A Comparison of Threshold versus Annoyance Based Noise Criteria

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For twenty-five centuries, Western knowledge has tried to look upon the world. It has failed to understand that the world is not for the beholding. It is for hearing. It is not legible, but audible. Our science has always desired to monitor, measure, abstract, and castrate meaning, forgetting that life is full of noise and that death alone is silent: work noise, noise of man, and noise of beast. Noise bought, sold, or prohibited. Nothing essential happens in the absence of noise.

- Jacques Attali

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Introduction

- Threshold and Annoyance based methods are both used to establish regulatory criteria
- Alberta regulation (ERCB/AUC) is threshold based
- Federal (CEAA) assessments prefer annoyance based criteria, per Health Canada guidance
- Both focus on noise levels at receptors

Introduction

- The indicators used for the Alberta and Federal criteria are not directly comparable, often resulting in additional analysis when joint EIAs are completed
- This analysis provides a comparison of the ERCB threshold criteria to the annoyance criteria preferred by Health Canada

NOISE, *n*.

A stench in the ear. Undomesticated music. The chief product and authenticating sign of civilization.

- *Ambrose Bierce*

The Devil's Dictionary

Threshold Criteria – ERCB Directive 038

- ERCB Noise regulation is Directive 038: *Noise Control*
- The criteria is a Permissible Sound Level (PSL)
  - Determined using set values for ambient noise level based on density of development and presence of transportation routes
- Key indicators are the $L_{eq(day)}$ and $L_{eq(night)}$ measured in dBA

Threshold Criteria – ERCB Directive 038

- The PSL is derived from a basic sound level (BSL), adjusted for other extraneous conditions, where warranted
- In most cases, the BSL (Table 1 of Directive 038) becomes the PSL for the nighttime period
- The daytime PSL is 10 dBA higher than the nighttime PSL
- The PSL allows for 5 dBA of noise above the ambient sound level (ASL)

Threshold Criteria – ERCB Directive 038

Table 1: Basic Sound Levels for Nighttime

	Dwelling unit density per quarter section of land		
Proximity to transportation	1 - 8 dwellings; 22:00 - 07:00 (nighttime) (dBA Leq)	9 - 160 dwellings; 22:00 - 07:00 (nighttime) (dBA Leq)	>160 dwellings; 22:00 - 07:00 (nighttime) (dBA Leq)
Category 1 (>500m)	40	43	46
Category 2 (<500m)	45	48	51
Category 3 (<30m)	50	53	56

Table Source: Energy Resources Conservation Board (ERCB 2007). *Directive 038: Noise Control.* (Revised Edition February 16, 2007). Alberta, pp. 8

The typewriting machine, when played with expression, is no more annoying than the piano when played by a sister or near relation.

- Oscar Wilde

Annoyance Criteria – Health Canada

- For CEAA assessments, Health Canada has issued an updated draft Guideline (February 2011)
- Guideline outlines primary Health Canada concerns as occupational, sleep disturbance for on-site camps, speech comprehension, and complaints or annoyance at off-site receptors

Annoyance Criteria – Health Canada

- Preference for an analysis based CAN:ISO 1996-1:2003 *Acoustics – Description, measurement and assessment of environmental noise*
- Portions of ANSI Standard 12.9-2005/Part 4 are used to address low frequency noise or high energy impulsive (blasting)
- Key indicators are the L_{dn} (DNL) and % HA (highly annoyed)

Annoyance Criteria – Health Canada

- L_{dn} values are determined and penalties attributed based on character of sound
- The % HA is determined using the Schultz Curve:

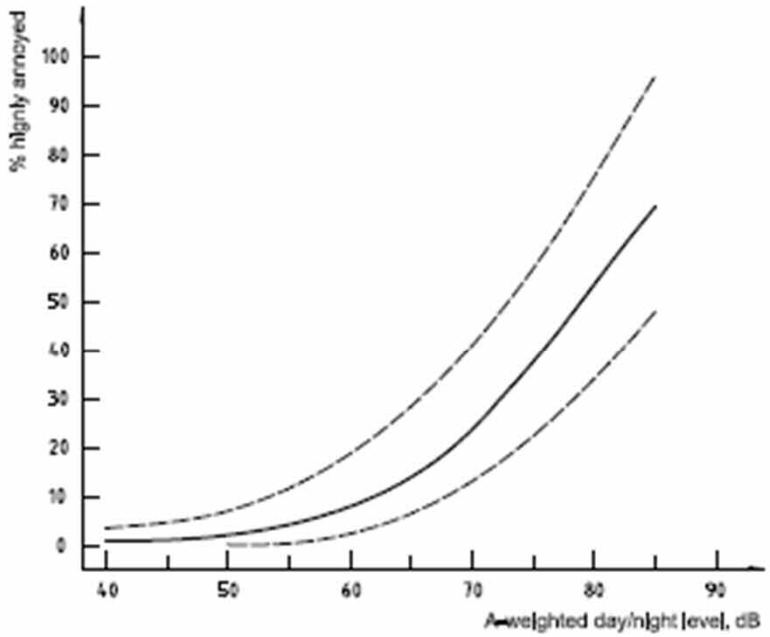

Figure D.1 — Percentage of respondents highly annoyed by road traffic sounds, as a function of the A-weighted day/night level

Annoyance Criteria – Health Canada

Source penalties are applied based on sound character:

- Air Traffic +5
- Rail Traffic - 5 (for LRT)
- Impulsive +5
- Highly Impulsive +12
- Tonal +5

Annoyance Criteria – Health Canada

- Additional penalty of +10 dB overall is applied in “quiet rural areas”
- Health Canada indicates that a change in the % HA indicator of more than 6.5% is considered a significant impact requiring mitigation

Approach

- ERCB ASL and PSL L_{eq} values were used to calculate the L_{dn}
- These L_{dn} were used to calculate the %HA
- The change in %HA due to the ERCB ceiling criteria was calculated based on:

  %HA(PSL) - %HA(ASL)

- The result was compared to the Health Canada limit of 6.5% change in %HA

Assumptions

- ERCB PSL values are the BSL values in Table 1 of Directive 038 for the nighttime period
- Daytime PSLs are the BSL values plus 10 dBA, per Directive 038
- No penalties were applied for character of sound for initial analysis
- Subsequent analysis of penalties that may be applicable to oil and gas facilities were considered

Calculations

- ISO 1996 formula was used to calculate L_{dn}:

$$L_{dn} = 10 \times log\left[\left(\frac{15}{24} \times 10^{L_d/10}\right) + \left(\frac{9}{24} \times 10^{(L_n+10)/10}\right)\right]$$

Where:

- L_d = the daytime noise level (ASL or PSL, as appropriate)
- L_n = the nighttime noise level (ASL or PSL, as appropriate)

Results

ERCB Directive 038 ASL/PSL Recalculated as L_{dn}

Table 1 Category		Dwelling Density 1-8				Dwelling Density 9-160				Dwelling Density <160			
		Ld	Ln	Ldn	HA (%)	Ld	Ln	Ldn	HA (%)	Ld	Ln	Ldn	HA (%)
Category 1													
	ASL	45	35	45	1.1	48	38	48	1.7	51	41	51	2.5
	PSL	50	40	50	2.2	53	43	53	3.2	56	46	56	4.7
					1.0				1.5				2.2
Category 2													
	ASL	50	40	50	2.2	53	43	53	3.2	56	46	56	4.7
	PSL	55	45	55	4.1	58	48	58	6.0	61	51	61	8.7
					2.0				2.8				4.0
Category 3													
	ASL	55	45	55	4.1	58	48	58	6.0	61	51	61	8.7
	PSL	60	50	60	7.7	63	53	63	11.1	66	56	66	15.6
					3.6				5.0				6.9

Calculations

- Penalties on noise sources were evaluated by adding increments to the energy industry portion of the PSL:

$$PSL(penalized) = 10 \times log\left[\left(10^{ASL/10}\right) + \left(10^{(Industry+penalty)/10}\right)\right]$$

Where:

- *ASL* = 35 dBA in rural areas (or 5 dBA less than the PSL)
- *Industry* = 38.3 dBA (or the total allowed industry contribution to meet the PSL)

Results

ERCB Directive 038 ASL/PSL Recalculated as L_{dn}, +5dB

Table 1 Category		Dwelling Density 1-8				Dwelling Density 9-160				Dwelling Density <160			
		Ld	Ln	Ldn	HA (%)	Ld	Ln	Ldn	HA (%)	Ld	Ln	Ldn	HA (%)
Category 1													
	ASL	45	35	45	1.1	48	38	48	1.7	51	41	51	2.5
	PSL	54	44	54	3.6	57	47	57	5.3	60	50	60	7.7
					2.5				3.6				5.2
Category 2													
	ASL	50	40	50	2.2	53	43	53	3.2	56	46	56	4.7
	PSL	59	49	59	6.8	62	52	62	9.8	65	55	65	13.9
					4.6				6.5				9.1
Category 3													
	ASL	55	45	55	4.1	58	48	58	6.0	61	51	61	8.7
	PSL	64	54	64	12.4	67	57	67	17.3	70	60	70	23.7
					8.2				11.3				15.0

Results

ERCB Directive 038 ASL/PSL Recalculated as L_{dn}, +10dB

Table 1 Category		Dwelling Density 1-8				Dwelling Density 9-160				Dwelling Density <160			
		Ld	Ln	Ldn	HA (%)	Ld	Ln	Ldn	HA (%)	Ld	Ln	Ldn	HA (%)
Category 1													
	ASL	45	35	45	1.1	48	38	48	1.7	51	41	51	2.5
	PSL	59	49	59	6.5	62	52	62	9.3	65	55	65	13.2
					5.3				7.6				10.7
Category 2													
	ASL	50	40	50	2.2	53	43	53	3.2	56	46	56	4.7
	PSL	64	54	64	11.8	67	57	67	16.6	70	60	70	22.8
					9.6				13.4				18.1
Category 3													
	ASL	55	45	55	4.1	58	48	58	6.0	61	51	61	8.7
	PSL	69	59	69	20.6	72	62	72	27.8	75	65	75	36.4
					16.4				21.7				27.6

Calculations

- For “Quiet Rural Areas” (QRA) a 10 dB penalty is applied:

$$L_{dn}(QRA) = L_{dn} + 10$$

- The ERCB ASL and assumed baseline suggested by HC are compared

Results

Quiet Rural Areas – ERCB and Health Canada Ambient

Category 1		Dwelling Density 1-8			
		Ld	Ln	Ldn	HA (%)
ASL					
	HC Assumed Baseline	*35*	*25*	35	0.3
	HC Assumed Baseline with QRA Penalty	n/a	n/a	45	1.1
	ERCB Mandated	45	35	45	1.1
	ERCB with QRA Penalty	n/a	n/a	55	4.1
PSL					
	ERCB PSL	50	40	50	2.2
	ERCB PSL with QRA Penalty	60	50	60	7.7
%HA Change					
	HC Baseline (vs ERCB PSL)				1.9
	HC with QRA Penalty (vs ERCB PSL with Penalty)				6.6
	ERCB Mandated				1.0
	ERCB with QRA Penalty				3.6

Reality Check

- ERCB regulated facilities are designed around continuous nighttime operation as the more stringent criteria
- Don’t always have tonal or impulsive source on site
- %HA Penalties apply only to the individual source contribution at the receptor, not the total noise received

Reality Check

ERCB Compliant Case:

ERCB regulated facility		L_{eq} Daytime (dBA)	L_{eq} Nighttime (dBA)
ASL		45	35
Facility			
	Continuous sources	33.5	33.5
	Tonal source	33.5	33.5
	Highly Impulsive Source	33.5	33.5
	Total Facility Contribution	38.3	38.3
	Total Comprehensive Sound Level (ASL +Facility)	45.8	39.9
PSL		50	40

Reality Check

Re-calculated per Health Canada:

ERCB Regulated Facility		L_{eq} Daytime (dBA)	L_{eq} Nighttime (dBA)	Ldn	%HA
Baseline		45	35	45	1.1
Facility near existing development					
	Continuous sources	33.5	33.5		
	Tonal source	33.5	33.5		
	Highly Impulsive Source	33.5	33.5		
Facility with Penalties					
	Continuous sources	33.5	33.5		
	Tonal source	38.5	38.5		
	Highly Impulsive Source	45.5	45.5		
	Total Adjusted Operations Noise	46.5	46.5	52.9	3.2
	Change in %HA				2.0
Facility in "Quiet Rural Area"					
	Baseline			55.0	4.1
	Adjusted Operations			62.5	11.5
	Change in %HA				6.8

Reality Check

ERCB Non-Compliant Case:

ERCB regulated facility		L_{eq} Daytime (dBA)	L_{eq} Nighttime (dBA)
ASL		45	35
Facility			
	Continuous sources	35.0	35.0
	Tonal source	35.0	35.0
	Highly Impulsive Source	35.0	35.0
	Total Facility Contribution	39.8	39.8
	Total Comprehensive Sound Level (ASL +Facility)	46.1	41.0
PSL		50	40

Reality Check

Re-calculated per Health Canada:

ERCB regulated facility		L_{eq} Daytime (dBA)	L_{eq} Nighttime (dBA)	Ldn	%HA
Baseline		45	35	45	1.1
Facility near existing development					
	Continuous sources	35.0	35.0		
	Tonal source	35.0	35.0		
	Highly Impulsive Source	35.0	35.0		
Facility with Penalties					
	Continuous sources	35.0	35.0		
	Tonal source	40.0	40.0		
	Highly Impulsive Source	47.0	47.0		
	Total Adjusted Operations Noise	48.0	48.0	54.4	3.9
	Change in %HA				2.7
Facility in "Quiet Rural Area"					
	Adjusted Operations			64.0	13.1
	Baseline			55.0	4.1
	Change in %HA				8.9

Low Frequency Noise

- ERCB uses dBC-dBA >20 to screen for potential for LFN problems
- A tonal component must also be present

- HC approach adds a penalty term if dBC-dBA >10dB
- Penalty is calculated using the ***16Hz***, 31.5Hz an 63Hz octave band source contribution

Low Frequency Noise

- A recent analysis found both methods for screening new projects for LFN problematic based on the typical data available at the planning stages of projects (Patching, 2011)

Conclusion

- ERCB PSL criteria are more stringent in rural or lightly developed areas where there is already some industry presence
- ERCB PSL and Health Canada %HA are generally equivalent for rural areas with no industry presence
- Health Canada change in annoyance criteria appear more stringent in urban/densely developed areas

Knock on the sky and listen to the sound

- Zen Saying

Thank You