Icemeter tests at Studnice Station

Ing. Jaroslav Šabata, Ing. Lubomír Zeman
EGÚ Brno, a.s.
Hudcova 487/76a, 612 48 Brno-Medlánky, Czech Republic, jaroslav.sabata@egubrno.cz

***Abstract*— The test site Studnice, which is described in another paper at this workoshop, is among 5 other station through Europe that has been used for testing icemeters and validation of icing models.**

Two instruments – Combitech IceMonitor and Goodrich Rosemount ice detector were tested in the winter 2007/08 and 2008/09.

The paper describes comparative performance of these ice monitors.

I. Introduction

As part of the COST727 programme, the test site Studnice has been used for testing two instruments:

1. Combitech IceMonitor
2. Goodrich Rosemount ice detector.

Combitech IceMonitor and Goodrich ice detector were installed at the platform 10 m above ground (see Fig. 1).

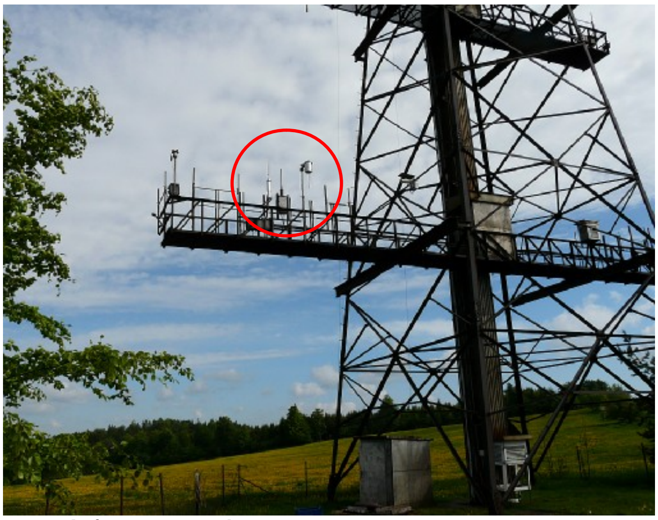


Fig. 1 Platform at 10 m with instruments

Instruments were connected to RS485 line. Data are collected on the PC server, recording every minute, associated with a date and time stamp.

The data from Combitech IceMonitor were used for validating icing models.

Both instruments were loaned by the manufactures free of charges.

II. IceMonitor

Combitech IceMonitor (Sweden) was tested in two winter seasons – 2007/2008 and 2008/2009. The model Combitech Ice Monitor Mk I was tested in winter 2007/2008 and till middle of winter 2008/2009, when was replaced by an updated model.

Basic information about the instrument:

- Measuring rod: length 0,5 m, diameter 30 mm, vertically oriented, freely rotated
- Measuring range: 0…100 kg/m
- Accuracy: ± 50 g
- Operating temperature: -40…+50 °C
- The bearing of the rod is electrically heated.

A. *Winter 2007/2008*

Combitech IceMonitor was installed at Studnice on December 21th, 2007 (see Fig. 2).

Fig. 2 Combitech IceMonitor (left)

Fig. 3 Combitech IceMonitor

B. *Winter 2008/2009*

Combitech IceMonitor was put in operation on 3rd October 2008. Updated version was installed at Studnice February 20, 2009 (see Fig. 4).

Fig. 4 Updated Combitech IceMonitor (left) and METEO (right)

Some improvements have been made (electronics, main body, fixing of measuring rod etc.) on the updated IceMonitor.

III. GOODRICH ICE DETECTOR

The second instrument selected by the Action was Goodrich/Rosemount (USA) ice detector. The tested instrument was model 0871LH1. The model is a low power sensor designed specifically for light ground-based freezing rain conditions. To detect the presence of an icing condition, the ice detection probe vibrates ultrasonically at a nominal resonant frequency of 40 kHz. As ice accretes on the probe, the added mass causes the resonant frequency to decrease, which initiates a self-deicing cycle that removes all accumulated ice from the probe.

Fig. 5 Ice detector Goodrich and METEO on the platform at 10 m

Fig. 6 Ice detector Goodrich in detail

Basic information about the instrument:

- Ice state: 0 = No ice, 1 = Ice
- Power consumption: de-icing 50 W
- Operating temperature: -55…+71 °C

IV. PERFORMANCE OF INSTRUMENTS

A. *Measurements in winter 2007/2008*

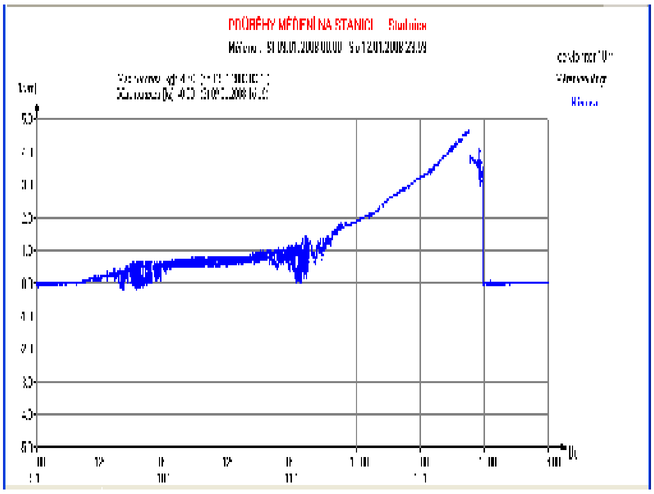
During winter 2007/2008 12 icing events were recorded. As IceMonitor was delivered to EGU Brno in the middle of

December 2007, last 5 events could be measured with this instrument.

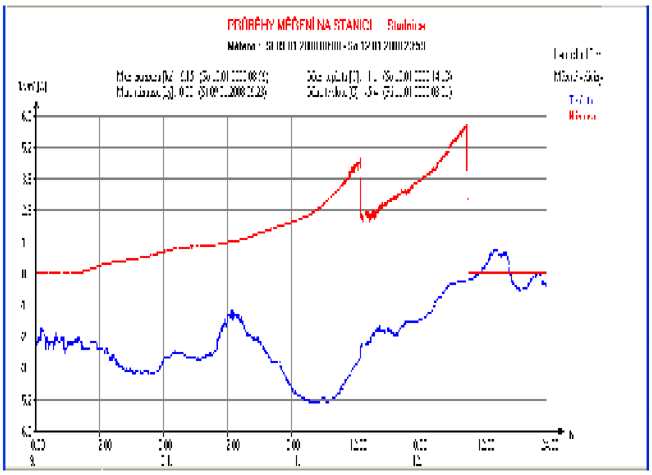
Diagrams with measured values from some icing cycles are presented further. Upper diagram in each column always shows measurement by IceMonitor (blue line), lower diagram by horizontal rod (ice load - blue line, temperature – red line). Measurement of ice load on horizontal rod was added to compare results from Combitech IceMonitor. The description of measuring horizontal rod can be found in [1].

Ice load measured by Combitech is recalculated to [kg/m].

Icing event 9-12.1.2008

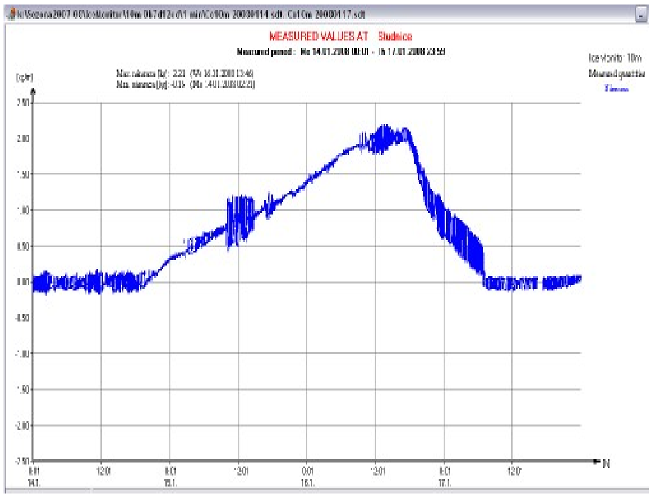


IceMonitor

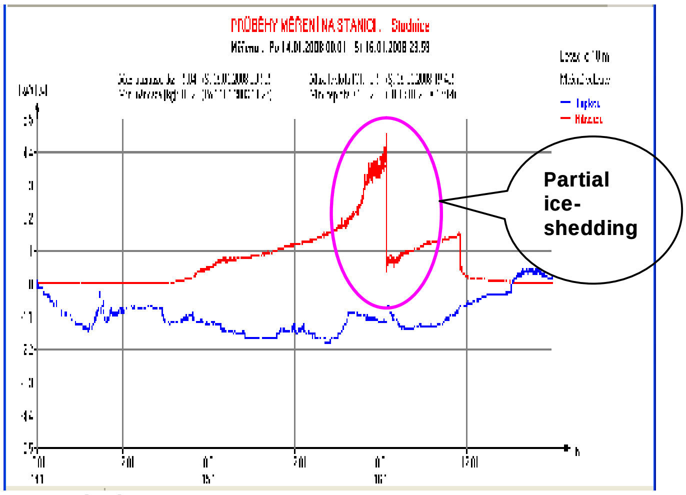


Horizontal rod

Icing event 14 – 16/17.1.2008

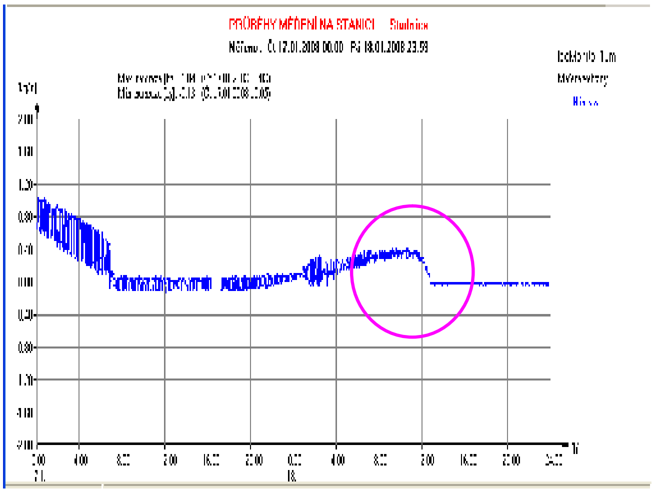


IceMonitor

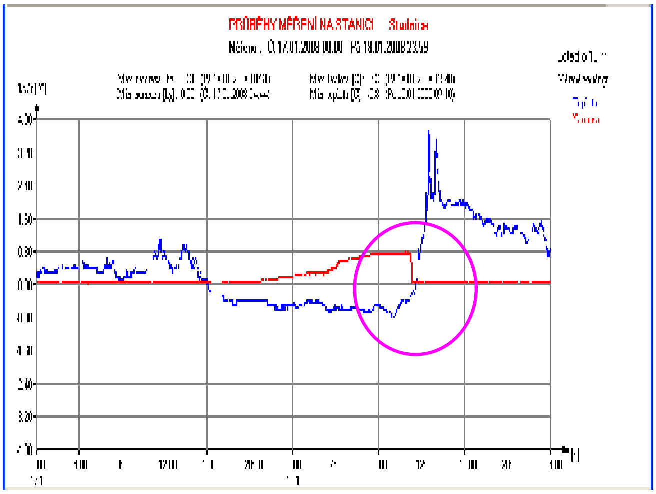


Horizontal rod

Icing event 17 – 18.1.2008

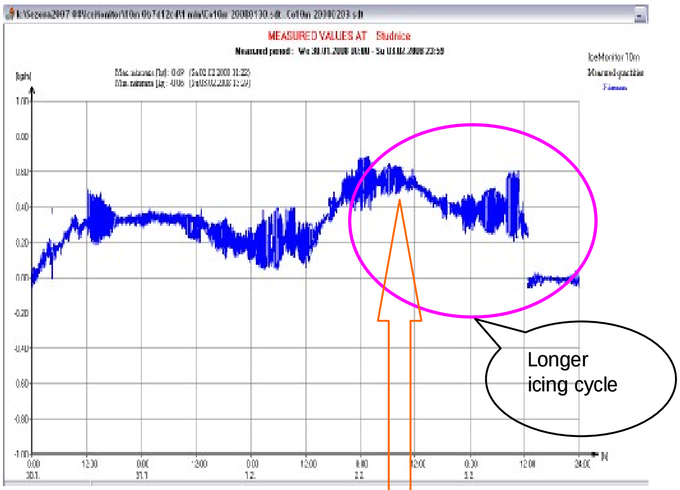


IceMonitor

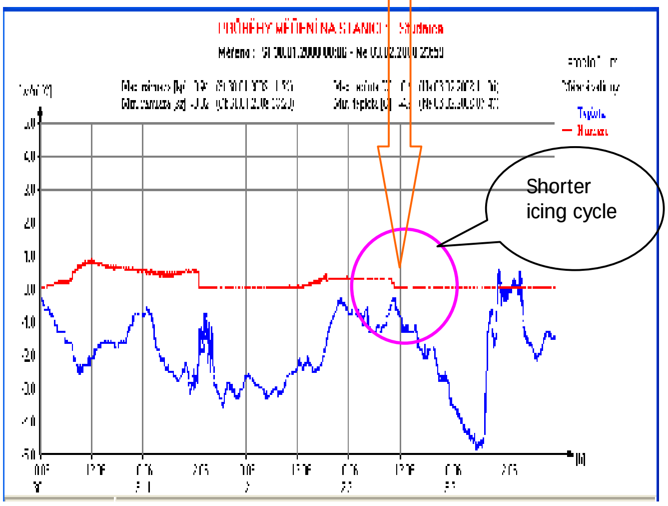


Horizontal rod

Icing event 30.1. – 2/3.2.2008



IceMonitor



Horizontal rod

Big oscillations of the output signal were recorded during winter season most of the time. The amplitude of the oscillations reached up to ±0,6 kg/m. No correlation to wind speed/temperature has been found.

It is interesting that icing cycle #10 on IceMonitor ended 17 January at 7 a.m., while on horizontal rod 16 January before 12 a.m. The reason might be big partial ice-shedding on horizontal rod.

Last icing cycle #12 was longer for almost 24 hours. While on measuring rod the icing cycle ended 2 February before noon (when the temperature almost reached zero ºC for short period), ice accreted on Combitech did not fall off. As the temperature then dropped down to -4 ºC and was below zero for next 24 hours, icing cycle ended next day round noon, when the temperature exceeded zero ºC.

In the table below maximum values measured during icing events by Combitech and horizontal rod are introduced. Due to output noise some maximums measured by Combitech had to be estimated.

TABLE I
LIST OF ICING EVENTS IN WINTER 2007-08

Icing event Nr	Icing event	Ice load [kg/m]	
		Combitech	Horizontal rod
8	21.12.07-7.1.08	8*	8,59
9	9.-12.1.08	4,68	6,15
10	14-16/17.1.08	2,21	5,04
11	17.1.-18.1.08	0,40	0,81
12	30.1.-2/3.2.	0,6*	0,94

* estimation of maximum

As can be seen, only in icing cycle from 21.12.07-7.1.08 measured maximum by Combitech IceMonitor and horizontal rod do not differ very much (0,5 kg out of 8,5 kg represents cca 6%).

In other icing events maximum ice loads, measured on IceMonitor and horizontal rod, differs a lot.

B. Measurements in winter 2008/2009

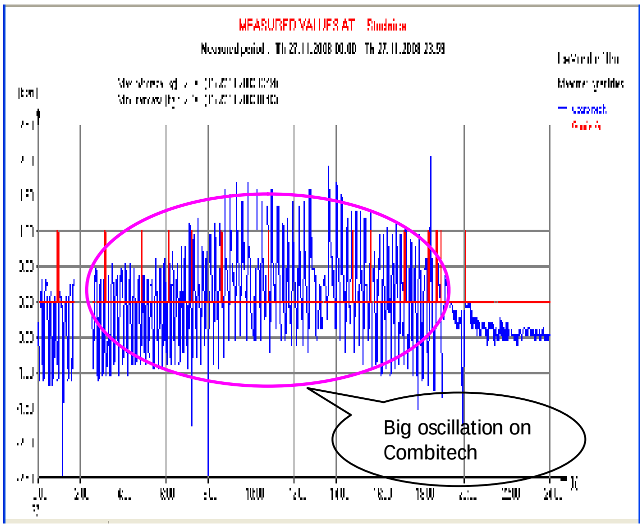
During this winter season 11 icing events were recorded, unfortunately all of them occured before installation of updated version of IceMonitor. We can not describe performance of this new model under icing conditions.

On next diagrams measured values from some icing cycles are presented. Upper diagram always shows measurement by IceMonitor (blue line) and Goodrich (red bar), diagram in the middle ice load measured on horizontal rod (ice load - blue line, temperature – red line) and graph at the bottom of the column values measured by METEO (ice load - blue line, temperature – red line).

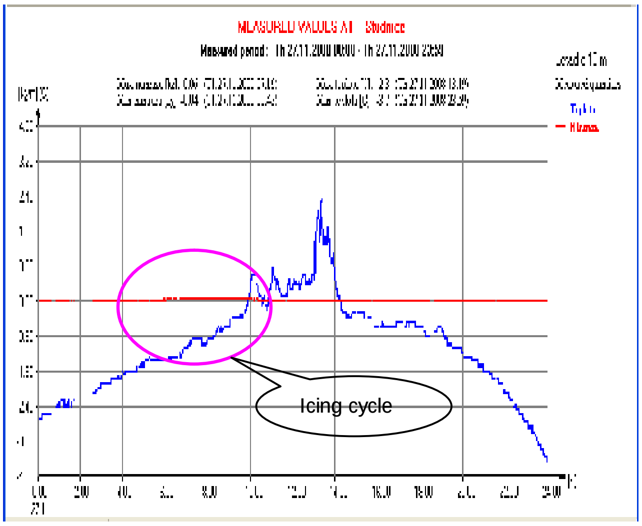
Red bar for Goodrich demonstrates the heating in the given minute was on (ice state = 1).

Ice load measured by Combitech and METEO are recalculated to [kg/m].

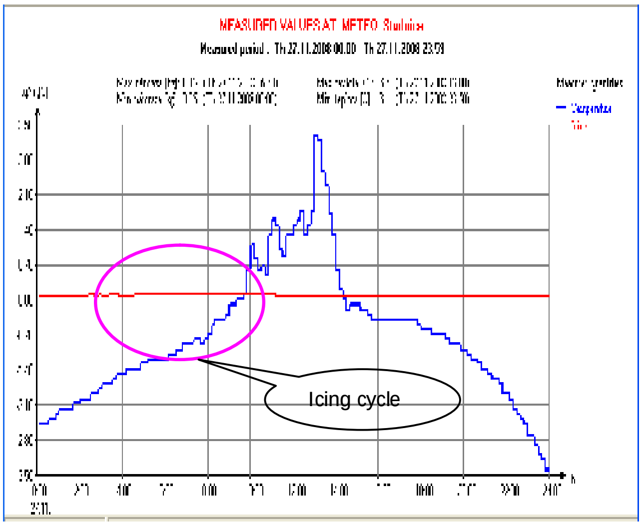
Icing event 27.11. 2008



IceMonitor and Goodrich

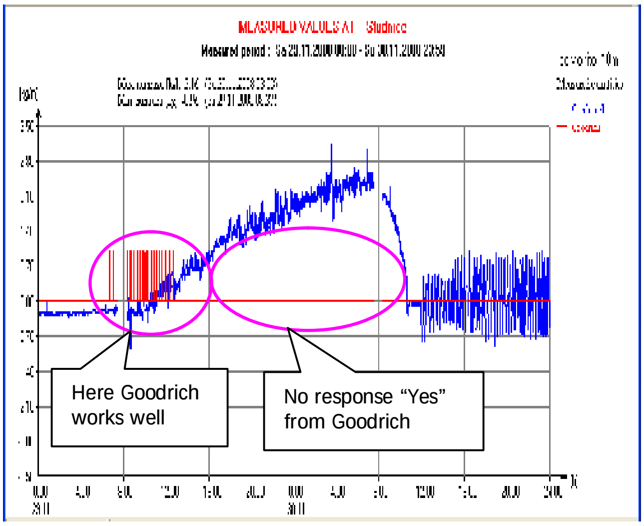


Horizontal rod



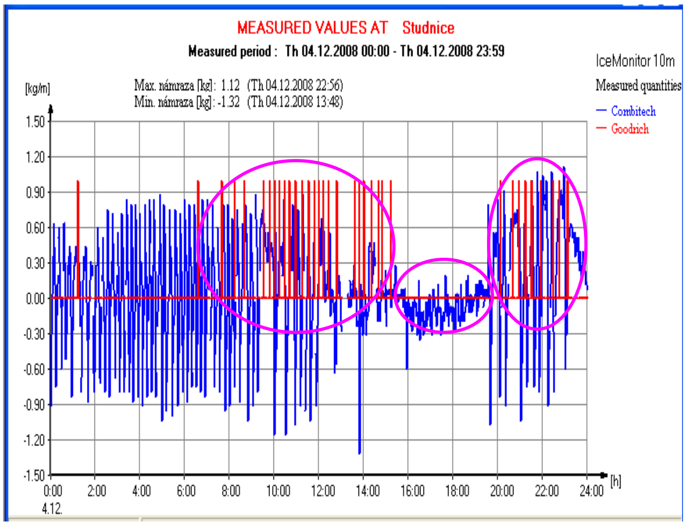
METEO

Icing event 29-30.11.2008

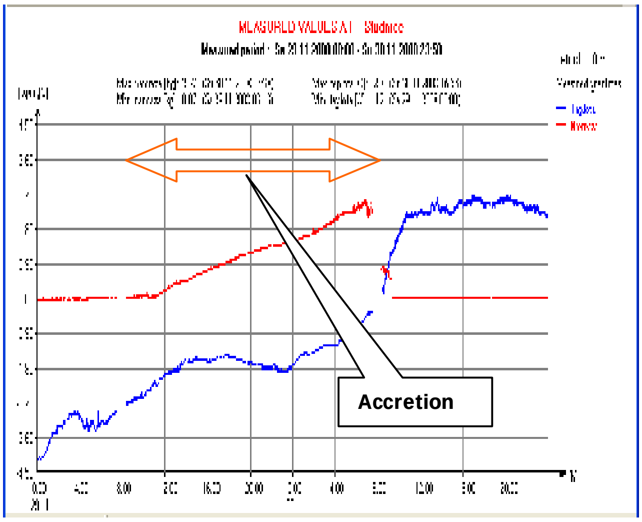


IceMonitor and Goodrich

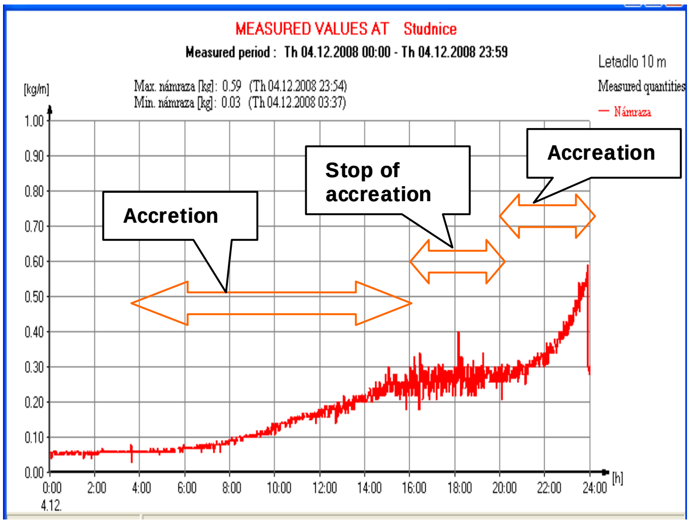
Icing event 4-5.12.2008



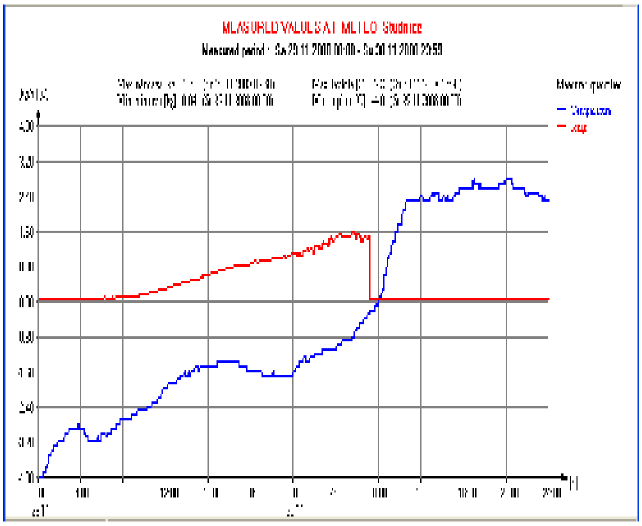
IceMonitor and Goodrich



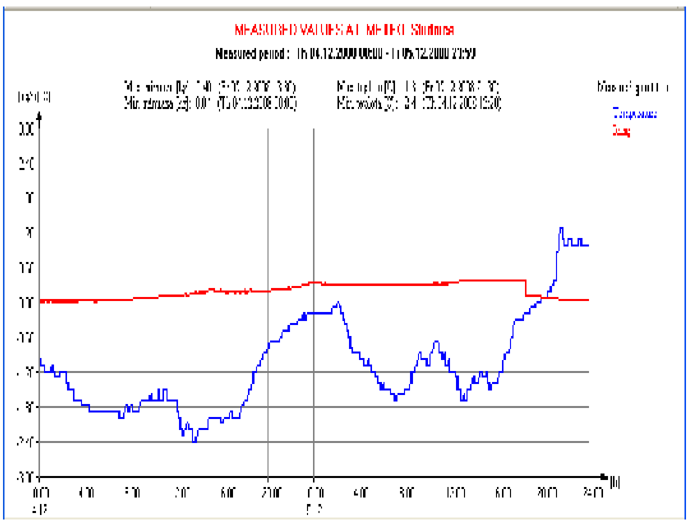
Horizontal rod



Horizontal rod

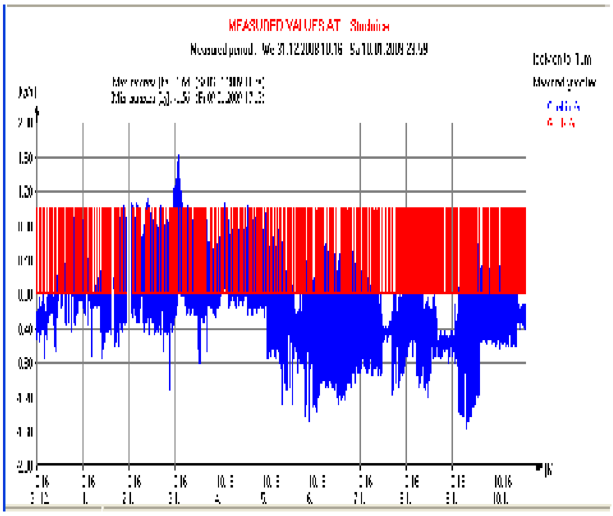


METEO

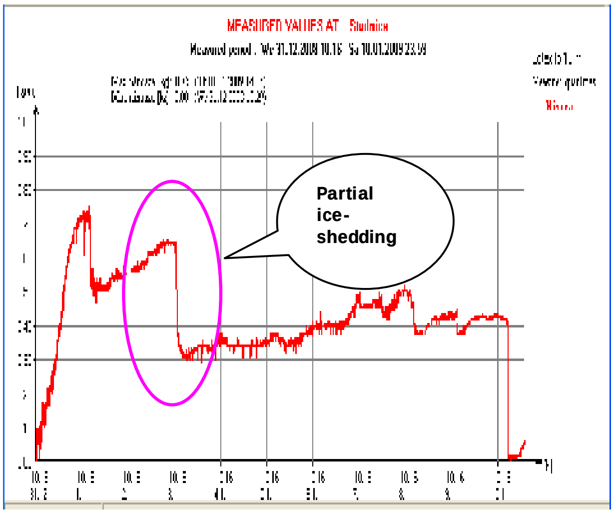


METEO

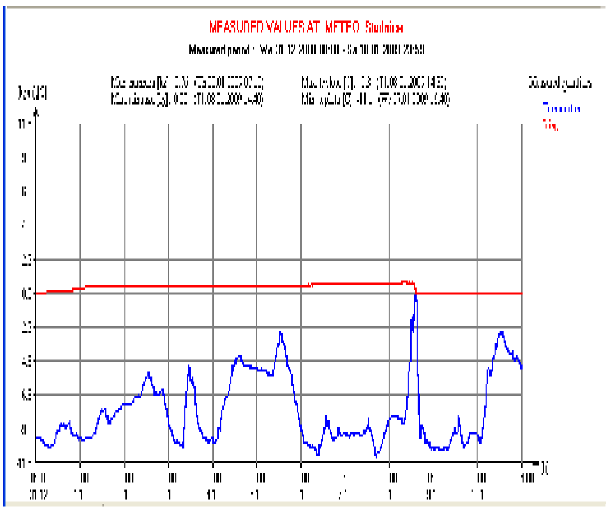
Icing event 31.12.2008 – 10.1.2009



IceMonitor and Goodrich

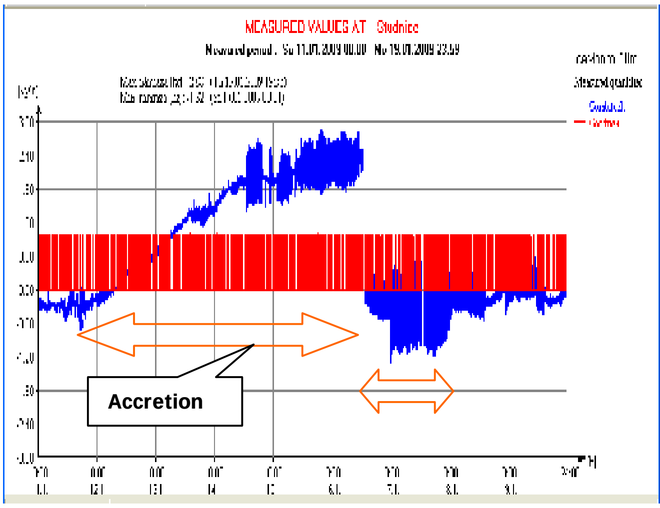


Horizontal rod

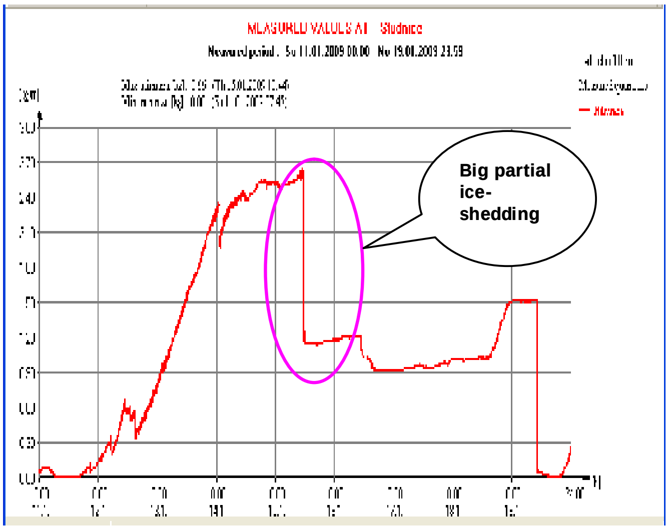


METEO

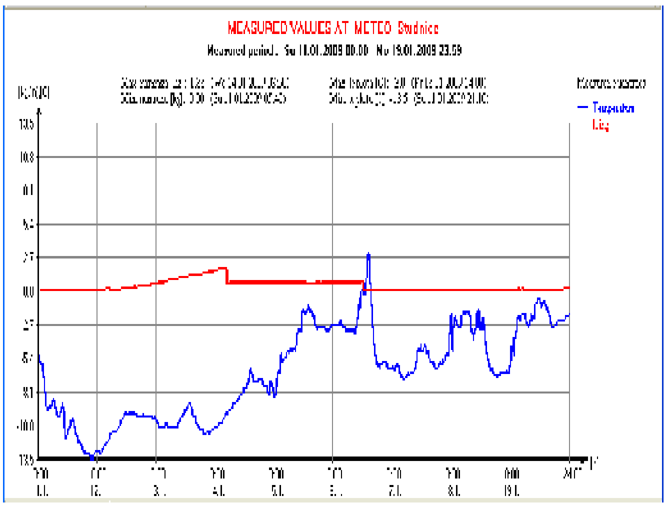
Icing event 11-19.1.2009



IceMonitor and Goodrich

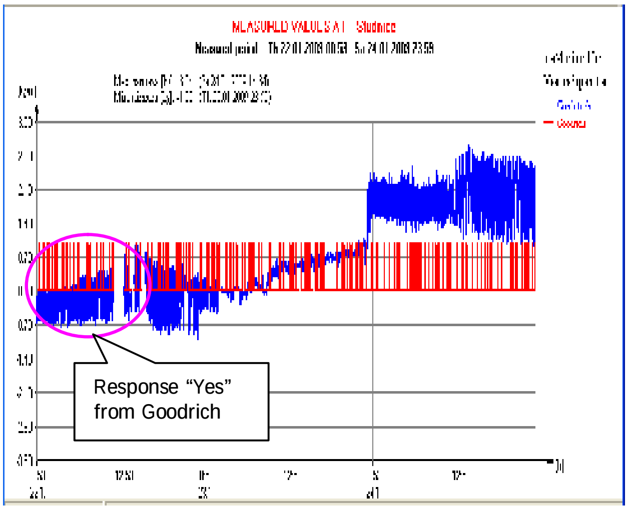


Horizontal rod

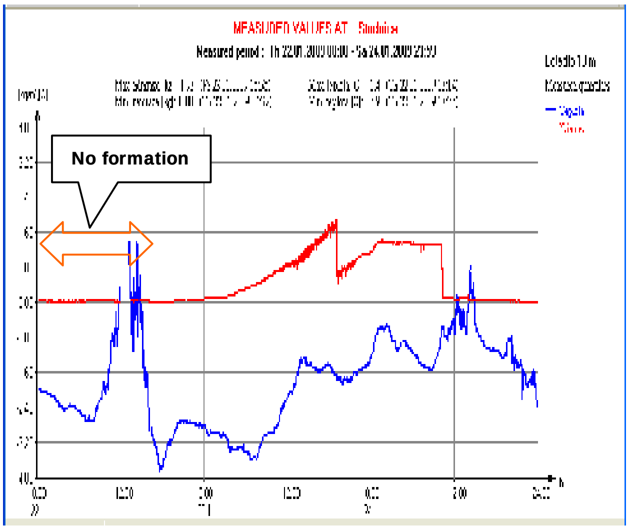


METEO

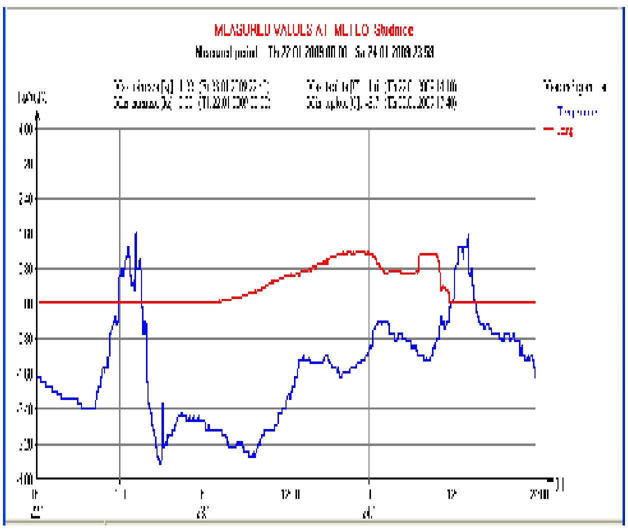
Icing event 21-24.1.2009



IceMonitor and Goodrich

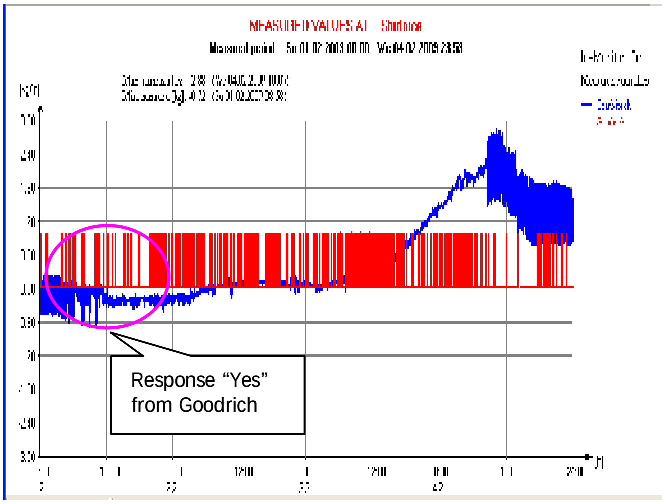


Horizontal rod

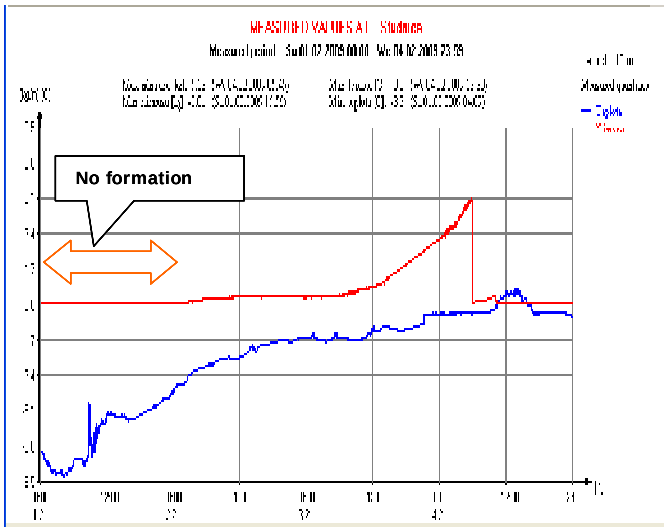


METEO

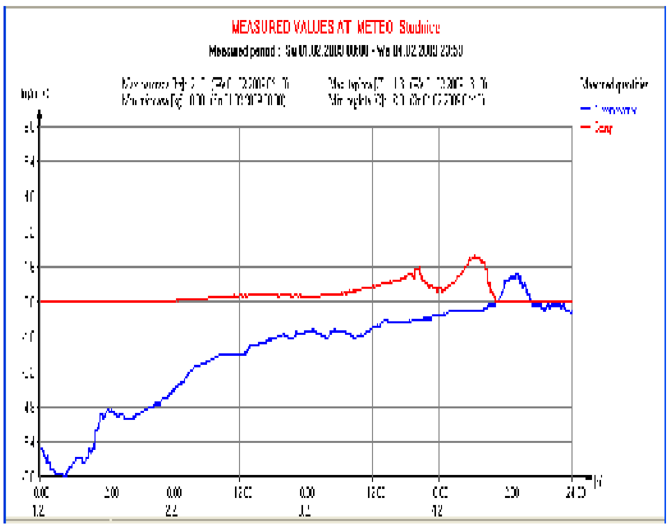
Icing event 1-4.2.2009



IceMonitor and Goodrich



Horizontal rod



METEO

From presented diagrams it is obvious the maximum ice loads measured during some icing events are heavy affected by partial falls-off (reasons – combination of too fragile icing, strong wind, short ups of temperature to zero…). Sometime it is very difficult to compare those values.

As can be seen the output signal from Combitech IceMonitor fluctuates significantly. Determination of maximum ice load (and also beginning of icing event) in some icing cycles was due to this univocal.

TABLE II
LIST OF ICING EVENTS IN WINTER 2008-09

Icing event	Ice load [kg/m]		
	Combitech	Horizontal rod	Meteo
27.11-27.11.08	N/A	0,06	0,10
29.-30.11.08	2,40	2,57	1,60
4-5.12.08	N/A	0,59	0,40
9-11.12.08	N/A	0,73	0,34
18-20.12.08	N/A	0,28	0,22
31.12.08-10.1.09	N/A	0,75	0,76
11.1-19.1.09	2,50	2,66	1,86**
19-20.1.09	0,90	1,10	0,94
22-24.1.09	1,1*	1,93	1,22**
1-4.2.09	2,90	5,13	2,10**
4-6.2.09	2,4*	1,96	0,76**

* estimation of maximum
** partial ice-shedding

1) Remarks to Goodrich ice detector

As can be seen on the diagram of second icing event (29-30.11.08) Goodrich sensor was working well at the beginning of the ice event indicating the ice accumulation. But then it stopped indicating ice accumulation.

Signals of state ice =1 were recorded during the days when the temperature was below zero, but no ice formation was measured neither by IceMonitor nor by other instruments. The reason might be in high (excessive?) sensitivity of sensor but much detailed observation would be needed to confirm this assumption.

Since the beginning of March false signals of ice state = 1 were recorded regularly (in spite of the outside temperature being above zero).

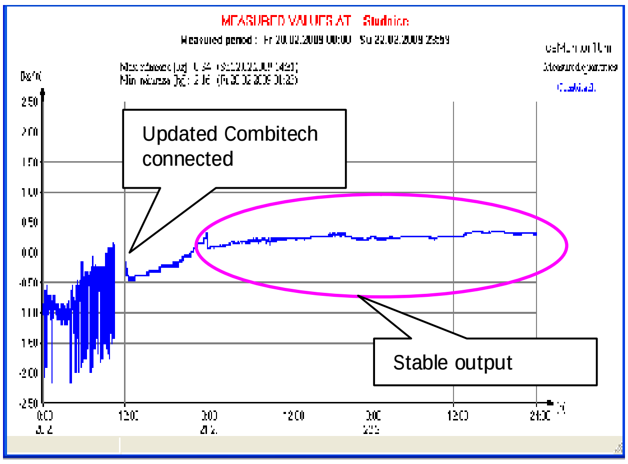
As can be seen from next picture (Fig. 7) when heavy icing occurs the heating power is not able to melt the ice round the sensor. In this case the sensor might give false signal on ice formation even though icing formation has stopped. But as stated before, this sensor is designed specifically for light freezing rain conditions, not for (heavy) in-cloud icing, which was this case.

Fig. 7 Ice detector Goodrich fully covered with ice

2) Updated IceMonitor

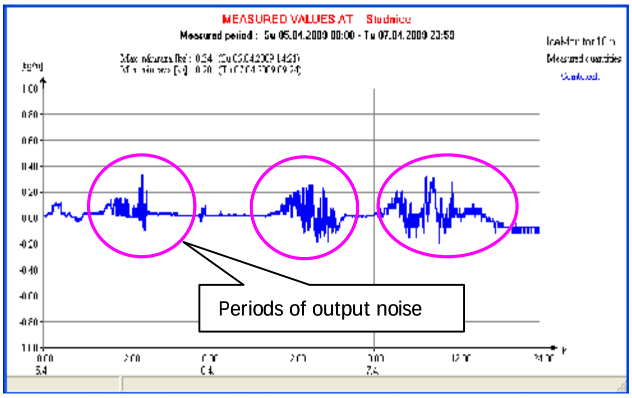
As mentioned before, updated Combitech IceMonitor was installed at the end of February 2009. After installation no icing event occured.

On the next picture signal output from the new version of IceMonitor is shown. Much stable output is obvious (from 20 February, 11 a.m.), compare to previous version.



Output [kg/m] from updated Combitech IceMonitor

But then after 2 days some fluctuations appeared again (see diagram below). New version shows smaller oscillations (up to ± 0.25 kg/m), probably due to new electronics. Oscillations appear very unexpectedly, usually take a few hours.



Output [kg/m] from updated Combitech IceMonitor

As signal errors were measured also during the days when ambient temperature was above zero, heating of the bearing can not be the cause of output noise. Also no correlation to wind speed was found.

V. CONCLUSION

In line with requests from COST727, two icemeters/sensors were tested at Studnice in conjunction with some other instruments, which EGÚ Brno has been used for ice load measurement.

New version of the Combitech IceMonitor seems to more stable, at least from the point of output signal amplitude. But random oscillations still appears.

Because after installation of updated IceMonitor no icing event occurred we could not evaluate its performance under icing conditions.

The second reference instrument selected by the Action - ice detector Goodrich/Rosemount – worked reliably only short time after installation. Later false signals “Yes” of ice detection were recorded though outside temperature was above zero.

Both instruments need an improvement in order to be reliable and ready for routine field measurement.

VI. REFERENCES

Papers Presented at Conferences (Unpublished):

[1] J. Šabata, "Studnice Test Station (EGÚ Brno)," presented at the 9th IWAIS, Andermatt, Switzerland, 2009. Poster PO.082

Papers from Conference Proceedings (Published):

[2] P. Lehký, J. Šabata, “Observation of Icing on the Stand at Studnice” in *Proc*. 2007 IWAIS