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# NOISE CHARACTERISTICS OF THE INOGEN ONE G2 OXYGEN CONCENTRATOR IN DIFFERENT OPERATING MODES

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**Abstract:** *This study analyzes the noise emission of the Inogen One G2 oxygen concentrator under operational conditions. The focus is on measuring sound pressure levels in different environmental settings and user positions. Measurements were conducted according to PN-EN ISO 11200 – 11204 standards, considering both direct and reflected acoustic waves. The main noise sources were identified, and the impact of the surrounding environment on sound propagation was examined. Based on the conducted research, recommendations were developed to optimize device usage while ensuring acoustic comfort. This study provides essential insights into the noise emission characteristics of the oxygen concentrator and its impact on the user under various operational conditions.*

**Keywords: Noise emission, Oxygen concentrator, Acoustic analysis, SPL, Environmental impact**

## 1. Introduction

Noise in medical environments is a significant factor affecting both patient comfort and the working conditions of healthcare personnel. Rising noise levels in hospitals, often exceeding 70 dB, can lead to sleep disturbances, stress, and a decline in healthcare quality (Kacmarek et al., 2021). Workplace noise is widely studied due to its negative impact on health, including an increased risk of cardiovascular diseases, cognitive impairment, and sleep disorders (Basner et al., 2014). Devices used in oxygen therapy, such as oxygen concentrators, generate noise from compressors, filtration systems, and mechanisms regulating gas flow (Hardavella et al., 2019). The World Health Organization (WHO) states that oxygen concentrators should not exceed 50 dB(A) to ensure user comfort in both home and hospital settings (World Health Organization, 2015). However, studies indicate that certain devices imported from outside the EU and distributed within its member states exceed this limit, depending on operational intensity and environmental conditions. Oxygen concentrators are medical devices that provide oxygen-enriched air by separating nitrogen from atmospheric air. Their operation has been extensively described in respiratory therapy literature, emphasizing the importance of adjusting device parameters to meet patient needs (Kacmarek et al., 2021). Research by Kubo et al. (2018) demonstrated that the noise level generated by oxygen delivery systems, such as High-Flow Nasal Cannula (HFNC), increases with gas flow and can be reduced by implementing acoustic filters (Kubo et al., 2018). A similar phenomenon can be observed in oxygen concentrators, where noise generated by compression and flow mechanisms can be mitigated through modified device construction and improved acoustic insulation. Scientific literature also highlights the potential for active noise control (ANC), which could significantly reduce sound emissions from medical devices in the future (Elliott, 2010).

Noise measurements of oxygen concentrators should be conducted in compliance with international acoustic standards, such as PN-EN ISO 11200 – 11204, which outline procedures for evaluating noise emissions in different operational environments (ISO, 1995). According to Beranek (2006), precise acoustic measurements should consider both the directly emitted noise from the device and sound reflections from surrounding surfaces. Fugiel D. (2019) emphasizes that selecting the appropriate measurement strategy should be tailored to the specific characteristics of the noise source and measurement conditions to obtain

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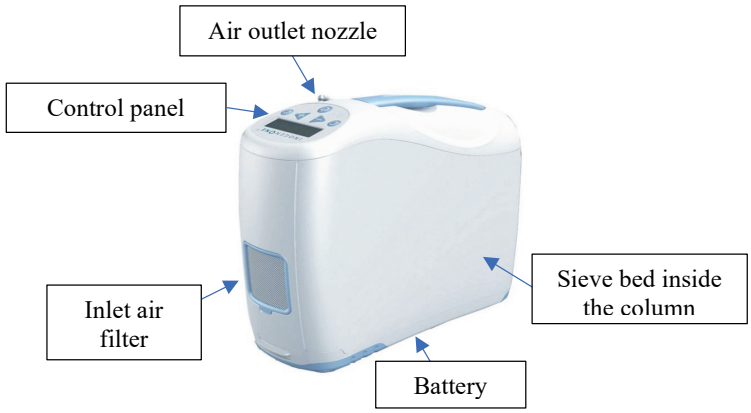
representative results (Fugiel A., 2019). Similarly, Hardavella et al. (2019) suggest that the selection of oxygen delivery systems should consider not only therapeutic efficiency but also noise levels and their impact on the patient. Additionally, Crocker (2007) highlights the importance of spectral noise analysis, which allows for identifying dominant frequencies in emitted sound and developing effective noise reduction methods (Łukasiewicz et al., 2019; Furgal et al., 2023). There are multiple directions for analyzing noise generated by oxygen concentrators. This study focuses on analyzing the noise emissions of oxygen concentrators in real-world operational conditions, assessing their levels in reference to acoustic standards, and developing recommendations to minimize their impact on users. These findings can contribute not only to improving patient comfort, especially in home oxygen therapy, but also serve as a valuable source of information for device manufacturers.

## 2. Object

The noise source subject to this assessment is the Inogen One G2 oxygen concentrator (Fig. 1). The device delivers high-concentration oxygen through a nasal cannula, which directs the oxygen from the concentrator to the patient.




Device catalog data Inogen One G2:
- Length – 27,2 cm,
- Width – 9,9 cm,
- Height – 24,1 cm,
- Noise level – < 38 dB (at setting Settings 2 → flow rate at ok. 360 ml/min.),
- Flow control settings: 1 – 6,
- Nominal power – 90 W,
- Warm-up time – 2 min.

Oxygen concentration – 90% - 3%/+6% at all settings (ok. 87 – 96%).

*Fig. 1: General structure of the oxygen concentrator Inogen One G2.*

## 3. Research Methodology

When evaluating the impact of the operating Inogen One G2 oxygen concentrator on its surroundings in terms of noise emission, two key aspects should be considered:

1) Limitations in the form of permissible noise levels in enclosed spaces, while maintaining the basic usage requirements specified in the user manual, particularly concerning audible frequencies corrected using the A-weighting curve.
2) Recognition of acoustic phenomena associated with the operation of the oxygen concentrator, focusing on variations in the sound pressure levels of the device depending on its operating mode.

Based on these considerations, it is appropriate to adopt a method for determining sound pressure levels of noise emissions that are relevant for workplaces and other designated areas surrounding operating machines or devices. In the operational environment, the oxygen concentrator affects the potential user not only through direct acoustic waves emitted by the device but also through reflected waves. Therefore, the PN-EN ISO 11200 – PN-EN ISO 11204 standards apply in this case. For this analysis, the measurement of sound pressure levels was conducted in conditions approximating a free-field environment, with environmental correction applied for sound reflections as specified in PN-EN ISO 11202. The oxygen concentrator was installed relative to the reflective surface in a single position characteristic of normal use, ensuring sufficient distance from walls, the ceiling, and other sound-reflecting objects, as indicated in Figure 2. The measurements were conducted with the device operating under the following conditions: Connected to mains power, Preheated (after 2 minutes of operation), Set to service mode, with "Settings 2" corresponding to a specific air flow level, Operating in AutoPULSE mode.

The measurements were conducted in two microphone positions. In the first position, the microphone simulated a seated user, while in the second position, it simulated a standing user. Seated position: The microphone was placed at a height of approximately 0.8 m from the seat surface and 0.2 m from the center of the user's head plane, aligned with the eyes. The reference direction of the microphone was parallel to

the user's line of sight and positioned on the side where the A-weighted sound pressure level was observed to be higher.

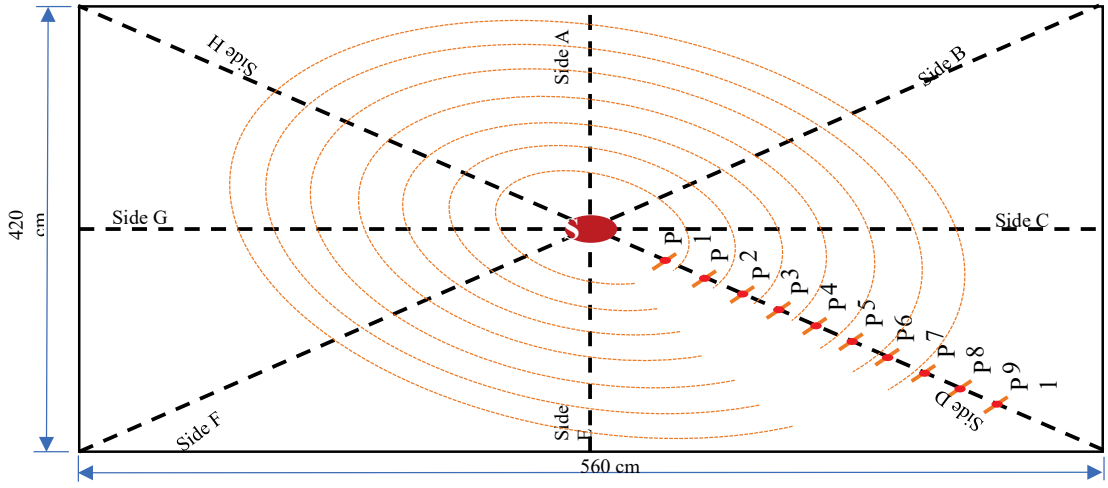



*Fig. 2: Measurement space around the device (P1 ÷ P10 – measurement points along specific measurement axes, Side A ÷ H – measurement axes).*

Standing position: The microphone was placed at a height of approximately 1.6 m. Due to the uniform (cyclically variable) operation of the device, after 2 minutes of operation, the measurement time was set to 30 seconds at each measurement point. The measurement location simulated the position of a person near the device in a home environment. The measurements were conducted in an enclosed room with dimensions of 560 cm × 620 cm and a total area of 34.72 m². The room height was 320 cm. Within the room, a free-field area was designated in the shape of a rectangle with dimensions of 560 cm × 420 cm.

## 4. Results and conclusions

Table 1 presents the results of the noise measurements of the Inogen One G2 device conducted under in situ conditions in accordance with PN-EN ISO 11202, with the user in a seated position.

*Tab. 1: Summary of key measurement results from all sides.*

| L.p. | Side A | Side B | Side C | Side D | Side E | Side F | Side G | Side H |
|---|---|---|---|---|---|---|---|---|
| | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] | $L_{Aeq}$ [dB] |
| 1 | 38,4 | 38,3 | 37,8 | 37,2 | 39,5 | 38,2 | 37,6 | 37,1 |
| 2 | 37,6 | 36,9 | 36,8 | 37,3 | 37,7 | 38,2 | 38,7 | 37,3 |
| 3 | 37,8 | 37,6 | 36,6 | 36,4 | 37,9 | 38,4 | 38,9 | 37,3 |
| 4 | 37,8 | 36,9 | 36,1 | 36,2 | 36,8 | 37,5 | 37,5 | 37,0 |
| 5 | 35,9 | 35,9 | 36,1 | 36,6 | 37,0 | 36,3 | 36,7 | 36,8 |
| 6 | 36,8 | 36,3 | 35,3 | 36,1 | 36,8 | 37,5 | 36,0 | 35,9 |
| 7 | 36,4 | 35,6 | 35,3 | 37,3 | 36,2 | 36,4 | 36,0 | 37,2 |
| 8 | 35,4 | 34,8 | 35,5 | 37,0 | 35,3 | 36,4 | 36,2 | 36,0 |
| 9 | 35,7 | 35,9 | 35,9 | 37,1 | 35,7 | 37,3 | 37,0 | 35,1 |
| 10 | 34,9 | 36,0 | 35,7 | 35,6 | 36,8 | 37,9 | 36,0 | 35,7 |

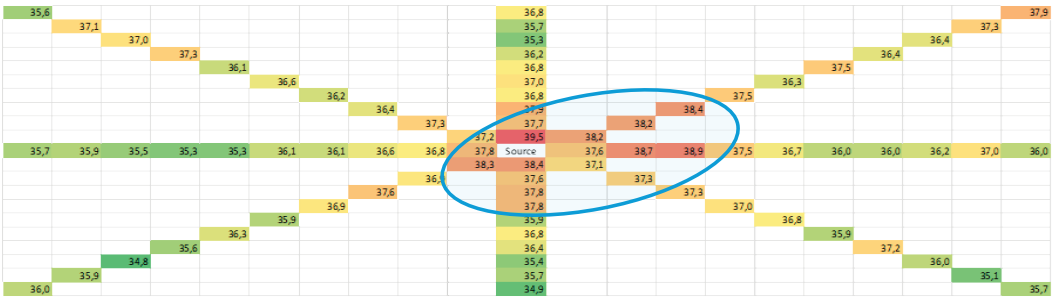



*Fig. 3: Noise emission depending on the position of the Inogen One G2 oxygen concentrator. Measurement points set every 20 cm.*

Conclusions:

1) The manufacturer of the Inogen One G2 device has specified that the permissible noise emission level is < 38 dB of the A-weighted equivalent sound pressure level.
2) The measured noise levels, with the microphone simulating a seated user position at a distance of 0.8 – 2.0 meters, do not exceed the permissible noise emission level specified by the manufacturer.
3) The measured noise levels, with the microphone simulating a seated user position at a distance of 0.2 – 0.8 meters, exceed the permissible noise emission level. However, the magnitude of the exceedance beyond the 38 dB limit falls within the measurement device's error margin.
4) The noise measurement results, presented in the form of an acoustic map, clearly indicate that the primary noise sources are concentrated around the air outlet nozzle and the inlet air particle filter of the device.
5) Therefore, the operation of the oxygen concentrator does not pose a significant noise-related hazard to users, especially if operating conditions are set in accordance with these measurement results and adopted criteria.
6) It is recommended that the minimum distance between the operating oxygen concentrator and the user (preferably in a seated position) should not be less than 0.8 meters.
7) It should be noted that the environmental conditions during the measurements were approximated to a free-field environment (the space from the noise source up to 2.0 meters was free of any sound-reflecting surfaces). These conditions do not reflect real-world scenarios, where users operate the oxygen concentrator in various indoor environments that may contain furniture, armchairs, chairs, tables, vases, etc. Each of these objects serves as a potential sound-reflecting surface, which can positively or negatively affect the user's auditory perception.
8) In conclusion, the operation of the Inogen One G2 oxygen concentrator in free-field-like conditions does not exceed environmental standards regarding noise emissions within the audible frequency range.

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