NOISE MODELLING VERSUS REALITY UNDER WORST-CASE METEOROLOGICAL CONDITIONS

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1. INTRODUCTION

A constant challenge to acoustic consulting professionals is community sensitivity to noise versus the reality of an adverse noise impact from an industrial neighbour.

Conestoga-Rovers & Associates (CRA) was retained to investigate intermittent noise complaints about an energy Facility. The power generating Facility provides energy to the grid 24-hours per day and is a source of constant and steady state noise emissions. The local government received intermittent noise complaints from adjacent residential neighbors and requested an investigation.

An extensive ambient noise monitoring program was conducted and compared to theoretical noise modelling predictions for the Facility to determine if the perceived adverse impact was reality.

2. METHOD

2.1 Standard ISO 9613-2 Modelling Standard

The Facility's significant environmental noise sources included two landfill gas generator exhausts and two roof mounted radiator units.

A combination of source measurements and manufacturer sound level data were used to develop a standard acoustic model using ISO 9613-2 "Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation." ISO 9613-2 is based on the principle of "predictable worst-case" where downwind propagation is projected for all sources to all receiver locations simultaneously under wind speeds of between 1 to 5 metres per second (m/s) [1].

The off-site noise impacts were evaluated for the nearest surrounding sensitive residential receivers approximately 450 metres (m) (POR1) and 700 m (POR2) from the Facility. The noise impacts predicted at all receivers were below the most stringent government rural nighttime noise limit of 40 dBA.

A far-field audit measurement was conducted on-site for comparison and validation of the acoustic model set-up parameters and to confirm the dominant noise sources. The audit location was approximately 30 m straight-line distance southwest of Generator 2 at an extended microphone height of 4 m above grade, with clear lines of sight to all major noise sources. The modelled noise impact predicted 61 dBA at the audit location, and the audit measurement was 61.5 dBA, which shows good agreement with the modelling work. The exhaust and radiator sources were audible but the exhausts were predominant at the audit measurement location.

2.2 Sound Level Monitoring Program

The Facility is a continuous and steady state noise source, which interrupts operation for temporary maintenance shutdown periods only. Although the noise emissions from the Facility and equipment are constant and do not fluctuate, intermittent noise complaints continued, prompting CRA's investigation. The monitoring was conducted for an extended time period in order to capture a variety of meteorological conditions in an attempt to understand the irregularity of noise complaints received by the government.

Continuous 24-hour environmental sound level monitoring was conducted in March 2010 under late winter conditions (no foliage, minimal snow cover and zero noise influence from wildlife and insects). Type 1 precision sound level monitoring and continuous data logging systems were established approximately 3 to 4 metres (m) from the most exposed façades of the two residences (POR1 and POR2) and the microphones were extended approximately 3 m above grade. A sound recorder was also set-up at one residence (POR1) and audio samples were collected when the environmental noise reached or exceeded the 40 dBA noise limit.

The one-hour Leqs, excluding extraneous background and weather noise influence, representative of noise impact from the Facility generally occur during the quietest nighttime period between the hours of approximately 12 a.m. and 4 a.m. when non-Facility background noise influence was minimal.

3. RESULTS

3.1 Monitoring Program Results

The sound level-monitoring program determined that under select down wind and atmospheric conditions the off-site environmental noise impact from the Facility at POR1 is significantly increased from 44 dBA to 46 dBA. Under downwind conditions, POR2 also experienced increased sound levels from 38 dBA to 42 dBA. The measured sound levels exceed the 40 dBA limit at the nearest residences, which confirmed an adverse noise impact was being experienced at night. However, when winds were blowing upwind and opposite from the Facility, sound levels at the receivers were measured as low as 33 dBA to 35 dBA.

The ISO 9613 standard modelling protocol was under-predicting the noise impact at POR1 and POR2 by approximately 5 dBA.

3.2 Meteorological Data Analysis

CRA evaluated 5 years of meteorological data specific to the site from 2004 to 2008 and a windrose was generated. The 5-year data analysis was useful in order to determine wind speeds and the overall frequency in which the wind was blowing from the Facility toward each complainant POR based on the critical downwind directions of 345 degrees for POR1 = 3%, and 40 degrees for POR2 = 8%.

The 5-year meteorological data analysis determined an average wind speed of 4 m/s. Wind induced sound is estimated to be approximately 40 dBA.

ISO 9613-2 [1] allows for a meteorological correction, using the following equation:

$$Cmet = C_0 [1 - 10(H_s + H_r) / d_p]$$

Where

h_s is the source height (m)

H_r is the receiver height (m)

d_p is the distance between the source and receiver (m)

C_0 is a factor, in decibels, which depends on local meteorological statistics for wind speed and direction and temperature gradients

The correction accounts for conditions that are unfavorable to propagation as experienced by the off-site receivers POR1 and POR2.

ISO 9613-2 states, “Experience indicates that values of C_0 in practice are limited to the range of zero to approximately +5 dB, and values in excess of 2 dB are exceptional” [1]. The ISO 9613 standard modelling protocol was under-predicting the actual noise impact experienced at POR1 by approximately 5 dBA, which confirmed the practical findings of ISO 9613 and the need for a meteorological correction for the Facility.

The standard model protocol was adjusted to evaluate the true worst-case based on receiver-specific wind speed and wind direction. The frequency of these critical downwind conditions were very low overall, and therefore any noise impact assessment specific to these conditions can be considered extremely conservative, or “exceptional” per ISO 9613, but justified as the cause of noise complaints. A “D - Neutral” atmospheric stability class was used.

The modelled downwind noise impacts are very comparable to the sound level range measured under downwind conditions in March 2010 as follows:

Point-of-Reception	Model Name	Model Result	Monitoring Result Range
POR1	Downwind Conditions at POR1 (4 m/s wind, D stability class)	44.7 dBA	44 to 46 dBA (40 wind + 44.7 Facility = 46 dBA)
POR2	Downwind Conditions at POR2 (4 m/s wind, D stability class)	38.3 dBA	38 to 42 dBA (40 wind + 38.3 Facility = 42 dBA)

4. DISCUSSION

Acoustic professionals must be aware that the unadjusted ISO 9613-2 equations may under-predict the environmental noise impact by up to 5 dBA and critical for sensitive acoustic environments such as rural areas that experience low background noise and have direct line of sight noise exposure.

Meteorological data must be analyzed to determine the appropriate receiver-specific meteorological conditions to evaluate the predictable worst-case.

REFERENCES

ISO 9613-2: 1996(E) Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation.