LOW FREQUENCY HVAC NOISE ASSESSMENT

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Introduction There has been much interest over recent years in the issue of assessment of low frequency noise. One of the main issues is whether Loudness and Annoyance is the same at low frequencies (< 100 Hz). For example, Broner and Leventhall [1] established that loudness based metrics did not properly assess low frequency noise complaints. In a similar way, Zwicker [2] pioneered recognition that to determine annoyance, sound quality factors such as fluctuation strength would need to be considered in addition to a simple loudness metric. This recognition has not yet resulted in a change away from the old and purely loudness-based assessment metrics such as the dBA or NCB. Below we report on the results of recent research sponsored by ASHRAE.

Noise Stimuli And Subject Testing For the purpose of the testing, a total of 60 HVAC noise stimuli with varying degrees of low frequency content were used. These had characteristics that could be described as Neutral, Neutral marginal, Rumble and Strong Rumble. Each noise stimulus was presented for 10 seconds, followed by a 10 second period of silence during which the subjects rated the test stimulus for both Loudness and Annoyance and other attributes. Figure 1 below shows a SPL vs. Time trace for part of one the sequences. The figure shows five stimuli separated by five periods of silence. The different temporal characters of the stimuli can be easily seen.

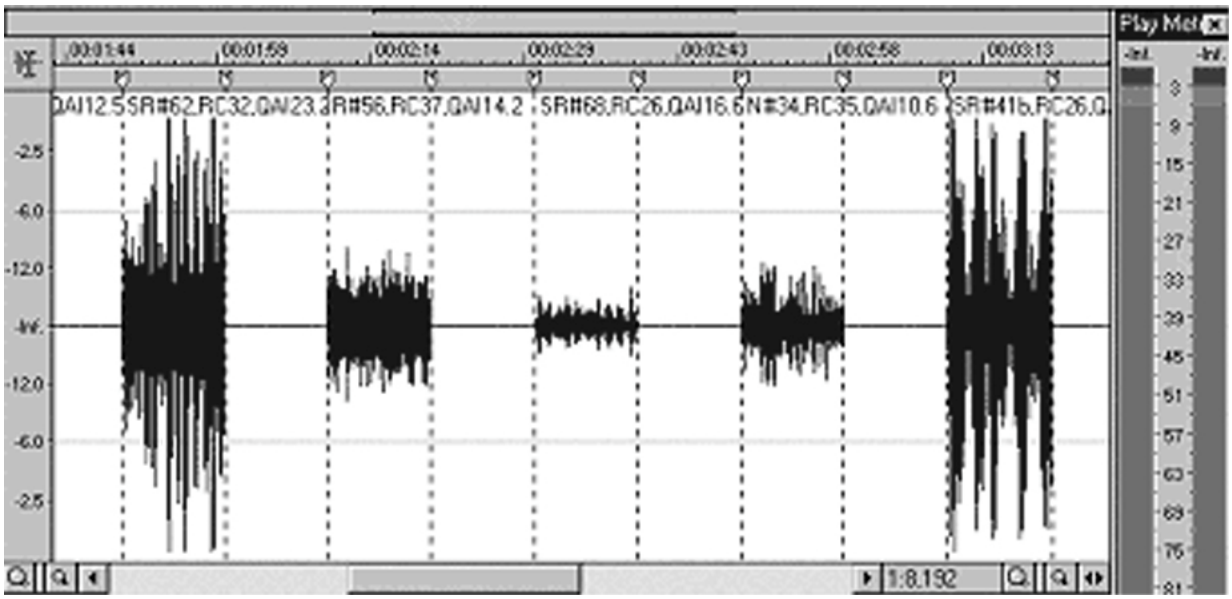

Figure 1 SPL vs. Time trace for part of Sequence C.

Response Rating To determine the subjective response of subjects for both loudness and annoyance, the Absolute Magnitude Estimation method was used. In this psycho-acoustical method, the subject assigns a rating number to the perceived loudness or annoyance without the use of a reference. This method has been used previously to characterise perception of loudness eg [3].

Test Method The subjects were seated at a desk in the Vipac psycho-acoustic test room and completed the rating task by means of keyboard on a laptop computer. This room has a double wall construction and is floated on isolators so as to minimise any noise intrusion from the outside. The room is 6700 long by 3100 wide by 2350 high and is a reasonably sized meeting room. Eleven male subjects average age 36 years and ten female, average age 30 years were used. All subjects reported normal hearing. The Group Mean Loudness and Annoyance for each stimulus was then obtained and the Annoyance-to-Loudness (A/L) ratio was also calculated. The subjective responses were then plotted against various noise metrics to determine if any relationships existed.

Results Figure 2 shows that the A/L ratio varies over a range of 0.9 to 2.0 and that the A/L ratio can be quite different for stimuli with very similar A-weighted SPL. Indeed, the coefficient of determination is very close to zero, thus showing that the A-weighted SPL alone will not be a good predictor of response, and in particular, of Annoyance relative to Loudness.

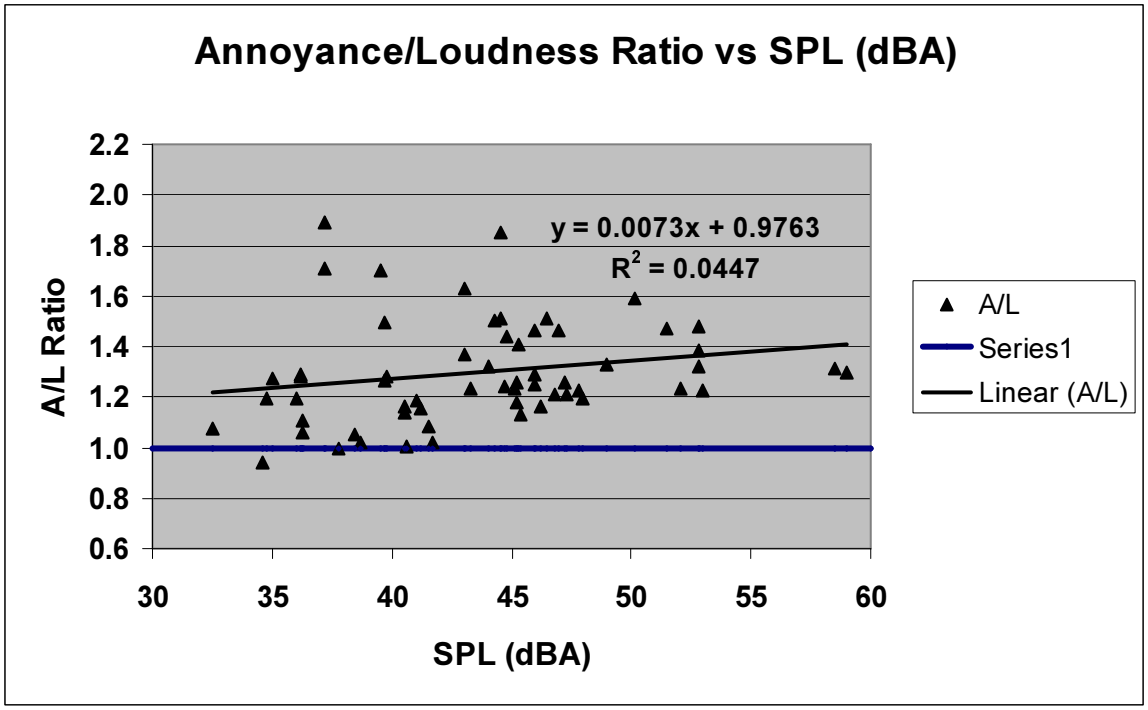

Figure 2 Annoyance/Loudness Ratio versus SPL (dBA)

The strong implication of these results is that, for HVAC noises with rumble and temporal variations, the loudness and annoyance *cannot* be assumed to be the same. This research suggests that a revision to the NCB curves at low frequencies (< 100 Hz) may be appropriate.

References

1. Broner N. and Leventhall H. G. "Low Frequency Noise Assessment by Low Frequency Noise Rating (LFNR) Curves" J. Low Frequency Noise and Vibration, 2(1), 20 –28, 1983
2. Zwicker, E. "On the Dependence of Unbiased Annoyance on Loudness" Proc InterNoise 89, 809-814, 1989
3. Canevet, Hellman and Scharf "Group Estimation of Loudness in Sound Fields" Acustica, 60, 277-282, 1986