Lydnivåer på nyfødtintensiv avdeling

Master av Sarah Løvald

COWI

Kort om oppgaven

- Masteroppgave – Bygg- og Miljøteknikk (NTNU)
- Skrevet i perioden Januar.2022 – Juni.2022
- Levert: 11.Juni.2022
- Lydnivåer på nyfødtintensiv avdeling //
  Sound Conditions at the Neonatal Intensive Care Unit

Agenda

- Bakgrunn og motivasjon
- Metode
- Resultater
- Konklusjon
- Videre forskning

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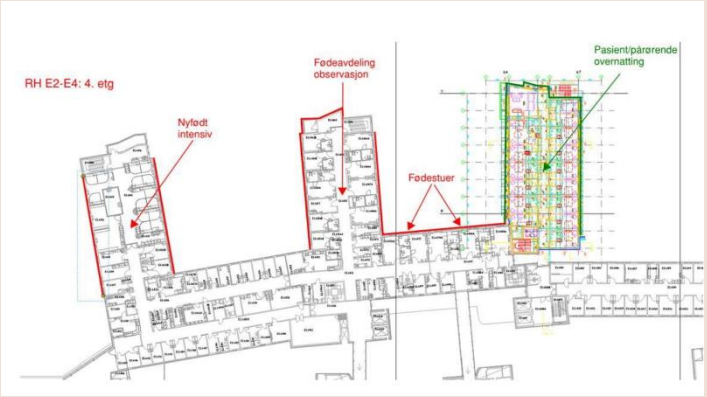
Bakgrunn og Motivasjon

Bakgrunn og Motivasjon

- **Sommerjobb hos COWI sommeren 2021**
- **Lydmålinger på Rikshospitalet – Helikopterstøy**



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Bakgrunn og Motivasjon

	Limit values and recommendations
American Academy of Pediatrics (Health, 1997)	The neonatal intensive care unit shall develop routines and monitor noise so that L_{eq} does not exceed 45 dBA.
Journal of Perinatology: Recommended Standards for NICU design (Martin, 2003)	Noise level in neonatal intensive care unit should not exceed continuous sound level $L_{eq} < 45$ dBA, $L_{10} < 50$ dBA and $L_{max} < 65$ dBA.
Guideline Values (World Health Organization, 1999)	Guidelines recommend that hospital noise levels do not exceed $L_{eq} < 30$ dBA and $L_{max} < 40$ dBA. Indicative values for sound levels in incubators must await future research.
IEC 60601-2-19: Particular requirements for the basic safety and essential performance of infant incubators (IEC, 2020)	The noise level inside the incubator should not exceed the sound pressure level, $L_{max} < 60$ dBA. If an alarm is triggered, it shall not exceed 80 dBA.

Table 3: An overview of the limit values that are most often used in the literature when discussing sound levels at newborn intensive care units.

Tabell hentet fra masteroppgave

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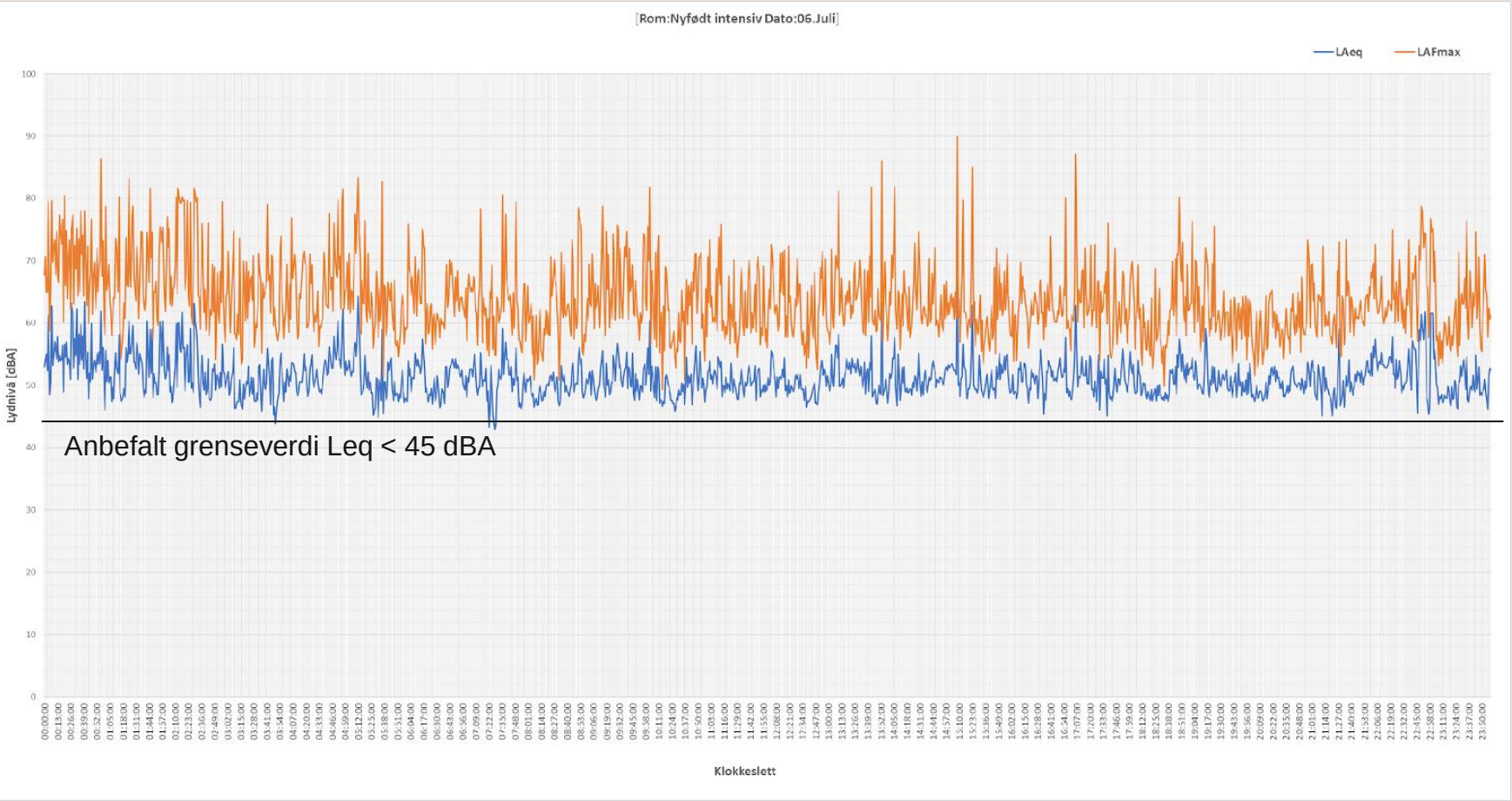
[Rom:Nyfødt intensiv Dato:06.Juli]
LAeq
LAFmax
Lydnivå [dBA]
Anbefalt grenseverdi Leq < 45 dBA
Klokkeslett

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Bakgrunn og Motivasjon

Høsten 2021: Prosjektoppgave

- Litteraturstudie: Støynivå på nyfødtintensiv avdeling

1. Hva anbefaler litteraturen som grenseverdier for lydnivå på nyfødtintensiv avdeling?
2. Hva sier litteraturen om lydnivå og **-kilder** på nyfødtintensiv avdeling?
3. Hva er mulige **tiltak** for å unngå uakseptable lydnivå på nyfødtintensiv avdeling?

	Limit values and recommendations
American Academy of Pediatrics (Health, 1997)	The neonatal intensive care unit shall develop routines and monitor noise so that L_{eq} does not exceed 45 dBA.
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Table 3: An overview of the limit values that are most often used in the literature when discussing sound levels at newborn intensive care units.

Country	Leq [dBA]	L10 [dBA]	Lmax [dBA]	Source
Taiwan	53,4	56,1	70,1	Chen et al. (2009)
Iran	63,46	65,81	71,3	Valizadeh et al. (2013)
France	60,4	62,1	89,1	Parra et al. (2017)
India	72	No Data	92	Joshi and Tada (2016)
USA	60,44	59,26	78,39	Krueger et al. (2005)
USA	56,4	60,6	90,6	Krueger et al. (2007)

Table 4: L_{eq}, L_{10} og L_{max}, measured at neonatal intensive care units in five different countries.

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Bakgrunn og motivasjon

Hvordan påvirker høye lydnivå spedbarn?

- **Hørselstap**
- **Økt blodtrykk og puls -> Høyere stressnivå**
- **Redusert oksygenmetning**
- **Økt smerteoppfatning**
- **Endret atferd**

Bakgrunn og motivasjon

1. What are the sound levels to which infants are exposed to inside and outside of an incubator at neonatal intensive care unit?

2. How does the incubator contribute to these sound levels?

3. Which measures can be used to achieve the recommended sound level limit values inside of the incubator?

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Bakgrunn og motivasjon

1. **HVA ER LYDNIVÅENE INNI OG UTENFOR EN KUVØSE PÅ NYFØDTINTENSIV AVDELING?**

2. **HVOR MYE BIDRAR KUVØSEN I SEG SELV TIL LYDNIVÅENE?**

3. **HVORDAN KAN MAN REDUSERE LYDNIVÅENE??**

Metode

Metode

3.2.1 Measuring object

Figure 7: Pictures of the Giraffe OmniBed Care Station (Some Tech, n.d.)

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Metode - Rikshospitalet

- 2 lydmålere
  - Nor145, Nor150
- 3 mikrofoner
- 4 dager

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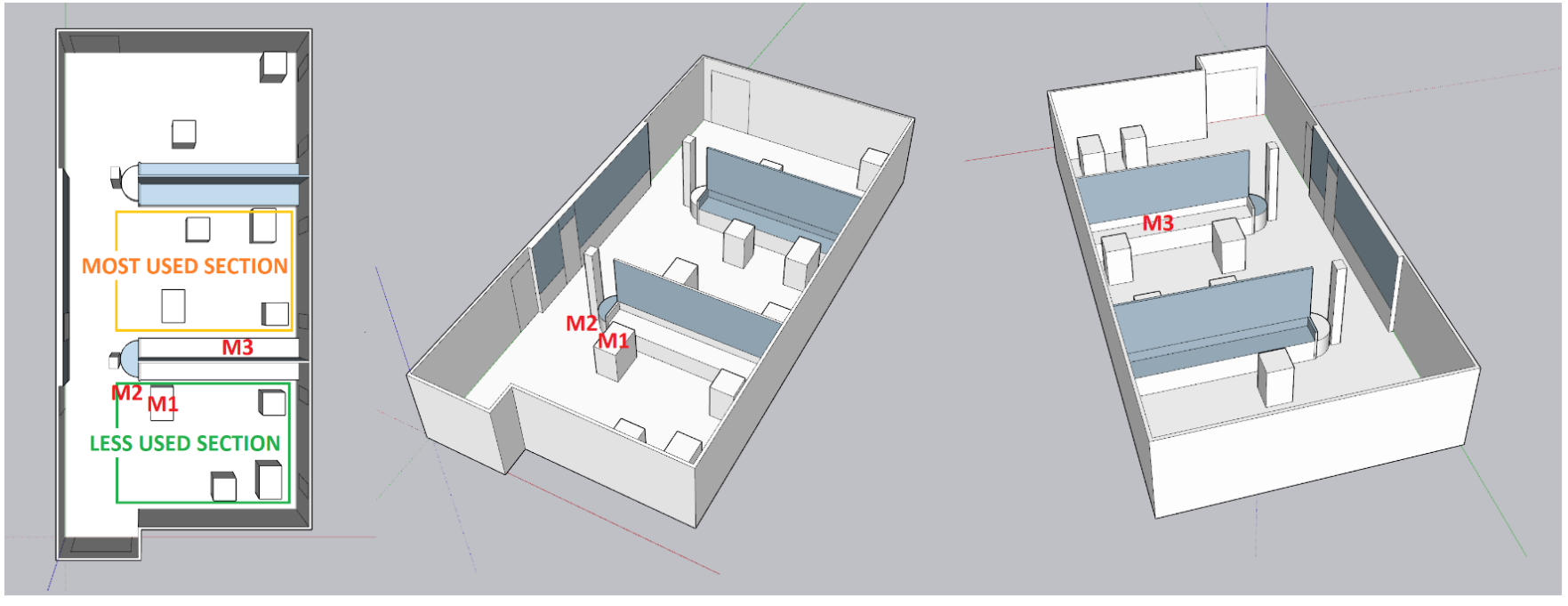
Metode - Rikshospitalet



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Metode – St.Olavs Hospital

- 1 lydmåler
  - Nor150
- 2 mikrofoner
- 5 dager

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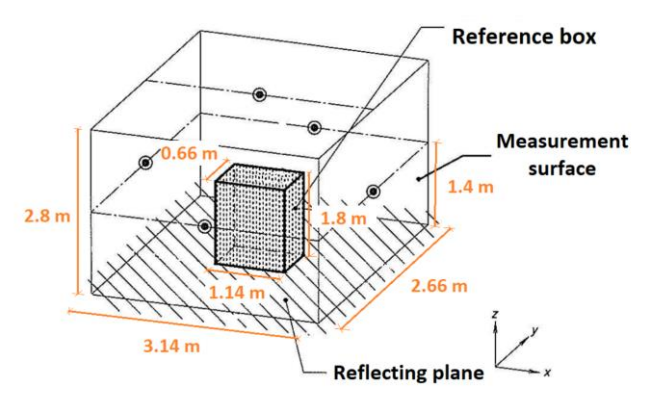
Metode – St.Olavs Hospital

- **Målt lyd fra aktiv kuvøse (utvendig) - ISO 3746**
- **Målt lyd innvendig**



COWI

Metode – St.Olavs Hospital

- **Målt lyd fra aktiv kuvøse (utvendig) - ISO 3746**
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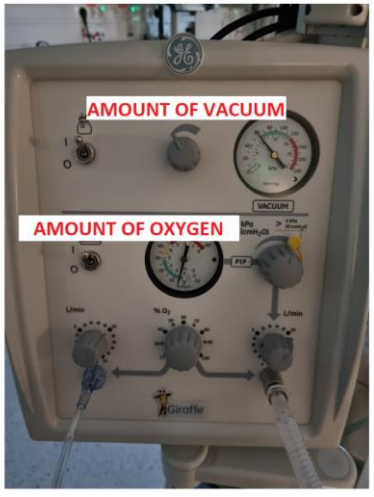
Metode – St.Olavs Hospital



- Combination 1: Incubator turned on, climate control is active, external machine is inactive.
- Combination 2: Incubator turned on, climate control is active, external machine produces 70 kPa vacuum.
- Combination 3: Incubator turned on, climate control is active, external machine produces 70 kPa vacuum, oxygen supply is turned on.
- Combination 4: Incubator turned on, climate control is active, vacuum turned off, oxygen supply is turned on.

Metode – St.Olavs Hospital

- Combination 1: Incubator turned on, climate control is active, external machine is inactive.
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- Combination 4: Incubator turned on, climate control is active, vacuum turned off, oxygen supply is turned on.

Metode – St.Olavs Hospital

- Combination 1: **Kuvøse er påskrudd** e control is active, external machine is inactive.
- Combination 2: **Kuvøse er påskrudd + vakumpumpe** external machine produces 70 kPa vacuum.
- Combination 3: **Kuvøse er påskrudd + vakumpumpe + oksygentilførsel** ces 70 kPa vacuum, oxygen supply is turned on.
- Combination 4: **Kuvøse er påskrudd + oksygentilførsel** cuum turned off, oxygen supply is turned on.

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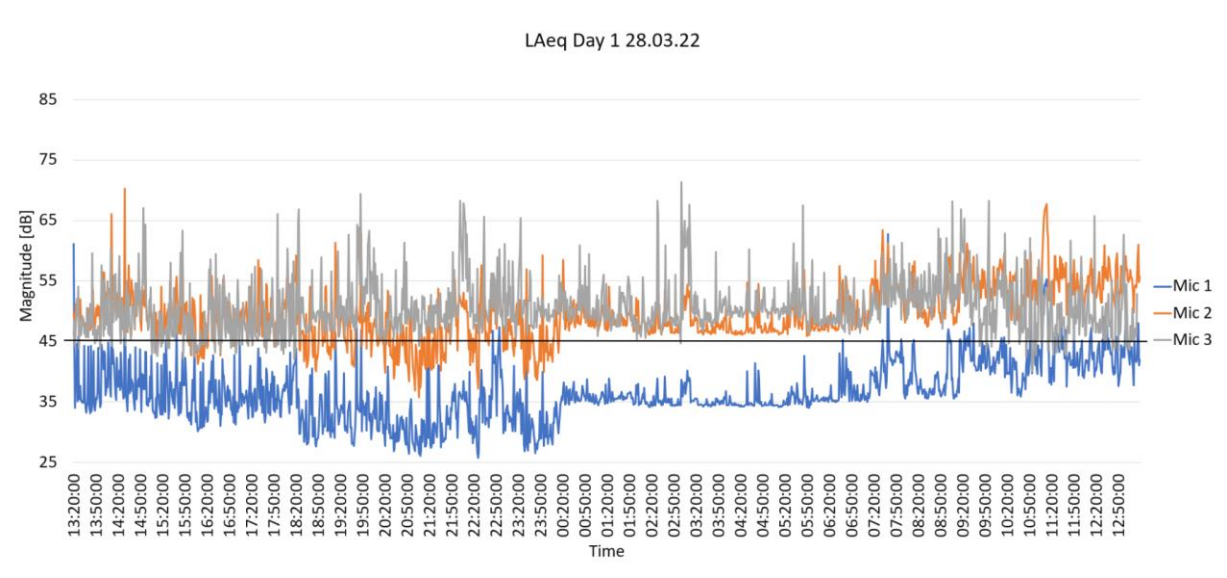
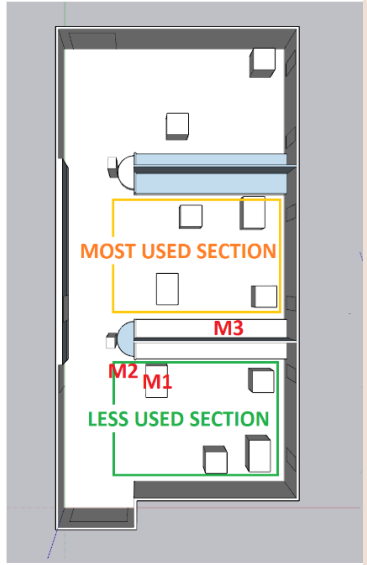
Resultater

Resultater - Rikshospitalet





Resultater - Rikshospitalet

	Day 1:			Day 2:		
	Leq	**Lmax**	**L10**	**Leq**	**Lmax**	**L10**
M1	38.6 dBA	83.2 dBA	37.7 dBA	42.7 dBA	85.2 dB	44.3 dBA
M2	50.8 dBA	95.0 dBA	52.1 dBA	54.7 dBA	90.7 dBA	56.7 dBA
M3	55.0 dBA	97.6 dBA	55.8 dBA	No Data	No Data	No Data

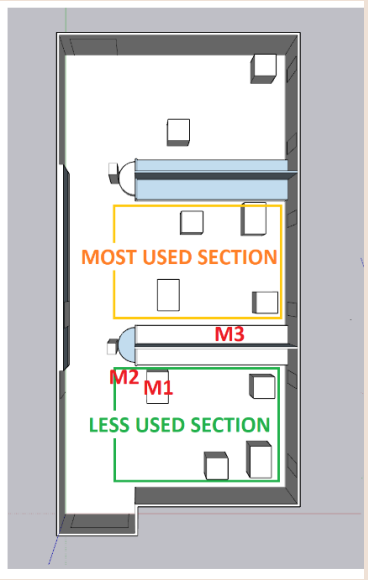
	Day 3:			Day 4:		
	Leq	**Lmax**	**L10**	**Leq**	**Lmax**	**L10**
M1	42.7 dBA	78.3 dBA	44.9 dBA	44.5 dBA	92.4 dBA	45.2 dB
M2	55.3 dBA	87.8 dBA	57.2 dBA	56.5 dBA	100.3 dBA	57.7 dBA

Logarithmic average over four days (28.02.22-03.03.22) at microphone position M2 and M3 (i.e average sound pressure levels outside of the incubator):

L_{eq} = 54.8 dBA

L_{max}= 96.3 dBA

L_{10}= 56.3 dBA



Journal of Perinatology: Recommended Standards for NICU design (Martin, 2003)	Noise level in neonatal intensive care unit should not exceed continuous sound level $L_{eq} < 45$ dBA, $L_{10} < 50$ dBA and $L_{max} < 65$ dBA.

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Resultater - Rikshospitalet

	$L_{eq,mic2}$ - $L_{eq,mic1}$
Day 1	12.2 dB
Day 2	12.0 dB
Day 3	12.6 dB
Day 4	12.0 dB

Table 6: Difference in equivalent sound pressure level outside of incubator versus inside of incubator.

Environmental noise influence on acoustic environment in Giraffe OmniBed™ Carestation™ and Giraffe Incubator Carestation™

Engineering White Paper

The Giraffe Carestation baby compartment enclosure attenuates the outside noise level by about 12 dBA[7]. In case of attenuation, decibels could be subtracted directly. This means that if noise level in the NICU room is 60 dBA, only 48 dBA (60 - 12) will reach inside the Giraffe Carestation's baby compartment.

Discussion

Let us examine the patient noise exposure contributions from the incubator itself and noise coming from the NICU room.

Room background noise penetrates the incubator hood with about 12 dBA attenuation. The recommended NICU background noise level (≤45 dBA) is considered safe and represents a comfortable environment in a very quiet room.

Let us calculate the patient noise exposure inside the incubator with NICU background noise level of 45 dBA.

The outside noise will be attenuated by the incubator baby enclosure to 33 dBA (45-12). The combined noise level from 40 dBA generated inside the incubator in Whisper Quiet™ mode and 33 dBA reaching the patient from the room will be 41 dBA.

Conclusion

The acoustic environment inside the Giraffe OmniBed Carestation and Giraffe Incubator Carestation allows clinicians to achieve sound levels below the AAP-recommended sound level of 45 dBA. In Whisper Quiet Mode, the Giraffe Carestation delivers a quiet acoustic environment. With Giraffe Carestation providing a quiet noise level (40 dBA), the ambient noise in the NICU room becomes the major factor affecting the neonate noise exposure in incubators.

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Resultater - St.Olavs Hospital

Day 1:				Day 2:		
	Leq	Lmax	L10	Leq	Lmax	L10
Mic 1	49.3 dBA	84.8 dBA	51.2 dBA	48.7 dBA	85.9 dBA	50.0 dB
Mic 2	48.2 dBA	82.5 dBA	50.4 dBA	50.4 dBA	89.7 dBA	52.0 dBA

Day 3:				Day 4:		
	Leq	Lmax	L10	Leq	Lmax	L10
Mic 1	48.3 dBA	84.6 dBA	51.0 dBA	48.1 dBA	82.7 dBA	50.1 dBA
Mic 2	50.7 dBA	88.8 dBA	53.3 dBA	48.8 dBA	84.4 dBA	50.9 dBA

Day 5:			
	Leq	Lmax	L10
Mic 1	46.6 dBA	82.6 dBA	47.2 dB
Mic 2	47.7 dBA	92.6 dBA	48.1 dBA

Logarithmic average over five days (09.03.22-13.03.22) at microphone position M1 and M2 (i.e average sound pressure levels outside of the incubator):

L_{eq} = 48.8 dBA
L_{max}= 87.3 dBA
L_{10}= 50.7 dBA

Journal of Perinatology: Recommended Standards for NICU design (Martin, 2003)	Noise level in neonatal intensive care unit should not exceed continuous sound level $L_{eq} < 45$ dBA, $L_{10} < 50$ dBA and $L_{max} < 65$ dBA.

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Resultater - St.Olavs Hospital

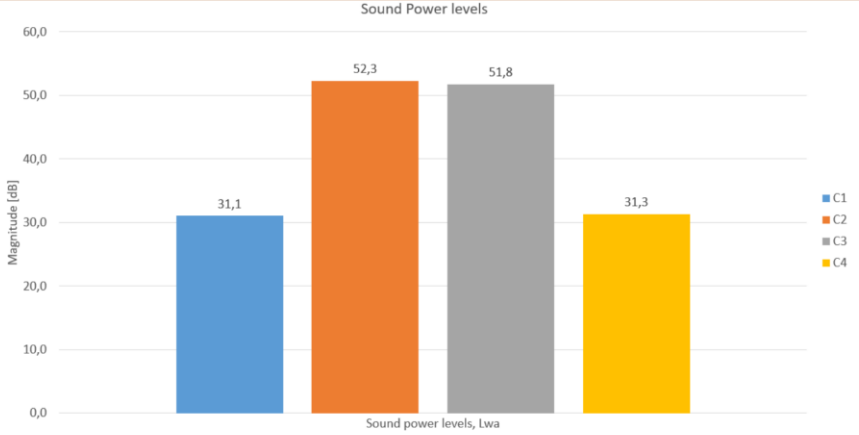

Figure 19: A-weighted sound power levels, L_{WA} from active incubator. Measured using incubator setting combination 1 to combination 4 (C1 to C4).
C1: Climate control is active
C2: Climate control and vacuum pump are active
C3: Climate control, vacuum pump and oxygen supply are active
C4: Climate control and oxygen supply are active

Resultater - St.Olavs Hospital

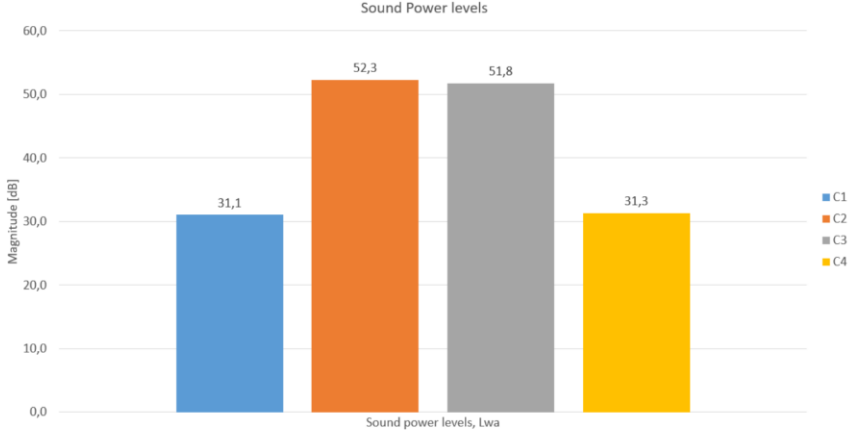

Figure 19: A-weighted sound power levels, L_{WA} from active incubator. Measured using incubator setting combination 1 to combination 4 (C1 to C4).
C1: Climate control is active
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C4: Climate control and oxygen supply are active

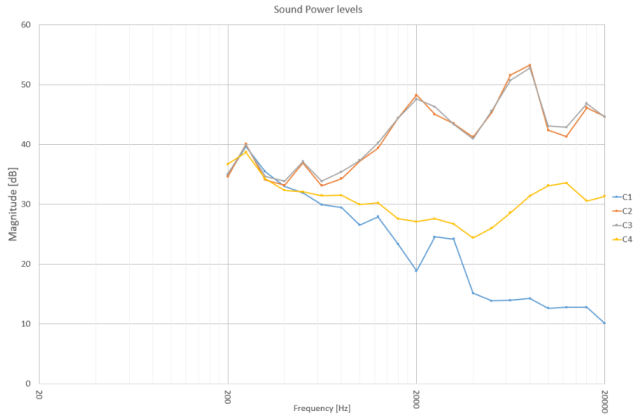

Figure 20: Sound power levels from active incubator. Measured using incubator setting combination 1 to combination 4 (C1 to C4).
C1: Climate control is active
C2: Climate control and vacuum pump are active
C3: Climate control, vacuum pump and oxygen supply are active
C4: Climate control and oxygen supply are active
Each combination is described in Section 3.2.1.
Measurements below 200 Hz are not included due to background sound pressure levels exceeding sound levels from the incubator.

Resultater - St.Olavs Hospital

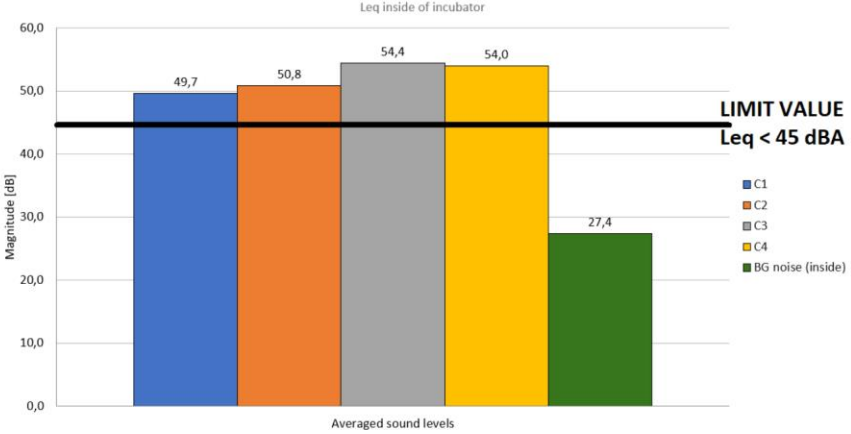

Figure 22: Sound levels measured inside of active incubator. Measured using incubator setting combination 1 to combination 4 (C1 to C4).
C1: Climate control is active
C2: Climate control and vacuum pump are active
C3: Climate control, vacuum pump and oxygen supply are active
C4: Climate control and oxygen supply are active
BG Noise: Incubator is turned off, only background noise
Each combination is described in Section 3.2.1.
The sound levels given in the figure were measured at each microphone position and then averaged logarithmic.

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Resultater - St.Olavs Hospital

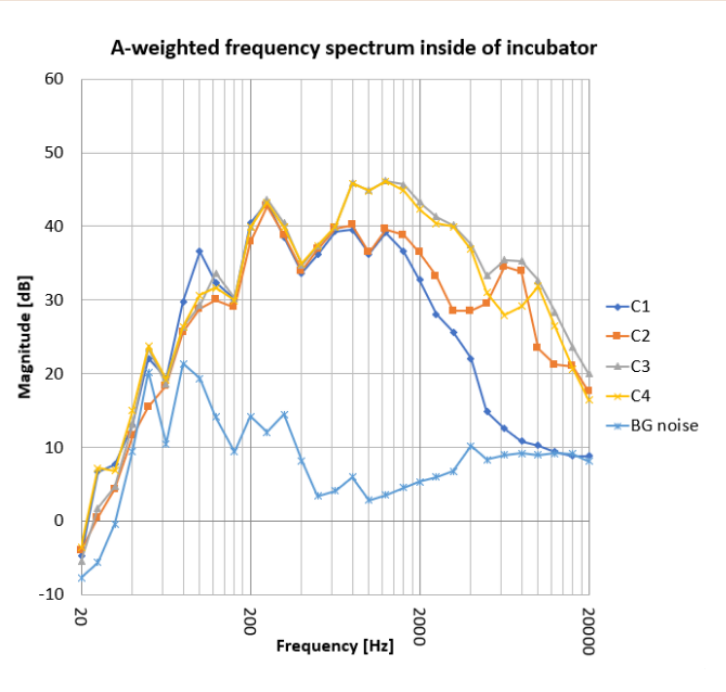

Figure 25: Frequency spectrum inside of active incubator at different incubator settings. Incubator setting combination 1 to combination 4 (C1 to C4):
C1: Climate control is active
C2: Climate control and vacuum pump are active
C3: Climate control, vacuum pump and oxygen supply are active
C4: Climate control and oxygen supply are active
BG Noise: Incubator is turned off, only background noise

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Konklusjon

Konklusjon

1. What are the sound levels to which infants are exposed to inside and outside of an incubator at neonatal intensive care unit?

2. How does the incubator contribute to these sound levels?

3. Which measures can be used to achieve the recommended sound level limit values inside of the incubator?

Konklusjon

1. What are the sound levels to which infants are exposed to inside and outside of an incubator at neonatal intensive care unit?

	Day 1:			Day 2:		
	Leq	Lmax	L10	Leq	Lmax	L10
M1	38.6 dBA	83.2 dBA	37.7 dBA	42.7 dBA	85.2 dB	44.3 dBA
M2	50.8 dBA	95.0 dBA	52.1 dBA	54.7 dBA	90.7 dBA	56.7 dBA
M3	55.0 dBA	97.6 dBA	55.8 dBA	No Data	No Data	No Data

	Day 3:			Day 4:		
	Leq	Lmax	L10	Leq	Lmax	L10
M1	42.7 dBA	78.3 dBA	44.9 dBA	44.5 dBA	92.4 dBA	45.2 dB
M2	55.3 dBA	87.8 dBA	57.2 dBA	56.5 dBA	100.3 dBA	57.7 dBA

Logarithmic average over four days (28.02.22-03.03.22) at microphone position M2 and M3 (i.e average sound pressure levels outside of the incubator):

L_{eq} = 54.8 dBA

L_{max}= 96.3 dBA

L_{10}= 56.3 dBA

	Day 1:			Day 2:		
	Leq	Lmax	L10	Leq	Lmax	L10
Mic 1	49.3 dBA	84.8 dBA	51.2 dBA	48.7 dBA	85.9 dBA	50.0 dB
Mic 2	48.2 dBA	82.5 dBA	50.4 dBA	50.4 dBA	89.7 dBA	52.0 dBA

	Day 3:			Day 4:		
	Leq	Lmax	L10	Leq	Lmax	L10
Mic 1	48.3 dBA	84.6 dBA	51.0 dBA	48.1 dBA	82.7 dBA	50.1 dBA
Mic 2	50.7 dBA	88.8 dBA	53.3 dBA	48.8 dBA	84.4 dBA	50.9 dBA

	Day 5:		
	Leq	Lmax	L10
Mic 1	46.6 dBA	82.6 dBA	47.2 dB
Mic 2	47.7 dBA	92.6 dBA	48.1 dBA

Logarithmic average over five days (09.03.22-13.03.22) at microphone position M1 and M2 (i.e average sound pressure levels outside of the incubator):

L_{eq} = 48.8 dBA

L_{max}= 87.3 dBA

L_{10}= 50.7 dBA

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Konklusjon

1. What are the sound levels to which infants are exposed to inside and outside of an incubator at neonatal intensive care unit?

	$L_{eq,mic2}$ - $L_{eq,mic1}$
Day 1	12.2 dB
Day 2	12.0 dB
Day 3	12.6 dB
Day 4	12.0 dB

Table 6: Difference in equivalent sound pressure level outside of incubator versus inside of incubator.

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Konklusjon

2. How does the incubator contribute to these sound levels?

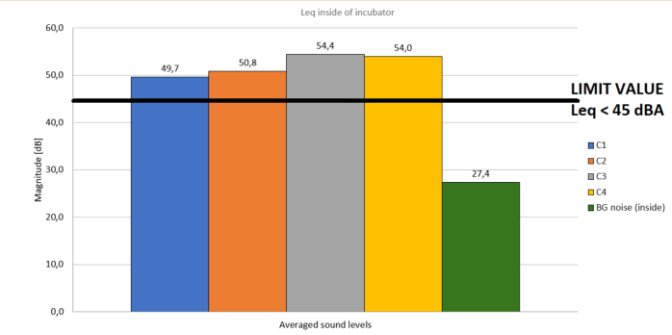

Figure 22: Sound levels measured inside of active incubator. Measured using incubator setting combination 1 to combination 4 (C1 to C4).
C1: Climate control is active
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C3: Climate control, vacuum pump and oxygen supply are active
C4: Climate control and oxygen supply are active
BG Noise: Incubator is turned off, only background noise
Each combination is described in Section 3.2.1.
The sound levels given in the figure were measured at each microphone position and then averaged logarithmic.

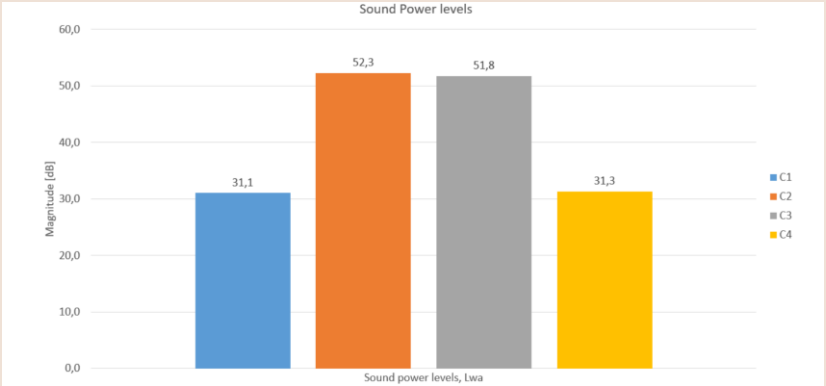


Figure 19: A-weighted sound power levels, L_{WA} from active incubator. Measured using incubator setting combination 1 to combination 4 (C1 to C4).
C1: Climate control is active
C2: Climate control and vacuum pump are active
C3: Climate control, vacuum pump and oxygen supply are active
C4: Climate control and oxygen supply are active

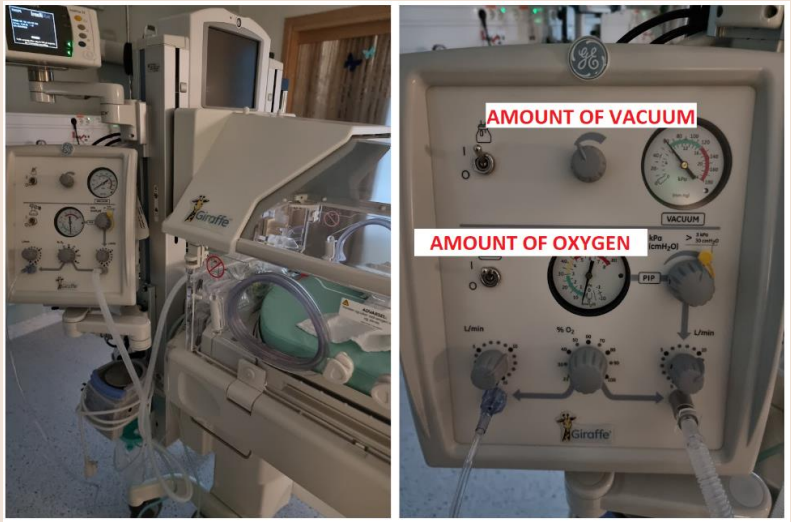
Konklusjon

3. Which measures can be used to achieve the recommended sound level limit values inside of the incubator?

Konklusjon

3. Which measures can be used to achieve the recommended sound level limit values inside of the incubator?

- **Endre planstruktur**
- **Endringer av kuvøse**
  - **Vakum pumpe**
  - **Oksygentilførsel**
  - **Klimakontroll**



Videre forskning

Videre forskning

- **Teste tiltak på kuvøse**
- **Vurdere grenseverdier**

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Takk for oppmerksomheten