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COMPARATIVE ANALYSIS OF THE SOUND CONDITIONS AT THE NEONATAL INTENSIVE CARE UNITS OF TWO NORWEGIAN HOSPITALS

Sarah Margrethe Løvald[1] **Simone Conta**[2*]

[1] COWI, Karvesvingen 2, 0579 Oslo, Norway
[2] SINTEF, Høgskoleringen 7b, 7034 Trondheim, Norway

ABSTRACT

Excessive sound levels of preterm infants may contribute to negative physiological effects. Yet, recommended sound level limits are consistently exceeded at neonatal intensive care units (NICU), both inside and outside of the incubator.

We present the results of a measurement campaign at two Norwegian hospitals with different design of the NICU. The first hospital had a shared unit with several incubators in one room while the second one featured single patient room. Sound pressure levels were measured continuously for several days inside of an unoccupied incubator and outside several active incubators. Additionally, sound pressure levels of an incubator were measured in a quiet room for several operation modes.

The sound levels at both hospitals exceeded the recommended limit values. Although the incubator provides considerable attenuation of the environmental sound, the sound level inside the incubator was dominated by the contribution of the machine itself and exceeded the recommended limit values considerably. We conclude that the design of the NICU has some effect on the sound levels inside the incubator. However, without reducing the sound levels from the incubator itself, such measures have a minor effect on the infant exposure to excessive sound levels.

*__Corresponding author__: Simone.Conta@sintef.no.

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1. INTRODUCTION

Excessive sound levels of preterm infants may contribute to negative physiological effects [1–3]. Different limit values for the sound pressure levels at NICU are found in the literature [4, 5]. Yet, recommended sound level limits are consistently exceeded at neonatal intensive care units (NICU), both inside and outside of the incubator [6–8]. The main goal of the work was to assess the sound levels at a neonatal intensive care unit (NICU), focusing on the room layout. We compared a NICU (location 1) with several patient stations in the same room with a NICU with single patient rooms. We measured the sound levels in the room outside and inside of an incubator. We then became aware that the incubator itself is a major source of noise and extended the measurements to an assessment of the sound levels produced by the incubator at different operating conditions. In this short paper, we describe the measurement objects and the measurement setup (Section 2 - method), present the main results (section 3 – Results) and discuss the main findings (section 4 – discussion).

2. METHOD

We measured the sound levels at two Norwegian hospitals with NICUs featuring different designs. At location 1 the unit had 10 incubators in one shared room. Location 2 featured single patient rooms with one incubator per room. At location 1, the sound pressure levels were measured continuously for several days at three microphone

position, two in the room and one inside of an unoccupied and inactive incubator (Fig. 1). At location 2, the sound levels were measured only in the room, at two different locations, also over several days (Fig. 2). Additionally, sound pressure levels inside and outside of an incubator for several operation modes were measured in a quiet room. The microphone inside the incubator was placed at the expected position of the head (Fig. 3). Outside the incubator we used four measurement positions at the four sides. Both locations used the same type of incubator; Giraffe OmniBed Care Station.

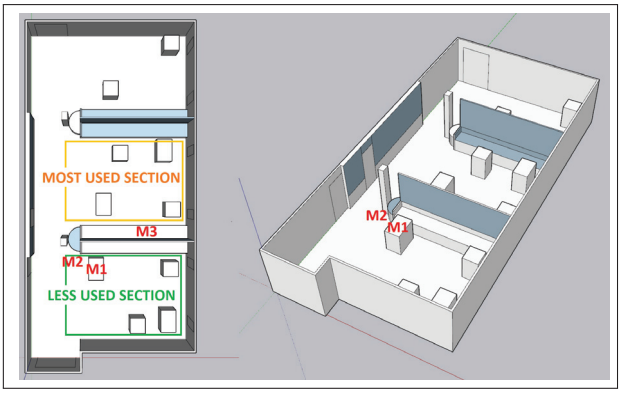

Figure 1. Layout of the NICU at location 1. The incubators are the block in the room. The microphone positions are shown. M1 is the microphone inside the unoccupied incubator.

Figure 2. Patient room at location 2 with the measurement positions outside the incubator.

Figure 3. Microphone position inside the incubator.

3. RESULTS

Table 3 presents the measured sound levels at the two locations in the room (outside incubator) and inside the incubator. The values were calculated first averaging over the whole measurement period, and so averaging between the two microphone positions. The inside incubator values for location 2 are calculated from the measured values outside and the measured attenuation due to the incubator.

Table 1. Limit values according to [4] and measured sound pressure levels in the room (outside) and inside of an inactive incubator. Calculated values are marked with *.

		$L_{A,eq}$ dB	$L_{A,10}$ dB	$L_{A,max}$ dB
Limit values	outside	45	50	65
	inside	n.a.	n.a.	60
Loc 1- shared room	outside	54.8	56.3	96.3
	inside	42.6	43.8	87.7
Loc 2 - single room	outside	48.8	50.7	87.3
	inside	36.8*	38.7*	75.3*

Figure 4 shows the measured sound pressure level outside the incubator at the two locations, calculated as above.

Figure 5 shows the measured sound pressure level spectra inside and outside the incubator at location 1. In this case the incubator was inactive. The values give an in-

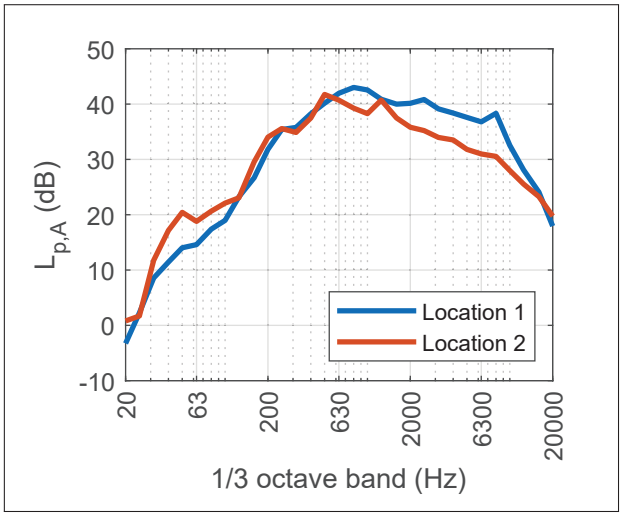

Figure 4. Measured A-weighted sound pressure level outside the incubator at the two locations.

dication of how the environmental noise affects the sound level inside the incubator. This data was used to calculated the attenuation of the environmental sound by the incubator.

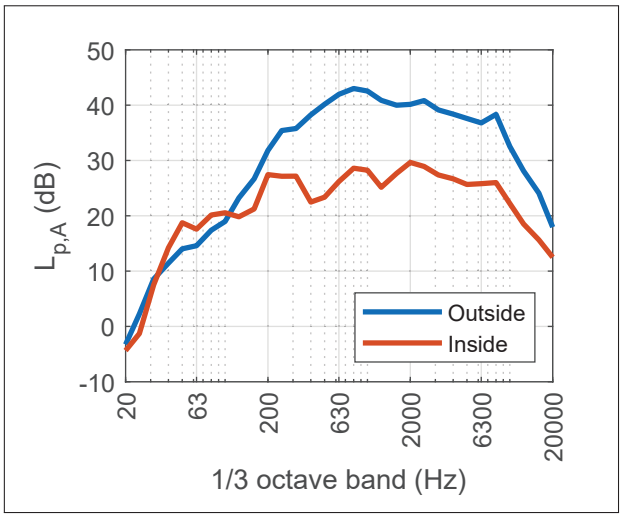

Figure 5. Measured A-weighted sound pressure level inside and outside the incubator at location 1.

Figure 6 shows the measured sound pressure level spectra inside and outside the incubator, with the incubator operating at different conditions in a quiet environment. The values outside the incubator are averaged over the four measurement positions. The operating conditions were; C1 climate control is active, C2 climate control and vacuum pump are active, C3 climate control, vacuum pump and oxygen supply are active, C4 climate control and oxygen supply are active.

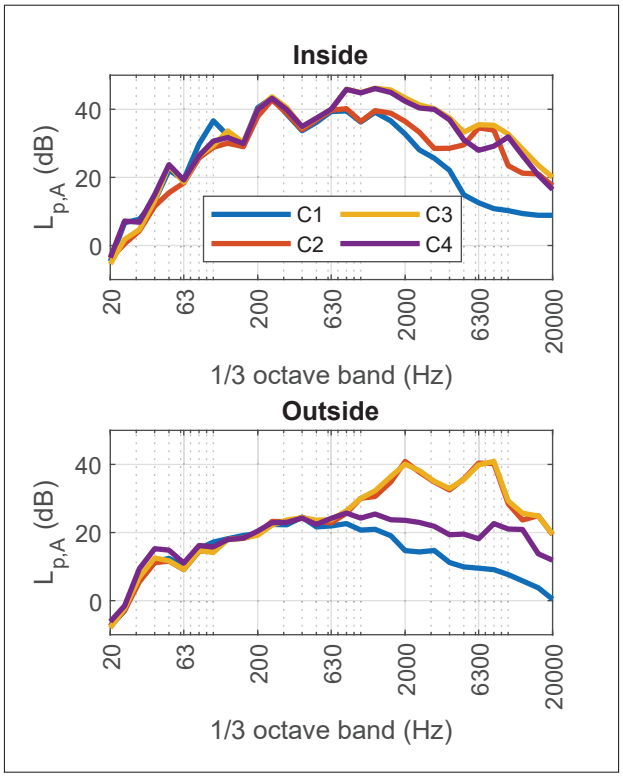

Figure 6. Measured A-weighted sound pressure level inside and outside the incubator, with the incubator operating at different conditions.

4. DISCUSSION

4.1 Sound levels outside the incubator

The values in table 3 show that the average L_{eq} at the NICU with single patient room is 6 dB lower than the average L_{eq} at the NICU with several patient stations. Similar trend is observed for L_{10} and a slightly higher difference is observed for L_{max}. The difference is important and expected considering the different level of activity in the room due to the occupancy by one patient /family compared to several patients/families. However, the limit values are still exceeded at both locations. Although the single patient NICU layout offers considerably

reduced sound levels, the change in layout is not sufficient to achieve sound levels in the room below the limit values.

4.2 Sound levels inside the incubator

The values in figure 6 show that the incubator attenuates the environmental sound with approximately 12 dB, confirming the results from previous investigation [9].

The values in table 3 show that the sound levels generated by the environmental sound inside the incubator are below the limit values in terms of L_{eq}, but exceed the limit values in terms of L_{max}.

Considering the results presented in figure 5 and 6, we see that the sound levels inside the incubator are dominated by the contribution of the machine itself. The values exceeded the recommended limit values considerably. This confirms the findings from other works [10]. This leads us to the conclusion that acoustic measures in the room are not sufficient to achieve sound levels inside the incubator below the limit values. To do so, it is necessary to reduce the noise produced by the machine itself by means of an improved design of the incubator and its components.

5. CONCLUSIONS

We measured the sound levels in the room and inside the incubator at two NICU with different layout. The results show that a layout of the neonatal intensive care unit based on several single patient rooms is beneficial in terms of sound levels in the room. However, the measured sound levels still exceed the limit values. Further reduction of the noise produced by the medical equipment is needed to reduce the sound levels in the room. The sound levels inside the incubator are dominated by the sound generated by the incubator itself. An upgraded design of the incubator is necessary to reduce the sound levels the new-born is exposed to.

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