

Proven WT15000 Wind Turbine

Mounted on TM1500 15m self supporting tower

Noise Emission Report

GENERAL

The dB (A) scale is the most common measure used to quantify noise. It covers sound intensity over the entire audible scale *and* takes account of the sensitivity of the human ear to give an overall measure of "loudness".

TYPICAL DB(A) LEVELS

Sound Level	dB (A)
Threshold of hearing	0
Whisper	30
Talking	60
City Traffic	90
Rock Concert	120
Jet Engine (10m away)	150

CURRENT BEST PRACTICE

In assessing the noise from a proposed wind turbine installation we are often interested in what noise levels will be at various distances from the wind turbine. It is accepted practice to *calculate* noise contributions from the wind turbine. This is because it is only practical to *measure* the wind turbine contribution accurately when it is 10 dBA above background noise. For example, background noise in a "quiet" environment is typically 30-40 dBA making it impossible to *measure* contributions less than 40-50 dB(A).

PROVEN WT15000 WIND TURBINE NOISE CALCULATIONS

Figure 1 shows how the noise emitted by a Proven WT15000 wind turbine on a 15m mast will disperse over the local environment. Maximum noise output at the base of the machine was recorded at 65dB(A) at a wind speed of 20 m/s. The noise output at the base of the mast in light winds 5m/s was 48 dB(A). The sound meter was held at a height of 1.5m from the ground. Background noise is louder than the turbine when more than 60m from the mast in both cases.

Figure 2 shows how the combined noise of wind turbine plus background; this is what will be detected by the human ear.

Figure 3 graphs the dBA difference between wind turbine and background plus common complaint classifications. *It can be generally taken that there will be no noise complaints where the turbine specific noise is 10dBA less than background.* This happens at a distance of 70-190m depending on wind speed.

Details of the calculations used in these graphs are given in Appendices B & C.

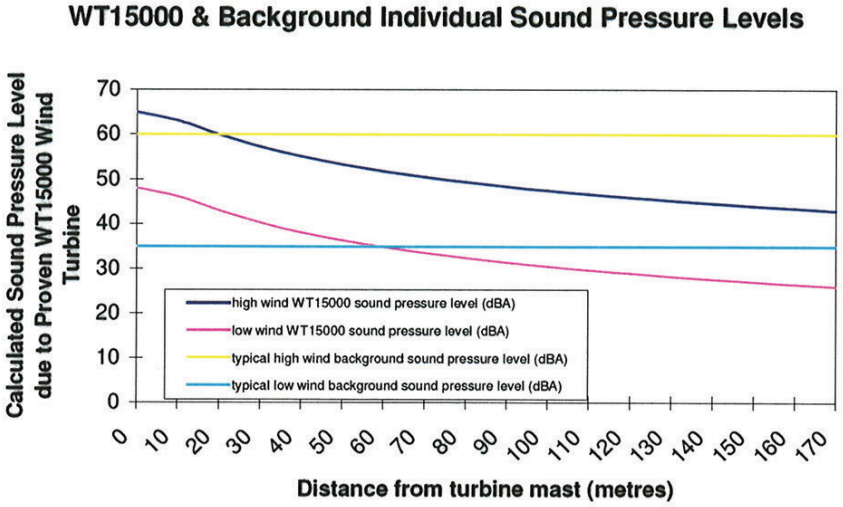


Figure 1

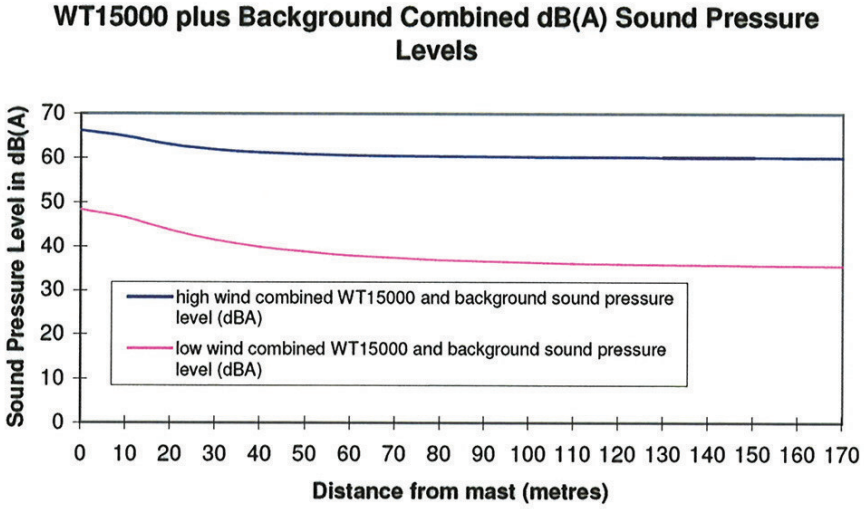


Figure 2

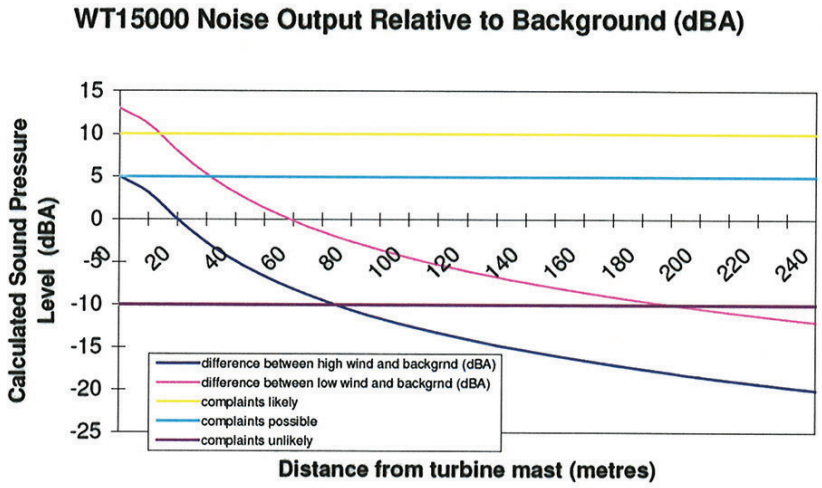


Figure 3

Note on Measurements Used in This Report

All measurements were taken on a portable SL-25 dBA sound meter at our demonstration wind turbine site in Kilmarnock. Proven Wind Turbines emit a swishing noise only - we do not believe full tonal analysis is needed for our small wind turbines (see also Appendix A).

COMMENT ON THE CALCULATIONS AND ASSUMPTIONS USED IN THIS REPORT

The above method does not take account of wind "streaming" noise to the downwind side of the turbine. In practice, turbine dBA levels will be shifted downwind by a variable amount depending on the individual site.

In both cases the dB(A) readings taken as coming from the wind turbine **certainly also included a contribution from background noise in a nearby tree.** Secondly, in the graphs shown, the typical background dBA readings have been chosen very conservatively (low).

For both of the above reasons, the results shown can be taken to be a "worst case scenario". A 1996 market survey of present Proven customers indicated that all would be happy to have the turbine closer to their houses than at present and that none had had complaints from neighbours about turbine noise after installation.

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Appendix A - Noise Reduction Features in Proven Wind Turbines

Feature	Benefit
Proven rotors are specially designed to operate at low rpm (typical max Tip Speed Ratio 6)	Blades and bearings rotate slowly keeping air noise to a minimum.
Direct Drive Permanent Magnet Generator	There is no gearbox as the rotor is coupled direct to the generator. This eliminates the gearbox hum which is the main source of noise in turbines with gearboxes. There are no touching parts.
Specially shaped blade tips	The rounded tips on Proven Wind Turbine blades are designed to reduce the vortices present at the end of any aerofoil. This keeps wind noise to a minimum.

Appendix B - Calculating Sound Pressure Levels

DEFINITIONS

1. Sound Pressure Level in dB(A) = 10 x $\log_{10}$ (sound power in W/m^2)

2. Sound Power in Watts/m^2 = $10^{0.1 \times (dB-120)}$

Given a sound power P_1 at distance d_1 from a noise source the sound power P_2 at distance d_2 may be calculated by the formula

3. $P_2 = P_1 x \left(\frac{d_1}{d_2}\right)^2$

ADDING DBA SOUND PRESSURE LEVELS FROM DIFFERENT SOURCES AT POINT X

First convert the dBA ratings at their initial distances to sound powers using equation 2.

Use the equation 3 to work out the sound powers at point X where you are interested in the total sound pressure level

Add all the sound powers together to find P_{total}

Convert back using equation 1 to find $dB(A)_{total}$

Appendix C - Calculations used in this report

height to hub	15		dBA high	65													
height meter	1.5		dBA low	48													
initial height	13.5																
initial dist	0																
db=10log(power in w/m2)+120																	
sound power=10^(0.1(db-120)																	
horizontal distance (m)	actual distance	sound high (w/m2)	sound low (W/m2)	high wind WT15000 sound pressure level (dBA)	low wind WT15000 sound pressure level (dBA)	typical high wind background sound pressure level (dBA)	typical low wind background sound pressure level (dBA)	combined WT15000 plus background sound high	combined WT15000 plus background sound low	high wind combined WT15000 and background sound pressure level (dBA)	low wind combined WT15000 and background sound pressure level (dBA)	difference between high wind and backgrnd (dBA)	difference between low wind and backgrnd (dBA)	complaint s likely	complaint s possible	complaint s unlikely
0	13.5	3.16E-06	6.31E-08	65	48	60	35	4.16E-06	6.63E-08	66	48	5	13	10	5	-10
10	16.8	2.04E-06	4.07E-08	63	46	60	35	3.04E-06	4.39E-08	65	46	3	11	10	5	-10
20	24.1	9.9E-07	1.97E-08	60	43	60	35	1.99E-06	2.29E-08	63	44	0	8	10	5	-10
30	32.9	5.33E-07	1.06E-08	57	40	60	35	1.53E-06	1.38E-08	62	41	-3	5	10	5	-10
40	42.2	3.23E-07	6.45E-09	55	38	60	35	1.32E-06	9.61E-09	61	40	-5	3	10	5	-10
50	51.8	2.15E-07	4.29E-09	53	36	60	35	1.21E-06	7.45E-09	61	39	-7	1	10	5	-10
60	61.5	1.52E-07	3.04E-09	52	35	60	35	1.15E-06	6.2E-09	61	38	-8	0	10	5	-10
70	71.3	1.13E-07	2.26E-09	51	34	60	35	1.11E-06	5.42E-09	60	37	-9	-1	10	5	-10
80	81.1	8.76E-08	1.75E-09	49	32	60	35	1.09E-06	4.91E-09	60	37	-11	-3	10	5	-10
90	91.0	6.96E-08	1.39E-09	48	31	60	35	1.07E-06	4.55E-09	60	37	-12	-4	10	5	-10
100	100.9	5.66E-08	1.13E-09	48	31	60	35	1.06E-06	4.29E-09	60	36	-12	-4	10	5	-10
110	110.8	4.69E-08	9.36E-10	47	30	60	35	1.05E-06	4.1E-09	60	36	-13	-5	10	5	-10
120	120.8	3.95E-08	7.89E-10	46	29	60	35	1.04E-06	3.95E-09	60	36	-14	-6	10	5	-10
130	130.7	3.37E-08	6.73E-10	45	28	60	35	1.03E-06	3.84E-09	60	36	-15	-7	10	5	-10
140	140.6	2.91E-08	5.81E-10	45	28	60	35	1.03E-06	3.74E-09	60	36	-15	-7	10	5	-10
150	150.6	2.54E-08	5.07E-10	44	27	60	35	1.03E-06	3.67E-09	60	36	-16	-8	10	5	-10
160	160.6	2.24E-08	4.46E-10	43	26	60	35	1.02E-06	3.61E-09	60	36	-17	-9	10	5	-10
170	170.5	1.98E-08	3.95E-10	43	26	60	35	1.02E-06	3.56E-09	60	36	-17	-9	10	5	-10
180	180.5	1.77E-08	3.53E-10	42	25	60	35	1.02E-06	3.52E-09	60	35	-18	-10	10	5	-10
190	190.5	1.59E-08	3.17E-10	42	25	60	35	1.02E-06	3.48E-09	60	35	-18	-10	10	5	-10
200	200.5	1.43E-08	2.86E-10	42	25	60	35	1.01E-06	3.45E-09	60	35	-18	-10	10	5	-10
210	210.4	1.3E-08	2.6E-10	41	24	60	35	1.01E-06	3.42E-09	60	35	-19	-11	10	5	-10
220	220.4	1.19E-08	2.37E-10	41	24	60	35	1.01E-06	3.4E-09	60	35	-19	-11	10	5	-10
230	230.4	1.09E-08	2.17E-10	40	23	60	35	1.01E-06	3.38E-09	60	35	-20	-12	10	5	-10
240	240.4	9.97E-09	1.99E-10	40	23	60	35	1.01E-06	3.36E-09	60	35	-20	-12	10	5	-10
						sound w/m	sound w/m2									
						0.0000011	3.16E-09									