Comparison of icing measurements from nacelle-mounted and blade-mounted ice sensors with icing simulations on a wind turbine blade

Winterwind 2017, Skellefteå, Sweden

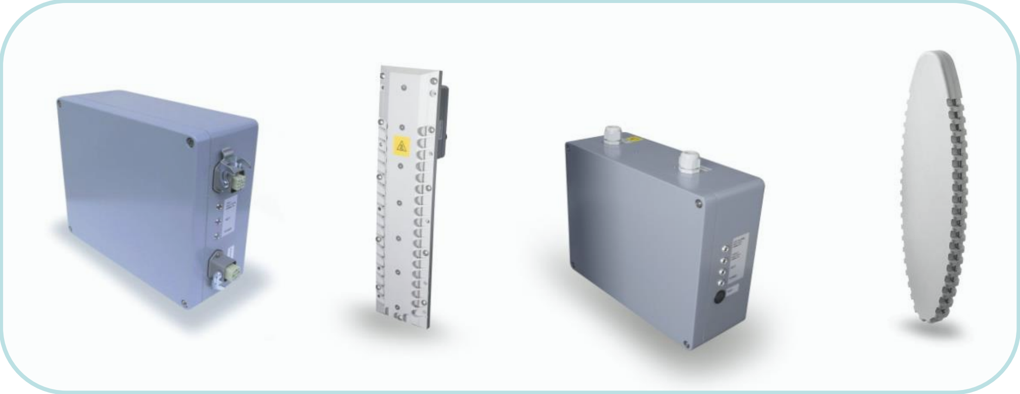
Company: Labkotec Oy

Author: Tatu Muukkonen (Product Manager)

Content of the presentation

1. History and present status of Labkotec Ice detectors
2. VTT Pre-sertificate 2016 update from 2011
3. Blade-mounted Ice detectors
4. Summary

History of the nacelle-mounted ice detectors



	LID-3210C **Control Unit and Ice Sensor**	**LID-3210D** **Control Unit with** – Ice Alarm LED – Test button	**LID/IS** **Ice Sensor** – Sensitivity improved		**LID-3300IP Control Unit** – Web server (remote access) **LID/ISD Ice Sensor** – Sensitivity further improved
1994 ->	2002..2008	1Q/2008...2014	4Q/2008..2014		1Q/2010..

Component Certificate

CC-GL-013A-2014 **GL Renewables Certification (GL RC)**

Normative references:
GL Rules and guidelines –
IV Industrial Services-Part 1
“Guideline for the the Certification of Wind Turbines”, edition 2010.

Ice Detector LID-3300IP has been assessed by GL Renewables Certification (GL RC), concerning the Design, the “Implementation of the design requirements in Production and Erection” IPE, the prototype Testing and manufacturer´s quality system.

The GL certificate is valid for Ice Detectors with Software version of v1.30 and newer.

Component Certificate

GL Renewables Certificate No. CC-GL-013A-2014

This Component Certificate for the

Ice Detector LID-3300IP

is issued to

Labkotec Oy
Myllyhaantie 6
FI-33960 Pirkkala
Finland

We hereby certify that the Ice Detector LID-3300IP has been assessed by GL Renewables Certification (GL RC) concerning the Design, the "Implementation of the design requirements in Production and Erection" (IPE), the Prototype Testing and the manufacturer's quality system.

The Component Certificate is based on the indicated documents as listed in the Annex.

Normative references: GL Rules and Guidelines – IV Industrial Services – Part 1 – "Guideline for the Certification of Wind Turbines", Edition 2010

Changes of the design, the production or the manufacturer's quality system are to be approved by GL RC, otherwise this Component Certificate loses its validity.

This Component Certificate is valid until 2019-11-20, provided that a valid "Certificate for the Quality Management System" according to ISO 9001 is available for this period and the annual update is successfully performed on the basis of Section 1.2.2.2 of above mentioned normative reference.

Hamburg, 2014-11-21
Schl

GL Renewables Certification

ppa Mike Woebbeking
Head of Certification Body

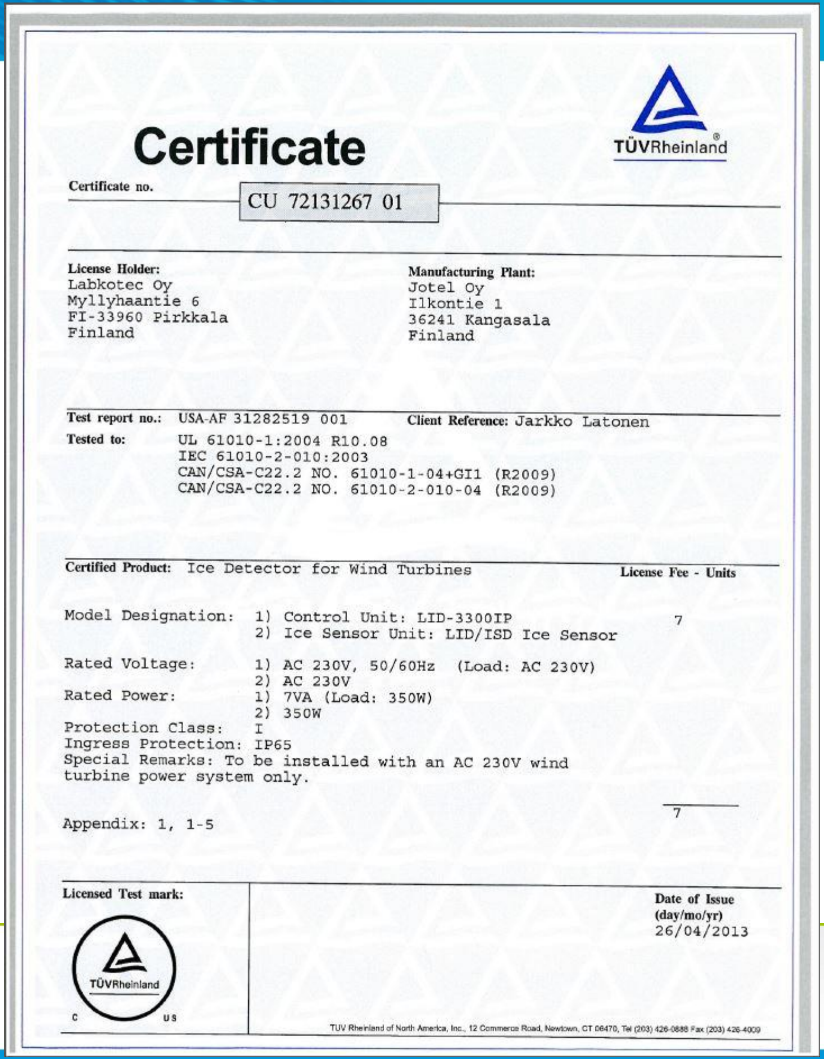
i. V. Axel Dombrowski
Head of Department

DAkkS

LID-3300IP

GL certificate:

- ”Safe to use in wind turbine”
- ”Detects in-cloud and freezing rain ice”.



Certificate

TÜVRheinland®

Certificate no. CU 72131267 01

License Holder:
Labkotec Oy
Myllyhaantie 6
FI-33960 Pirkkala
Finland

Manufacturing Plant:
Jotel Oy
Ilkontie 1
36241 Kangasala
Finland

Test report no.: USA-AF 31282519 001 **Client Reference:** Jarkko Latonen

Tested to:
UL 61010-1:2004 R10.08
IEC 61010-2-010:2003
CAN/CSA-C22.2 NO. 61010-1-04+GI1 (R2009)
CAN/CSA-C22.2 NO. 61010-2-010-04 (R2009)

Certified Product: Ice Detector for Wind Turbines **License Fee - Units**

Model Designation: 1) Control Unit: LID-3300IP 7
2) Ice Sensor Unit: LID/ISD Ice Sensor

Rated Voltage: 1) AC 230V, 50/60Hz (Load: AC 230V)
2) AC 230V
Rated Power: 1) 7VA (Load: 350W)
2) 350W
Protection Class: I
Ingress Protection: IP65
Special Remarks: To be installed with an AC 230V wind turbine power system only.

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Appendix: 1, 1-5

Licensed Test mark:

TÜVRheinland C US

Date of Issue (day/mo/yr)
26/04/2013

TUV Rheinland of North America, Inc., 12 Commerce Road, Newtown, CT 06470, Tel (203) 426-0888 Fax (203) 426-4009

LID-3300IP

UL/CSA certificate:

- ”Safe to use in wind turbine”
- Now selling also in the USA and Canada.

PRE-CERTIFICATION (2016) of LABKOTEC LID-3300IP ICE DETECTOR FOR WIND ENERGY APPLICATIONS (VTT-CR-03658-16)

Motivation

This pre-certificate (2016) was made to verify the ice detection capability of Labkotec LID-3300IP ice detector control unit and LID/ISD ice sensor. This certificate is an update to pre-certificate (VTT-CR-04740-11) prepared by VTT on June of 2011.

PRE-CERTIFICATION (2016) of LABKOTEC LID-3300IP ICE DETECTOR FOR WIND ENERGY APPLICATIONS (VTT-CR-03658-16)

Summary

Based on VTT Icing Wind Tunnel (IWT) tests and TURBICE™ ice accretion simulation results, it can be said that the LID-3300IP ice detector is capable for detecting the start of an in-cloud icing event and freezing rain event at the installation position in the wind turbine and meteorological station applications. With current sensor ice alarm factory settings (amplitude value 60 %), in "standard" icing conditions are detected within 54 minutes and in "harsh" icing conditions in 18 minutes after start of in-cloud icing event, resulting to simulated blade tip section ice thicknesses of 12 mm and 6 mm respectively.

Table 1. *Summarized VTT Icing Wind Tunnel test results and TURBICE™ ice mass simulations in "standard" icing conditions. /3, 4/*

Icing Wind Tunnel Tests Standard Icing Condition 013E090216P	Average Time [h:mm]	Average deviation [h:mm]	Ice Mass [kg] one blade
1. Amplitude 99 %	0:31	0:03	8
2. Amplitude 90 %	0:33	0:03	no simulation results
3. Amplitude 80 %	0:36	0:04	no simulation results
4. Amplitude 70 %	0:53	0:03	no simulation results
5. Amplitude 60 %	0:54	0:03	15
6. Amplitude 50 %	1:20	0:18	no simulation results
7. Amplitude 40 %	1:28	0:00	26

Icing Wind Tunnel Tests Standard Icing Condition 013E090216P
1. Amplitude 99 %
2. Amplitude 90 %
3. Amplitude 80 %
4. Amplitude 70 %
5. Amplitude 60 %
6. Amplitude 50 %
7. Amplitude 40 %

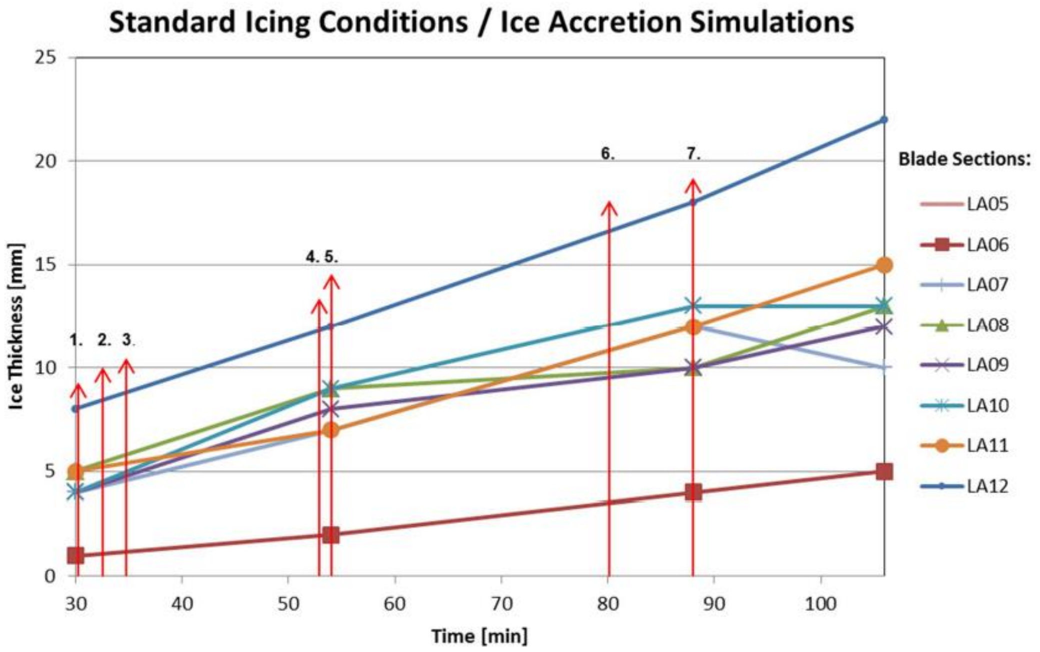


Figure 2. TURBICE™ ice thickness [mm] according to simulation results in "standard" icing conditions. /3, 4/ *At ice alarm moment (54 minutes - amplitude value 60 %) the simulated ice thickness varied between 2 mm – 12 mm. This time is also marked with number 5 and pointed with red arrow.*

Table 2. *Summarized VTT Icing Wind Tunnel test results and TURBICE™ ice mass simulations in "harsh" icing conditions /3, 4/*

Icing Wind Tunnel Tests Harsh Icing Condition 013E090216P	Average Time [h:mm]	Average deviation [h:mm]	Ice Mass [kg] one blade
1. Amplitude 99 %	0:10	0:00	5,3
2. Amplitude 90 %	0:11	0:00	5,3
3. Amplitude 80 %	0:11	0:00	no simulation results
4. Amplitude 70 %	0:17	0:00	no simulation results
5. Amplitude 60 %	0:18	0:00	no simulation results
6. Amplitude 50 %	0:18	0:00	no simulation results
7. Amplitude 40 %	0:18	0:00	no simulation results

Icing Wind Tunnel Tests Harsh Icing Condition 013E090216P
1. Amplitude 99 %
2. Amplitude 90 %
3. Amplitude 80 %
4. Amplitude 70 %
5. Amplitude 60 %
6. Amplitude 50 %
7. Amplitude 40 %

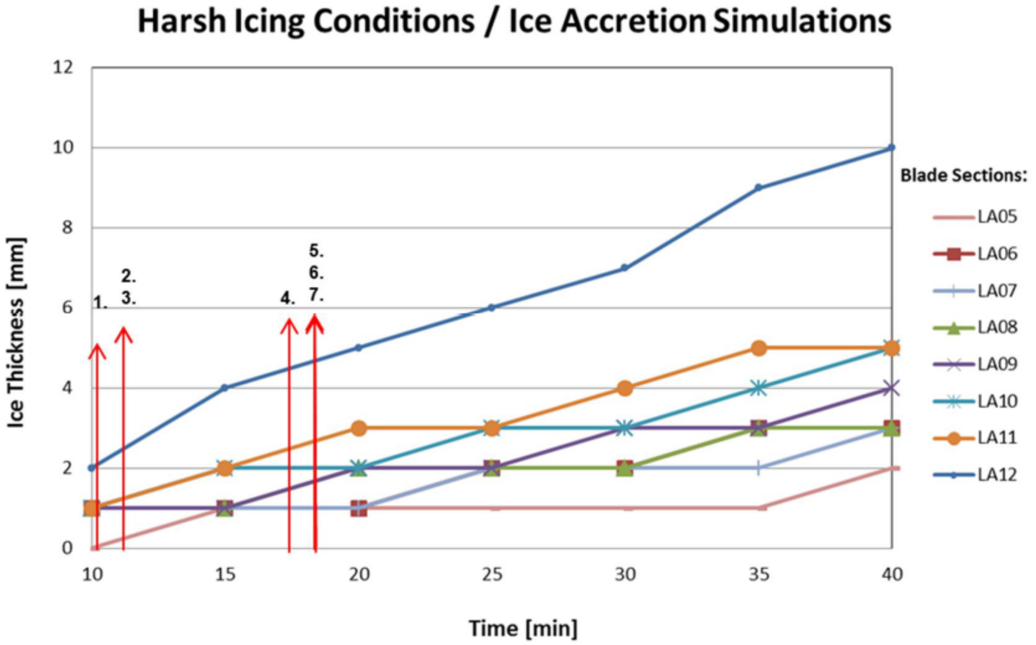


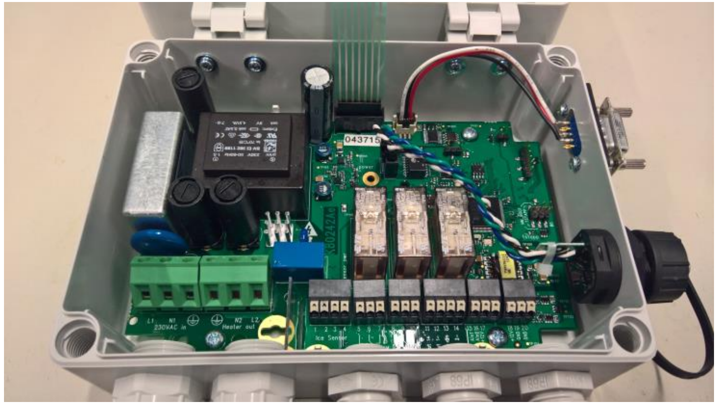
Figure 3. TURBICE™ ice thickness according to simulation results in "harsh" icing conditions. /3, 4/ At icing alarm moment (18 min - amplitude value 60 %) the simulated ice thickness varied between 1 mm – 5 mm. This time is also marked with number 5 and pointed with red arrow.

LID-3300IP Type 2 (release 2017)

Functional safety:
- Functional safety level has been further improved from PLb to PLc/PLd (TBD)
- According to the standard ISO 13849-1.

Compatibility:
- Fully compatible with current LID-3300IP; same features, interfaces and look and feel.

System interfaces:
- Power
- Signal
- Heating
- RS-232
- Analog outputs
- Relay outputs
- Ethernet RJ-45
- Optical fibre.



Interface upgrades:
- Improved transient voltage protection
- RS-232 and analog outputs isolated
- Safety relay outputs with feedback
- Easy access connectors.

Ice alarm test:
- Ice sensor starts sending low signal levels, which simulate a real icing condition
- Therefore, the whole chain of safety functions will be tested.

Functional safety

Development on nacelle-mounted ice detector LID-3300IP Type 2 (release 2017) has been focusing on functional safety aspects. Comparing to the current product, LID-3300IP, functional safety classification of LID-3300IP Type 2 has been further improved based on customer needs.

Improved safety aspects include, for example, safety relays where relay position is constantly monitored and a separate safety processor is applied to double check information inside the ice detector. Also more advanced diagnostics is included.

Functional safety analysis has been carried out according to the standard ISO 13849-1. LID-3300IP base release has PL value b and LID-3300IP Type 2 has higher PL value c/d (TBD).

History of the blade-mounted ice detector 1994

First ever blade-mounted Ice detector was delivered by Labko Oy (nowadays Labkotec Oy) to Finland, Pyhätunturi, 1994.

→ Start blade heating

Figure BF. The first blade mounted ice detector delivered by Labko Oy. Pyhätunturi test station 1994.

Status of the blade-mounted ice detectors

- Labkotec is developing new generation ice detection system
- Ice sensors are mounted on the turbine blades
- Direct ice accumulation measurement and ice detection from the blades
- Radio communication between the sensors and the control unit.

Blade-mounted ice detectors

Installation:

- 3 MW turbine in Finland
- Retrofit installation
- Installed in 2016.

References:

- LID-3300IP
- LID-3300IP Type 2 (release 2017).

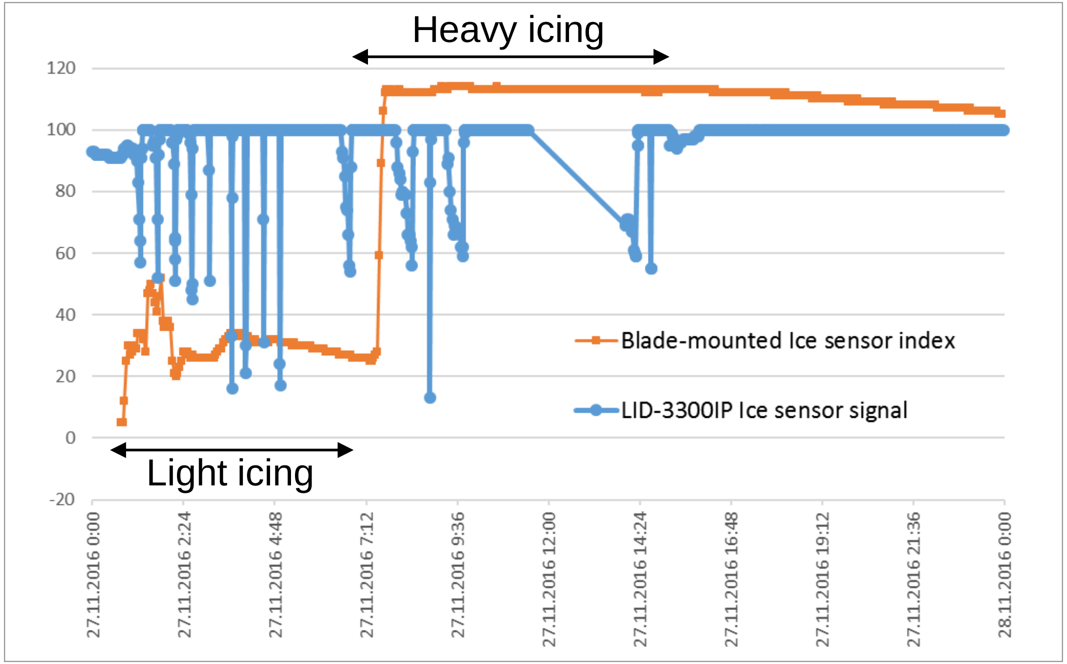
Blade-mounted ice detectors

Analysis:

- 24 h, T=-3…-6C
- LID-3300IP (reference)
- Blade-mounted sensor.

Conclusion:

- Correlation between LID-3300IP and blade-mounted sensor.



Summary

- Labkotec is a pioneer and market leader in wind turbine ice detection.
- Labkotec has and will introduce new innovations for ice detection regardless of the fact that no standards, published best practices or test methods exist for icing or ice detection testing
- Labkotec is developing a blade-mounted Ice detector to detect ice directly on wind turbine blades.