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Information Note

31.10.11

The Den Brook Amplitude Modulation Noise Condition

Introduction

The noise most commonly associated with wind farms, and frequently complained of, is the repetitive swishing beat occurring at turbine blade rotation frequency, which is known as Amplitude Modulation (AM) of the aerodynamic turbine noise. In 2007 the Government commissioned the University of Salford and the Hayes McKenzie Partnership (HMP) to investigate AM noise by means of a survey of wind farm noise complaints lodged with local authorities. At the time of publication the resulting Salford report[1] did not reveal the names of any of the wind farms with noise problems nor the specifics of the noise complaints.

The Renewable Energy Foundation (REF) submitted a Freedom of Information request to the University of Salford to obtain this data, and following a ruling by the Information Commissioner, this data was ultimately disclosed. The survey data was published in 2009[2] and revealed that a significant number of noise complaints were potentially attributable to AM noise.[3]

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[1] Moorhouse, Hayes, von Hunerbein, Piper, Adams, "Research into Aerodynamic Modulation of Wind Turbine Noise" (NANR233) July 2007. Available from: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file40570.pdf

[2] http://www.ref.org.uk/publications/151-ref-publishes-data-on-wind-farm-noise-obtained-under-the-freedom-of-information-act

[3] G. P. van den Berg, 'Why is wind turbine noise noisier than other noise?', Euronoise (2009).

There has been an increasing debate, including those at Public Inquiries into proposals for specific wind farms, about the need for an AM noise condition to protect wind farm neighbours from excessive AM noise, which has been blamed for sleep disturbance.

Of particular interest is the case of the Den Brook wind farm application. This project was consented in December 2009 following a second public inquiry during which noise issues were extensively discussed. The Inspector accepted that a planning condition to prevent excessive AM noise was both necessary and reasonable, and included a new AM condition as part of the consent.

Unfortunately, the Inspector's drafting of the terms surrounding enforcement of this AM condition was ambiguous, resulting in an appeal to the Courts, essentially for clarification. An Appeal Court decision provided that clarity by stating that the AM limits defined in Condition 20 of the Inspector's decision must be complied with for the 25 year lifetime of the planning permission.[4]

The Den Brook AM condition

The Den Brook AM condition, Condition 20 of the decision, states:

> 20. At the request of the local planning authority following the receipt of a complaint the wind farm operator shall, at its expense, employ a consultant approved by the local planning authority, to assess whether noise immissions at the complainant's dwelling are characterised by greater than expected amplitude modulation. Amplitude modulation is the modulation of the level of broadband noise emitted by a turbine at blade passing frequency. These will be deemed greater than expected if the following characteristics apply:
>
> a) A change in the measured L Aeq, 125 milliseconds turbine noise level of more than 3 dB (represented as a rise and fall in sound energy levels each of more than 3 dB) occurring within a 2 second period.
>
> b) The change identified in (a) above shall not occur less than 5 times in any one minute period provided the L Aeq, 1 minute turbine sound energy level for that minute is not below 28 dB.

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[4] See Hulme v SoS for Communities & Local Government & Ors 2011 EWCA Civ 638. Available from: http://www.richardbuxton.co.uk/v3.0/node/520.

c) The changes identified in (a) and (b) above shall not occur for fewer than 6 minutes in any hour.

Noise immissions at the complainant's dwelling shall be measured not further than 35m from the relevant building and not closer than within 3.5m of any reflective building or surface, or within 1.2m of the ground.

At first glance this condition appears complex and it has excited controversy, in part because it has been argued that it is difficult to distinguish wind farm AM noise from other noises in the environment.

We believe that it would be a useful contribution to the understanding of the potential application of the Den Brook noise condition if it were used to assess actual, i.e. real and empirical, wind farm noise data.

However there is little useful wind farm noise data in the public domain. We are fortunate in that we have recently obtained data collected by the Hayes McKenzie partnership as part of a Government contract in 2005 to investigate low frequency noise at wind farms.[5]

That this raw noise data has come into the public domain is testament to the determination of an individual who, with the assistance of the local MP and advice from the Campaign for Freedom of Information and the Information Commissioner, succeeded in obtaining the data from the Department of Energy and Climate Change in spite of a surprising unwillingness on the part of DECC officials to facilitate its release.[6]

Applying the Den Brook Noise Condition to Real Wind Farm Data

In order to demonstrate the Den Brook noise condition in application to wind farm noise data we have extracted a sample subset from the Hayes McKenzie data. This consists of noise

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[5] 'The measurement of low frequency noise at three UK wind farms', DTI 06/1412 Hayes McKenzie Partnership Ltd, 2006, http://webarchive.nationalarchives.gov.uk/+/http://www.dti.gov.uk/energy/sources/renewables/publications/page31267.html

[6] The private individual who received the data from DECC has kindly given REF a copy. The released material consists of approximately 70 GB of data on a hard drive in a format only readable using proprietary software. We have extracted some of the 100ms LAeq wind turbine noise data and would be happy to provide that as a text file on request for others to analyse.

levels (LAeq) measured at 100 millisecond (ms) intervals, where the overall level exceeds 28dB as dictated by condition 20(b). This measurement frequency is a finer level of granularity than required by the condition and a good match for the LAeq, 125 milliseconds measurements defined in 20 (a) of the condition.

The following graph shows a one minute period of this data, a time interval chosen because it is that which is specified in condition 20(b).

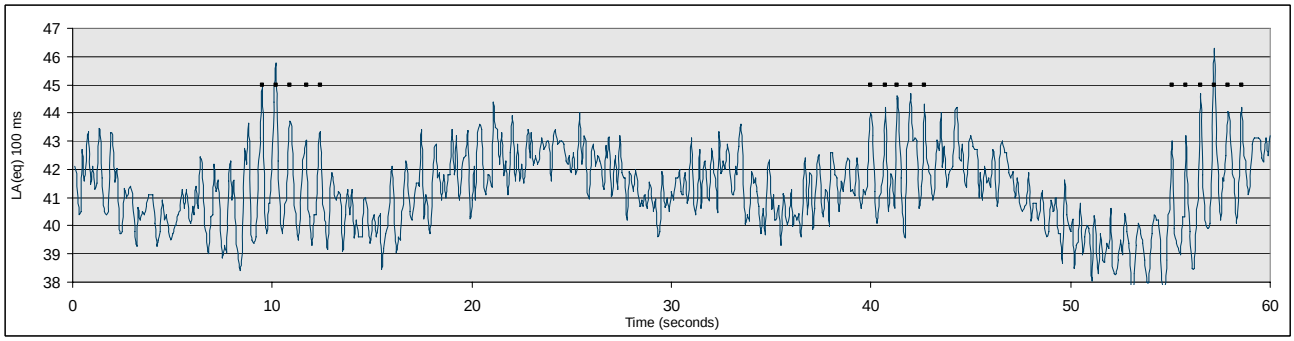

Figure 1: Period 10: One minute of LAEq (100ms) wind turbine noise levels from 14 May 2005, 03:09:00. The dots above the general noise level line show AM peaks in noise level where the rise and fall exceeds 3dB.

For this one-minute period, a breach of the AM condition requires, firstly, that the overall level exceeds 28 dB(A): the minimum level is 37.3dB(A) in this period so that requirement is met. Secondly, it requires that AM peak-to-trough changes in LA(eq) exceed 3 dB '(represented as a rise and fall in sound energy levels each of more than 3 dB) occurring within a 2 second period'. A dot has been placed above every peak in Figure 1 that exceeds 3 dB.

The following chart displays a six-second period extracted from Figure 1 that demonstrates more clearly the levels of rise and fall in each two-second period. It can be seen that in each of the three two-second periods there is at least one example of a rise and fall in noise level of more than 3 dB. These changes demonstrate a breach of the condition under the terms of 20 (a). Counting the number of similar amplitude peaks in Figure 1 (marked with a dot above the line of the turbine noise level), it can be seen that there are at least 16 in that one-minute sample. This demonstrates that this particular minute is in breach of the AM condition as described at 20 (b).

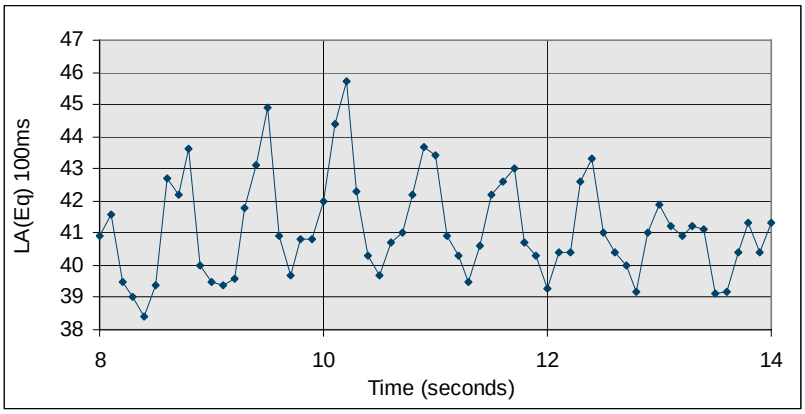

Figure 2: Period 10. The six-second period from 8–14 seconds taken from Figure 1, demonstrating the rise and fall in noise levels.

The final stage necessary to demonstrate breach of the condition is described at 20(c) and requires that there are at least six minutes in an hour demonstrating the defined level of AM. In Appendix 1 of this report we give a further five charts of one-minute periods within the same hour that also display the features typical of AM in breach of the condition.

We therefore conclude that this dataset indicates a breach of the Den Brook AM Condition 20.

It is also relevant to this discussion to consider if the amplitude modulation displayed here is attributable to wind farm noise or perhaps arises from some other noise in the environment. There are a number of ways of ensuring that the noise measured is wind farm noise, the obvious one being a simultaneous audio recording.

However, we can also inspect the noise levels displayed in the various graphs for any characteristic signature or structure, and in this case we observe that there are periods of clearly regular beats. If the wind farm is the source of the noise then the frequency of the beats will agree with the blade passing frequency of the turbines. The data in Figure 1 indicates beating approximately once per 0.7 second, corresponding to a blade passing frequency of 1.4 per second or 28 revolutions per minute, which is a plausible rate of rotation for this wind turbine. This conclusion could be verified against the SCADA (Supervisory Control and Data Acquisition) data automatically accumulated at each turbine, but unfortunately we do not have access to this information.

Conclusion

We believe that this exercise demonstrates that the Den Brook condition is straightforward and that it is possible for this condition to be employed in a transparent and objective manner to demonstrate the existence of excess AM in wind turbine noise.

The point of the current analysis is simply and solely to demonstrate the technical application of the key elements of the Den Brook noise condition to real wind farm noise data and we have shown that this is possible and can be conducted in a clear and objective manner. It should be noted, however, that we have not set out in this paper to prove that the particular wind farm in question would breach the Den Brook AM noise condition in a legal sense and indeed this AM condition does not apply to that windfarm. To do so would require evidence demonstrating that the noise measurements were compliant with the final part of the condition, namely that the measurements were taken not closer than 3.5m to any reflective building or surface, or within 1.2m of the ground, and we have no information on this matter, but if such evidence were available then legal breach of the condition could, in principle, be demonstrated.

These findings should be welcomed by both wind-farm neighbours, developers, and decision makers in the planning process. AM noise provokes complaints and heated debates, and an enforceable, objective, condition to cap such noise gives all parties clarity, as well as sparing neighbours and developers the trouble, expense, and uncertainty of private nuisance actions. The Den Brook condition appears to be a readily workable solution to this very real problem.

Dr Lee Moroney
Dr John Constable

Appendix 1

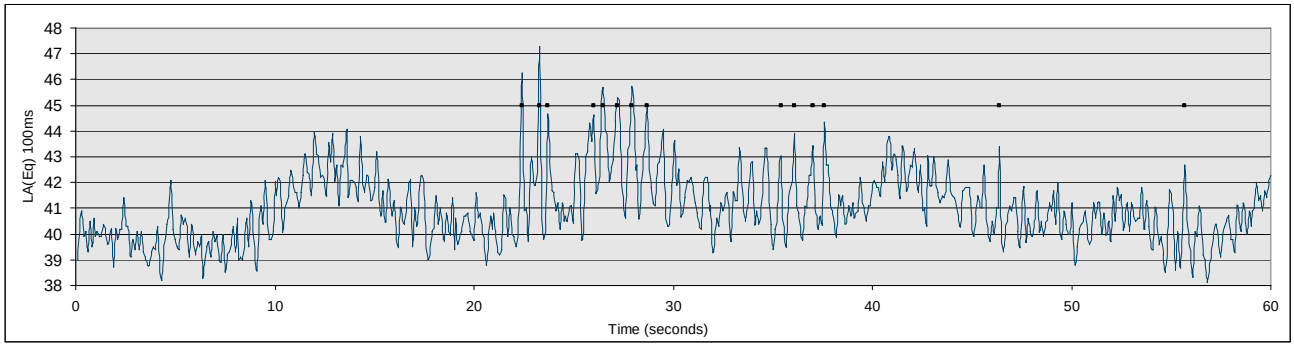

Figure 3: Period 9: One minute of LAEq (100ms) wind turbine noise levels from 14 May 2005, 03:08:00. The dots above the general noise level line show AM peaks in noise level where the rise and fall exceeds 3dB.

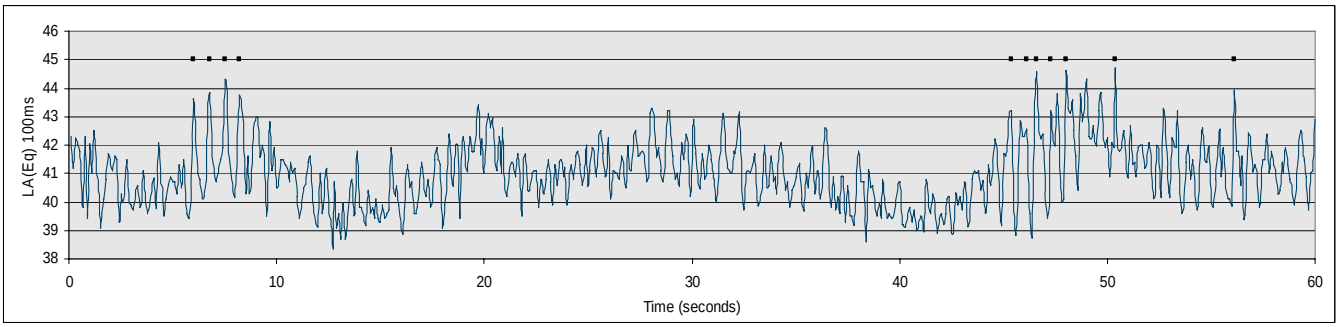

Figure 4: Period 2: One minute of LAEq (100ms) wind turbine noise levels from 14 May 2005, 03:01:00. The dots above the general noise level line show AM peaks in noise level where the rise and fall exceeds 3dB.

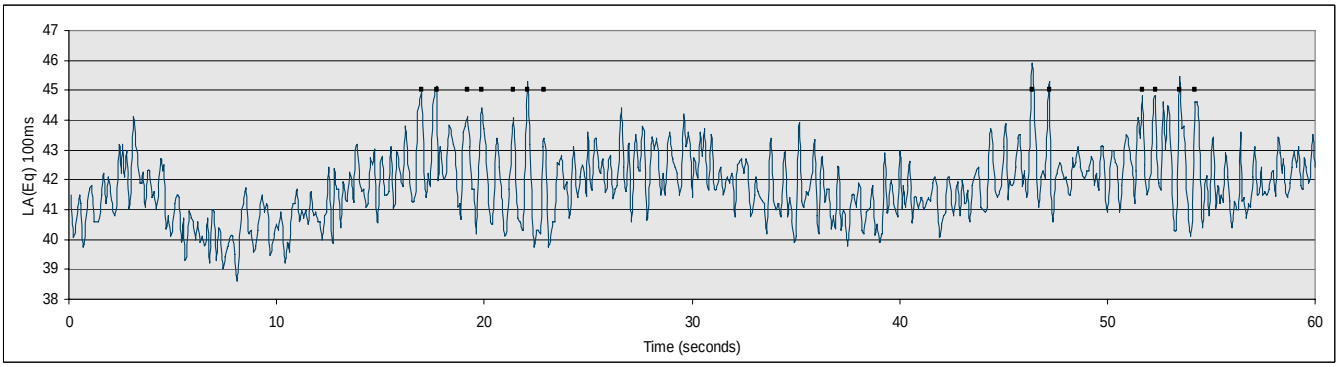

Figure 5: Period 13: One minute of LAEq (100ms) wind turbine noise levels from 14 May 2005, 03:12:00. The dots above the general noise level line show AM peaks in noise level where the rise and fall exceeds 3dB.

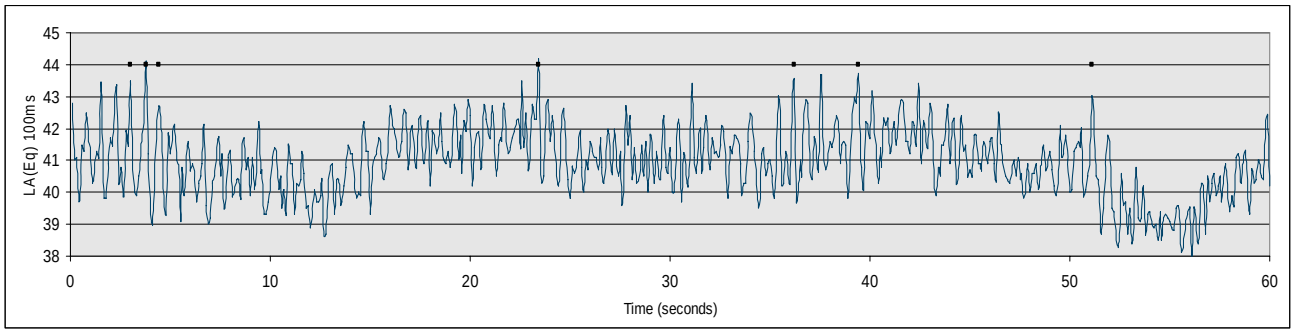

Figure 6: Period 3: One minute of LAEq (100ms) wind turbine noise levels from 14 May 2005, 03:02:00. The dots above the general noise level line show AM peaks in noise level where the rise and fall exceeds 3dB.

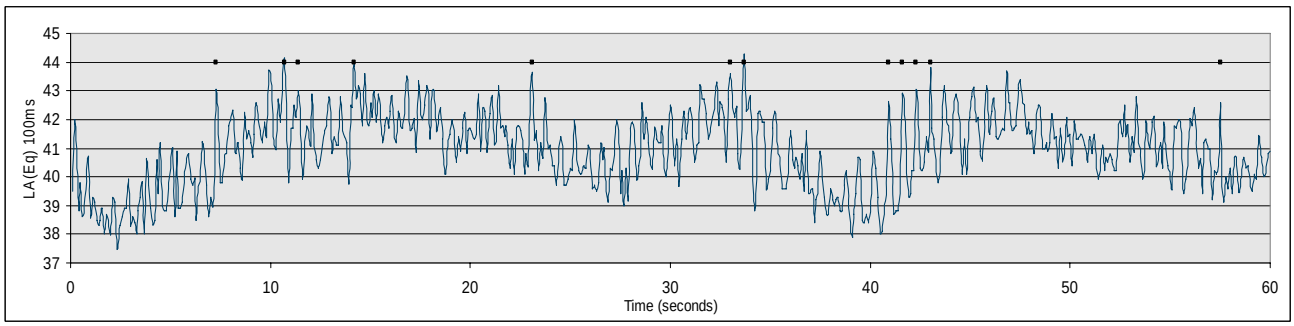

Figure 7: Period 6: One minute of LAEq (100ms) wind turbine noise levels from 14 May 2005, 03:05:00. The dots above the general noise level line show AM peaks in noise level where the rise and fall exceeds 3dB.