STANDARD METHODS AND CRITERIA CONSIDERATIONS FOR RESIDENTIAL NOISE COMPLAINTS

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1 Introduction

Acoustic consultants receive many inquiries about noisy neighbours, particularly from occupants of multi-unit residential buildings. There are currently no standards or regulations that objectively define thresholds for what is considered an annoyance or unacceptable noise intrusion. Noise intrusion can diminish quality of life, increase stress, and interrupt sleep. Long-term health effects are also likely (WHO [1]) without considering additional stress from conflict with a neighbor.

Legal counsel is often sought, which can be futile without standard criteria. The only reprieve for most chronic noisy neighbour problems is attained when someone moves.

The intent of this paper is to review the literature, outline major components for consideration in the development of a standard procedure and criteria, and recommend a standard method and criteria for discussion.

2 Literature review

2.1 Canadian codes and by-laws

The 2010 National Building Code of Canada (NBCC) [2] has been either fully or largely adopted by all of Canada's provinces. The only acoustic requirement of the NBCC is for dwelling 'separation' construction. Current provincial codes reference the 2010 NBCC which requires a minimum STC 50 between adjacent units. The 2015 NBCC [3] has been revised to a minimum requirement of ASTC 47 between dwelling units, which is likely to be adopted in future versions of provincial building codes.

In both cases (STC and ASTC) the focus is on element construction with no published discussion about assumed activities and noise levels (talking, sound systems, etc.) or background noise levels, which are both critical components to the full discussion on neighbourly annoyance and peace.

Many Canadian by-laws limit sound intrusion at the property line in residential areas to 55/45 dBA for day/night-time or they have a 'shall not disturb the peace and quiet of neighbours' type of statement. The by-laws are largely limited to exterior property lines and steady or pseudo-steady (repeated) sounds such as dogs barking.

2.2 Guidelines

The Canadian Mortgage and Housing Corporation (CMHC) advocates on behalf of Canadian tenants and homeowners, publishing many research-based guidance documents.

Most of their acoustic documents relate to environmental and building services noise; however, Morin and Guerin [4] suggest a protocol for assessing and rating the acoustical comfort of a building based on several factors. For fluctuating or transient noise sources (elevators, garbage chutes or plumbing), they recommend limiting $L_{max,imp}$ to below NC 20. The Facility Guideline Institute (FGI [5]) recommends an hourly $L_{eq,slow}$ of 45 dBA and an L10 of 50 dBA with a transient sound limit of 65 dBA $L_{max,slow}$ for sleep areas in hospitals.

The World Health Organisation (WHO) [1] suggests that an internal $L_{eq,fast}$ of 30 dBA is needed to prevent negative effects on sleep and health. For non-continuous noise, sleep disturbance correlates best with $L_{max,fast}$ with effects observed at 45 dBA or less. They suggest that the number of $L_{max,fast}$ events (not to exceed 10-15 per night over 45 dBA) and the difference between $L_{max,fast}$ and $L_{eq,fast}$ levels must be taken into account. Lower limits are recommended for sensitive people. WHO also state that indoor noise during the daytime should not exceed an $L_{eq,fast}$ of 35 dBA to limit annoyance to 'moderate'. To address low-frequency noise, WHO recommend a frequency analysis and lower limits if the difference between dBA and dBC is greater than 10 dB.

The WHO Night Noise Guidelines for Europe [6] suggests that an indoor $L_{max,fast}$ of 45 dBA is likely too high for limiting sleep disturbance, based on newer research.

2.3 Scientific community

The authors were unable to find published research that specifically addresses the problem of noisy neighbours.

Park and Bradley [7] provide an indication of level of annoyance relative to various noise metrics. They found reasonable correlation between annoyance and the simple A-weighted signal-to-noise ratio (SNR(A)) for both music and speech. They recommend modifications to many conventional assessment methods, including the SNR(A), to improve correlation with annoyance. The study indicates that people become 'moderately annoyed' when the SNR(A) is approximately 2 dB for speech and music.

3 Considerations for a standard assessment

3.1 Source, receiver, and transmission path

The critical components in a noise annoyance study are the source, transmission path, and receiver.

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Common sources are raised voices, footsteps, children, pets, TV, music (including via subwoofers), intimacy, musical instruments, construction, building systems, and cooking (banging of pots, pans, cupboards, or dishes). People vary in awareness of the effect of their activities, their concern for others, and/or their right to enjoy their own space as they please.

Common receiver activities are sleeping, reading, focused work (computer work), meal times, watching TV, and cooking. The time of day and demographics (coupled with expectations) can significantly affect the response of receivers. Background noise levels in a receiver dwelling can make intrusive noises more audible if too low.

Canadian building codes address the transmission path based on assumptions of source levels (regular talking, TV) and background noise levels in the receiver space (30 dBA). These assumptions have no longer kept up with society as sub-woofers and low (<25 dBA) interior background noise levels have become more commonplace.

3.2 Assessment measurements

Most intrusive noise sources that garner complaints are intermittent, ranging from relatively predictable or completely random with respect to time of day, frequency of occurrence, and duration. Measurements will be either short-term attended or long-term unattended. Short-term measurements can be time consuming and may not capture an event, but provides the benefit of witness to the events. Long-term unattended monitoring is more likely to capture the offending sounds, but requires recordings to confirm noise sources; however, recordings compromise privacy for residents, if they are present during monitoring.

3.3 Metrics and criteria

The intent of sound measurement metrics are to provide a simple numerical representation of how the average person is expected to respond to a particular sound. Some things to consider (in combination) include: integration time (slow/fast/impulsive/peak), measurement duration/averaging time (1 s to 24 hr), level type (L_{max}, L_n, L_{eq}, SEL), event definition (level, number, duration), frequency (broadband, octave band, 1/3rd-octave band, narrow-band, and the frequency range included in each), and tonality (directly or indirectly).

If the metric(s) chosen are appropriate, then criteria become easier to define. Criteria should consider: levels, definition of day/night, events (level, quantity, duration), background levels, intermittency, and character (tonality).

4 Recommended method and criteria

Measurements must be taken in an unoccupied space with a 'Type I' sound level meter in the 'fast' setting, can be attended and/or unattended, and should include recordings for post-processing and source verification of events. The metrics and criteria provided in Table 1 should be met in all 1/3rd-octave bands from 50 Hz to 10 kHz for both airborne and impact noise intrusion.

Table 1: Proposed noise intrusion assessment criteria

Evaluation Metric (in each 1/3rd-octave band from 50 Hz to 10 kHz)	**Daytime (7am to 9pm)**	**Nighttime (9pm to 7am)**
$L_{eq,1hr}$	$L_{90,1hr}$ +2 dB	$L_{90,1hr}$ +2 dB
L_{max} threshold (L_{MT})	$L_{90,1hr}$ +12 dB	$L_{90,1hr}$ +12 dB
# L_{MT} exceedances allowed	28/day*	10/night*
# L_{MT}+5 dB exceedances	14/day*	0/night

*Note: Cumulative number of events inclusive of all 1/3rd-octave bands

The basis of the proposed assessment criteria is a signal-to-noise (SNR) ratio that uses $L90_{1hr}$ to represent the interior background sound level (i.e., 'noise') with allowable 'signal' levels based on Park and Bradley [7] ($L_{eq,1hr}$), and WHO [1] (L_{max} and number of exceedances). Using SNR provides dynamic criteria that are expected to align well with perception and annoyance.

Further, our experience has demonstrated that simplification to broadband metrics is insufficient for evaluating noise intrusion issues because background and intrusive sound spectra often differ significantly. We have therefore recommended evaluation in 1/3rd octave bands.

5 Limitations and intent

This paper outlines many of the considerations around residential noise complaints, but excludes the practicality and complexities related to political, social, economic, market, and other forces that would influence and be influenced by the intended standard criteria.

The intent of the proposed standard criteria is to hold neighbours accountable for the noise they create, regardless of construction (i.e., if noise transmits easily, extra care is required).

A further goal of this paper is to initiate the future development of an appropriate national or international standard criteria and method for assessment. Further research to confirm the proposed metrics and criteria are expected.

References

[1] World Health Organization (WHO), Guidelines for Community Noise, 1999.

[2] National Building Code of Canada, 2010.

[3] National Building Code of Canada, 2015.

[4] M. Morin and J.M. Guerin, Research Project on the Qualification of the Degree of Acoustic Comfort Provided by Multi-Family Buildings – Phase II. Revised and translated June 5, 2012 by Michel Morin. Original report submitted to Canada Mortgage and Housing Corporation (CMHC), December 17, 2002.

[5] Facility Guidelines Institute (FGI), Sound and Vibration Design Guidelines for Healthcare Facilities, Public Draft 2.0, 2010.

[6] World Health Organization (WHO), Night Noise Guidelines for Europe, 2009.

[7] Park. H.K. and J.S. Bradley, Evaluating Signal-to-Noise Ratios, Loudness, and Related Measures as Indicators of Airborne Sound Insulation, *JASA* 126, 1219, 2009.