Mike Smith

From: Robert Doobovsky
Sent: Monday, July 22, 2013 9:24 AM
To: Mike Smith
Subject: Small Wind Turbine Performance and Safety Standard
Attachments: AWEA_Small_Turbine_Standard_Adopted_Dec09.pdf

Mike,

The Small Wind Turbine Performance and Safety Standard is:
(American Wind Energy Association)
AWEA 9.1 – 2009 (see attached).

Purpose
This standard was created by the small wind turbine industry, scientists, state officials, and consumers to provide consumers and municipalities with realistic and comparable performance ratings and an assurance the small wind turbine products certified to this standard have been engineered to meet carefully considered standards for safety and operation.

Sincerely,
Robert Doobovsky

City of Ellensburg WASHINGTON
Assistant Building Official
509-925-8663
doobovskyr@ci.ellensburg.wa.us

AWEA Standard
AWEA 9.1 - 2009

AWEA Small Wind Turbine Performance and Safety Standard

American Wind Energy Association
1501 M Street NW, Suite 1000
Washington, DC 20005

FOREWORD and BACKGROUND

The Foreword and Background sections are included with this document for information purposes only, and are not part of the AWEA Small Wind Turbine Performance and Safety 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 meeting this standard, and to provide consumers with performance data that will help them make informed purchasing decisions. 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

AWEA is recognized by the American National Standards Institute (ANSI) as an Accredited Standards Developer and the AWEA standard will be submitted for adoption as an American National Standard. This standard has been 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.

The draft that follows has been developed over the last five years in a process that involved over 60 participants, three meetings, 22 hours of conference calls, countless e-mails, a list serve, and five intermediate drafts. It represents hundreds of hours of detailed discussion, debate, compromise, revision, and formal response. The Canadian Wind Energy Association has been actively involved since the beginning and the British Wind Energy Association has now adopted and approved this standard almost word for word.

The proposed standard was developed by the AWEA Small Wind Turbine Standard Subcommittee, which was chaired by Mike Bergey of Bergey Windpower Co. Members of the subcommittee have included the following people. Please note that there has been some turnover in the subcommittee, some positions have changed, and not all members were active (though they did receive the drafts and correspondence).

Name	Affiliation	Stakeholder Category
Bill Colavecchio	Underwriters Laboratory	Certifying Agency
Lex Bartlett	Aeromag	Manufacturer
David Blittersdorf	Earth Turbines	Manufacturer / Consumer
David Calley	Southwest Windpower	Manufacturer
Jito Coleman	Northern Power	Manufacturer
David Laino	Endurance	Manufacturer
Robert Preus	Abundant Ren. Energy	Manufacturer
Steve Turek	Wind Turbine Industries	Manufacturer
Dr. Craig Hansen	Windward Engineering	Technical Expert
Robert Poore	Global Energy Concepts	Technical Expert
Ken Starcher	Alternate Energy Institute	Technical Expert
Trudy Forsyth	National Renewable Energy Laboratory	Researcher / Technical Expert
Jim Green	National Renewable Energy Laboratory	Researcher / Technical Expert
Hal Link	National Renewable Energy Laboratory	Researcher / Technical Expert
Brian Vick	USDA/Bushland	Technical Expert
Brent Summerville	SWCC	Technical Expert
Alex DePillis	Wisconsin Energy Office	State Energy Office / Consumer
Jennifer Harvey	NYSERDA	State Energy Office
Cassandra Kling	New Jersey BPU	State Energy Office
Dora Yen	California Energy Comm.	State Energy Office
Paul Gipe	California	Consumer
Mike Klemen	North Dakota	Consumer
Heather Rhoads Weaver	Washington	Consumer / AWEA
Mick Sagrillo	Wisconsin	Consumer
Brad Cochran	Colorado	Interested Party
Samit Sharma	Canada	CanWEA
Svend de Bruyn	Deltronics	Canadian Industry

Other participants in the development of this proposed standard have included (as they were affiliated at the time of their involvement):

Mark Bastasch
Ralph Belden, Synergy Power
Michael Blair
David Blecker, Seventh Generation
Bob Clarke, Ventera Energy
Dean Davis, Windward Engineering
John Dunlop, AWEA
Henry DuPont, Lorax

Mike Gray, Gray Engineering
Jeffrey Haase, State of Minnesota
Tod Hanley, Bergey Windpower
Robert Hornung, CanWEA
Arlinda Huskey, NREL
Dale Jones, Geocorp
Dan Juhl, DanMar
Steve Kalland, NCSU
Peter Konesky, State of Nevada
Andy Kruse, Southwest Windpower
Jean-Daniel Langlios
Amy Legere, Southwest Windpower
Malcomb Lodge, Entegrity Wind
Charles Newcomb, Entegrity Wind
Chuck Maas
Dennis Makeperce, E.R.D.
Tom Maves, State of Ohio
Michael Mayhew
Richard Michaud, US-DOE
Jacques Michel, E.R.D.
Paul Migliore, NREL
Lawrence Mott, Earth Turbines
Jennifer Oliver, Southwest Windpower
Philippe Quinet
Doug Selsam, Selsam Engineering
David Sharman, Ampair / BWEA
Robert Sherwin, Vermont Wind Power Int'l
Larry Sherwood, IREC
P.V. Slooten
Eric Stephens
Brian Smith, NREL
Jeroen van Dam, NREL / UL
David VanLuvanee
Jane Weismann, IREC
Kyle Wetzel, Consultant
Sean Whittaker, CanWEA

AWEA Small Wind Turbine Performance and Safety Standard

Table of Contents

Section	Page
1. General Information	1
2. Performance Testing	4
3. Acoustic Sound Testing	4
4. Strength and Safety	5
5. Duration Test	6
6. Reporting	6
7. Labeling	7
8. Changes to Certified Products	8
9. References and Appendices	8
Appendix A	Addendum

AWEA Small Wind Turbine Performance and Safety Standard

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 the small wind turbine products certified to this standard have been engineered 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 meeting this standard and an improved basis for comparing the performance of competing products.

1.2 Overview

1.2.1 This performance and safety 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 largely 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 account for technical differences between large and small wind turbines, 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 generally applies to small wind turbines for both on-grid and off-grid applications.

1.3.2 This standard applies to wind turbines having a rotor swept area of 200 m^2 or less. In a horizontal-axis wind turbine this equates to a rotor diameter of ~ 16 m (~ 52 ft)

1.3.3 A turbine system includes the wind turbine itself, the turbine controller, the inverter, if required, wiring and disconnects, and the installation and operation manual(s).

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 most 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. For example, a wind turbine available in both grid-intertie and battery charging versions would need

separate performance tests if both versions were to be certified, but would not need a separate safety evaluation in most cases.

1.3.5 Except as noted in Sections, 4.2, 4.5, 5.2.3, 5.2.4, 5.2.5 and 6.1.8, towers and foundations are not part of the scope of this standard because it is assumed that conformance of the tower structure to the International Building Code, Uniform Building Code or their local equivalent will be required for a building permit.

1.4 Compliance

1.4.1 Certification to this standard shall be done by an independent certifying agency such as the Small Wind Certification Council (SWCC) or a Nationally Recognized Testing Laboratory (NRTL). Self-certification is not allowed.

1.4.2 It is the intent of this standard to allow test data from manufacturers, subject to review by the certifying agency.

1.4.3 Compliance with this standard for the purposes of advertising or program qualification, or any other purpose, is the responsibility of the manufacturer.

1.5 Definitions

1.5.1 Definitions contained in IEC 61400-12-1, ed.1 (Performance); IEC 61400-11, ed.2 (Acoustic Noise); and IEC 61400-2, ed.2 (Design Requirements) are hereby incorporated by reference.

1.5.2 Additional Definitions

1.5.2.1 AWEA Rated Power: The wind turbine's power output at 11 m/s (24.6 mph) per the power curve from IEC 61400-12-1, except as modified in Section II of this Standard.

1.5.2.2 AWEA Rated Annual Energy: The calculated total energy that would be produced during a one-year period at an average wind speed of 5 m/s (11.2 mph), assuming a Rayleigh wind speed distribution, 100% availability, and the power curve derived from IEC 61400-12-1 (sea level normalized), except as modified in Section II of this Standard.

1.5.2.3 AWEA Rated Sound Level: The sound level 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, 100% availability, and an observer location 60 m (~ 200 ft.) from the rotor center[1], calculated from IEC 61400-11 test results, except

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

as modified in Section III of this Standard.

1.5.2.4 Cut-in Wind Speed: The first wind speed bin in the averaged power curve that is positive.

1.5.2.5 Cut-out Wind Speed: The wind speed above which, due to control function, the wind turbine will have no power output.

1.5.2.6 Maximum Power: The maximum one-minute average power output a wind turbine in normal steady-state operation will produce (peak instantaneous power output can be higher).

1.5.2.7 Maximum Voltage: The maximum instantaneous voltage the wind turbine will produce in operation including open circuit conditions.

1.5.2.8 Maximum Current(s): The maximum instantaneous current(s) the wind turbine will produce on each side of the system's control or power conversion electronics.

1.5.2.9 Overspeed Control: The action of a control system, or part of such system, which prevents excessive rotor speed.

1.5.2.10 Power Form: Physical characteristics which describe the form in which power produced by the turbine is made deliverable to the load.

1.5.2.11 Rotor Swept Area: Projected area perpendicular to the wind direction swept by the wind turbine rotor in normal operation (un-furled position). If the rotor is ducted, the area inscribed by the ducting shall be included.

1.5.2.12 Turbulence Intensity: The standard deviation of wind speed divided by the mean wind speed based on 1-minute averaged data that is sampled at 1 Hz.

1.6 Units

1.6.1 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)].

1.7 Test Turbine and Electronics

1.7.1 Tested wind turbines and their associated electronics shall conform to the specific requirements of the governing IEC wind generator standard referenced for each test, but incorporating any amendments contained in this standard.

2 Performance Testing

2.1 Wind turbine performance shall be tested and documented in a test report per the latest edition of IEC 61400-12-1, Annex H, but incorporating the additional guidance provided in this section.

2.1.1 In 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 In item e, the total wire run length, measured from the base of the tower, must be at least 8 rotor diameters and the wiring is to be sized per the manufacturer's installation instructions.

2.1.3 In item n, the database shall include 10 minutes of data for all wind speeds at least 5 m/s beyond the lowest wind speed at which power is within 95% of Maximum Power (or when sustained output is attained).

3 Acoustic Sound Testing

3.1 Wind turbine sound levels shall be measured and reported in accordance with the latest edition of IEC 61400-11 ed.2, but incorporating the additional guidance provided in this section.

3.1.1 The averaging period shall be 10-second instead of 1-minute.

3.1.2 Measuring wind speed directly instead of deriving wind speed through power is the preferred method.

3.1.3 The method of bins shall be used to determine the sound pressure levels at integer wind speeds.

3.1.4 It shall be attempted to cover as wide a wind speed range as possible, as long as the wind screen remains effective.

3.1.5 A description shall be provided of any obvious changes in sound at high wind speeds where overspeed protection becomes active (like furling or pitching).

3.1.6 A tonality analysis is not required, but the presence of prominent tones shall be observed and reported.

4 Strength and Safety

4.1 Except as noted below, mechanical strength of the turbine system shall be assessed using either the simple equations in Section 7.4 of IEC 61400-2 ed.2 in combination with the safety factors in Section 7.8, or the aeroelastic modeling methods in the IEC standard. Evaluation of, as a minimum, the blade root, main shaft and the yaw axis (for horizontal axis wind turbines) shall be performed using the outcome of these analyses. A quick check of the rest of the structure for obvious flaws or hazards shall be done and if judged needed, additional analysis may be required.

4.2 Variable speed wind turbines are generally known to avoid harmful dynamic interactions with towers. Single/dual speed wind turbines are generally known to have potentially harmful dynamic interactions with their towers. Therefore, in the case of single/dual speed wind turbines, such as those using either one or two induction generators, the wind turbine and tower(s) must be shown to avoid potentially harmful dynamic interactions. A variable speed wind turbine with dynamic interactions, arising for example from control functions, must also show that potentially harmful interactions are likewise avoided.

4.3 Other safety aspects of the turbine system shall be evaluated including:

4.3.1 procedures to be used to operate the turbine;

4.3.2 provisions to prevent dangerous operation in high wind;

4.3.3 methods available to slow or stop the turbine in an emergency or for maintenance;

4.3.4 adequacy of maintenance and component replacement provisions; and

4.3.5 susceptibility to harmful reduction of control function at the lowest claimed operating ambient temperature.

4.4 A Safety and Function Test shall be performed in accordance with Section 9.6 of IEC 61400-2 ed.2.

4.5 The manufacturer shall submit design requirements for towers including:

4.5.1 mechanical and electrical connections;

4.5.2 minimum blade/tower clearance;

4.5.3 maximum tower top loads; and

4.5.4 maximum allowable tower top deflection.

5 Duration Test

5.1 To establish a minimum threshold of reliability, a duration test shall be performed in accordance with the IEC 61400-2 ed.2 Section 9.4.

5.2 Changes and additional clarifications to this standard include:

5.2.1 The test must include at least 25 hours in wind speeds of 15 m/s (33.6 mph) and above.

5.2.2 Minor repairs are allowed, but must be reported.

5.2.3 If any major component such as blades, main shaft, generator, tower, controller, or inverter is replaced during the test, the test must be restarted.

5.2.4 The turbine and tower shall be observed for any tower dynamics problems during the duration test and the test report shall include a statement of the presence or absence of any observable problems.

5.2.5 The tower used for the duration test must comply with the tower design requirements described in section 4.5.

6 Reporting and Certification

6.1 The test report shall include the following information:

6.1.1 Summary Report, containing a power curve, an Annual Energy Production curve, and the measured sound pressure levels (Section 9.4 of IEC 61400-11 ed.2). The report is intended to be publicly available once approved by the certifying agency.

6.1.2 Power Performance Test Report

6.1.3 Acoustic Test Report

6.1.4 The AWEA Rated Annual Energy

6.1.5 The AWEA Rated Sound Level

6.1.6 The AWEA Rated Power

6.1.7 Wind Turbine Strength and Safety Report

6.1.8 The tower design requirements shall be reported

6.1.9 Duration Test Report

6.2 The manufacturers of certified wind turbines must abide by the labeling requirements of the certifying agency.

7 Labeling

7.1 The AWEA Rated Annual Energy (AWEA RAE) shall be stated in any label, product literature or advertising in which product specifications are provided.

7.1.1 The AWEA RAE shall be rounded to no more than 3 significant figures.

7.2 The manufacturer shall state the AWEA Rated Power if a rated power is specified.

7.3 The manufacturer shall state the AWEA Estimated Sound Level if a sound level is specified.

7.4 Other performance data recommended to be stated in specifications about the turbine are:

7.4.1 Cut-in Wind Speed

7.4.2 Cut-out Wind Speed

7.4.3 Maximum Power

7.4.4 Maximum Voltage

7.4.5 Maximum Current(s)

7.4.6 Overspeed Control

7.4.7 Power Form

8 Changes to Certified Products

8.1 It is anticipated that certified wind turbines will occasionally be changed to provide one form of improvement or another. In some cases such changes will require review by the certifying agency and possible changes to the certified product parameters. The following guidance is provided concerning when product changes will require certifying agency review:

8.1.1 Any changes to a certified wind turbine that will have the cumulative effect of reducing AWEA Rated Power or AWEA Rated Annual Energy by more than 10%, or that will raise the AWEA Rated Sound Level by more than 1 dBA will require retesting and recertification by the certifying agency. Only those characteristics of the wind turbine affected by the design change(s) would be reviewed again.

8.1.2 Any changes to a certified wind turbine that could reduce the strength and safety factors by 10%, or increase operating voltages or currents by 10%, will require resubmission of the Wind Turbine Strength and Safety Report and recertification by the certifying agency.

8.1.3 Any changes to a certified wind turbine that could materially affect the results of the Duration Test will require retesting, submission of a new Duration Test Report, and recertification by the certifying agency.

8.2 The manufacturer is required to notify the certifying agency of all changes to the product, including hardware and software, for the life of the turbine certification. The certifying agency will determine whether the need for retesting and additional review under the guidelines provided in Section 8.1.

8.3 The use of Engineering Change Orders or their equivalent is recommended.

9 References and Appendices

9.1 References

9.1.1 Evaluation Protocol for Small Wind Systems, Rev. 3. NREL internal document

9.1.2 IEC 61400-12-1 ed.1, Wind Turbines – Part 12-1: Power performance measurements of electricity producing wind turbines

9.1.3 IEC 61400-11 ed.2, Wind turbine generator systems - Part 11: Acoustic noise measurement techniques

9.1.4 IEC 61400-2, ed.2, Wind Turbines – Part 2: Design requirements of small wind turbines

Appendix A

Sound Levels for Different Observer Locations and Background Sound Levels

The AWEA Rated Sound 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 dBA (quiet) to 50 dBA (urban setting)

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

$$turbine\ sound\ level = L_{AWEA} + 10\log(4\pi 60^2) - 10\log\left(4\pi R^2\right) \quad (1)$$

Where:
L_{AWEA} is the AWEA Rated Sound Level [dBA].
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 AWEA Rated Sound Level of 40 dBA

Distance from rotor center [m]	L_{AWEA}: 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 AWEA Rated Sound Level of 45 dBA

Distance from rotor center [m]	L_{AWEA}: 45 dBA				
	background noise level (dBA):				
	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 AWEA Rated Sound Level of 50 dBA

Distance from rotor center [m]	L_{AWEA}: 50 dBA				
	background noise level (dBA):				
	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 AWEA Rated Sound Level of 55 dBA

Distance from rotor center [m]	L_{AWEA}: 55 dBA				
	background noise level (dBA):				
	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

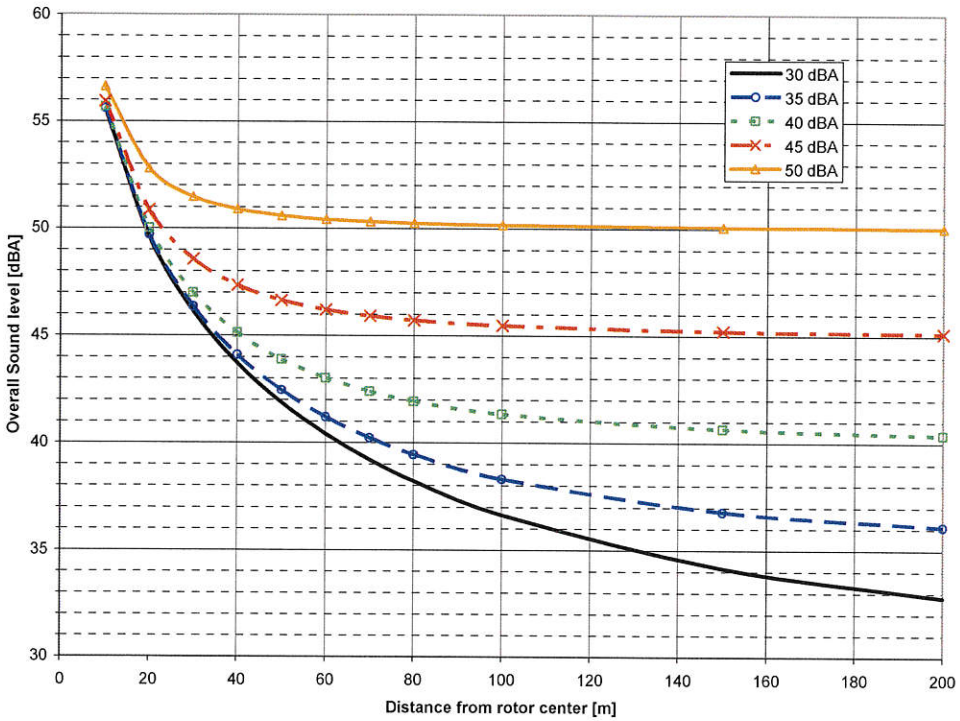

Figure 1 Sound levels as a function of distance and background noise levels for AWEA rated sound level of 40 dBA

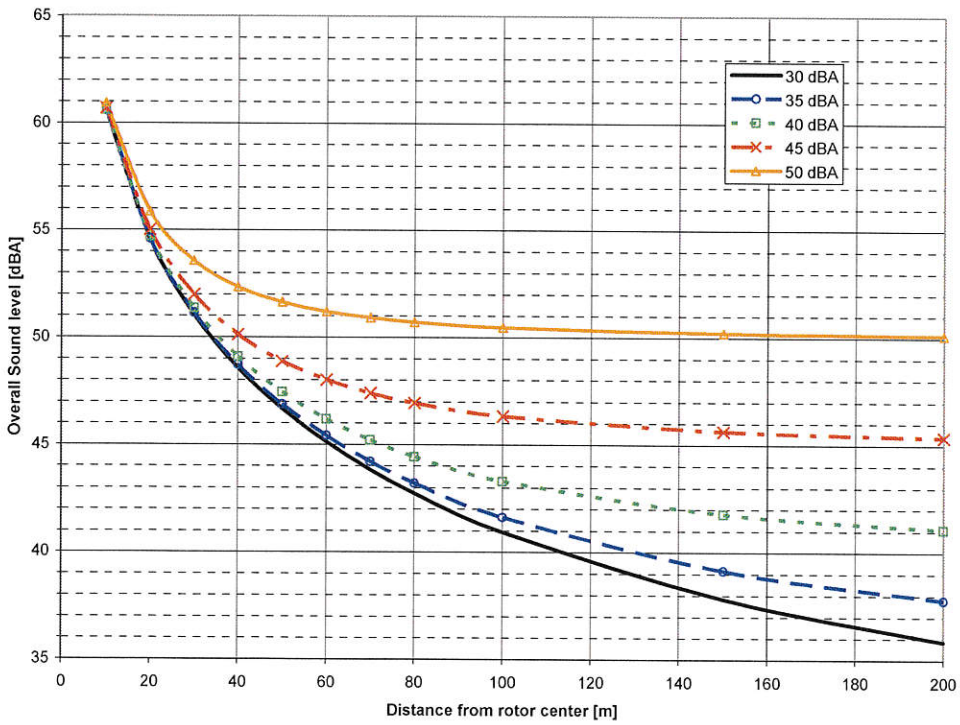

Figure 2 Sound levels as a function of distance and background noise levels for AWEA rated sound level of 45 dBA

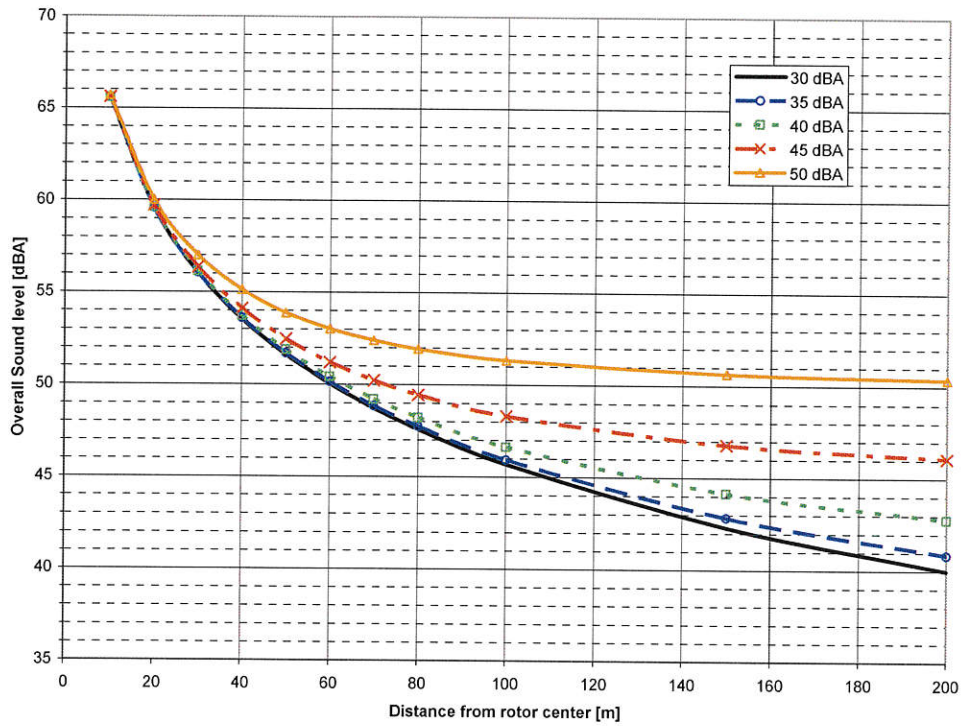

Figure 3 Sound levels as a function of distance and background noise levels for AWEA rated sound level of 50 dBA

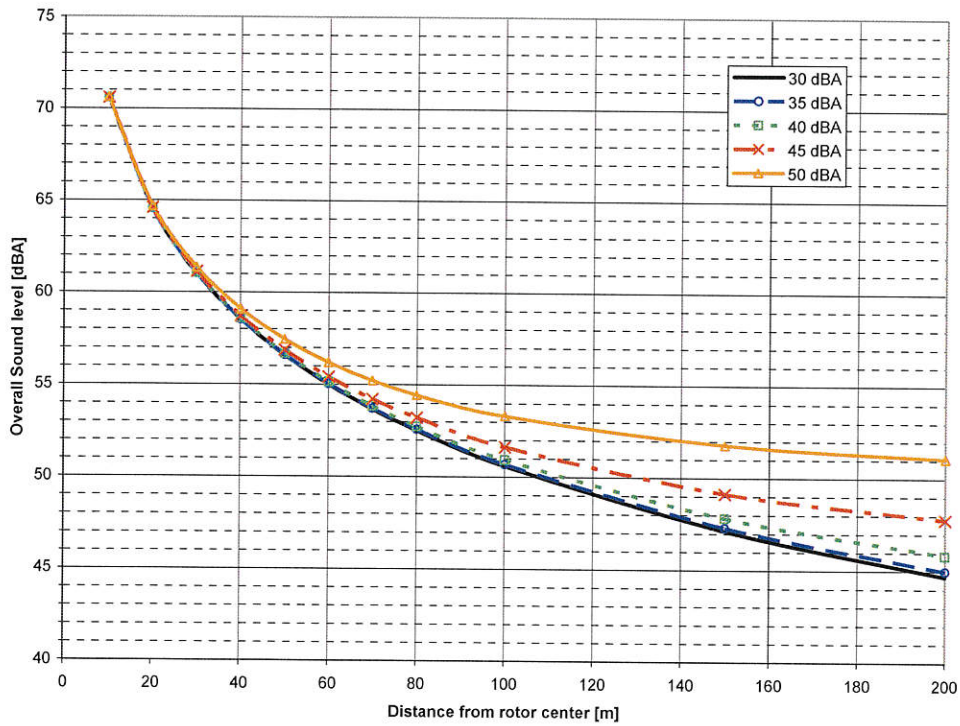

Figure 4 Sound levels as a function of distance and background noise levels for AWEA rated sound level of 55 dBA