Characterization of Sound Emitted by Wind Machines Used For Frost Control

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Introduction

Wind machines are tall (~ 10m high), fixed-in-place, engine-driven fans that pull warm air down from high above ground during a strong thermal inversion [1], raising air temperatures around cold-sensitive crops such as grapes and tender fruits, thereby protecting crops from cold-injury. Fan diameters are typically about 5.4 m to 6.0 m and fan RPM ranges from 375 to 525. A single machine covers about 10 acres of crops as it rotates slowly over 360 degrees at a rate of about 4.5 to 6.5 minutes per revolution.

Figure 1: Typical wind machine in a vineyard

The number of wind machines has about double annually from a handful in the late 1990's to more than 425 in 2006[2]. proliferation of wind machines has occurred mainly in Niagara-on-the-Lake's (NOTL) grape growing area has led to noise complaints: 'it sounds like a helicopter'; 'there's a droning-sound', 'it's a thumping-sound', 'my dishes are vibrating', and 'it is worse upstairs in the bedrooms'.

There are no environmental impact controls for wind machines in Ontario. Farmers are protected from nuisance complaints under Ontario's *Farming and Food Production Protection Act, 1998*, providing that the nuisance is created as a result of a normal farm practice. A 3-year applied research project commenced in November 2005 to establish best environmental management practices so the use of wind machines would be limited to those times when absolutely needed to protect crops from damage. One part of this project entailed the characterization of the sound as discussed in this paper.

Noise Generation by Wind Machines

As the orientation of the fan changes, so does the sound pressure level at a fixed point in the far field. The expected pattern is illustrated in figure 2.

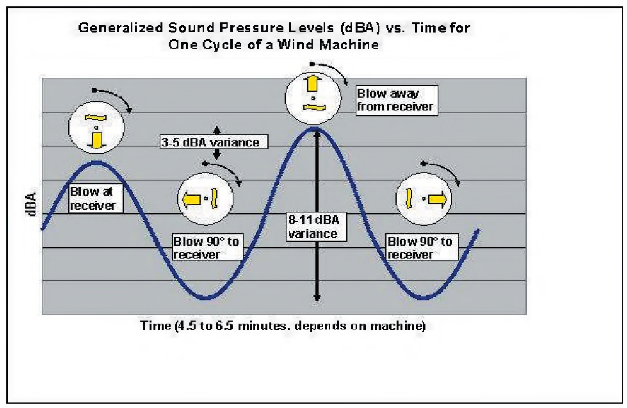

Figure 2: SPL vs. time over one rotation cycle

The sound levels vary in a sinusoidal fashion, the period being of the order of a few minutes; level changes of up to 11 dBA have been measured. The highest levels are observed when the machine blows away from the receiver. .

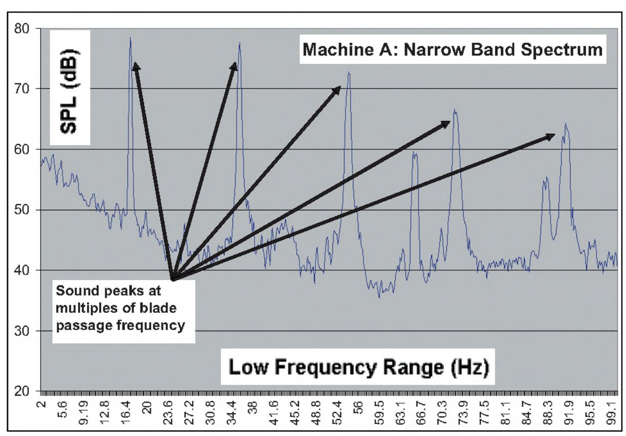

Figure 3: Narrow band spectrum a wind machine.

The predominantly low frequency sounds can penetrate homes and excite a variety of acoustic-standing waves and structural-resonant modes within any given dwelling space. This may lead to annoyances that are at times perceived to be worse inside than outside[3,4].

Figure 4 shows the amplitude time history measured inside a dwelling[5]. The data is presented in with different weightings. A strong correlation is observed between the vibration velocity (as measured on an interior dwelling wall) and infrasound levels measured (dBG)[6]. In contrast, the dBA levels do not track the level changes with any degree of consistency.

Conclusions

A limited number of measurements have been conducted and it is clear that there is still much to be studied about the various operating scenarios under which this equipment is operated. However, the following conclusions can be drawn about wind machines.

- Noise from wind machines is due to both aerodynamic and mechanical effects, but aerodynamic sounds are deemed to be the most significant.
- There is evidence of low frequency blade slapping or impulsive sounds, during little to no winds (<5kph) and especially in the presence of mild to moderate ambient winds (5 to 10kph).
- The A-weighting descriptor has deficiencies in depicting noise from wind machines.
- Low frequency and infrasonic energy from wind machines is capable of exciting components such as floors, walls roofs and windows that comprise a building structure, thus causing increased annoyance potential.
- Perceptible infrasound is present at some receptors that are in proximity to wind machines.

References

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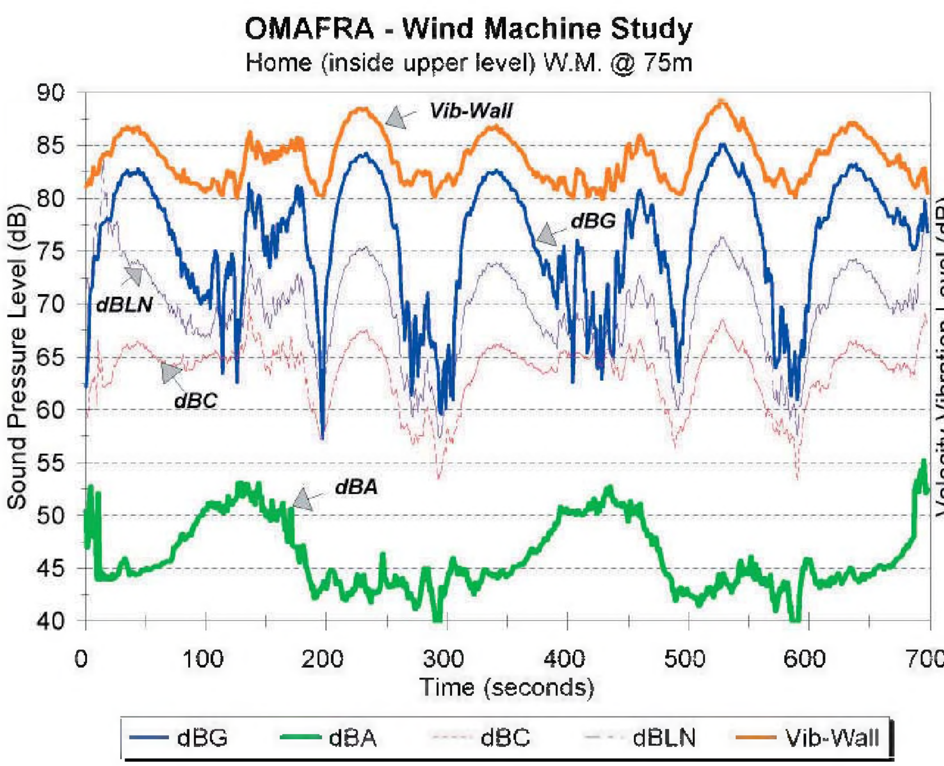

Figure 4: Weighted SPLs (A, C, G, Lin, & Vel.) vs. time over two cycles of a wind machine