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OBTAINING NOISE LEVELS FROM PROJECTED OVERPRESSURE LEVELS GENERATED BY BLASTING OPERATIONS

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ABSTRACT

The overpressure levels generated by blasting generally increase with greater charge mass and decrease with greater distance from the blast site. Scaling methods are often used to determine the relationship between charge mass, distance and peak blast overpressure levels. The overpressure levels were calculated using a cube root scaling equation, taking into account constants that respond to the type of terrain of the blasting site. However, these peak overpressure levels are obtained as a global level in dBL. Therefore, this research gathers background information to provide a more comprehensive understanding of the noise caused by blasting and to advance its analysis. The results can be used for evaluations that require various weightings such as A, C and Z.

Keywords: *noise, blasting, mining*

1. INTRODUCTION

To determine the noise coming from a blasting at a given receiver we use an equation and constants that provide a single value of overpressure level. However, in some cases we need the noise level in different descriptors and/or weightings. For example, when evaluating fauna impact thresholds may be specified in dBA or dBZ. [1]
In Chile, the technical document "Evaluation criteria in the SEIA: Evaluation of noise impacts on native fauna" [1], has brought renewed attention to the assessment of noise effects on native wildlife.

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This technical document establishes impact threshold for groups of vertebrate animals, i.e., amphibians, reptiles, birds and mammals, thresholds that are determined based on the species (or group) being evaluated, the type of noise source (continuous, impulsive or intermittent) and the associated adverse effects (physiological and behavioral). The thresholds are weighted using different curves such as A and C.
According to current legislation [2], it is required to study the impact of noise generated by blasting on all objects of protection. In the case of fauna, the object of protection is the relevant habitat for nesting, reproduction, or feeding, which must be located within the project's noise influence area (Guide for the Description of Soil, Flora and Fauna Components of Terrestrial Ecosystems in the SEIA, 2015) [3].
Therefore, this presents the challenge of predicting the noise levels generated by blasting at different weightings and distances in order to determine the impact area and assess compliance with the proposed thresholds.

2. ASSESSMENT OF IMPULSIVE NOISE ON WILDLIFE

For the specific case of impulsive noise, there are thresholds for birds and mammals, which are indicated below:

Table 1. References for the determining of reference thresholds for evaluating the noise impact on terrestrial fauna. Avifauna.

Effect description	Effect Type	Source Type	Threshold	Reference
Increased alertness and vigilance	Behavio-ral	Impulsive (military or blasting)	80 dBA max 63 dBA average	(Shannon et al., 2016) [4] [5] [6]
Direct	Physio-	Single	140 dBA	(Dooling

Effect description	Effect Type	Source Type	Threshold	Reference
hearing damage	logical	impulse (blasting)	max	& Popper, 2007) [7]

Table 2. References for the determining of reference thresholds for evaluating the noise impact on terrestrial fauna. Mammals.

Effect description	Effect Type	Source Type	Threshold	Reference
Increased alertness and vigilance	Behavio-ral/ Physio-logical	Impulsive (military)	85 dBZ average	(Shannon et al., 2016) [4]

In the case of avifauna, the thresholds are presented with the frequency weighting filter A, or dBA. Additionally, “max” refers to the maximum Sound Pressure Level (SPL) recorded during the measurement period, it is sub understood, of the event or blasting, given the short duration that these have, while one of them is indicated not maximum SPL, but average, not indicating the integration time or “averaging”.

On the other hand, for mammals a single threshold applies to both behavioral and physiological effects and it based on an unweighted frequency measurement or dBZ and an average value, without specifying the integration time. However, due to the impulsive nature of the source, it can be inferred that the integration time is short.

3. SOUND PROPAGATION EQUATION

The accurate estimation of ground vibration and airblast levels is a complex task. The blasting process is highly non-linear and the variability of most rock types also contributes to the difficulty in accurate predictions of the environmental outcomes. The random character of the blasting outcomes suggests the need for probability distributions to describe strictly the range of possible ground vibration and airblast levels. [8]

In the absence of either field data or the opportunity to conduct blasting trials in the region of interest, it is possible to estimate likely ground vibration and airblast levels using simple charge weight scaling laws. Such laws incorporate the charge weight per delay and the distance from the blast to the monitoring location. Two site parameters are assumed and these influence the peak level and the rate of decay for the levels.

Airblast levels have been commonly estimated using the following cube root scaling formula:

$$P = K_a \left(\frac{R}{Q^{1/3}} \right)^{\alpha} \quad (1)$$

Where:

P = pressure, in kilopascals.

Q = explosives charge mass, in kilograms (charge mass per delay, (MIC)).

R = distance from charge, in meters.

Ka = site constant.

α = site constant.

For unconfined surface charges, in situations that are not affected by meteorological conditions, a good estimate may be obtained by using a site exponent (α) of -1.45, ((which corresponds to an attenuation rate of 8.6 dBL with doubling of distance), and a site constant (Ka) of 516.

For confined blasthole charges, when using a site exponent (α) of -1.45, the site constant (Ka) is commonly in the range 10 to 100.

Airblast is proportional to the cube root of the charge mass. This limits the effectiveness of charge mass reduction as a method of reducing airblast levels; other factors are often more important, especially for confined blasthole charges. In unfavorable meteorological conditions, it is common for airblast levels to be increased by up to 20 dBL due to the combined effects of an increase with altitude of temperature (an inversion) and/or wind velocity (windshear). Effective assessment of meteorological reinforcement requires accurate measurement of temperature, wind speed, and wind direction, generally at heights up to 1000 m above the ground.

4. FREQUENCY SPECTRUM OF BLASTING EVENT

In March 2019 Journal of Vibroengineering article Vibroacoustic measurements and analysis of blasting works by Józef Pyra and Maciej Kłaczyński of AGH University of Science and Technology in Kraków, Poland, sound spectra of measurements made during blasting events are shown. [9]

The investigation was conducted near one of the largest military training camps in Poland within a built-up area.

The study focused on the impact range of explosive charges during detonation, including structural vibrations, overpressure (AB) and acoustic waves (AW). During the measurements, three series of ANFO-type explosive material were detonated, with the following masses: series I - 150 kg, series II - 300 kg and series III - 450 kg. In all cases, the explosive charges were detonated on the surface.

Measurements were taken simultaneously at two points located at the nearest positions in the direction of propagation. At each station, a full set of equipment was used to measure ground vibration intensity, overpressure and noise level (acoustic waves). The distance from the blasting site to measurement point No. 1 (town 1) was approximately 7.5 km, and to measurement point No. 2 (town 2) was approximately 6.5 km.

The following figure shows the spectrum of the maximum unweighted sound pressure level for the explosion event, along with the background noise level at the same location, corresponding to point No. 2.

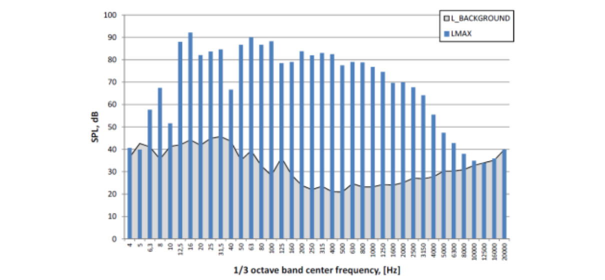

Fig. 4. Spectra of maximum sound pressure level unweighted (LIN) – L_{MAX}, sound pressure level of background ($L_{BACKGROUND}$). Place No. 2 (village 2), detonation No. 2

Figure 1. Spectrum of the maximum sound pressure level of the blasting event and background noise in dBZ.

The following table presents the spectrum in numerical form. Additionally, weighting is applied to obtain values in dBA and dBC.

Table 3. Maximum sound pressure level of the blasting event in spectral weightings Z, A and C.

Frequency Hz	Lmax dBZ	Lmax dBA	Lmax dBC
6,3	57,0	-28,4	35,7
8	67,0	-10,8	49,3
10	52,0	-18,4	37,7
12,5	88,0	24,6	76,8
16	92,0	35,3	83,5
20	82,0	31,5	75,8
25	84,0	39,3	79,6
31,5	85,0	45,6	82,0
40	62,0	27,4	60,0
50	86,0	55,8	84,7
63	90,0	63,8	89,2
80	86,0	63,5	85,5
100	88,0	68,9	87,7
125	78,0	61,9	77,8
160	79,0	65,6	78,9
200	84,0	73,1	84,0
250	82,0	73,4	82,0
315	83,0	76,4	83,0
400	83,0	78,2	83,0
500	77,0	73,8	77,0
630	79,0	77,1	79,0
800	79,0	78,2	79,0
1000	77,0	77,0	77,0
1250	75,0	75,6	75,0
1600	70,0	71,0	69,9
2000	70,0	71,2	69,8
2500	67,0	68,3	66,7
3150	64,0	65,2	63,5
4000	55,0	56,0	54,2
5000	47,0	47,5	45,7
6300	43,0	42,9	41,0
8000	38,0	36,9	35,0
10000	35,0	32,5	30,6
12500	34,0	29,7	27,8
16000	36,0	29,4	27,5
20000	40,0	30,7	28,8
Global	**98,2**	**86,4**	**95,9**

The following figure graphically represents the spectra considering the three indicated weightings .

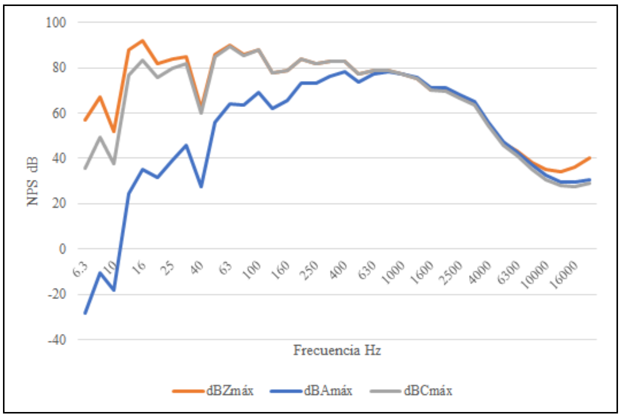

Figure 2. Maximum blasting event sound pressure level spectrum in dBZ, dBA and dBC.

5. ADJUSTMENT FOR OBTAINING NPS, FROM OVERPRESSURE LEVELS IN dBL PEAK

As specified, the results of the projections using the given equation are expressed in terms of overpressure in linear dB, or dBL. In this regard, AS 2187.2-2006 states: "... if a sound level meter measures an airblast level of 115 dBL, the same meter would measure approximately 90 dBA for the same event.
The frequency content of the particular airblast time history will determine the relative levels between the dBL and dBA readings.
This same correlation was found and reported in the document "Prediction and Control of Air overpressure from blasting in Hong Kong". Appendix A, "Analysis of dBA v/s dBL measurements Choi Wan Road and Jordan Valley" records and compares in detail a total of 137 blasting events in dBA and dBL. [10]
In consideration of the above, this correlation is already applied as a factor or correction to obtain the results from the projections. That is, overpressure in dBL is used to estimated sound pressure levels with dBA weighting. Then using a known spectrum from the data above, the levels can be determined at any scale (A, C, Z, etc.), using the following procedure:

(i) Perform the overpressure projection using Equation (1), with the result expressed in dBL peak;
ii) Apply the correction subtracting 25 to the overpressure level result, obtaining the value expressed in dBA;

Considering the blast spectrum presented in chapter 4, this time, between 20 Hz and 20 kHz and applying the A-weighting curve, the results are summarized in the following table:

Table 4. Frequency response of blasting in 1/3 octave bands in dBA.

Frecuency	Lp dBA	Frecuency	Lp dBA
20	31,5	**800**	78,2
25	39,3	**1000**	77,0
31.5	45,6	**1250**	75,6
40	27,4	**1600**	71,0
50	55,8	**2000**	71,2
63	63,8	**2500**	68,3
80	63,5	**3150**	65,2
100	68,9	**4000**	56,0
125	61,9	**5000**	47,5
160	65,6	**6300**	42,9
200	73,1	**8000**	36,9
250	73,4	**10000**	32,5
315	76,4	**12500**	29,7
400	78,2	**16000**	29,4
500	73,8	**20000**	30,7
630	77,1	**Global**	86,4

iii) Express the result in 1/3 octave frequency bands by adjusting the spectrum to the global dBA value obtained in ii). From there, convert it to any other desired weighting.

6. CONCLUSIONS

With the proposed methodology, sound pressure level values can be derived from overpressure levels using any spectral weighting, such as dBZ, dBA and dBC. Therefore, these values can be compared with impact thresholds using different weighting curves.
There is limited information on impact thresholds for blasting noise on reptiles and amphibians. It is important to continue the researching for information maximum acceptable limits for impulsive noise, especially for species where such data are not yet available.
Finally, it would be beneficial to have more noise measurements with spectral information from blasting events and to assess the noise generated in the fauna through empirical results. However, an alternative for

making projections is to follow the steps outlined in this work.

7. REFERENCE

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