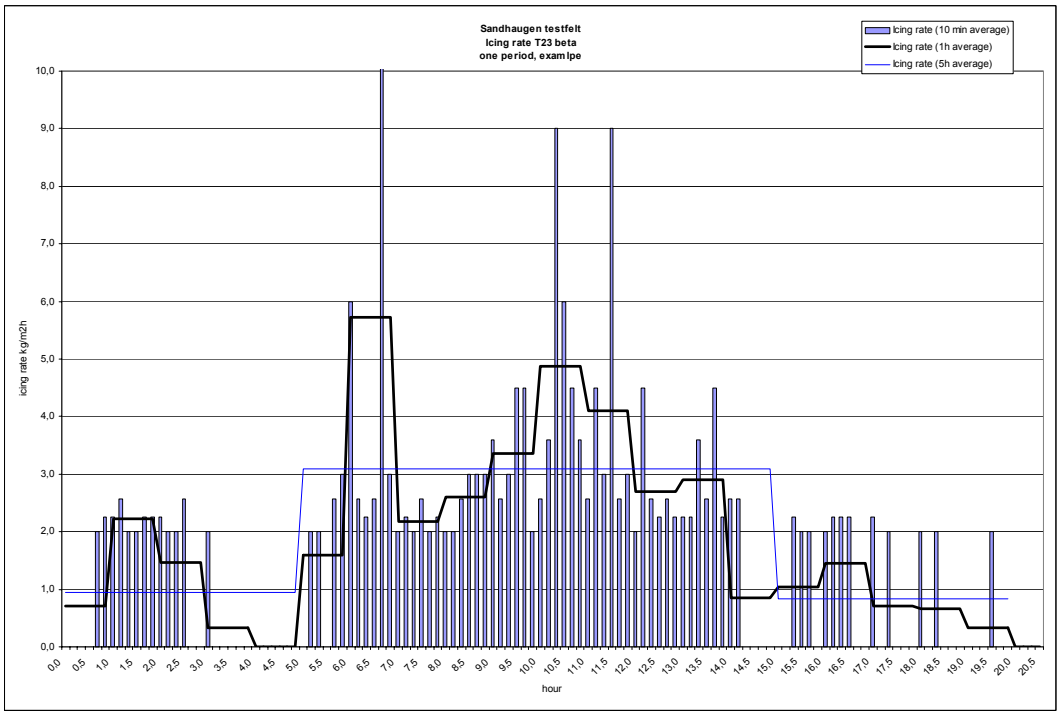


Figure 5 Icing rate

7. Developments

The T20-series ice indicators and sensors available

T21 Ice-Duration Indicator™ and Ice-Guard™

Indicating the duration of ice on not heated structures.
Controller of anti-icing or defroster equipment.
Sensitivity: 50 g/m^2
Available: October 2005

T23 Clear-Ice Indicator™

Indicating the presence of atmospheric ice.
Sensitivity: 50 g/m^2
Available: spring 2006

T26 Icing-Rate Sensor™

Measure the atmospheric icing rate.
Sensitivity: 50 g/m^{2}h – 18 kg/m^{2}h[1)]
Available: spring 2006

T26 Icing-Rate Sensor™ is to be introduced in next note from HoloOptics.

Common features

The T20-series is without moving parts. This gives high reliability.

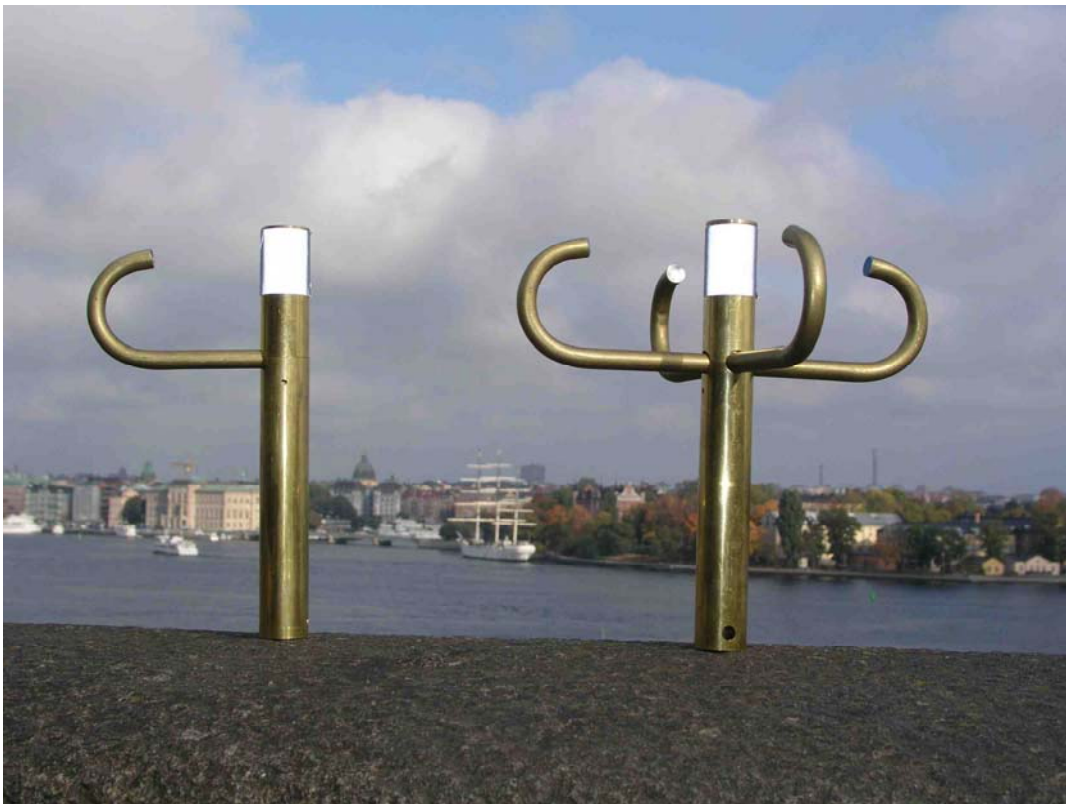
Due to the use of four heads position in different direction the sensitivity is independent of wind speed and wind direction. This also gives redundancy if one head fails.

The probe is mounted on a cylinder θ=30 mm according to ISO 12494:2001.

The T20-series is issued with a health-test giving an early warning if the sensors performance is degraded.

[1)] Higher capacity is possible

Installation is easy due to true open gate and supply voltage acceptable between 12 and 24 V.



T26 Icing-Rate Sensor™ single and omni