

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

Engineering White Paper



**Giraffe
Incubator Carestation**



**Giraffe
OmniBed Carestation**



For over 50 years GE Healthcare has offered advanced technology and innovative designs that help meet the demanding clinical care needs in the Neonatal Intensive Care Unit (NICU) area. Its innovative technology and signature products – Giraffe OmniBed Carestation and Giraffe Incubator Carestation microenvironment devices – provide controlled environmental settings that contribute to a neuroprotective environment, supporting growth and development for newborn infants, and helping them go home healthy.

The GE Healthcare neonatal neurodevelopmental care philosophy places emphasis on patients' quality of life immediately after birth. A low acoustic noise environment is an important aspect of neonatal neurodevelopmental care.

The purpose of this paper is to describe the acoustic environment inside the Giraffe OmniBed Carestation and Giraffe Incubator Carestation.

OVERVIEW

Giraffe OmniBed Carestation

The Giraffe OmniBed Carestation is a combination system that brings together the features of a traditional incubator and a radiant warmer. It provides the environmental control necessary to support and promote neurodevelopmental care.

Clinicians control temperature, humidity, and oxygen levels inside the incubator, and can help protect the infant from excess noise and light. As a radiant warmer, the Giraffe OmniBed Carestation provides the caregiver open warmer access for stabilization, transition and open bed therapy. By easily converting from open bed to closed bed, the Giraffe OmniBed Carestation is a complete solution for single bed care during transport or daily care; it reduces the need for transfers between differing bed types or transport equipment.

Giraffe Incubator Carestation

The Giraffe Incubator Carestation provides support for the infant in a closed microenvironment.



Acoustic environment in Giraffe OmniBed Carestation and Giraffe Incubator Carestation

The Giraffe Incubator Carestation and Giraffe OmniBed Carestation, when closed, achieve low acoustic noise within the baby compartment by employing an air circulation fan with advanced aerodynamic design. Primarily, the closed incubator operates in Whisper Quiet™ mode. In this mode, the fan circulates air at the Low Fan Speed (LFS) with an average compartment noise level of 40 dBA. In certain cases, the fan will rotate at High Fan Speed (HFS) for short periods of time with average noise level of 50dBA. For example, to preheat the incubator, the fan will rotate at a HFS during the first 90 minutes after the incubator is switched ON. This achieves faster incubator warmup time and allows more expedient patient admission.

Clinical implication of neonatal noise exposure

In her 1869 book "Notes on Nursing", the founder of modern nursing Florence Nightingale said, "Unnecessary noise, then, is the most cruel absence of care which can be inflicted either on sick or well."

By 26 weeks gestation, preterm infants already perceive and respond to sounds in their environment¹. Multiple studies demonstrated adverse effect of excessive noise exposure on infants. Hypoxemia (an abnormally low concentration of oxygen in the blood) occurred in infants in conjunction with sudden loud noise (of approximately 80 dB)². Loud noises in the NICU significantly change the behavioral and physiological responses of infants³.

NICU noise level

The American Academy of Pediatrics (AAP) recommends that sound levels in the Neonatal Intensive Care Unit (NICU) be lower than 45 dBA⁴. According to the AAP, exposure to noise above 45 dBA may result in cochlear damage or disrupt the normal growth and development of premature infants.

Unfortunately, achieving the recommended ambient sound level in the NICU is a rarity. Many factors contribute to excessive noise within the NICU. Staff, device alarms, devices operational noise, communication devices are included in published reports which demonstrate that newborn infants noise exposure in the NICU is commonly significantly higher than recommended 45 dBA level⁵.

In the United States, recent reports of sound levels in NICUs have ranged from an Leq of 50 dBA - 89.5 dBA with peaks (or Lmax) of 105 dBA, some of which occur for as much as 70% of the time. These conditions are not specific to the United States. For example, in Taiwan the hourly Leq within two locations in an NICU averaged 61.4 dBA and 62 dBA with 86% of the peaks or Lmax ranging from 65 dBA to 74 dBA. Average NICU noise levels in India were reported to range from 61.2 dBA to 68.0 dBA in non-ventilator versus ventilator-assisted rooms, respectively⁶.

Environmental noise influence on Giraffe OmniBed Carestation and Giraffe Incubator Carestation baby compartment noise level

The neonate inside the incubator is exposed to the combined noise from two sources. One source is the noise from the incubator and another source is the noise coming from the NICU environment.

Sound, or more precise the Sound Pressure Level (SPL) is measured in decibels - dB. The sound meter reading could be adjusted to mimic sensitivity of human ear. This adjustment is standardized and called A-weighting. To indicate that sound measurement is A-weighted, the decibel units will be written as dBA or dB(A). In acoustics, decibel is the logarithmic unit used to express the ratio of two values of air pressure. To calculate noise exposure, decibels could not be added or subtracted directly. Additional sound depends only on the difference between two sources. If any two sounds are equally loud, then the combined level always will be

3 dB higher, in other words, the absolute values are not meaningful in the determination of total noise level.

For example: The normal speech sound level is around 60 dBA. The jet engine sound level (100 meters away) is around 120 dBA. Two people speaking at 60 dBA each are not as loud as a jet engine at 120 dBA. The conversation noise level will be 63 dBA. If a third person joins the conversation, total noise level will be 63 dBA + 60 dBA = 64.8 dBA. The second person added 3 dBA to the conversation sound level, but the third person added only 1.8 dBA. This could be explained by noting that if one sound is much louder than the other, the louder sound drowns out the softer sound, and the softer sound contribution is small and becomes insignificant as sound levels difference increase.

The formula to add two sound sources as follow:

$$L_{\text{sum}} = 10 \cdot \log_{10} (10^{L_1/10} + 10^{L_2/10}) \text{ dB}$$

WHERE:

L_{sum} is combined sound level,

L_1 and L_2 are sound levels of individual sound sources.

Due to the response of our ears, we can barely notice a difference of 3 dBA. An increase of 10 dBA sounds approximately twice as loud, and an increase of 20 dBA sounds about four times as loud.

The Giraffe Carestation baby compartment enclosure attenuates the outside noise level by about 12 dBA⁷. 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.



- (1) Hall JW III. Development of the ear and hearing. *J Perinatol* 2000;20:S12-S20
- (2) Long JG, Lucey JF, Philip AG. Noise and hypoxemia in the intensive care nursery. *Pediatrics*. 1980;65: 143-145
- (3) Zahr LK, Balian S. Responses of premature infants to routine nursing interventions and noise in the NICU. *Nurs Res*. 1995;44:179-185
- (4) American Academy of Pediatrics, Committee on Environmental Health Noise: a hazard for the fetus and newborn. *Pediatrics* 1997; 100(4): 724-727.
- (5) Paul E. Marik et al, Neonatal incubators: A toxic sound environment for the preterm infant?: *Pediatr Crit Care Med*. 2012;13(6):685-689
- (6) Charlene Krueger et al, Safe Sound Exposure in the Fetus and Preterm Infant: *J Obstet Gynecol Neonatal Nurs*. 2012 Mar; 41(2): 166-170.
- (7) Wubben, et al: 2011 The sound of operation and the acoustic attenuation of the Ohmeda Medical Giraffe OmniBed Noise Health J. 13:50 37-44

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.

The table below shows patient noise exposure level inside the baby compartment while the incubator operates in Whisper Quiet™ mode combined with the NICU area at different background noise levels:

| Combined noise level inside incubator baby compartment from incubator generated and external noise sources (dBA) | Incubator generated noise in Whisper Quiet™ mode (dBA) | Noise attenuation by incubator hood (dBA) | NICU room background noise level (dBA) |
|--|--|---|--|
| 41 | 40 | 12 | 45 |
| 42 | 40 | 12 | 50 |
| 45 | 40 | 12 | 55 |
| 49 | 40 | 12 | 60 |
| 53 | 40 | 12 | 65 |
| 58 | 40 | 12 | 70 |
| 63 | 40 | 12 | 75 |
| 68 | 40 | 12 | 80 |

A noise level above 45 dBA could be of concern.⁴ We could see that 45 dBA level inside the Giraffe OmniBed Carestation and Giraffe Incubator Carestation reaches this limit when the NICU room background noise approaches 55 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.

