EVALUATION OF THE ZWICKER METHOD AS A SUITABLE ENVIRONMENTAL NOISE MEASUREMENT TECHNIQUE

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Background: Environmental noise is a common by-product of industrial energy facilities. Many of these energy facilities have components which radiate a considerable amount of acoustical energy. The acoustical energy may consist of high or low frequencies often containing prominent tonal components. Some of the characteristic sources responsible include compressors, diesel engines, fans, pumps, etc.[1]

The Energy and Utilities Board (EUB) is the primary regulator of the energy industry in Alberta. The EUB maintains a receptor based Noise Control Directive which utilizes an A-weighting Energy Equivalent Sound Level ($L_A$eq) to regulate environmental noise. The $L_A$eq with the unit dB(A), is a metric that emphasizes the middle frequency components similar to the frequency response of the human ear. It simply compresses sound from a broadband of frequencies into a relative response of the middle frequency band (1000-2000 Hz) by eliminating low frequency sounds. This measurement scale is well suited for measuring broadband noise. The Noise Control Directive is receptor based, meaning that it measures the noise of a facility at some distance away. Higher frequency sounds emitted from facilities tend to diminish over distance leaving predominantly low frequency sounds. As a result, it could be said that from the receptor stand point, the energy facilities emit low frequency sounds. Although $L_A$eq is readily accepted as a standard community noise metric it may not fully quantify the true impact of energy industry noise at a distant residence.

Project Scope: Based on this and the EUB experience in dealing with noise complaints, a research program was initiated in 1995 to determine if there was a better method to measure and quantify the dominant low frequency sounds of the energy industry. A method was required that would recognize low frequency sounds and capture the impact of any tonal components. Affected residents often described the tonal component sounds as being the most annoying.

Earlier work by the EUB began research into the Zwicker Method for calculating loudness as described in the ISO 532 Method B as a potential supplemental metric system. The Zwicker Method met the necessary criteria and testing has been ongoing to understand how it might be applied within the framework of the EUB Noise Control Directive.[2] The idea was to develop a supplement to the $L_A$eq measurement if possible.

Research Phase: The techniques employed were carefully chosen and controlled to obtain valid and consistent results. This included the effects of meterological factors, no abnormal activities in the vicinity of research testing, suitability of monitoring location to a noise source, topographical features, etc.[3] With this in mind, the type of sound measurements conducted were series of instantaneous linear, slow response 1/3 octave band measurements. This measurement method produced a frequency spectrum of the sounds. The results were converted to loudness using Zwicker's method and placed into a number of statistical models for analysis and assessment.

Primarily, measurements were conducted at residences near energy industry facilities, however, to obtain a better perspective of loudness results in general, various other ambient measurements were taken. These included natural background sounds, highway traffic, rivers, and other non-energy related industries. Along with the noise surveys, a resident survey was conducted to help determine the quality of the noise and how it affected them. The survey consisted of ten questions designed to understand the way the noise was perceived by the residents and to gauge their level of satisfaction with the industrial operator in case there was some other root concern besides noise.

Evaluation of Results: Analysis of the data concluded that loudness quantifies low frequency noise and tonal components more effectively than the current $L_A$eq method. If used, loudness results should be converted into $L_A$eq using an appropriate technique. However, loudness cannot distinguish between pleasant or annoying sounds. Using loudness measurements for all complaints would hardly be warranted and would effectively result in setting an artificially lower permissible sound level at residences. This is clearly unacceptable as it would unfairly penalize some industry operators. The resident survey questionnaire should be used to determine noise perception and quality as the first step in the assessment for conducting loudness calculations and applying any resulting adjustment factor to compliance survey results.

References:

1. "Environmental noise criteria for pure tone industrial noise source." J.G. Lilly, Noise-Con 94 (May 94).
2. "The application of loudness in environmental noise legislation for the energy industry." David C. DeGagne and James G. Farquharson, Inter-noise 95 (July 95).
3. "Noise Control Directive ID 94-4" Alberta Energy and Utilities Board (August 94).