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ICING IN STANDARDS

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ABSTRACT: Cold climates and icing affect wind turbines in several ways. Some of these are considered in standards, some are noted and some completely ignored. In addition, adapted technology such as blade-heating systems might change the turbine design enough to require separate certification or testing. The paper reviews existing and drafted international standards with respect to as well cold climate issues and icing conditions as adapted technology and ice prevention techniques. Some recommendations are presented.

1 BACKGROUND

International standards are developed for harmonising various national type-approval procedures and certification schemes. Wind turbine standardisation started in 1988 and topics that are covered so far include structural safety, offshore technology, power performance testing, acoustic testing, structural blade testing, power quality, certification, load measurements and lightning protection. In addition there are still national standards and individual requirements from the different certification agencies. This paper will primarily adhere to international standards, predominantly the IEC 61400 series.

Some of the technical requirements and solutions needed for operating wind turbines under harsh cold and/or icing climates require changes to turbine design or even structure. Some of these might have an impact on load bearing functions. In addition, especially heavy icing will introduce additional loads to the structure that should be considered in the design and type approval process.

Cold climates and icing affect wind turbines in several ways. Some are considered in international standards whereas others are completely ignored. In general there is a lot in common with complex terrain issues. The following is a non-exclusive list of which parts of different standards that should consider cold climate issues. Some of them will be further discussed in this paper.

– Structural safety calculations and structural tests
– Certification
– Wind speed measurements and power performance measurements
– Protective measures as safety of personnel and public
– Lightning protection
– Offshore issues

2 TOPICS COVERED

2.1 Structural safety

The current standard [1] for structural safety issues presents wind turbine safety classes and load cases to be calculated.

The standard defines operating conditions as "normal" for temperatures down to -10 º C and extreme" down to -20 º C. Clearly, temperatures get lower in northern Europe and mountainous areas, not to mention more remote regions at high latitudes or elevations.

The standard also introduces a set of wind turbine classes according to mean (or reference) wind speeds and turbulence levels. All extraordinary sites, including offshore and icing conditions, belong to the special class S, in which load cases have to be agreed upon between the customer and the manufacturer. Thus the project developer and turbine buyer have to ensure that the product is adequate for the site conditions.

Table 1. Wind turbine classes according to IEC 61400-1 Ed. 2 [1].

WT class		I	II	III	IV	S
v_{ref}	(m/s)	50	42,5	37,5	30	Values to be specified by the designer
v_{ave}	(m/s)	10	8,5	7,5	6	
A	I_{15} (–)	0,18	0,18	0,18	0,18	
	a (–)	2	2	2	2	
B	I_{15} (–)	0,16	0,16	0,16	0,16	
	a (–)	3	3	3	3	

Further, it also presents partial safety factors and material factors to be used in the load and fatigue calculations. As there still is little knowledge of precisely the turbine is loaded under icing conditions the partial safety factors should probably be higher due to uncertainty.

Some special load cases for icing conditions should be developed. There should be a variety to the amount, distribution properties of accreted ice as some principal load imbalance cases.

2.2 Power performance measurements

The current standard [2] for power performance measurements states that ice-free anemometer to be used when necessary. The topical work to update the standard will introduce a classification scheme for anemometers, c.f. [3].

When testing turbines at "arctic" sites it is important get the right results from wind speed measurements also under icing conditions. There are a number of ice-free anemometers but it has been shown [4] that they, if they really are ice-free, seldom have very good properties as anemometers, i.e. response, distance constants, calibration curves etc.

In addition also other the requirements for anemometer placing and mounting [5] have to be noted if carrying out power performance tests under icing conditions. Top mounting and proper adherence to mast and boom effects might require that not only the anemometer itself but also masts and booms are heated.

The proper way to address this issue is to extend the anemometer classification and have an uncertainty penalty for functional ice-free anemometers.

The revised standard will also introduce data rejection criteria instead of data acceptance criteria. I.e. by default all measured data is valid for analysis except if data rejection criteria are met and reported. This typically means deviations from ”normal” operating conditions.

A typical reason for data rejection is that the anemometer has malfunctioned or been iced. Also temperatures outside the ”normal” operating range of the anemometer is a valid reason and e.g. in Germany all data when temperatures are below +2 º C is rejected. The question, however, is whether such a power curve is representative for conditions in northern Finland, where temperatures below < +2 º C are seen even half the year? On the other hand, it is not reasonable to require ice-free anemometers to be used and cold temperature data reported for sites where these are rare.

Therefore the external conditions during test that affect turbine operation, like temperatures and turbulence intensities, and data rejection criteria should be stated in the measurement report.

Another reason for data rejection might be turbine malfunction and at certain sites blade icing might count for this. Again, at cold climate sites blade icing, if no protective measure is taken, is within ”normal” operating conditions.

2.3 Certification requirements

Presently there is no certification scheme for ice preventing systems. Features that should be assessed are at least functionality tests and lightning protection. Also load bearing modifications to blades, i.e. integrated heating elements, may require new structural blade tests.

In any case required material properties for metals and plastics and required properties for lubricants and seals should be defined for cold climate applications. In case of icing, the functionality of pitch, yaw and electronic devices should be tested.

2.4 Offshore

IEC work on standards for offshore applications has just started. The standard will deal with combined loading of wind and wave loads and surface sea ice loads. In addition, there might be cases of combined wind, wave and ice loads, due to atmospheric icing of strucures.

3 CONCLUSINS

All in all there are icing and cold climate issues that should be addressed in most standardisation work. However, standards should reflect the current industrial know-how and thus complex requirements can be introduced only after there is a agreed method to treat the problem.

However there are a number of issues that should be the subject of joint research, with the objective to update international standards. This includes:

– A simple variety of load cases for iced turbines should be developed and verified.

– A classification of anemometers should be extended to include ice-free anemometers under icing conditions.

– A type approval of ice prevention systems to be developed.

– Safety of public not addressed in present technical standards but methodologies for defining safety distances and for ice risk reports should be developed perhaps within environmental impact assessments?

REFERENCES

1. IEC 61400-1 Ed. 2: "Safety of wind turbines"

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5. Hunter, Ray et al. IEA recommended practices No. 11. Wind Speed Measurement and Use of Cup Anemometry, 1. edition 1999.

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