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EVALUATION OF WORKSHOP ROOM COMFORT TO IMPROVE OCCUPATIONAL HEALTH AND SAFETY (OHS)

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ABSTRACT

The establishment of a comfortable and safe work environment is fundamental to facilitate worker productivity and well-being. The workshop room, as one of the prime facilities in the workings of discovery and practice, must have light conditions, thermal comfort, and noise levels in accordance with occupational health and safety standards. The purpose of the study is to assess the light conditions, thermal comfort, and noise levels in the workshop room and provide strategic recommendations to improve the quality of the working environment. The research methodology employed is quantitative, where direct measurements are made with respect to the lighting levels, temperature, humidity, airspeed, and noise levels in the workshop room. The data were obtained to compare it with the relevant standards to determine whether the work environment conditions comply with the required regulations. The outcomes of the study reveal that lighting conditions in the workshop room do not meet the recommended levels entirely, especially in some work areas where light intensity is below the suggested threshold. The other major concern is thermal comfort because the room users would not be comfortable under very high temperature and humidity conditions. Noise levels, however, were found to be below standard. However, these noise levels which are almost hitting the upper limit could affect work comfort and health. Hence, with respect to these findings, the study recommends the redesigning of the lighting layout, improving the ventilation system, and applying noise abatement methods to raise the quality of the workshop room working environment.

Keywords: ***lighting, noise, thermal comfort, work environment, workshop***

INTRODUCTION

An efficient work environment is evidently one of the most important elements that contribute to help workers thrive in productivity. In the workshop, factors like lighting, thermal comfort, and the noise level of a place act as significant influencers for the aspects of comfort and safety within the premises. These important aspects have been laid down and regulated nationally and internationally through established standards of determining ideal parameters based on the health standard and the efficiency of a working environment. However, in reality today, few workshop spaces meet the stipulations of such standards, with venues including many educational and vocational training institutions.

Inadequate lighting can cause strain in the eyes, reduce the accuracy of work, and increase accidents in the workplace (Asadi et al., 2024). Poor thermal comfort often leads to high temperature, humidity, and poor ventilation, which reduces comfort and productivity of workers (Cabral et al., 2024; Yang et al., 2024). Similarly, when noise levels exceed the safety limits, they result in concentration disturbance, while at the same time leading to health outcomes such as hearing impairment and psychosocial stress (Lyon, 2025; Najmaldin Ezaldin Hassan, 2024). Therefore, it is very important to look into how lighting, thermal comfort, and noise levels were set at workshop spaces to identify the existing problems and come up with appropriate solutions.

The Workshop Building of the Faculty of Engineering in Universitas Negeri Manado will be the object of evaluation for workspace comfort. A workshop itself is an artistic or educational practice that emphasizes experiential and participatory learning, where activities are done by hands and tailored to fit the needs and interests of a group (Bordiug et al., 2020; Linds & Gee, 2023). Workshops are designed in a learning environment to encourage collaborative and mutual support between participants to achieve certain objectives in interactive programming or training (Bordiug et al., 2020). Workshop activities cover various purposes, such as conducting research, inquiry, and skill development, enabling participants to create a sense of community while taking concern over common societal issues (Linds & Gee, 2023). In specialized fields such as technogenic training and environmental safety, workshops are vital to preparing competent and competitive professionals through hands-on, practice-oriented experience and developing crisis monitoring systems and responses for such cases (Radić-Bojanić et al., 2018). The essence of a workshop is the empowerment of learners in applying the knowledge and skills they acquired into real-life scenarios, which promotes learning for life and continuing professional development (Radić-Bojanić et al., 2018).

These questions therefore have become the major focus of inquiry within this study: First, what is the lighting condition in the workshop, and does it comply with any of the established standards? Second, how is the thermal comfort in the workshop in terms of temperature, humidity, and air velocity? Third, what is the noise level in the workshop, and does it follow the occupational safety standards? Fourth, which solutions could be made to enhance the quality within the workshop environment?

The study aims to evaluate the lighting conditions in the workshop and compare them with the standards, analyze thermal comfort according to temperature, humidity, and airspeed, measure noise levels in the workshop, and finally, assess these factors from the standpoint of user's comfort and health. In addition, based on those findings, recommendations will be made for the improvement of lighting quality, thermal comfort, and noise control within the workshop.

To ensure a focused and structured analysis, the scope of this study is limited to examining the working environment conditions in the workshop at Universitas Negeri Manado. This analysis addresses only the lighting, thermal comfort, and noise levels and excludes other forms of ergonomic evaluation. Moreover, these measurements are carried out under normal conditions and do not consider seasonal variations or extreme environmental conditions..

Much is expected from this study. The findings of research will not only provide empirical evidence regarding lighting conditions, thermal comfort, and noise levels in the workshops but also give actionable recommendations to improve the work environment. This study can also serve as a reference material for academics, workshop managers, and learning institutions in general on optimal workspace condition as far as occupational safety and comfort is concerned. In a broader sense, this study aims at creating awareness regarding the importance of having a comfortable and safe work environment towards achieving productivity and enhancing worker wellbeing.

The Workshop Building is on Jl. Kampus Unima, Tataaran Satu, South Tondano District, Minahasa Regency, in North Sulawesi. It is within the Faculty of Engineering area and serves as a dual function workshop, namely for Wood Working Workshop and Automobile Workshop. The activities in the workshops require high precision and concentration and are mostly machine driven. The Woodworking Program covers six types of work: scrollwork techniques, lathe work techniques, planing techniques, carving techniques, and finishing techniques. Meanwhile, the Mechanical Engineering Program includes four categories: machine design techniques, development techniques, production techniques, and operational maintenance techniques.

The building is located at coordinates 1.268° North Latitude and 124.886° East Longitude. Its orientation extends from east to west, with the front side facing north. The total site area is 6,607 m², while the building area is 604.2 m². Accessibility to the site is relatively easy, as it is positioned directly in front of the main road

METHODS

The research method used in this study follows a systematic approach to assess the quality of the Workshop Building based on relevant standards, such as SNI (Indonesian National Standard). Data collection was conducted through direct observation of the building's physical condition, field measurements using environmental measuring

Figure 1. Location
Source: AAP Putra and Google, (2025).

instruments, and interviews to gather feedback from users regarding their experiences related to the comfort, health, and safety of the Workshop Building. In support of the analysis, documentation through photographs and technical notes was also recorded.

This study employs experimental and measurement methods to evaluate environmental quality parameters of the building, including air temperature, humidity, light intensity, air velocity, and noise levels. The measurement results were compared against the minimum standards set by SNI, such as SNI 03-6572-2001 for thermal comfort, SNI 6197:2020 for light intensity comparison, and Minister of Manpower Regulation No. 5 of 2018 on Occupational Safety and Health in the Work Environment.

The SNI 03-6572-2001 standard recommends that the ideal temperature for tropical regions can be categorized into :

1. Cool and comfortable, with an effective temperature range of 20.5°C to 22.8°C.
2. Optimally comfortable, with an effective temperature range of 22.8°C to 25.8°C.
3. Warm and comfortable, with an effective temperature range of 25.8°C to 27.1°C.(Nasional, 2001).

For tropical regions, the recommended relative humidity ranges between 40% and 50%. However, in densely populated spaces such as meeting rooms, a relative humidity level of 55% to 60% is still considered acceptable (Nasional, 2001). For optimal thermal comfort, air velocity directly above the head should not exceed 0.25 m/s, with values below 0.15 m/s being preferable (Nasional, 2001). The SNI 6197:2020 standard for lightning recommends 200 lux for rough work and 500 lux for fine work (Indonesia & Nasional, 2020). Lastly, Ministerial Regulation Number. 5 of 2018 on Occupational Safety and Health in the Work Environment establishes that the permissible noise exposure limit for workers over an 8-hour period is 85 dB (decibels) (Nomor, 5 C.E.). The relationships between these variables are then analyzed in relation to Occupational Health and Safety (OHS).

Measurements were conducted using the Krisbow Environment Meter 5 in 1 Pro, a multifunctional device capable of measuring air temperature (thermometer), relative humidity (hygrometer), light intensity (lux meter), noise levels (sound level meter), and wind speed (anemometer). This device was selected for its portability and accuracy, enabling efficient and relevant data collection at the research site.

The study was carried out from November 4 to 8, 2024, at 10:00 AM each day, to ensure consistency in measurement results. This time was chosen as environmental conditions tend to be stable, particularly regarding temperature and lighting. The measurement errors of the device followed manufacturer specifications, with an accuracy tolerance of ±1°C for air temperature, ±5% RH for humidity, ±5% for light intensity, ±1.5 dB for noise levels, and ±3% for wind speed. This assessment serves two key purposes: (1) to establish measurement tolerances that ensure the validity and accuracy of collected data, and (2) to evaluate overall post-occupancy housing quality while recommending improvements. The recorded tolerances help validate the accuracy of reported data. This methodology aims to conduct a comprehensive evaluation of post-occupancy housing quality and provide actionable improvement measures.

RESULT AND DISCUSSION

Lighting

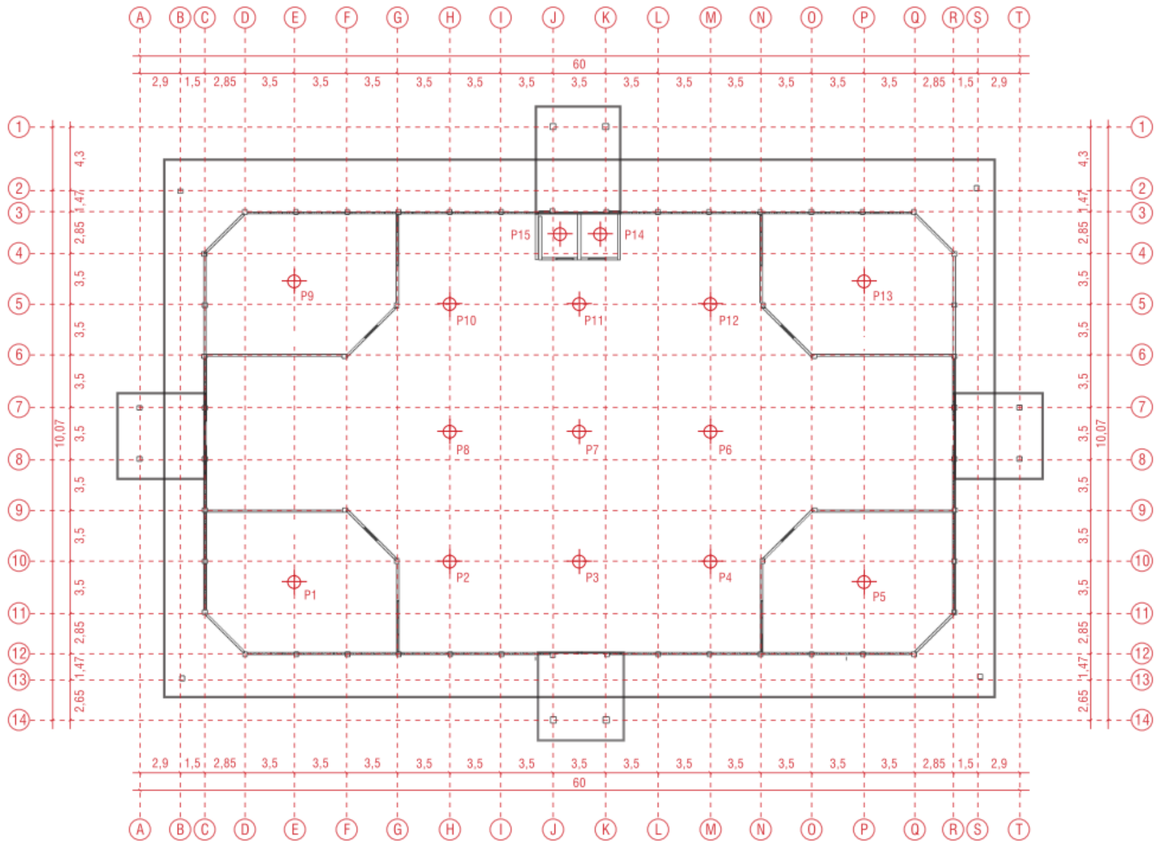

Figure 1. Lighting Point Placement
Source: AAP Putra, (2025).

Figure 2. Documentation of Light Intensity Measurement in the Work Area and Under Light
Source: AAP Putra, (2025).

Measurements were taken from five different locations: four of them are situated directly beneath the lights (P2, P4, P10, and P12) while one is located directly above the wooden workbench. The results of the light intensity measurements in the workshop building can be summarized as follows :

Table 1. Light Intensity Measurement Results

Light Point	Maximum Light Intensity (Lux)	Average Light Intensity (Lux)	Minimum Light Intensity (Lux)
P2	83,6	80,7	78,2
P4	75,7	64,7	50,4
P10	55,0	34,1	27,4
P12	33,3	12,5	19,5
Bidang Kerja	62,7	60,8	56,7

Source: AAP Putra, (2025).

The results for the measurements regarding light intensity show some variation over the five measuring points, which correspond to the important work areas within the room, including the P2 and P4, near the entrances. During measurement, the direction of the incoming sunlight effectively contributed to both these measuring points. At P2, for example, the maximum value of recorded attainable light intensity measured 83.6 lux with an average of 80.7 lux and a minimum of 78.2 lux. In contrast at P4, the maximum intensity was 75.7 lux with an average of 64.7 lux and a minimum of 50.4 lux. Hence, high light intensity gained at these two points through door openings would show that much of their illuminance relied on natural light that penetrated through the door.

While at the other points farthest from Natural Light Source, it was much lesser in illumination. One such example is the measuring point P10, which had the maximum intensity of only 55.0 lux with an average of 34.1 lux and a minimum of 27.4 lux. At P12, the light intensity was even lower, with a maximum of 33.3 lux, an average of 12.5 lux, and a minimum of 19.5 lux. The workbench area, located in the middle of the room, had a more stable light intensity, with a maximum of 62.7 lux, an average of 60.8 lux, and a minimum of 56.7 lux.

According to SNI 6197:2020, the recommended minimum light intensity for workspaces such as workshops or areas requiring precision is 200 lux for rough work and 500 lux for fine work (Indonesia & Nasional, 2020). The light intensity measurements at the five points in the workshop indicate that all recorded values are well below these standards, regardless of whether they are the highest or lowest intensity points.

At P2, the maximum recorded intensity was 83.6 lux, with an average of 80.7 lux and a minimum of 78.2 lux. Compared to the standard, the maximum intensity at this point only reaches 41.8% of the minimum standard for rough work (200 lux) and 16.7% of the standard for fine work (500 lux). At P4, the maximum measured intensity was 75.7 lux, with an average of 64.7 lux and a minimum of 50.4 lux, covering only 37.8% of the standard for rough work and 15.1% for fine work.

At P10, the maximum recorded intensity was 55.0 lux, with an average of 34.1 lux and a minimum of 27.4 lux. This maximum intensity only reaches 27.5% of the standard for rough work and 11.0% of the standard for fine work. At P12, the maximum light intensity was 33.3 lux, with an average of 12.5 lux and a minimum of 19.5 lux, covering only 16.7% of the standard for rough work and 6.7% for fine work. Meanwhile, in the workbench area, the maximum recorded intensity was 62.7 lux, with an average of 60.8 lux and a minimum of 56.7 lux, reaching only 31.4% of the standard for rough work and 12.5% for fine work. An improvement in light intensity in the workshop environment is one pressing necessity in these findings so as to conform to the recommended minimum standards for light, ensuring efficiency and safety in that area.

The measurement results show that the lighting levels at every point in the workshop are below the minimum standards outlined by SNI. Even in areas of highest measurements, such as P2 and P4, the maximum intensity measured is not even a third of the required standard. This implies lighting upgrades are urgent, either by enhancing the artificial lighting with good-quality LED lights or by improving the architectural design to maximize natural light utilization.

Artificial LED lighting quality and performance can be enhanced by aligning its spectral power distribution with natural daylight patterns. This approach simultaneously supports visual task performance and circadian rhythm regulation - both critical factors for human productivity (Moreno et al., 2024). Besides, some architectural interventions can be made to support natural light penetration and improve lighting condition. Such interventions include window arrangements and reflective surfaces that would distribute the light much better (Maharani et al., 2024). An optimal lighting scenario through the integration of natural and artificial light will maintain proper conditions of illumination quality and energy efficiency. A hybrid lighting arrangement of sunlight plus LEDs was found to be best in energy saving and illumination quality (Al Kailani et al., 2024; Pratama et al., 2023).

These considerations are necessary for the establishment of equilibrium between none-too-dim and far-too-bright lighting conditions, ensuring comfort and an even flow in terms of a working environment. The space should be comfortable and supportive of productivity while also reducing fatigue and strain on the eyes, which usually occurs due to lighting levels that are too dim for proper work (Yusop et al., 2013). Moreover, lighting that is less than or more than optimal increases the possibility of accidents and illnesses (Reinhold & Tint, 2009).

Temperature, Humidity, and Air Velocity

Nevertheless, for heavy work, special consideration must be given to control temperature and ventilation to increase workplace comfort. These factors will inform recommendations for improving the workshop's ventilation system, insulation, or thermal control strategies. The average daily temperature ranged from 27.1°C to 28.4°C - suitable for light to moderate physical work - while relative humidity levels measured between 80.3% and 84.7%. The air velocity in the workshop ranges from 0.1 to 0.3 m/s, which demonstrates that some air movement occurs, but it is insufficient to restore temperature and humidity to acceptable comfortable levels. This indicates that the workshop cannot fully satisfy the thermal comfort criteria necessary to achieve a perfect working environment.

Simulation results using the CBE Thermal Comfort Tool, based on the measured parameters, indicate the following conditions: operative temperature of 27.7°C, air velocity of 0.2 m/s (without local control), relative humidity of 82.5%, metabolic rate of 1.0 met (light to moderate activity), and clothing level of 0.61 clo (typical summer clothing). The results show that the workshop does not meet ASHRAE 55-2023 standards, as reflected in the Predicted Mean Vote (PMV) of 0.86, indicating that the environment is perceived as "slightly warm." Additionally, the Predicted Percentage of Dissatisfied (PPD) is 20%, meaning that 20% of users are expected to feel uncomfortable in these conditions. Finally, the Standard Effective Temperature (SET) is 28.8°C, representing the perceived temperature experienced by users.

Concerning thermal discomfort, high humidity (82.5%) is the most dominant factor in aggravating high temperature by restricting evaporation of sweat. Excessive humidity decreases the body's cooling capacity and may lead to heat-related disorders (Amaripadath et al., 2023; Baldwin et al., 2023). Furthermore, low air velocity (0.2 m/s) does not produce a cooling effect, which adds to the warmer feeling of the ambience. Studies based on Computational Fluid Dynamics (CFD) reveal that increasing airspeed can markedly enhance thermal comfort in the built environment (Huang et al., 2019). Therefore, these combined effects practically push the resultant operative temperature slightly outside the thermal comfort zone within the psychrometric chart, indicated by the red circle sitting outside the blue comfort area.

Table 2. Results of Temperature, Humidity, and Wind Speed Measurements in the Workshop from November 4 to 8, 2024

No	Temperature (°C)					Relative Humidity (%)	Wind Speed (m/s)
	Dates						
	04/11/2024	05/11/2024	06/11/2024	07/11/2024	08/11/2024		
1	27,8	27,9	27,7	27,8	27,6		
2	27,6	27,5	27,6	27,7	27,5		
3	27,7	27,6	27,8	27,9	27,7		
4	27,8	27,7	27,7	27,6	27,8		
5	28,3	28,4	28,2	28,3	28,3		
6	28	28,1	28,3	28,2	28,2		
7	27,1	27,3	27,2	27,4	27,3		
8	27,6	27,8	27,7	27,7	27,6	80,3-84,7	0,1-0,5
9	28,1	28	28,1	28,1	28		
10	27,5	27,6	27,4	27,5	27,5		
11	27,6	27,7	27,8	27,7	27,6		
12	28,3	28,2	28,3	28,4	28,1		
13	27,8	27,9	27,6	27,8	27,7		
14	27,5	27,4	27,5	27,6	27,4		
15	27,6	27,8	27,5	27,6	27,5		
Min	27,1	27,3	27,2	27,4	27,3	80,3	0,1
Max	28,3	28,4	28,3	28,4	28,3	84,7	0,3
Average	27,75	27,79	27,76	27,82	27,72	82,52	0,2

Source: AAP Putra, (2025).

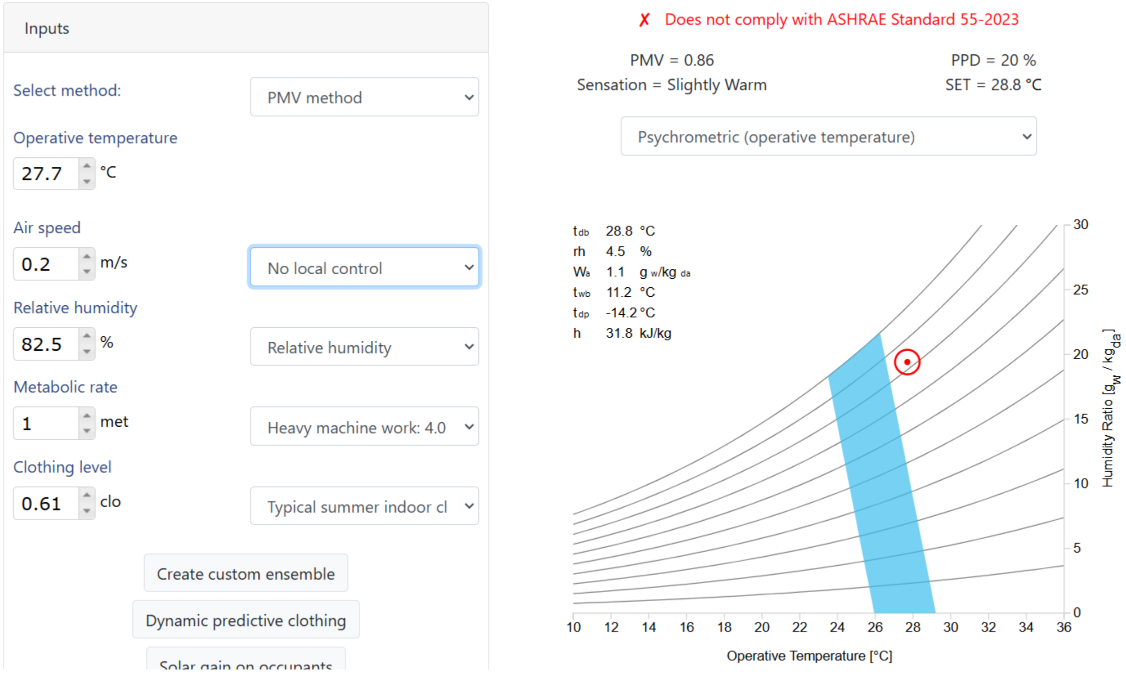

Figure 3. Operative Temperature Simulation Using the CBE Thermal Comfort Tool with Measured Parameters from the Workshop Building
Source: CBE Thermal Comfort Tool, (2025).

The couple of architectural strategies to improve thermal comfort in the workshop include one, augmentation of the mechanical ventilation system by means of introducing exhaust fans to attain adequate air movement through the space. Additionally, natural ventilation can be optimized by enlarging windows or doors in strategic locations to maximize airflow from outside. For thermal control, measures such as installing thermal insulation on the roof and walls should be applied to reduce heat transfer from the outside into the room. The addition of air conditioning and dehumidifiers is also essential to lower temperature and humidity to levels closer to the recommended comfort standards. Operational schedules can be optimized by planning strenuous activities during cooler periods, such as morning hours. Additionally, worker comfort can be improved by providing lighter-weight clothing with reduced thermal insulation (lower clo values) where feasible. Clo is a measure of thermal resistance, including the insulation provided by each layer of trapped air between the skin and clothing as well as the insulation value of the clothing itself. The implementation of these strategies is expected to create a more comfortable work environment and support productivity. By adopting these measures, the workspace conditions can be optimized to meet the comfort and productivity standards outlined in SNI 03-6572-2001 and ASHRAE 55-2023.

An uncomfortable work environment that fails to meet standards can negatively impact worker health and safety. Heat and excessive humidity combined cause heat stress. Symptoms of this condition include dehydration, fatigue, and reduced levels of concentration. In the extreme cases, this syndrome is associated with the risk of heatstroke, which may be a critical health hazard for employees. Thus, in an occupational safety perspective, it is in a disenabling work environment that an employee may decrease alertness, therefore increasing the chances of even fatal accidents posed by dangerous heavy machinery or equipment. Poor environmental conditions can also be regarded to

Table 3. Noise Intensity Measurement Results

No	Measurement Point	Max	Min	Average
1	Machine Workshop	82	75,7	78,9
2	Mid Point	82,3	54,7	69,2
3	Mid Point	67,2	56,3	55,6
4	Woodworking Workshop	71	64,5	66,9
5	Woodworking Workshop	70,6	66,1	68

Source: AAP Putra, (2025).

worsen the issue of declining productivity among workers as such conditions slow down work completion and also lower the quality of work produced at the end of the process.

Noise Intensity

Measurements of noise intensity taken at five points showed varying levels of noise emission from the Automotive Workshop, Mid Point, and Woodworking Workshop. Maximum recorded noise intensity in the Automotive Workshop was 82 dB, while the minimum was 75.7 dB, and the average readings stood at 78.9dB. In the Mid Point area also, measurements were made at two locations, with the first point measuring a maximum level of noise to be 82.3 dB, a minimum of 54.7 dB, and an average of 69.2 dB. While the second point recorded a maximum noise level of 67.2 dB, a minimum of 56.3 dB, and an average of 55.6 dB. In the Woodworking Workshop, two points for measuring recorded maximum levels of noise of 71 dB and 70.6 dB, with minimum values of 64.5 dB and 66.1 dB, and average values of noise level of 66.9 and 68 dB, respectively.

Compared to Ministerial Regulation No. 5 of 2018 on Occupational Safety and Health in the Work Environment, which set a maximum allowable noise level of 85 dB for an eight-hour shift, the results of these measurements indicate that noise levels at all points remain below this threshold limit. Still, average noise levels approaching upper limits seen in the case of the Automotive Workshop (78.9 dB) and Mid Point (69.2 dB) may compromise comfort in the workplace. When noise approaches its maximum limits, it affects occupational health and safety. Long exposure to noise may cause permanent hearing loss (Noise-Induced Hearing Loss), stress, and mental fatigue. Excessive noise levels can mask warning signals and critical communications, elevating workplace accident risks. Furthermore, noise-induced distractions impair worker concentration, reducing productivity while increasing error rates.

Protective measures are to be made in favor of worker health and safety: wall and floor sound absorption material installation inside the workspace, provision of personal protective equipment (PPE) like earplugs or earmuffs, and scheduling regular rest breaks to prevent prolonged noise exposure. Further monitoring of noise intensity should be conducted periodically, and these periodic measurements provide assurance that noise levels will remain within permissible limits, thereby safeguarding worker health and safety.

CONCLUSION

Assessment of illumination conditions, thermal comfort, and ambient noise levels as per measured results suggested in this study for workshop evaluation. The main results are listed as follows.

Measurements for lighting at 5 points showed that all its values remained far short of the minimum standards prescribed by SNI 6197:2020 for workspaces. At P2, the highest intensity point, the standard was reached only by 41.8% and of the standard for fine work by 16. 7%. Thus, this needs to be improved through appropriate combinations of natural and artificial illumination techniques. This strategy involves the use of good quality led lights, room design for better penetration of natural light, and the use of hybrid lighting systems. This emphasizes the need to improve lighting through a combination of natural and artificial illumination. Recommended strategies include the use of high-quality LED lights, optimizing room design to enhance natural light penetration, and implementing hybrid lighting systems.

The daily average temperature in the workshop ranges from 27.1°C to 28.4°C, while relative humidity remains high (80.3%–84.7%), with low air velocity (0.1–0.3 m/s). Simulation results indicate that the workshop does not meet ASHRAE 55-2023 thermal comfort standards, with a PMV of 0.86 ("slightly warm") and a PPD of 20%. To enhance thermal comfort, several measures are recommended. One approach is to install mechanical ventilation systems, such as exhaust fans, while also optimizing natural ventilation by strategically placing windows and openings to improve airflow. Additionally, incorporating thermal insulation in walls and roofs, along with air conditioning units, can help regulate indoor temperatures and maintain a more stable environment. Another important measure is working according to the cooler portions of the day such as mornings and having workers wear suitable clothing with lower thermal resistance (clo value) for comfort while carrying out tasks. These steps will improve thermal conditions significantly, and the workshop becomes more comfortable and productive.

Background noise measurements in the Automotive Workshop, Mid Point, and Woodworking Workshop remain below the 85 dB threshold specified in Ministerial Regulation No. 5 of 2018. However, recorded levels approach this limit - particularly in the Automotive Workshop, which averaged 78.9 dB. To maintain compliance and ensure worker safety, noise control measures should be implemented, including: (1) installation of sound-absorbing materials, and (2) strict management of noise exposure durations.

This study reveals that substandard work environments can adversely affect workers' health, safety, and productivity. Corrective measures are necessary to address these deficiencies. In particular, improving lighting conditions plays a crucial role in enhancing both work efficiency and safety by providing better visibility and reducing eye strain. Thermal comfort represents another critical aspect, achievable through architectural design and technological solutions that regulate temperature, humidity, and air circulation - all essential factors for ensuring overall workplace comfort. Managing noise levels is also essential for the indelible long-term health consequences it can make, such as hearing loss and stress, reducing productivity as well as well-being. With these recommendations, it is now expected that the workshop will provide a more comfortable environment to work in, a safer one, and a more productive working environment, all of which conform to the applicable standards and improved quality inside the workspace.

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