ANSI/ACP 101-1 2021

The Small Wind Turbine Standard

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AMERICAN CLEAN POWER ASSOCIATION

Standards Committee

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FOREWORD and BACKGROUND

The Foreword and Background sections are included with this document for information purposes only and are not part of the American Clean Power Association (ACP) ANSI/ACP 101-1 2021 The Small Wind Turbine Standard.

Foreword

The goal of this standard is to provide meaningful criteria upon which to assess the quality of the engineering that has gone into a small wind turbine and to provide consumers with performance data that will help them make informed purchasing decisions and an assurance that a turbine has been certified to a national standard. The standard is intended to be written to ensure the quality of the product can be assessed while imposing only reasonable costs and difficulty on the manufacturer to comply with the standard.

Background

ACP is recognized by the American National Standards Institute (ANSI) as an Accredited Standards Developer. This standard was developed in a regimented ANSI process for "voluntary consensus standards" which requires participation from a range of representatives for manufacturers, technical experts, public sector agencies, and consumers. This standard was originally drafted as the American Wind Energy Association (AWEA) Small Wind Turbine Performance and Safety Standard (ANSI/AWEA Standard 9.1 – 2009) by the AWEA Small Wind Turbine Standard Subcommittee which was chaired by Mike Bergey of Bergey Windpower Company. The initial draft standard, which was released in December of 2009, has been in use by the small wind turbine industry for the purpose of testing and certifying small wind turbines and served as the basis of the working document to circulate to affected parties.

This standard is now being promulgated by the ACP SWT-Subcommittee of the ACP Wind Technical Standards Committee. The subcommittee consists of co-chairs Brent Summerville of the Small Wind Certification Council, Jeroen van Dam of the National Renewable Energy Laboratory, and Mike Bergey of Bergey Windpower. As part of this promulgation process, this standard has been renamed the ANSI/ACP 101-1 2021 The Small Wind Turbine Standard.

The changes in this new edition include:

- Changes and removal of items to bring the standard in line with the updated IEC 61400 standards incorporated within this standard;
- Incorporate lessons learned during the use of AWEA Standards 9.1 – 2009;
- Changes to lessen the burdens of certification and increase the value to the consumer; and
- Segregate the technical requirements from the conformity assessment requirements.

Revision Log

Revised on	Version	Description	Approved by ANSI
~~October 2023~~March 2025	A~~ddendum~~mendment 1	Clarify control system evaluation and loads validation testing requirements	

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1 General Information

1.1 Purpose

This standard was created by the small wind turbine industry, scientists, state officials, and consumers to provide consumers with realistic and comparable performance ratings and an assurance theat small wind turbine products certified to this standard have been engineered and tested to meet carefully considered standards for safety and operation. The goal of the standard is to provide consumers with a measure of confidence in the quality of small wind turbine products and an improved basis for comparing the performance and characteristics of competing products. Compliance with this standard for the purposes of advertising or program qualification, or any other purpose, is the responsibility of the manufacturer.

1.2 Overview

1.2.1 This standard provides a method for evaluation of wind turbine systems in terms of safety, reliability, power performance, and acoustic characteristics. This standard for small wind turbines is derived from existing international wind turbine standards developed under the auspices of the International Electrotechnical Commission (IEC). Specific departures from the IEC standards are provided to streamline their use and to present their results in a more consumer-friendly manner.

1.2.2 No indirect or secondary standards references are intended. Only standards directly referenced in this standard are embodied.

1.3 Scope

1.3.1 This standard applies to electricity-producing wind turbines having a Peak Power of 150 kW or less.

1.3.2 A turbine system includes the wind turbine itself, the turbine controller, the inverter, if required, and all other components between the wind turbine and the point of connection with the electrical load.

1.3.3 Towers and foundations are not considered part of the turbine system because it is assumed that conformance of the support structure to the International Building Code, Uniform Building Code or their local equivalent will be required for a building permit. Additional guidance on tower and foundation design can be found in IEC 61400-6. However, tower design requirements ~~must~~ shall be supplied (section 5).

1.3.4 In cases where several variations of a turbine system are available, it is expected that a full evaluation would be performed on one of the more representative arrangements. Other variations, such as different power output forms, need only be evaluated or tested in the ways in which they are different from the base configuration. Annex A (Variants of small wind turbine systems) of IEC 61400-2 ed.3 provides guidance on this topic.

1.4 Definitions

1.4.1 Definitions contained in IEC 61400-12-1, ed.2, IEC 61400-11, ed.3, and IEC 61400-2, ed.3 are hereby incorporated by reference.

1.4.2 Additional Definitions

Term	Definition
Micro wind turbine	A wind turbine with a Peak Power up to 1 kW.
Reference Power	The wind turbine's power output, expressed as kW, at 11 m/s (24.6 mph), or the maximum output power of the wind turbine system at a lower wind speed if this is a higher power output, per the power curve from IEC 61400-12-1 ed.21, except as modified in Section 2 of this standard.
Reference Annual Energy	The calculated total energy, expressed as kWh, that would be produced during a one-year period at an average wind speed of 6 m/s (13.4 mph), assuming a Rayleigh wind speed distribution, 100% availability, and the power curve derived from IEC 61400-12-1 ed. 2. Within this standard Reference Annual Energy is AEP-measured and sea-level normalized.
ACP Reference Sound Pressure Level [1]	The sound pressure level, expressed as dB(A), that will not be exceeded 95% of the time, assuming an average wind speed of 5 m/s (11.2 mph), a Rayleigh wind speed distribution, and 100% availability. For these conditions, the wind speed of 9.8 m/s would not be exceeded 95% of the time. The ACP Reference Sound Pressure Level is calculated from IEC 61400-11 ed. 3 test results at an observer location 60 m (197 ft.) from the rotor center, except as modified in Section 3 of this standard.

[1] Appendix A contains guidance on obtaining sound levels for different observer locations and background sound levels.

ACP Consumer label	A label that states: manufacturer and model, Reference Annual Energy, Reference Power, ACP Reference Sound Pressure Level, certification body.
Peak Power	Highest bin-averaged power output of all filled wind speed bins per the procedure defined in Section 4 Safety and Function expressed as [Peak Power] kW @ [Peak Power Wind Speed] m/s.
Peak Power Wind Speed	Wind speed bin at which Peak Power occurs.

1.5 Units

1.5.1 The primary units shall be SI (metric). The inclusion of secondary units in the English system is recommended [e.g., 10 m/s (22.4 mph)].

2 Power Performance Testing

[Informative note: Power performance testing results in a measured power curve which is determined by collecting simultaneous measurements of wind speed and power output at the test site for a period that is long enough to establish a statistically significant database over a range of wind speeds and under varying wind and atmospheric conditions. The estimated annual energy production of the wind turbine is calculated by applying the measured power curve to a reference wind speed frequency distribution, assuming 100 % availability. Consumers can utilize the resulting performance characteristics for comparing wind turbine models. The measured power curve can be used to estimate site-specific annual energy production if estimations are properly adjusted for the local conditions including wind resource and distribution, elevation, terrain, turbulence, obstacles, hub height, etc.

The procedure for determining Peak Power is provided in Section 4, Safety and Function, because for its purposes the full requirements of IEC 61400-12-1 are not deemed necessary.]

2.1 Wind turbine power performance shall be tested and reported in accordance with IEC 61400-12-1 ed. 2, including ~~and must be in compliance with~~ Annex H (Power performance testing of small wind turbines), with the additional requirements listed below.

2.1.1 In Annex H, item b, battery banks are considered to be part of the wind turbine system for grid-connected wind turbines that incorporate a battery bank.

2.1.2 A site calibration is not required.

2.1.3 When determining exclusion sectors, sectors where the turbine is affected by the obstacle may be used as long as the anemometer is not affected; note that turbine power and Cp may be lower in these sectors.

2.1.4 The Reference Power and Reference Annual Energy shall be determined and reported in the test report.

3 Acoustic Sound Testing

[Informative note: Acoustic sound testing involves the measurement and analysis of acoustical emissions by small wind turbines and enables the acoustic emissions to be characterized. The results of the testing can be used by the consumer to compare the acoustic characteristics of different turbine models. Consumers can utilize the provided appendix to calculate sound pressure levels for different observer locations and background sound levels.]

3.1 Wind turbine sound levels shall be measured and reported in accordance with IEC 61400-11 ed. 3, ~~and must be in compliance~~including with Annex F (Small wind turbines), with the additional requirements listed below.

3.1.1 A tonality analysis is not required, but the presence of prominent tones shall be observed and reported. Prominent tones are tones that are clearly audible over the broadband sound of the wind turbine. The tones can change in frequency or loudness with rpm or yawing.

3.1.2 Uncertainty should be calculated and reported.

3.1.3 The ACP Reference Sound Pressure Level shall be calculated per the guidance below and reported in the test report.

3.1.3.1 Given a Rayleigh wind speed distribution, and the requirement for determining a sound level not to be exceeded 95% of the time, sound power levels ~~must first be~~are determined in the 9 m/s and 10 m/s bins so an interpolation to 9.8 m/s can be performed. 9.8 m/s is the wind speed that will not be exceeded 95% of the time given a Rayleigh wind speed distribution and a site annual average wind speed of 5 m/s.

Note: If the bin average wind speed in the 10 m/s bin is greater than 9.8 m/s, then the interpolation will be between the 9 and 10 m/s bins. If the bin average wind speed in the 10 m/s bin is less than 9.8 m/s, then the interpolation will be between the 10 and 11 m/s bins.

3.1.3.2 The method of interpolation to determine sound power level at 9.8 m/s shall follow section 9.2.4 of IEC 61400-11 ed.3, specifically utilizing equations 20 and 21. Equations 22 - 25 are not necessary as uncertainty of the ACP Reference Sound Pressure Level is not required.

3.1.3.3 IEC 61400-11 ed.3 Equation 21 is first applied to determine the t value at the given wind speed of V = 9.8 m/s.

3.1.3.4 After establishing a known t value at 9.8 m/s, the principle of IEC 61400-11 ed.3 Equation 20 is then applied, but instead using the sound power values resulting from equation 27 (as opposed to sound pressure values as shown in equation 20). The resultant sound power level at 9.8 m/s, LWA,9.8, is then used to determine the ACP Reference Sound Pressure Level.

IEC 61400-11 ed.3 Equation 26 is rearranged and $L_{WA,9.8}$ is utilized to calculate the Reference Sound Pressure Level, L_{ACP}.

The equation below is used:

$$L_{ACP} = L_{WA,9.8} - 10\log[4\pi r^2]$$

Where r = distance to observer (60 m)

Note: The 6 dB constant in Equation 26 is removed from the rearranged equation above because it is already factored into the determination of sound power levels given in Equation 27.

4 Safety and Function Testing

[Informative note: The purpose of safety and function testing is to verify that the turbine under test displays the behavior predicted in the design and that provisions relating to personnel safety are properly implemented. Critical functions of the control and protection system - such as power and speed control, wind alignment (yaw), over speed protection, start-up and shutdown - are tested and verified.]

4.1 A Safety and Function Test shall be performed in accordance with Section 13.6 of IEC 61400-2 ed. 3, with the additional requirements listed below.

4.1.1 The manufacturer shall define the critical control and protection system functions to be tested and the expected resultant turbine behavior.

4.1.2 Power limitation shall be demonstrated by measuring the power output of the wind turbine system.

Note: to demonstrate power limitation it may be necessary to measure power at more than one point in the turbine system. For example, the output of the turbine system may be limited by the inverter even if the rotor power is still increasing.

4.1.3 To determine Peak Power the following procedure shall be used:

4.1.3.1 The anemometer should be at hub height, but no direction sectors need be excluded, no terrain assessment is required, and no site calibration is required.

4.1.3.2 The methods of normalization and binning of hub height wind speed and power per IEC 61400-12-1 shall be used.

4.1.3.3 1-minute averaging shall be used for wind speed and power.

4.1.3.4 Bins shall be filled (at least 10 1-minute data points in each 0.5 m/s bin) over at least the following wind speed range:

4.1.3.5 From 5 m/s below the lowest wind speed at which power is within 95% of Peak Power.

4.1.3.6 To 5 m/s beyond the lowest wind speed at which power is within 95% of Peak Power; or up to the wind speed where the turbine shuts down as a power regulation response.

4.1.3.7 The highest binned power of the filled wind speed bins covering the wind speed range listed above is defined as Peak Power. Per 1.4.2.7, the bin average wind speed at which Peak Power occurs is defined as Peak Power Wind Speed.

4.1.4 Rotor speed limitation shall be demonstrated by measurement of rotor speed during the Safety & Function test. The testing parameters described in Section 13.2.4 (Maximum rotational speed) of IEC 61400-2 ed. 3 shall be utilized.

5 Strength and Safety

[Informative note: The engineering and technical requirements to ensure the safety of the structural and mechanical systems of the wind turbine are given in the following section. Design loads are obtained through either calculation or, simulation modeling, and/or direct measurement for a variety of load cases: a set of design situations covering the most significantnormal and extreme conditions which the turbine system may experience in its life. Safety factors are applied to these loads and the mechanical strength of the major components is evaluated considering the material properties, ultimate loads and fatigue loads. The maximum operating load as predicted by the design calculations or modeling is physically applied to the rotor blade in the static blade test to verify blade strength and deflection.]

5.1 Design loads for turbines with a Peak Power greater than 1 kW shall be determined per IEC 61400-2 ed.3 using Class II and a turbulence intensity at 15 m/s (TI15) of 20% or Class S. The IEC SWT class per Table 1 of IEC 61400-2 ed. 3 is limited to Class II or S and TI15 is assumed to be 20%.

5.2 Use of the Simplified Load Methodology shall be limited to turbines with a Peak Power less than 30 kW but is not recommended for turbines with a Peak Power greater than 10 kW. ~~Use of the Simplified Load Model is not recommended for turbines with a Peak Power greater than 10 kW.~~

5.3 The S~~s~~trength of the turbine system shall be assessed using the design loads determined in Section 5.1 and other design data and in accordance with ~~following the guidance given in Section 5.2 of~~ IEC 61400-2 ed.3, Section 5.2, in combination with the requirements for stress calculations in Section 7.7, the safety factors in 7.8, and limit state analysis in 7.9.

5.3.1 In Table 6 Partial safety factors for materials, intermediate factors between minimal and full characterization may be used; ~~see~~ refer to ~~Annex E of~~ IEC 61400-2 ed. 3, Annex E.

5.4 The strength evaluation shall include the following major components, as a minimum:

1. ~~: the~~ B~~b~~lades,
2. B~~b~~lade root to hub connection,
3. H~~h~~ub,
4. M~~, m~~ain shaft,
5. B~~b~~earings,
6. Y~~y~~aw shaft ~~,~~ (for horizontal axis wind turbines),
7. C~~c~~onnection to the tower,
8. C~~c~~ritical safety / protection systems and components,
9. ~~and n~~Nacelle frame.

The rest of the structure shall be checked to verify that sound engineering practices have been employed in the design to maintain normal operation of the wind turbine and for the prevention of any potential hazards.

5.5 A static blade test shall be conducted in accordance with Section 13.5.2 of IEC 61400-2 ed. 3.

5.6 To ensure the turbine is paired with an appropriate tower, the manufacturer shall submit design requirements for towers including:

5.6.1 mechanical and electrical connections;

5.6.2 minimum blade/tower clearance;

5.6.3 maximum tower top loads;

5.6.4 maximum allowable tower top deflection; and

5.6.5 fundamental frequencies to avoid as evidenced by a resonance diagram (e.g. Campbell diagram) per IEC 61400-2 ed. 3 Annex I.

5.7 Model inputs and outputs~~As required by the table in Appendix B certain design input parameters must~~shall be validated per the requirements below.

5.7.1 For turbines using the Simplified Load Methodology, inputs shall be validated per 5.7.1.1 and 5.7.1.2.

5.7.1.1 Design parameters shall be validated by conducting Tests to Verify Design Data in IEC 61400-2. Ed. 3, Section 13.2.4

5.7.1.2 Major component weights, for components listed in Section 5.4, shall be verified.

5.7.2 For turbines using simulation modeling, model inputs and outputs shall be validated per the requirements below as applicable based on turbine size categories as shown in Table 5.7.~~:~~ ~~This may be accomplished via the guidance given below. The purpose of the validation testing is for validations of the aero elasticdesign model inputs. Validations are required for designs following either the simple load methodology or utilizing a valid simulation model.~~

Table 5.7 Required Design Loads Validation Per Turbine Size

Validation	**Micro wind turbines**	**>1 kW to 30 kW Peak Power**	**>30 kW to 65 kW Peak Power**	**>65 kW to 150 kW Peak Power**
Power curve validation	*Loads Validation Not Required*	*x*	*x*	*x*
Rotor speed validation		*x*	*x*	*x*
Blade first flapwise (static) natural frequency			*x*	*x*
Tower loads validation				*x*
Major component weights		*x*	*x*	*x*

5.7.2.1~~1~~ ~~Turbines above 65 kW and less than 150 kW Peak Power require the following for simulation model validation:~~

~~5.7.1.1~~ Power curve validation shall be performed by one of the following methods:~~:~~

a) IEC 61400-12-1 power performance testing~~ shall suffice for validation.~~

b) IEC 61400-13, Section~~ Cl~~ 6.3.2.1 power production testing, except that testing per ~~may alternatively be completed, but~~ 6.3.5.2 is only recommended for data collection guidance and is not required.

5.7.2.2~~1.2~~ Rotor speed validation shall be performed by one of the following methods:~~:~~

a) IEC 61400-2. Ed. 3, Section 13.2.4, Tests to Verify Design Data for maximum rotational speed.

b) IEC 61400-13, Table 12 rotor speed measurement validation with controller data ~~may also be allowed~~ along with other controller signals gathered for power performance or duration testing. This requires an IEC 61400-12-1 compliant meteorological~~measurement~~ tower.

5.7.~~1.~~2.3~~3~~ Blade first flapwise (static) natural frequency values shall be validated by one of the following methods:

a) IEC 61400-23 blade property tests for blade mass, center of gravity, and natural frequencies, which can be gathered during the blade static testing.

b) IEC 61400-13, ~~Table 9 Load Quantities for blade root flatwise bending may alternatively be completed.~~ refer to ~~In this situation the simulation model may need to be rerun to attempt to match the conditions of the experimental data.~~ Table 3 for guidance on how to obtain these frequencies.~~This requires an IEC 61400-12-1 compliant measurement tower.~~

5.7.2.4~~1.4~~ Tower loads validation shall be conducted using~~:~~ IEC 61400-13, Table 9 Load Quantities for tower base normal and tower base lateral.

5.7.2.~~.1.~~5 Major component weights, for components listed in Section 5.4, shall be verified.~~.~~

5.7.2.6 Where the measured design data does not match the design data used for loads and strength analyses, the models may be rerun to match the conditions of the experimental data.

5.7.2 Turbines above 30 kW and less than 65 kW Peak Power require all items from 5.7.1 above, except for 5.7.1.4 tower loads, for simulation model validation.

5.7.3 Turbines less than 30 kW Peak Power require the IEC 61400-2 clause 13.2 Tests to verify design data regardless of chosen design method; simplified load methodology or simulation model. Where a simulation model is performed major component weights are also required. Design validation testing is recommended but not required for Micro turbines with less than 1 kW Peak Power.

5.7.34 VAWTs and other novel designs may require additional validations where non-validated design codes are used or do not accurately reflect the turbine archetype. VAWTs specifically mustshall refer to IEC 61400-13 ed.1 Annex J; load quantity requirements may be adjusted based on VAWT design features. Tower top loads may additionally be required for some archetypes.

5.8 Wind turbine control and protection systems shall be designed to be fail-safe in accordance with IEC 61400-2 ed. 3, Section 8. Critical functions of the control and protection system - such as power and speed control, wind alignment (yaw), over speed protection, start-up and shutdown – shall be tested and verified in accordance with the Safety and Function Testing requirements in Section 4.

6 Duration Test

[Informative note: A duration test is conducted to establish a minimum threshold of reliability. The test is designed to investigate structural integrity and material degradation (corrosion, cracks, deformations), and quality of environmental protection of the wind turbine. The test parameters are determined based on the SWT class chosen by the designer.]

6.1 A duration test shall be performed in accordance with IEC 61400-2 ed.3, Section 13.4, with the modifications listed below:

6.1.1 Wind speed is defined as the 1-min average of wind speed samples.

6.1.2 The wind turbine will have passed the duration test when it has achieved:

6.1.2.1 Reliable operation during the test period;

6.1.2.2 The test must shall include at least 10 hours in wind speeds of 15 m/s (33.6 mph) and above. The wind turbine must shall be in its normal operational mode for the wind speed; and,

6.1.2.3 The test must shall include at least 1000 hours of power production.

6.1.3 Calculation of operational time fraction and analysis of power degradation are not required.

6.1.4 Dynamic behavior observation (per IEC 61400-2 ed. 3, 13.4.3) is not required.

7 Labeling

7.1 An ACP consumer label shall be created that contains the following:

7.1.1 Manufacturer and model of wind turbine;

7.1.2 Reference Annual Energy;

7.1.3 Reference Power;

7.1.4 Peak Power @ Peak Power Windspeed;

7.1.5 ACP Reference Sound Pressure Level; and,

7.1.6 Name and website of certification body granting certification to the SWT model according to this standard.

7.2 A test summary report shall be created with, at a minimum, the following:

7.2.1 Description of test turbine(s) and test location(s);

7.2.2 Turbine Ratings:

7.2.2.1 Reference Power;

7.2.2.2 Reference Annual Energy;

7.2.2.3 Peak Power;

7.2.2.4 ACP Reference Sound Pressure Level;

7.2.3 Power performance test:

7.2.3.1 Sea-level normalized power curve and table;

7.2.3.2 Sea-level normalized AEP curve and table;

7.2.4 Acoustic test:

7.2.4.1 Measured sound pressure levels;

7.2.4.2 Sound power levels at integer wind speeds;

7.2.5 Duration test:

7.2.5.1 IEC small wind turbine class;

7.2.5.2 Hours at required wind speeds

7.2.6 For additional guidance of items that may be included see Annex M of IEC 61400-2.

7.3 The ACP consumer label and the corresponding test summary report are to be made continuously and publicly available, in the English language as a minimum, on the manufacturer's web site and/or the certification body's web site.

7.4 Reference Power, ACP Reference Sound Pressure Level, and Peak Power shall be rounded to one decimal place.

7.5 Reference Annual Energy shall be rounded to three significant figures.

8 References and Appendices

8.1 Normative References

Reference Number	Reference Title
IEC 61400-12-1 ed.2	Wind Turbines – Part 12-1: Power performance measurements of electricity producing wind turbines
IEC 61400-11 ed.3	Wind Turbines – Part 11: Acoustic noise measurement techniques

IEC 61400-2 ed.3	Wind Turbines – Part 2: Small wind turbines
IEC 61400-13 ed. 1	Wind turbines - Part 13: Measurement of mechanical loads
IEC 61400-23 ed. 1	Wind turbines - Part 23: Full-scale structural testing of rotor blades

8.2 Informative References

Reference Number	Reference Title
IEC 61400-6 ed. 1	Wind energy generation systems - Part 6: Tower and foundation design requirements
~~IEC 61400-13 ed. 1~~	~~Wind turbines - Part 13: Measurement of mechanical loads~~
~~IEC 61400-23 ed. 1~~	~~Wind turbines - Part 23: Full-scale structural testing of rotor blades~~

Appendix A

Sound Levels for Different Observer Locations and Background Sound Levels

The ACP Reference Sound Pressure Level is calculated at a distance of 60 meters from the rotor hub and excludes any contribution of background sound. As the distance from the turbine increases, the background sound becomes more dominant in determining the overall sound level (turbine plus background).

Background sound levels depend greatly on the location and presence of roads, trees, and other sound sources. Typical background sound levels range from 35 dB(A) (quiet) to 50 dB(A) (urban setting)

Equation 1 can be used to calculate the contribution of the turbine to the overall sound level using the ACP Reference Sound Pressure Level. Equation 2 can be used to add the turbine sound level to the background sound level to obtain the overall sound level.

$$turbinesoundlevel = L_{ACP} + 10\,log(\,4\pi 60^2) - 10\,log(4\pi R^2) \quad (1)$$

Where:

L_{ACP} is the ACP Reference Sound Pressure Level [dB(A)].

R is the observer distance from the turbine rotor center [m]

$$overall\ sound\ level = 10\log(10^{\frac{turbine\ level}{10}} + 10^{\frac{background\ level}{10}}) \quad (2)$$

Table 1 Overall Sound Levels at Different Locations for an ACP Reference Sound Pressure Level of 40 dB(A)

Distance from rotor center [m]	L_{ACP}: 40 dBA				
	background noise level (dBA):				
	30	35	40	45	50
10	55.6	55.6	55.7	55.9	56.6
20	49.6	49.7	50.0	50.9	52.8
30	46.1	46.4	47.0	48.6	51.5
40	43.7	44.1	45.1	47.3	50.9
50	41.9	42.4	43.9	46.6	50.6
60	40.4	41.2	43.0	46.2	50.4
70	39.2	40.2	42.4	45.9	50.3
80	38.2	39.4	41.9	45.7	50.2
100	36.6	38.3	41.3	45.5	50.2
150	34.1	36.8	40.6	45.2	50.1
200	32.8	36.1	40.4	45.1	50.0

Table 2 Overall Sound Levels at Different Locations for an ACP Reference Sound Pressure Level of 45 dB(A)

Distance from rotor center [m]	L_{ACP}: 45 dB(A)				
	background noise level [dB(A)]:				
	30	35	40	45	50
10	60.6	60.6	60.6	60.7	60.9
20	54.6	54.6	54.7	55.0	55.9
30	51.1	51.1	51.4	52.0	53.6
40	48.6	48.7	49.1	50.1	52.3

50	46.7	46.9	47.4	48.9	51.6
60	45.1	45.4	46.2	48.0	51.2
70	43.8	44.2	45.2	47.4	50.9
80	42.7	43.2	44.4	46.9	50.7
100	40.9	41.6	43.3	46.3	50.5
150	37.8	39.1	41.8	45.6	50.2
200	35.9	37.8	41.1	45.4	50.1

Table 3 Overall Sound Levels at Different Locations for an ACP Reference Sound Pressure Level of 50 dB(A)

Distance from rotor center [m]	L_{ACP}: 50 dB(A)				
	background noise level [dB(A)]:				
	30	35	40	45	50
10	65.6	65.6	65.6	65.6	65.7
20	59.5	59.6	59.6	59.7	60.0
30	56.0	56.1	56.1	56.4	57.0
40	53.5	53.6	53.7	54.1	55.1
50	51.6	51.7	51.9	52.4	53.9
60	50.0	50.1	50.4	51.2	53.0
70	48.7	48.8	49.2	50.2	52.4
80	47.6	47.7	48.2	49.4	51.9
100	45.7	45.9	46.6	48.3	51.3
150	42.3	42.8	44.1	46.8	50.6
200	40.0	40.9	42.8	46.1	50.4

Table 4 Overall Sound Levels at Different Locations for an ACP Reference Sound Pressure Level of 55 dB(A)

Distance from rotor center [m]	L_{ACP}: 55 dB(A)				
	background noise level [dB(A)]:				
	30	35	40	45	50
10	70.6	70.6	70.6	70.6	70.6
20	64.5	64.5	64.6	64.6	64.7
30	61.0	61.0	61.1	61.1	61.4
40	58.5	58.5	58.6	58.7	59.1
50	56.6	56.6	56.7	56.9	57.4
60	55.0	55.0	55.1	55.4	56.2
70	53.7	53.7	53.8	54.2	55.2
80	52.5	52.6	52.7	53.2	54.4
100	50.6	50.7	50.9	51.6	53.3
150	47.1	47.3	47.8	49.1	51.8
200	44.7	45.0	45.9	47.8	51.1

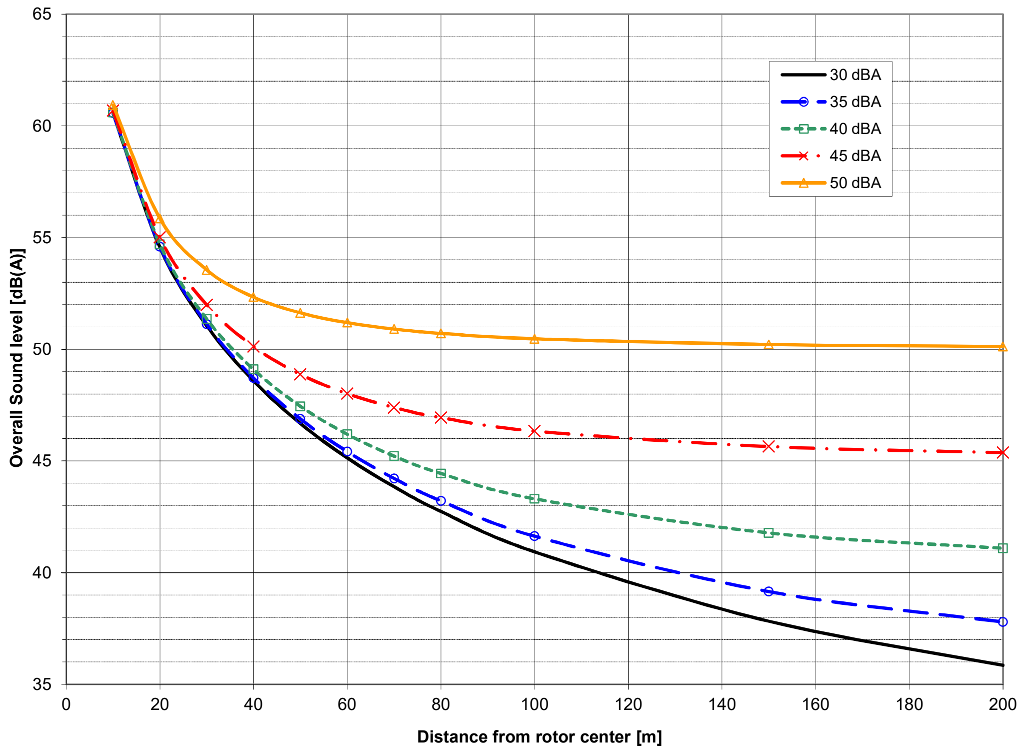

Figure 1 Sound levels as a function of distance and background noise levels for an ACP Reference Sound Pressure Level of 40 dB(A)

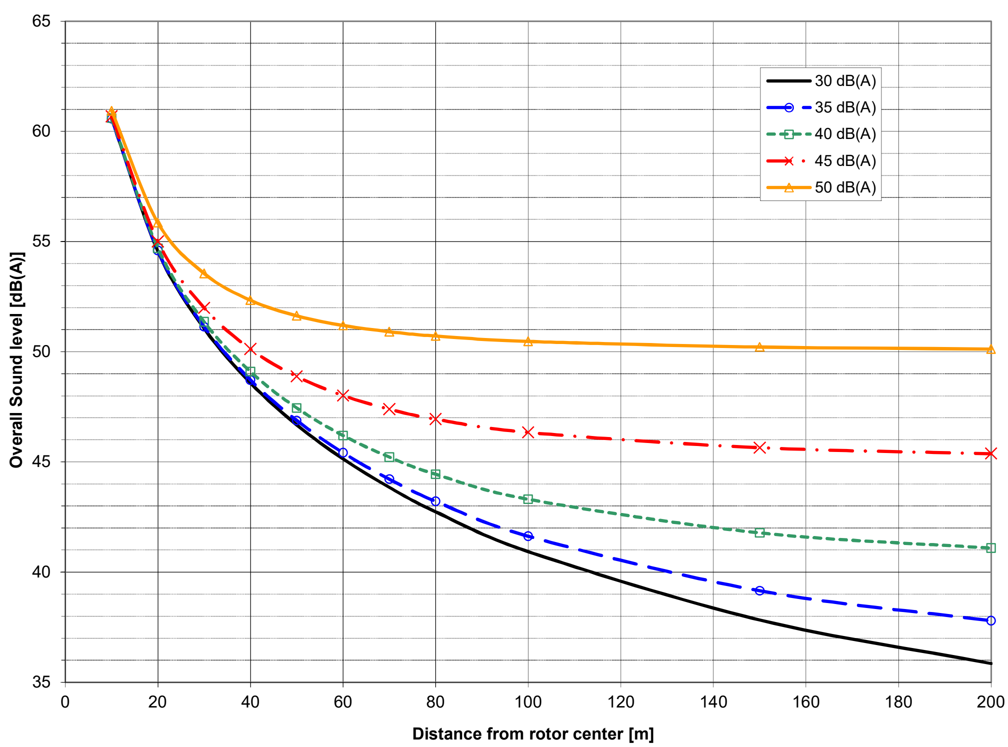

Figure 2 Sound levels as a function of distance and background noise levels for an ACP Reference Sound Pressure Level of 45 dB(A)

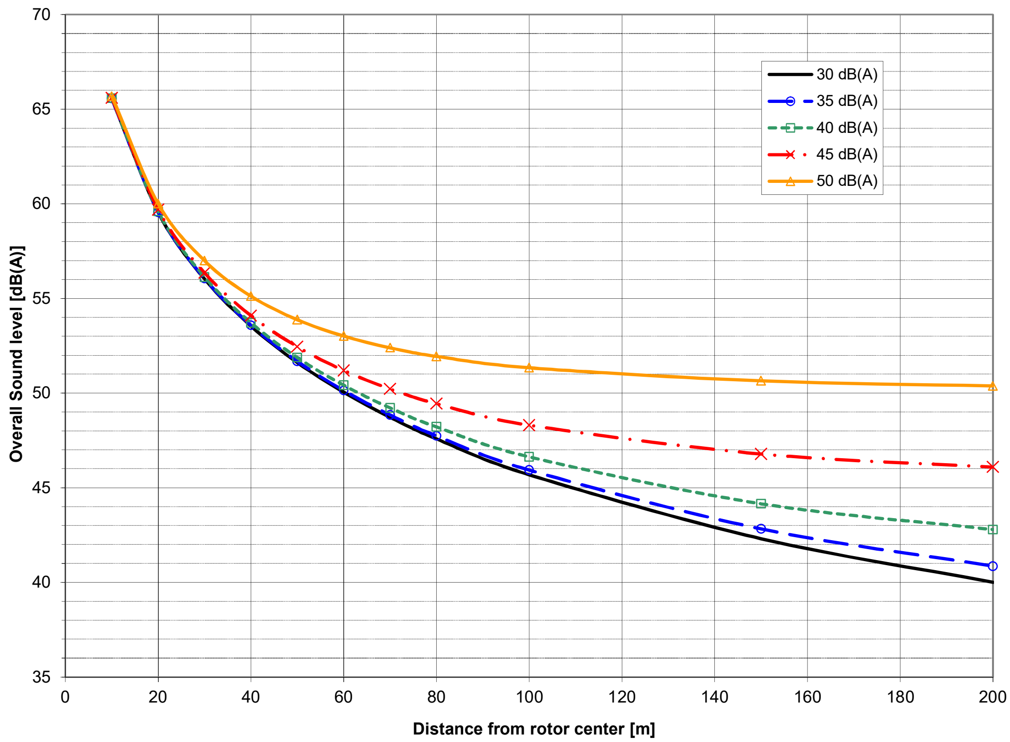

Figure 3 Sound levels as a function of distance and background noise levels for an ACP Reference Sound Pressure Level of 50 dB(A)

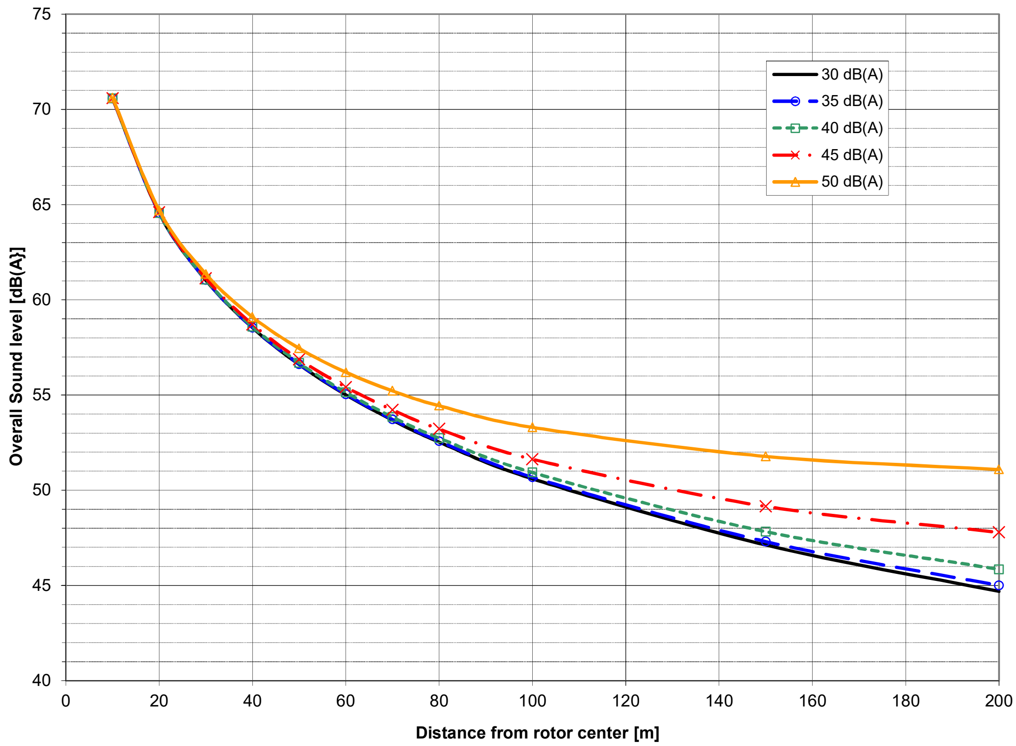

Figure 4 Sound levels as a function of distance and background noise levels for an ACP Reference Sound Pressure Level of 55 dB(A)

Appendix B

Conformity Assessment

The requirements in this appendix are related to the process of certification to this standard and are thus not technical requirements.

1. Small wind turbines certified to this standard shall be evaluated by a certification body (CB) accredited to ISO/IEC 17065 with ACP 101-1-2021 in their scope.
2. To maintain validity of a small wind turbine certification, the certification body shall utilize the following surveillance activities:
   a. An initial factory inspection followed by an inspection every two years;
   b. Field inspections of a sample of certified turbines per the Routine Inspection requirements of IEC 61400-2 ed. 3 section 11.2.5.3 with the following additional requirements:
      i. Sample size shall be five (5) turbines at different sites; turbines chosen by OEM and CB.
      ii. Inspections shall be performed annually by a party chosen by the OEM and CB (e.g. the installer or service provider).
      iii. The duration of the annual field inspections period shall be three (3) years. After the third consecutive field inspection is complete, per turbine, the inspection requirement is satisfied and the certification will be maintained through annual reporting, as listed in 2.a, 2.c and 2.d.
      iv. Inspection reports shall include photos of major components, as identified by the OEM and CB, and any signs of cracking, degradation or significant wear.

v. Report annual energy production and estimated annual average hub wind speed. Provide the source of wind speed estimate, e.g. NREL Wind Prospector or turbine-mounted anemometer.

c. Annual reporting of all design changes, field failures, complaints, and sales.

d. Significant design changes and safety related field failures shall be reported to the CB without delay.

3. Test data from the turbine manufacturer may be accepted if witnessed by the certification body.

4. The following guidance on changes to a turbine design that may require re-certification was adapted from IEC Certification Advisory Committee clarification sheet number CBC 4C:

Modifications to a certified wind turbine are permitted only if they do not change or affect the principal characteristics or if they change or affect the principal characteristics within the extent specified in the applicable design code or standard. Below are examples of changes which will normally require re-testing:

a. a change in rotor diameter by more than 5%

b. a change in rotor rotational speed by more than 5%

c. a different design of safety system

d. a different way of limiting the power output

e. modified blade profiles

f. modifications which lead to a significant increase in the load spectrum

g. increase of the rated power output by more than 5%

The impact on loads and strength shall be evaluated for any change in rotor diameter, rotor speed and/or power output. Additional measurements and tests may thus be avoided.

Conformity assessment components per turbine rating

The technical requirements for conformity assessment are dependent on the wind turbine Peak Power rating. The table below ~~shows~~ summarizes the required and permitted elements of certification to this standard.

	Micro wind turbines up to 1 kW Peak Power	**1-30 kW Peak Power**	**30-65 kW Peak Power**	**65-150 kW Peak Power**
STRUCTURAL DESIGN				
SLM	**Not required**	**Not recommended for turbines with Peak Power greater than 10 kW**	**Not allowed**	**Not allowed**
~~Aeroelastic Simulation~~ model	**Not required**	**~~Allowed with validation through power, rotor speed. Validate weight of major~~**	**~~Allowed with validation through power, rotor speed, blade first flapwise (static)~~**	**~~Allowed with validation through power, rotor speed, blade first flapwise (static) natural frequency, tower loads*. Validate weight of major components.~~Required**

		~~components.~~Allowed	~~natural frequency*. Validate weight of major components.~~Required	
Structural Analysis	**Not required**	**Required**	**Required**	**Required**
TYPE TESTING				
Duration Testing	**Required**	**Required**	**Required**	**Required**
Power Performance	**Required**	**Required**	**Required**	**Required**
Loads Validation Testing	**Not required**	~~Not required~~Required. See 5.7	Required. See 5.7~~Not required~~	Required. See 5.7~~Required (only load components listed for aeroelastic model validation, see above)~~
Acoustics Testing	**Not required**	**Required**	**Required**	**Required**
Safety and Function Testing	**Required**	**Required**	**Required**	**Required**
Blade Testing	**Not required**	**Static test required**	**Static test required**	**Static test required; accelerated fatigue testing according to IEC 61400-23 is not required but is encouraged**
Labeling	**Required**	**Required**	**Required**	**Required**

* for passive-yaw machines, yaw behavior should be validated