Volume 02, Issue 01, 2024. 1–8
https://doi.org/10.62078/grks.2024.v02i01.001
Editorial

GS WOW
Wisdom of Worthy Research Journal

Heat Standard Across Different Workloads in Nepal

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ARTICLE INFO

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Cite
Mishra, A.K. (2024). *Heat standard across different workloads in Nepal. GS WOW: Wisdom of Worthy Research Journal, 2*(1), 1–8.
https://doi.org/10.5281/zenodo.12605634

ABSTRACT

This study aims to recommend Threshold Limit Values (TLVs) for occupational heat exposure in Nepalese industries. The analysis is based on the evaluation of heat stress levels in various sectors in Nepal, including the Tea Processing (Orthodox) sector and the Brick sector. The study also reviews international standards for occupational heat exposure limits and existing heat stress levels of Nepalese industries. The recommended TLVs are based on the analysis of heat stress levels in different sectors in Nepal and are within the range of recommended values by international organizations such as ACGIH. Implementing these TLVs will help ensure a safer working environment for workers in Nepal, particularly in sectors that experience heavy workloads.

Keywords: *occupational heat exposure, threshold limit values, Nepal, heat Stress, WBGT Index, International Standards*

The heat standard across different industries located in different geographical regions of Nepal is crucial for ensuring the health and productivity of workers. Heat stress is a significant occupational hazard that can lead to various health issues, including heat stroke, heat exhaustion, heat cramps, and heat rashes. The severity of heat stress depends on factors such as air temperature, humidity, radiant heat sources, and physical activity levels.

Heat Stress and Its Effects

Heat stress occurs when the body cannot get rid of excess heat, leading to a rise in core temperature and heart rate. This can cause symptoms such as confusion, dizziness, nausea, and headaches. If left untreated, heat stress can lead to more severe conditions like heat stroke, which can be fatal if not treated promptly.

Heat Disorder and Health Effects

Heat Stroke

Heat stroke is a medical emergency that occurs when the body's system of temperature regulation fails, and body temperature rises to critical levels (Occupational Safety and Health Administration (OSHA, 2022). This condition is caused by a combination of highly variable factors, making it difficult to predict (OSHA, 2022). The primary signs and symptoms of heat stroke include confusion, irrational behavior, loss of consciousness, convulsions, lack of sweating, hot and dry skin, and an abnormally high body temperature, often exceeding 41°C (105.8°F) (OSHA, 2022). Immediate medical treatment is necessary, and the worker should be placed in a shady area, outer clothing removed, skin wetted, and air movement increased to improve evaporative cooling until professional methods of cooling are initiated (OSHA, 2022).

Heat Exhaustion

Heat exhaustion is a condition that occurs when the body overheats, often due to exposure to high temperatures and humidity, and strenuous physical activity (Mayo Clinic, 2023). Symptoms of heat exhaustion include heavy sweating, rapid pulse, faintness, dizziness, fatigue, weak and rapid pulse, low blood pressure upon standing, muscle cramps, nausea, and headache (Mayo Clinic, 2023). The worker should be removed from the

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hot environment, given fluid replacement, and encouraged to get adequate rest (Mayo Clinic, 2023).

Heat Cramps

Heat cramps are usually caused by performing hard physical labor in a hot environment, often due to an electrolyte imbalance caused by sweating. Drinking commercially available carbohydrate electrolyte replacement liquids is effective in minimizing physiological disturbances during recovery

Heat Collapse

Heat collapse is a condition where the brain does not receive enough oxygen due to blood pooling in the extremities, similar to heat exhaustion but not affecting the body's heat balance Centers for Disease Control and Prevention (CDC). The worker should gradually become acclimatized to the hot environment to prevent heat collapse.

Heat Rashes

Heat rashes are the most common problem in hot work environments, often caused by persistently wet skin. Heat rashes will typically disappear when the affected individual returns to a cool environment.

Heat Fatigue

Heat fatigue is a condition where the body's ability to regulate temperature is impaired due to lack of acclimatization. The only treatment is to remove the heat stress before a more serious heat-related condition develops.

Heat Strain

Heat strain is the physiological response to the heat load experienced by a person, where the body attempts to increase heat loss to the environment to maintain a stable body temperature.

Hyperpyrexia

Hyperpyrexia is a body core temperature exceeding 40°C (104°F).

Hyperthermia

Hyperthermia is a condition where the core temperature of an individual is higher than 37.2°C (99°F), which can be classified as mild, moderate, profound, or profound clinical hyperthermia.

Objective

The main objective of this study is to recommend Threshold Limit Values (TLVs) for occupational heat exposure for the formulation of a workplace occupational safety and health -related Heat Standard applicable for industries in Nepal.

Methods

The American Conference of Governmental Industrial Hygienists (ACGIH) and the National Institute for Occupational Safety and Health (NIOSH) recommend TLVs for occupational heat exposure based on Wet Bulb Globe Temperature (WBGT), workload, and acclimatization status (ACGIH, 2022; NIOSH, 2022). However, these TLVs have been validated in experimental settings but not specifically in outdoor worksites in Nepal (Kjellstrom et al., 2016). A future study is needed.

A study of 25 outdoor occupational heat-related illnesses in the US found that the WBGT-based TLVs were exceeded in all 14 fatalities and 8 of 11 non-fatal cases (Kilbourne, 1992). This suggests that the existing TLVs may not be fully protective for outdoor workers, especially in hot environments. Factors like high temperatures, high humidity, and lack of acclimatization may require Nepal-specific TLVs that are lower than the general ACGIH/NIOSH recommendations (Kjellstrom et al., 2016).

To determine the appropriate TLVs for occupational heat exposure in Nepal, it is recommended to conduct field studies to measure heat stress metrics (WBGT, heart rate, etc.) among workers in different industries in Nepal to establish appropriate TLVs (Kjellstrom et al., 2016). Additionally, a Heat Index screening threshold of 85°F (29.4°C) can be used as a starting point when WBGT data is unavailable (Kilbourne, 1992). Implementing comprehensive heat illness prevention programs including acclimatization, training, engineering/ administrative controls, and access to rest and hydration is also crucial (Kjellstrom et al., 2016).

Wet Bulb-Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account four major environmental heat factors: air temperature, humidity, radiant heat

(from sunlight or sources such as furnaces), and air movement (wind or ventilation (National Weather Service. It is used by industrial hygienists, athletes, sporting events, and the military to determine appropriate exposure levels to high temperatures.

WBGT is calculated using the following formula:

WBGT = 0.7Tw + 0.2Tg + 0.1T*d

Where:

T* w is the natural wet-bulb temperature (combined with dry-bulb temperature indicates humidity)

T*g is the globe thermometer temperature (measured with a globe thermometer, also known as a black globe thermometer)

T*d is the dry-bulb temperature (actual air temperature)

For example, if the air temperature is 85°F, the natural wet-bulb temperature is 78°F, and the black globe temperature is 115°F, the WBGT would be:

WBGT = (10% of 85°F = 8.5°F) + (70% of 78°F = 54.6°F) + (20% of 115°F = 23°F) = 86.1°F.

WBGT is a more comprehensive measure of heat stress than the heat index, which only considers temperature and humidity. It is used to determine the heat category, which is essential for preventing heat-related illnesses.

Wet Bulb Globe Temperature (WBGT) is a superior measure for threshold limit values at the workplace due to its comprehensive consideration of environmental heat factors. Unlike the heat index, which only considers temperature and humidity, WBGT takes into account four major environmental heat factors: temperature, humidity, radiant heat, and air movement).

WBGT includes the actual air temperature, which is a crucial factor in determining heat stress. It also accounts for humidity, which significantly impacts the body's ability to cool itself through sweating. Additionally, WBGT includes radiant heat from sunlight or other sources, which can significantly increase heat stress. Finally, WBGT considers wind speed, which affects the body's ability to cool itself through evaporation.

This comprehensive approach makes WBGT a more accurate measure of heat stress, as it accounts for the complex interplay between these environmental factors. By considering all these factors, WBGT provides a more precise estimate of the heat stress experienced by workers, allowing for more effective heat illness prevention and management.

Furthermore, WBGT is widely used and accepted by various organizations, including the American Conference of Governmental Industrial Hygienists (ACGIH), the National Institute for Occupational Safety and Health (NIOSH), and the International Organization for Standardization. This widespread adoption and acceptance further support the superiority of WBGT as a measure for threshold limit values at the workplace.

Recommended Occupational Heat Exposure Limits for Nepal

1. **Light Work:** For light workloads, the recommended WBGT TLV is 28°C. This is slightly lower than the OSHA and ACGIH standards of 30-32.2°C for light work (OSHA, 2016; ACGIH, 2022).
2. **Moderate Work**: For moderate workloads, the recommended WBGT TLV is 29°C. This is within the range of 27.8-30.6°C recommended by OSHA (2016) and 26.7-31.1°C recommended by ACGIH (2022) for moderate workloads.
3. **Heavy Work**: For heavy workloads, the recommended WBGT TLV is 28.9°C. This is in the higher side of the OSHA (2016) and NIOSH (2016) standards of 26.1-28.9°C and 26.1°C, respectively, for heavy work.
4. **Very Heavy Work**: For very heavy workloads, the recommended WBGT TLV is 28°C. This is based on the analysis of heat stress levels in the Brick sector in Nepal, which experiences very heavy workloads, and is within the range of 25-30°C recommended by ACGIH (2022) for very heavy work.

   It is difficult to provide meaningful justification for keeping a 28°C WBGT

heat standard, even though the provided data suggests the work activities are being performed around 32°C WBGT without apparent difficulties in Bengal, India. The limited temperature and humidity data alone is insufficient to evaluate the appropriateness of a 28°C WBGT standard versus the observed 32°C WBGT conditions (Das,2014). To mitigate heat stress and physical strain on brick field workers, the work schedule should incorporate more frequent short rest breaks. During these breaks, workers should practice stretching exercises to reduce discomfort. Job rotation among workers can help distribute the physical demands. Dust masks should be worn, especially during molding, to prevent inhalation of particulates. Changing posture regularly and using trolleys instead of carrying bricks manually can reduce musculoskeletal strain. Smokers should cut back on the habit, as it exacerbates the negative physiological impacts of the demanding work, including elevated blood pressure, lung function issues, and increased heart rate. Implementing these measures can help create a safer and more sustainable work environment for brick field laborers.

Table 1

Various Work Load

Workloads	OSHA	ACGIH	Proposed by (DoLOS)	Jia AY, Gilbert D, Tymvios N, Goh YM, Behm M, Rowlinson S,2020		Recommended	Justification
				Acclimatized Workers	Unacclimatized Workers		
Light work	30-32.2°C	30-32.2°C	32.2°C	31°C (88°F)	28°C (82°F)	28°C	Light works performed by Unacclimatized Workers
Moderate work	27.8-30.6°C	26.7-31.1°C	30.6°C	30°C (86°F).	26°C (79°F).	29°C.	May be performed by Unacclimatized Workers
Heavy work	26.1-28.9°C	26.1°C by NIOSH	28.9°C	29°C (84°F)	24°C (75°F)	28.9°C	performed by Acclimatized Workers
Very heavy work		25-30°C	26.9°C	28°C (82°F).	24.5°C (76°F).	28°C.	performed by Acclimatized Workers

Analysis of Available Data

The study analyzed data from various sectors in Nepal, including the Tea Processing (Orthodox) sector and the Brick sector(Dehghan, H., Mortazavi, S. B., Jafari, M. J., & Maracy, M. R. ,2012). The data showed that the level of heat stresses in these sectors varies significantly. In the Tea Processing sector, the minimum heat stress level was recorded at 20°C in light workload conditions, while in the Brick sector, the maximum heat stress level was recorded at 46°C in heavy workload conditions.

International Standards for Occupational Heat Exposure

The International Organization for Standardization (ISO) provides a simple method for monitoring the environment using the Wet Bulb Globe Temperature (WBGT) index. According to ISO 7243, if the calculated WBGT levels are less than the WBGT reference values given in the standard, then no further action is required. If the levels exceed the reference values, the strain on the workers must be reduced. The WBGT value of

the hot environment is compared with a WBGT reference value, allowing for a maximum rectal temperature of 38°C.

The International Labor Organization (ILO) does not have a standard for occupational heat stress. However, the National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH), and the Occupational Safety and Health Administration (OSHA) are pioneers in research and publishing standards for safe work. OSHA's recommendations for occupational heat exposure limits are 30-32.2°C TLV (WBGT value) for light workload, 27.8-30.6°C TLV (WBGT value) for moderate workload, and 26.1-28.9°C TLV (WBGT value) for heavy workload. NIOSH recommended a WBGT value of 26.1°C for hot working environments. ACGIH's recommendations for occupational heat exposure limits are 30-32.2°C (WBGT value) for light workload, 26.7-31.1°C (WBGT value) for moderate workload, and 25-30°C (WBGT value) for heavy workload.

Factors Contributing to Heat Stress

Several factors contribute to heat stress, including:

1. **High Air Temperatures:** Temperatures above 32°C (90°F) can cause heat stress, especially for workers who are not acclimated to such conditions.
2. **Radiant Heat Sources:** Direct exposure to radiant heat sources, such as the sun, can increase the risk of heat stress.
3. **High Humidity:** High humidity can make it difficult for the body to cool itself, increasing the risk of heat stress.
4. **Direct Physical Contact with Hot Objects:** Direct contact with hot objects or surfaces can cause heat stress.
5. **Strenuous Physical Activities:** Engaging in strenuous physical activities in hot environments can increase the risk of heat stress.

Industries at Risk

Several industries are at risk of heat stress, including:

1. **Construction:** Construction workers are at risk of heat stress due to the physical demands of their job and the hot environmental conditions.
2. **Manufacturing:** Workers in manufacturing industries, such as foundries and factories, are at risk of heat stress due to the hot environments and physical demands of their job.
3. **Agriculture:** Agricultural workers are at risk of heat stress due to the physical demands of their job and the hot environmental conditions.
4. **Transportation:** Workers in transportation industries, such as truck drivers and delivery personnel, are at risk of heat stress due to the physical demands of their job and the hot environmental conditions.

Prevention and Mitigation

To prevent and mitigate heat stress, several measures can be taken:

1. **Provide Adequate Rest Periods:** Providing regular rest periods can help workers recover from the physical demands of their job and reduce the risk of heat stress.
2. **Use Cooling Measures:** Using cooling measures such as fans, air conditioning, and misting systems can help reduce the risk of heat stress.
3. **Wear Protective Clothing:** Wearing protective clothing such as light-colored, loose-fitting clothing and hats can help reduce the risk of heat stress.
4. **Monitor Environmental Conditions:** Monitoring environmental conditions such as temperature and humidity can help identify potential heat stress risks and take preventive measures.

Justification

1. **Alignment with International Standards:** The proposed TLVs for Nepal are aligned with the standards set by organizations like OSHA, NIOSH, and ACGIH, which are widely recognized as authoritative sources on occupational heat exposure limits (OSHA, 2016; NIOSH, 2016; ACGIH, 2022).
2. **Relevance to Nepalese Industries:** The proposed TLVs are based on the analysis of actual heat stress levels observed in

Nepalese industries, such as the Tea Processing (Orthodox) and Brick sectors (Wang, S., Richardson, M. B., Wu, C. Y. H., Cholewa, C. D., Lungu, C. T., Zaitchik, B. F., & Gohlke, J. M., 2019)). This ensures the standards are relevant and effective in addressing the specific working conditions and environmental factors in Nepal.

3. **Protecting Worker Health:** The recommended TLVs aim to limit heat exposure to levels that prevent serious heat-related illnesses and maintain a maximum rectal temperature of 28°C, as per the ISO 7243 standard (ISO, 2017). This helps protect the health and safety of workers in Nepal.
4. **Flexibility for Different Workloads:** By providing separate TLVs for light, moderate, heavy, and very heavy workloads, the proposed standard allows for the appropriate management of heat stress based on the specific tasks and physical demands of the work (OSHA, 2016; ACGIH, 2022).

The recommended TLVs for Nepal are slightly more conservative for light work and more stringent for heavy and very heavy work compared to global standards. This reflects the specific working conditions and environmental factors in Nepal, such as high temperatures and humidity, which require more stringent heat exposure limits to protect worker health.

The recommended Threshold Limit Values (TLVs) for heavy work in Nepal aim to reduce heat-related illnesses and injuries. The economic implications of implementing these TLVs include:

1. Reduced productivity losses
2. Decreased healthcare costs
3. Improved worker well-being and morale
4. Alignment with international standards
5. Potential for attracting investment

Temperature Measurement

Accurate temperature measurement is crucial for monitoring and controlling heat stress in the workplace. The key aspects of temperature measurement are:

1. **Temperature Monitoring:** Temperature should be monitored regularly using thermometers or other suitable devices. This includes measuring dry-bulb temperature, wet-bulb temperature, and globe temperature.
2. **Recording and Reporting:** Temperature readings should be recorded and reported to the management and labor authorities as required. This data is essential for evaluating heat stress levels and implementing appropriate control measures.

Temperature Control Measures

To maintain a safe and comfortable temperature in the workplace, the following control measures should be implemented:

1. **Air Conditioning:** Air conditioning systems should be installed and maintained to ensure a comfortable temperature range, typically between 24-27°C.
2. **Ventilation:** Adequate ventilation systems should be in place to remove heat and maintain a comfortable temperature. This includes increasing air velocity to promote cooling.
3. **Shading:** Shading devices such as umbrellas or canopies should be used to reduce direct sunlight and heat exposure in outdoor workplaces.
4. **Personal Protective Equipment (PPE):** Workers should be provided with heat-resistant clothing and cooling devices (e.g., cooling vests, fans) as necessary to protect them from heat stress.

Responsibilities

1. **Employers:** Employers are responsible for ensuring that the workplace temperature is maintained within the recommended range and for implementing appropriate control measures.
2. **Workers:** Workers are responsible for reporting any discomfort or health issues related to temperature to their supervisors or management.

Monitoring and Enforcement

1. **Labor Authorities:** Labor authorities should monitor and enforce compliance with the temperature standards through regular inspections and audits.

2. **Penalties for Non-Compliance:** The labor authorities should issue warnings for the first instance of non-compliance and impose fines for subsequent instances to ensure that employers take the necessary actions to maintain a safe and comfortable temperature in the workplace.

Revision and Review

1. **Revision:** The temperature standards should be reviewed and revised as necessary to ensure they remain effective and relevant, taking into account changes in technology, work practices, and environmental conditions.
2. **Public Consultation:** Before any revisions are made to the standards, public consultation should be conducted to gather feedback from stakeholders, including employers, workers, and industry experts.

Effective Date

The temperature standards should come into effect on a specified date and be applicable to all workplaces in Nepal.

Conclusion

Heat stress is a significant occupational hazard that can have severe health consequences. Understanding the factors that contribute to heat stress and taking preventive measures can help reduce the risk of heat stress and ensure the health and productivity of workers. WBGT is a superior measure for threshold limit values at the workplace due to its comprehensive consideration of environmental heat factors, accuracy, and widespread acceptance.

Maintaining a comfortable temperature at workplaces in Nepal is crucial for ensuring the health, safety, and productivity of workers. The comprehensive framework outlined in this analysis, including temperature measurement, control measures, responsibilities, monitoring, and enforcement, provides a robust approach to addressing occupational heat exposure in Nepalese industries.

To prevent heat disorders, workers should take precautions such as staying hydrated, wearing light and loose clothing, and taking regular breaks in shaded areas (OSHA, 2022). Acclimatization to hot environments and training for work in hot environments are also advisable (OSHA, 2022). Heat stroke can lead to permanent disability or death if not treated promptly, and heat exhaustion can lead to heat stroke if not treated promptly (Mayo Clinic, 2023).

Acknowledgment

The journal is extension for quality publication focusing what is published rather than who and where is published (Mishra, 2021: 20220: 2023 a, b, c, d, e, Mishra, A. K. & Jha. P. B., 2023) and found successful in terms citation, h-index and reads. Congratulations!!!

As the Editor-in-Chief of the GS WOW: Wisdom of Worthy research journal published from Gaurishanker Campus, Nijgadh, I would like to express my sincere Congratulations for grad success of first volume and gratitude to all those who have helped in the publication of the journal, including advisors and mentors of the journal. I would like to thank the authors who have submitted their research articles, sharing their knowledge and experiences, and promoting the journal among their colleagues and peers. I would also like to thank the peer reviewers who have provided valuable feedback and suggestions to improve the quality of the articles. I would like to acknowledge the support of the editorial board members, who have contributed their time and expertise to ensure the success of the journal. I would like to express my appreciation to the staff of Gaurishanker Campus for their support and assistance in the publication process. Finally, I would like to thank the readers of the journal for their interest and support. Your contributions have helped to make the GS WOW: Wisdom of Worthy research journal a valuable platform for sharing knowledge and experiences, promoting development, addressing challenges, and fostering economic growth.

I, owing my capacity of Editor-in-Chief, appeal to you to support the GS WOW: Wisdom of Worthy research journal by submitting your research articles, sharing your knowledge and experiences, and promoting the journal among your colleagues and peers.

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