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EVALUATION OF NOISE EXPOSURE FROM PRINTING MACHINES IN A DIGITAL PRINTING LABORATORY

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Abstract: This paper presents an evaluation of noise exposure in a digital printing laboratory equipped with seven machines used for production and teaching. Equivalent continuous sound levels (Leq) ranged from 63.9 to 80.5 dB(A), all below the occupational threshold of 85 dB(A). Additional 1/3 octave band analyses were carried out for three representative machines. The spectra revealed dominant mid-frequency components (500–1000 Hz), overlapping with the range critical for speech, which may interfere with communication. Although the risk of hearing impairment is minimal, prolonged exposure could lead to fatigue and reduced concentration. Preventive measures are advised to improve acoustic conditions.
Key words: occupational noise, digital printing equipment, frequency spectra, communication interference

INTRODUCTION

The rapid expansion of digital printing technologies has significantly changed the printing industry. Digital printing equipment such as laser printers and photocopiers is now widely used not only for office documents, but also for industrial applications including ceramics, porcelain, glass decoration [1], and textile production [2]. These processes, while technologically advanced and flexible, also introduce new environmental and occupational challenges.
Noise is one of the most common physical stressors in printing facilities. It is generally defined as undesirable sound that negatively affects human health and wellbeing [3]. Prolonged exposure to elevated noise levels has been associated not only with hearing impairment but also with a range of non-auditory effects, including annoyance, concentration problems, fatigue, cardiovascular diseases, and interference with speech communication [4, 5]. International guidelines usually set occupational limits for noise between 85 and 90 dB(A), but even long-term exposure above 75 dB(A) may be considered harmful [6]. The human ear is most sensitive to frequencies between 400 and 4000 Hz, where excessive noise particularly interferes with speech comprehension.
Considering the importance of safe and effective work and study environments, this study aimed to evaluate noise levels generated by seven different printing machines used in a digital printing laboratory. Special attention was given to the comparison of measured values with permissible limits, and to the analysis of noise frequency spectra. .

MATERIAL AND METHODS

The study was conducted in the digital printing laboratory of the Department of Graphic Engineering and Design, Faculty of Technical Sciences, University of Novi Sad, Serbia. The laboratory is regularly used for both production and educational purposes. Two employees worked daily in the facility, with students attending practice sessions during the monitoring period.

The following seven machines were included in the study:
1. Single-color digital printing machine (Xerox D95A)
2. Four-color digital printing machine (Xerox DocuColor 252)

3. Cutting machine (Perfecta 76 HTVC)
4. Perfect binder (Horizon BQ-270)
5. Paper collating machine (Horizon VAC-100)
6. Screen printing machine (S550)
7. Saddle stitch binding machine (Hohner Exact)

The laboratory layout and machine arrangement allowed measurements to be taken next to each machine while others were not in operation.
To place the measurements into context, Table 1 summarizes adverse health effects related to occupational noise exposure, documented in epidemiological studies [7]. These reference values provide a framework for interpreting the results obtained in this study.

Table 1. *Examples of long-term effects related to noise exposure. Noise levels are given as L_{Aeq} levels measured over a period of time (eight hours).*

Effect	Exposure type	L_{Aeq} [dB(A)]	Location
Hearing impairment	Occupational	75	Indoors
Hypertension	Occupational	<85	Indoors
Annoyance	Occupational	<85 (Industry); <55 (Office)	Indoors

Noise measurements

Sound pressure levels (SPL) were measured using a TES-1358A Sound Level Meter (SLM) with RS-232 interface. Measurements were carried out over three working weeks. For each machine, five sets of measurements (n = 5), each of 15 minutes duration, were performed in standard operating mode at different times of the working week. The equivalent continuous sound level (L_{Aeq}) in dB(A) was recorded. Measurements were conducted according to EU and Serbian regulations on occupational noise exposure [8, 9].

Frequency analysis

For the saddle stitch binding machine, the cutting machine, and the single-color digital printing machine, additional analysis was carried out in 1/3 octave bands. The obtained spectra were compared with the interpolated NR-35 curve, an internationally recognized standard for acceptable indoor noise levels in relation to hearing protection, annoyance, and speech communication [10]. In addition, since the laboratory is used for teaching activities, the threshold level of 40 dB prescribed for classrooms and laboratories by the national regulation on environmental noise was also considered.

RESULTS AND DISCUSSION

Table 2 presents the mean noise levels with standard deviations for all machines included in the study. All measured L_{Aeq} values were below the occupational threshold of 85 dB(A). The highest level was recorded for the saddle stitch binding machine (80.5 dB(A)), followed by the cutting machine (74.9 dB(A)) and the perfect binder (74.2 dB(A)). The lowest average levels were observed for the four-color digital machine (63.9 dB(A)).

Table 2. *Average noise levels (L_{Aeq}) for different types of printing machines*

Printing machine	L_{Aeq} [dB(A)] (±SD)
Single-color digital machine	66.7 (±2.35)
Four-color digital machine	63.9 (±2.45)
Cutting machine	74.9 (±4.10)
Perfect binder	74.2 (±1.59)
Paper collating machine	72.2 (±2.12)
Screen printing machine	72.8 (±1.90)
Saddle stitch binding machine	80.5 (±3.90)

This paper examines noise effects from two perspectives: the potential impact on machine operators and on students attending practice sessions. As shown in Table 2, equivalent noise levels for all machines were well below 85 dB(A), while daily operating times typically did not exceed several hours. Based on these findings, it can be concluded that neither employees nor students are exposed to the risk of hearing impairment. Also, considering that the L_{Aeq} values for digital printing machines are 63.9 and 66.7 dB(A), and < 75 dB(A) for other machines, there is no risk of manifestation of potential non-auditory effects of noise.
Since the mean SPL values for all machines exceeded the 40 dB(A) limit prescribed for laboratories and classrooms [8, 9], additional measurements were carried out in 1/3 octave bands. Frequency spectra were obtained for all machines, while detailed graphical presentations are shown only for the cutting machine, the single-color digital printing machine, and the saddle stitch binding machine (Figures 1–3). The cutting machine produced the highest noise levels in the 500–2000 Hz range, with a peak at 800 Hz. A similar distribution was observed for the single-color digital machine, with a maximum at 500 Hz. IN contrast, the saddle stitch binding machine exhibited elevated levels across the spectrum, with distinct peaks at 630 and 1250 Hz and further increases up to 8000 Hz.

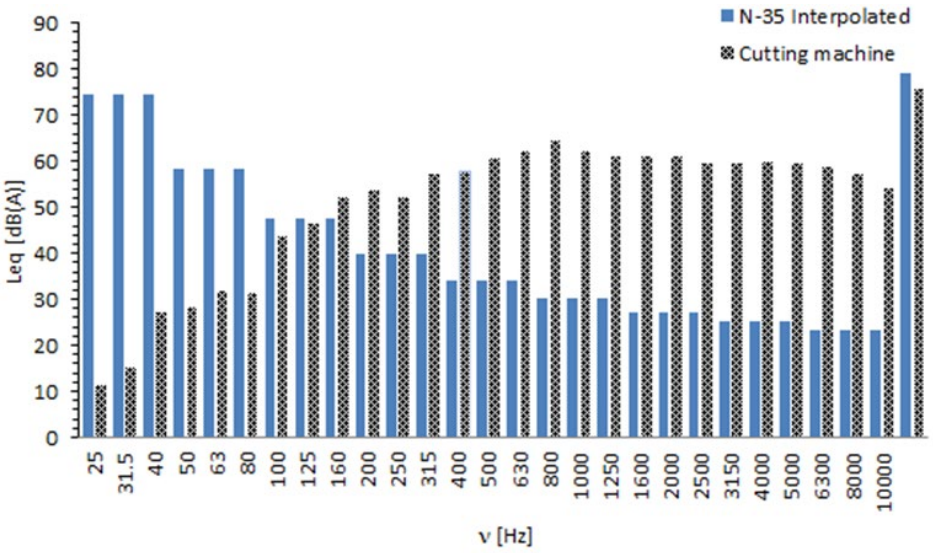

Fig. 1. *Noise spectrum of the cutting machine*

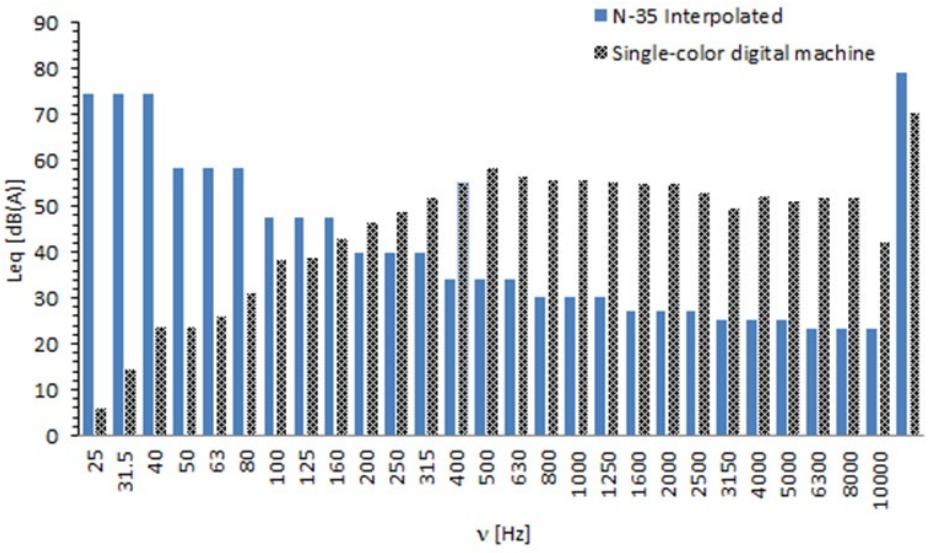

Fig. 2. *Noise spectrum of the single-color digital printing machine*

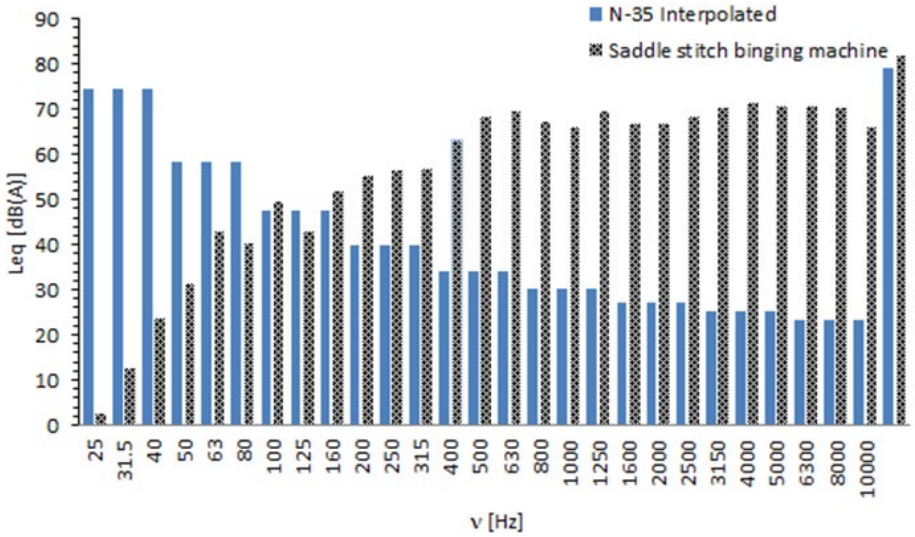

Fig. 3. *Noise spectrum of the saddle stitch binding machine*

Comparison with the NR-35 curve confirmed that all machines exceeded 35 dB(A) in the frequency range critical for human speech perception (300–700 Hz). This indicates potential interference with communication in the laboratory. The saddle stitch binding machine produced levels approaching the maximum allowed L_{Aeq}. Although immediate risk of hearing loss is unlikely, prolonged exposure may lead to fatigue, reduced concentration, and speech interference.

CONCLUSION

Noise as a physical stressor was present in the digital printing laboratory for all seven investigated machines, with measured L_{Aeq} values ranging from 63.9 dB(A) for the four-color digital printing machine to 80.5 dB(A) for the saddle stitch binding machine. Although all values were below the occupational threshold of 85 dB(A), several machines, particularly the cutting machine and the perfect binder, produced levels close to or above 75 dB(A), which may still be associated with non-auditory health effects such as fatigue and annoyance. Frequency analysis in 1/3 octave bands was performed for three representative machines. The spectra were dominated by mid-frequency noise components, with peaks around 500, 630, 800, and 1250 Hz. Since the critical frequency range for human speech is between 300 and 700 Hz, these noise levels indicate potential interference with communication during work or teaching activities in the laboratory. Overall, the results suggest that although the risk of permanent hearing damage is low, noise may affect concentration and speech intelligibility. Preventive measures such as minimizing simultaneous operation of multiple machines, occasional switching-off during classes, and optimizing room arrangement could contribute to improved acoustic conditions in the laboratory.

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