MEASUREMENTS OF PROPAGATION OF SOUND OVER WATER AT LOW TO MID FREQUENCIES APPLICABLE TO WIND TURBINE NOISE CALCULATION

Tim Kelsall

Director of Noise and Vibration, Hatch, 2800 Speakman Drive, Mississauga, ON L5K 2R7 - tkelsall@hatch.ca

The ISO 9613(2) standard for calculation of noise propagation over land was written excluding propagation over water. A series of measurements of sound at various distances from a large highway bridge have been taken and are compared to ISO 9613(2) calculations for the same scenario. They show that for lower frequencies, which are the most important for offshore wind turbine calculations, ISO 9613(2) provide a good approximation to the measured results and may prove suitable for offshore wind turbine noise predictions.

1. INTRODUCTION

Ontario has a moratorium on offshore wind turbines, at least in part due to the absence of a proven method of predicting their noise impacts. ISO 9613(2)[1] is used for this purpose on land; however the standard specifically excludes propagation over water.

A series of measurements were taken at night from a sailboat on Lake Ontario at various distances from the Burlington Skyway, a large highway bridge at the West end of the lake. This bridge is approximately 3km in length and 75m high, which is not dissimilar to a wind farm.

2. MEASUREMENTS

Measurements were taken at 0.54km, 1km and at 1km intervals out to 12 km from the bridge centreline. Temperatures, measured by an automatic meteorological station close to the bridge, dropped from 26 to 24^{o}C over the measurement period from 10pm to 1am while relative humidity rose from 64 to 75%. The winds were very light (6km/h) and off shore, i.e. out of the harbour towards the Lake, and it was sufficiently calm that the boat had to use its engine between measurement points and the waves died away as the boat approached the shore. At each measurement point the boat probably coasted about 50m during the nominal 1 minute measurement. The microphone was tied to a stay (wire) on the stern (back) of the boat, approximately 3m above the water and the boat was turned so that the microphone had a clear view of the bridge. As a quick check of repeatability the measurement at 2km was repeated two hours later at a distance of 2.13 km. The results differed by 1.5 dB.

3. TRAFFIC MODELLING

A model of the bridge and its surroundings was created using Cadna/A software, which implements ISO 9613(2), and it took into account terrain, residential and built-up areas, nearby highways, road barriers and the difference between ground absorption over land and over water. The bridge itself was modeled using line sources with a sound power of 130 dBA re10^-12W, which was calculated using the RLS90 traffic noise prediction, based on typical tabulated traffic counts, traffic mix and the speed limit for the bridge traffic.

4. RESULTS

Figures 1-5 compare the measured results with the ISO 9613(2) model. The model and the measurements were compared at each octave band. The model agreed well with measurements at the lower octave bands.

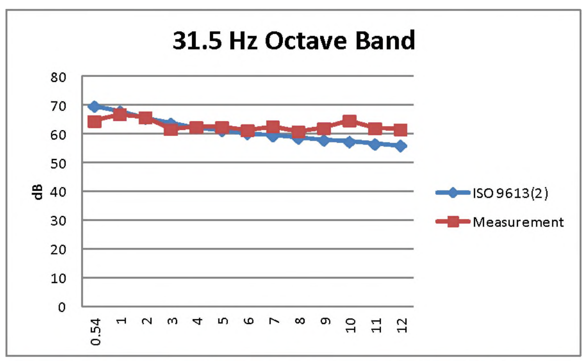

Figure 1 Comparing Model & Measurements at 31.5 Hz

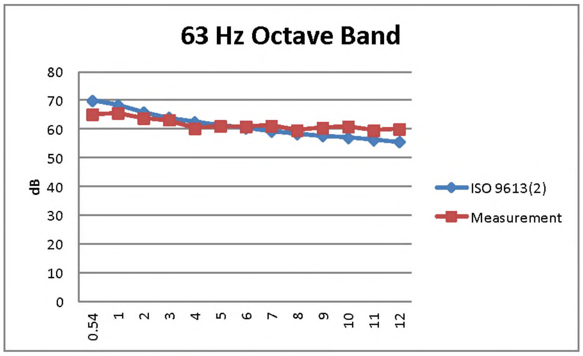

Figure 2 Comparing Model & Measurements at 63 Hz

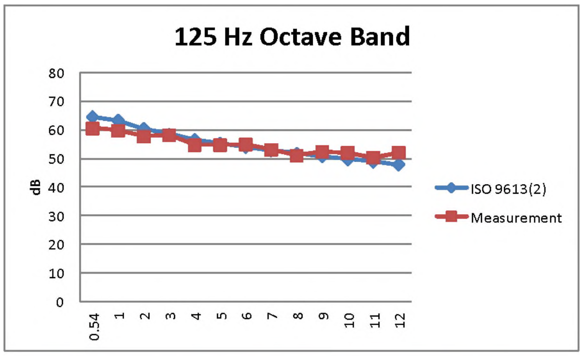

Figure 3 Comparing Model & Measurements at 125 Hz

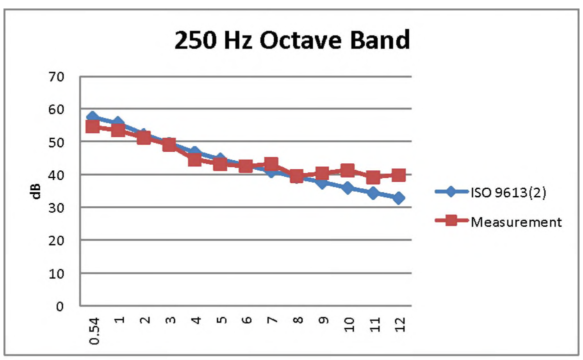

Figure 4 Comparing Model & Measurements at 250 Hz

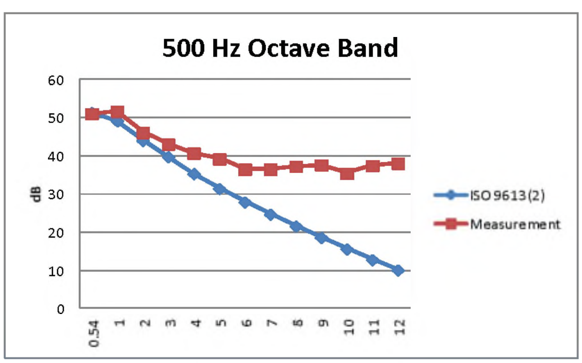

Figure 5 Comparing Model & Measurements at 500 Hz

There was good agreement at 31.5, 63, 125 and 250 Hz (Figures 1-4). The deviation was less than 4.1 dB for the 31 through 250 Hz octave bands at all measurements from 1-9 km from the bridge and less than 3.2 dB 2-8 km from the bridge. The close-in measurements were more affected by the barrier effect of the bridge deck.

At 500 Hz and above the measurements did not agree with the model at larger distances, primarily because higher frequencies drop off significantly at larger distances as air absorption becomes important, while the measured sound became increasingly dominated by the background noise of the waves hitting the hull of the boat and of wire halyards rattling inside the mast. However there was still adequate agreement out to 3-4km at 500 Hz. At 5 km air absorption at 500 Hz is already 13.5 dB and it roughly doubles for each octave above 500 Hz.

5. CONCLUSIONS

At long distances air absorption means lower frequencies dominate in any case. Even at 3 km wind turbine noise is dominated by frequencies of 500 Hz or below and at 4km by those below 250Hz. Although these are only preliminary results from a single measurement set, it appears that ISO 9613(2) may be suitable for predicting noise propagation from wind turbines over water at the distances of concern.

REFERENCES

1. ISO 9613(2) Attenuation of sound during propagation outdoors -- Part 2: General method of calculation

ACKNOWLEDGEMENTS

The Cadna modeling was done by Chloe Rourke, a Shad Valley student Intern. Initial data reduction was done by David Oliver, a student participating in Take Your Kid to Work day.