Sound Power of Construction Machines: Declared Values vs. *In-Situ* Measurements

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Introduction

In accordance with [1], a large number of construction machines are subject to noise labelling, and must not exceed a specified sound power emission as a function of a machine-specific characteristic. Knowledge of the sound power emitted by construction machines is prerequisite to the prediction of building-site noise. As a result of the labelling duty, only the sound power level declared by the manufacturer is readily available for this purpose (see also [6]).

A prediction of construction noise shall also take into account a penalty for impulse or tonal components to allow determination of the rating level to be used in the assessment [2].

Approving authorities often require a construction-noise prediction to be based on the declared sound power level of the construction machine (or the emission limit), including a penalty (usually + 6 dB for impulse noise). *In-situ* noise-emission measurements on construction machines have shown this value to be overrated by up to 10 dB(A) in many cases.

Determination of the actual sound power level is particularly in the interest of construction contractors, construction-machine rental companies, and the consulting engineers in charge of noise prediction. Equipment manufacturers, too, take an increasing interest in this problem, as they assume being able to influence the discussion about a further reduction of the sound-power limits. For the approving authorities, the above-mentioned procedure ($L_d + \Delta L$) is convenient as it obviously protects residents from excessive noise exposure.

Models

The noise emitted by a construction machine is due to

- machine noise (usually, internal-combustion engine, radiator fan, hydraulic system) and to
- process noise (usually the removal, loading, and transporting of material).

Measuring both noise components separately is not possible.

The residents' exposure to noise is characterised in terms of the rating level (as per [2]: $L_{AFTm5} + \Delta L_T$).

The sound power level declared by the manufacturer (L_d) does not allow to derive a characteristic for the assessment. The penalty for impulse or tonal components cannot be allocated to process noise alone.

Measurements

In 2003, track- and wheel-driven hydraulic excavators, wheel loaders, and dozers used on various building sites were investigated [3], and data found in literature were analysed [7, 8, 9]. The declared sound power levels of these construction machines are determined in accordance with 2000/14/EC [1] and ISO 6395 [4], implying, among other things:

- Maximum engine speed.
- Constant radiator-fan speed, maximum speed maximum speed for at least 70 % of the measuring duration).
- Simulation of a working cycle without material, wheel loader and dozer being driven.
- Hard, sound-reflecting plane surface (sandracks are used for driving the dozer).
- Measurement, microphone positions inaccordance with DIN EN ISO 3744 [5].

For *in-situ* measurements, building works were selected in such a manner that movement of the machines ensured best possible compliance with the standards. Measurement conditions:

- Engine speed varying between idling and nominal speed (approx. 800 RPM to 2300 RPM).
- Constant radiator-fan speed (high, machine warmed-up).
- Measuring surface plane, usually pebbles, gravel, top soil.
- Microphone position: usually 1 or 2 positions, r = 10 to 20 m, h = 1,5 m, calculation of sound power based on [5].

Results

Only construction machines built after 1996 were investigated. Figure 1 shows the comparison of declared sound power levels with those measured *in-situ*.

As for the three machines showing significantly higher *in-situ* values, the reasons are obvious: grading of metal scrap, breaking and grading of reinforced concrete, removal of paving stones and loading onto lorries.

No clear explanation can be given for the 14 machines showing significantly lower *in-situ* values (breaking of tarmac, excavation, and loading onto lorries, among others).

Nor is the difference ($L_{WAeq} - L_d$) correlated with the impulse components ($L_{AFTm5} – L_{AFeq}$) of the working noise.

Discussion of parameters

The parameters that can influence the difference (L_{WAeq} - L_d) by their varying magnitudes in the standard and *in-situ* measurements have been compiled in Table 1. Furthermore, an attempt is made to give a quantitative estimate of the influence of the parameters on the sound power determined.

Conclusion

With few exceptions, the total sound power of a construction machine, as measured *in-situ*, is lower than the sound power declared by the manufacturer. When based on the declared sound power level, ambient-noise predictions for building sites will, therefore, usually result in overrated ambient-noise values, which may, in individual cases, lead to work-time restrictions, noise-control measures, modifications in construction technology, or other requirements to be fulfilled.

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Table 1: Comparison of standard measurement and in-situ measurement of construction machines

Parameter	Standard measurement (2000/14/EC), L_d	In-situ measurement, L_{WAeq}	L_{WAeq} - L_d [dB(A)]
Motor speed	Constant operating speed	Varying speeds, emission profile	-(0 … 10)
Measurement surface	Concrete, sound-reflecting, even	Foundation soil, slightly sound-absorbing, uneven	-(1 … 2)
Measurement points	Hemispherical enveloping surface	Measurement points on top omitted	-(1 … 2)
Measurement distance	Constant (enveloping surface)	Distance varies depending on the working area, directivity pattern	-(0 … 3)
			$L_{AFTm5} - L_{AFeq}$ [dB(A)]
Noise due to building materials	None	Impulsive noise	+(0 … 8)

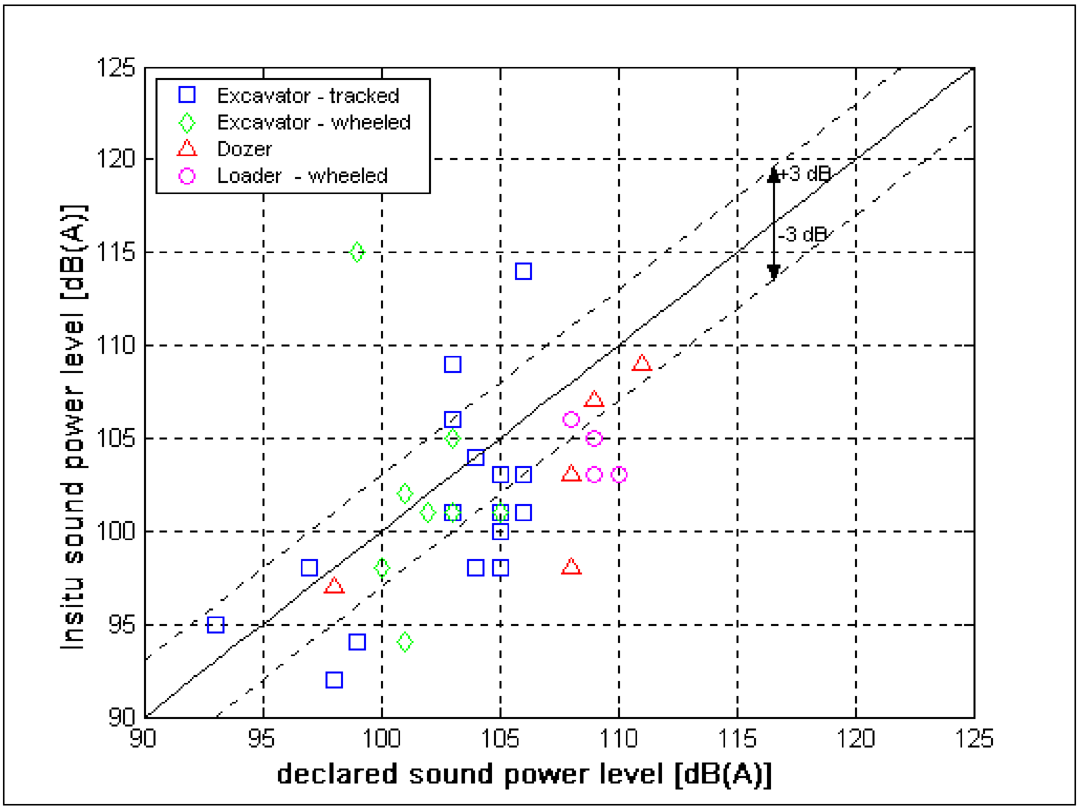

Figure 1: In-situ measured and declared sound power level of earth moving machinery [3]