II. Outdoor Heat Exposure Policy Rationale

Background Information for Developing the Policies of WAC 296-62-095, Outdoor Heat Exposure.

Trigger Temperatures

The Wet-Bulb Globe Thermometer (WBGT) method was developed by National Institute of Occupational Safety and Health (NIOSH), the research agency to the Occupational Safety and Health Administration (OSHA). This method is the accepted standard of heat measurement and promoted by the ACGIH (American Conference of Governmental Industrial Hygienists). However, this approach requires employers to take a series of measurements and conduct calculations to assess their worksites. The Department determined early on that this approach was not feasible because of the complex calculations and specialized equipment. Nonetheless, stakeholders requested a trigger to provide clear direction when the different elements of the rule would apply.

The Department worked with Dr. Thomas Bernard, Ph.D., Chair of the AGCIH Physical Hazards Committee to develop a temperature trigger that would apply to Washington State. This was accomplished using the WBGT method.

The WBGT formula is as follows:

With direct exposure to the sun: $WBGT = 0.7T_w + 0.2T_g + 0.1T_d$

Without direct exposure to the sun: $WBGT = 0.7T_w + 0.3T_g$

T_w= Natural wet-bulb temperature (humidity indicator)

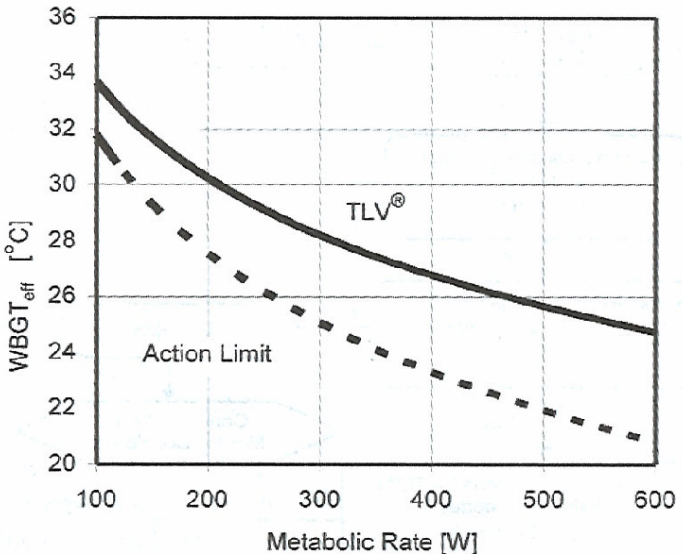
T_g=Globe thermometer temperature (measured with a globe thermometer, also known as a black globe thermometer, to measure solar radiation)

T_d=Dry-bulb temperature (normal air temperature)

The outcome being looked for was to solve the equation for the dry bulb temperature. In order to do this, definition of the other factors was needed to hold them as a constant. To start, the WBGT outcome needed to be defined.

To do this, a work rate of 300 watts was chosen. Although this is considered a moderate level of work, Dr. Bernard believed that this is the highest level of work the average person can sustain for an 8-hour workday. There may be periods where workers exceed this work rate, but then they will either take a short break or perform tasks that are at a lower work rate.

It was also assumed that workers are unacclimatized and therefore the action limit of the below curve was used instead of the TLV curve.



Taking a metabolic work rate of 300 on the action limit curve, the limit on the curve equals to 25° C or 77° F. This is the WBGT number.

The next factor to establish was the wet bulb measurement. Relative humidity is normally used for this, but it is variable throughout the day and from day to day. Another way to look at the wet bulb is by using the dew point. In reviewing the Washington State dew points for four cities (Vancouver, Seattle, Yakima, and Spokane) from the summer of 2007, Dr. Bernard calculated that a dew point of 50° F was the average within two standard deviations for Washington State and could be used as a constant for the wet bulb.

Dr. Bernard took this information and using a publicly available Excel® workbook that he developed (http://personal.health.usf.edu/tbernard/thermal/index.html) estimated the WBGT by changing the dry bulb temperature until the action limit was found. The clothing adjustments come from Dr. Bernard's research and were used in the equation.

This approach allows for assessment of the environmental factors (including clothing and work rate) and only required the employer to identify the air temperature. It is based on a rigorous scientific process specifically designed for Washington State's dew point.

Incidental Exposure

The Outdoor Heat Exposure rule was not intended to include workers that only went outside for short durations during their work shift. For example, individuals collecting shopping carts at stores or forklift drivers that occasionally go outside to unload a truck. Tom Bernard, Ph.D., Chair of the AGCIH Physical Hazards Committee, was asked if there was an amount of time that employees could be exposed to extreme temperatures without ill effects and could be incorporated into the definition of incidental exposure.

Dr. Bernard's research determined that if employee exposure was less than 15-minutes per hour to the outdoor environment, employees should not have health effects resulting from heat-related illness. This15-minute period is consistent with the Wet-Bulb Globe Thermometer (WBGT) values and the work-rest cycle for working in hot environments. When employees are doing very heavy work, the allocation of work in a cycle of work and recovery is up to 25% work with 75% rest or 15-minutes of work out of an hour.[8]

[8] American Conference of Governmental Industrial Hygienists (2007). "Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs)."Cincinnati, Ohio.

Outdoor Heat Exposure Program

The Department reviewed several research articles and studies regarding the measures and steps employers need to have in place in order to prevent the occurrence of heat related illness. The research articles and studies all emphasize the importance of implementing procedures to reduce exposure to and incidence of heat related illness.[9] Employers should have a comprehensive heat stress prevention program in place prior to seasonal exposure that identifies heat stress hazards, assesses the hazards in terms of severity and probability, implements the appropriate controls, and continuously evaluates the effectiveness of these controls.[10] Specifically, components of an employers' written comprehensive heat illness prevention program must include engineering controls, appropriate work practices for environmental conditions (including information on daily water requirements for hot environments and provisions to supply this water), employee training, personal protective equipment, and preventive medical practices.[11] Further, the studies emphasize that, preventing the occurrence of heat related illness requires knowledge and vigilance on the part of employers, management, and employees, and that employers must play an active role in preventing workers from experiencing heat related illness.[12]

Based these research articles and studies, including best practices, the Outdoor Heat Exposure rule requires employers to ensure their Accident Prevention Program addresses outdoor heat exposure. WAC 296-62-09530(1)(a).

Drinking Water

Numerous studies and research articles examine the importance of hydration and increasing the amount of water supplied to employees working in hot environments. The studies and articles establish that exposure to heat increases an employee's sweating rate and the body's water needs.[13] Employees performing moderate activities in hot environments may need 6 – 8 quarts of water per day; employees performing heavy work activities in hot environments may need 9 – 12 quarts of water per day.[14] Thirst is not an accurate indicator of the body's need for hydration and should not be used as a guide to fluid replacement; if thirst alone is used to guide fluid replacement, adequate hydration lags behind fluid needs for several hours and can lead to heat related illness.[15] The studies state that it is therefore important to establish drinking schedules and encourage frequent consumption of water.[16] The Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend workers drinking one cup of water every 20 minutes for work in warm environments and further indicate that deficits >2% of body mass can adversely impact on aerobic performance, orthostatic tolerance and cognitive function.[17]

Individuals with severe body water losses like those associated with physical work may require several hours of continued rehydration to reestablish water balance in the body.[18] If the fluid is not replaced by drinking water, dehydration will occur.[19] Dehydration of over 2% of an individual's body weight significantly degrades endurance but that fluid intake of one liter per hour is sufficient to prevent this fluid

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9 Department of the Army and Air Force (2003). "Technical Bulletin: Heat Stress Control and Heat Casualty Management." Washington, DC: Headquarters, Department of the Army and Air Force.

[10] Bonauto D, Anderson R, Rauser E, Burke B. (2007). "Occupational Heat Illness in Washington State, 1995-2005," *American Journal of Industrial Medicine* (in press).

[11] *Id.*; Department of the Army and Air Force (2003). "Technical Bulletin: Heat Stress Control and Heat Casualty Management." Washington, DC: Headquarters, Department of the Army and Air Force.

[12] Department of the Army and Air Force (2003). "Technical Bulletin: Heat Stress Control and Heat Casualty Management." Washington, DC: Headquarters, Department of the Army and Air Force.

[13] *Id.*

[14] *Id*.

[15] *Id*.

[16] *Id*.

[17] Kenefick, Robert and Michael Sawka (2007). "Hydration at the Work Site," *Journal of the American College of Nutrition*, Vol. 26(5): 597S-603S.

[18] *Id.*

[19] Department of the Army and Air Force (2003). "Technical Bulletin: Heat Stress Control and Heat Casualty Management." Washington, DC: Headquarters, Department of the Army and Air Force.

loss.[20] Significantly, a study of six healthy young men working in hot conditions found that subjects who forced themselves to drink water at the same rate they lost sweat felt well enough to continue at the same rate all day while the longer other subjects went without water during the exercise, the worse their symptoms became until they were not able to continue as a result of dehydration.[21] Additional studies found that significant deterioration in mental function for all the functions, i.e., short-term memory, arithmetic efficiency, and visumotor tracking involving motor speed and attention, occurred when dehydration of over 2% of an individual's body weight occurred.[22] Heat stress slows reaction and decision times, increases the likelihood of errors of omission, and that task performance will degrade slightly after 30 minutes and markedly after 2 to 3 hours of exposure.[23]

Prevention of HRI should center on recognizing when increased risks are present, minimizing fluid and electrolyte depletion, training the worker on the appropriate intake of fluids, use of appropriate clothing for hot environments, and assessing the appropriate level of work activity that can be performed safely in work environments with elevated temperatures.[24]

Based on these research articles and studies, including best practices, the Outdoor Heat Exposure rule requires employers to ensure sufficient quantities of water are available to employees and to increase the quantity supplied to ensure employees have access to one quart of water per hour when the temperature action levels of Table 1 are met or exceeded. WAC 296-62-09540(1). Employers are not required to start the work day with the entire quantity of water supply that may be needed, but must have effective procedures to replenish the water supply when necessary. WAC 296-62-09540(2).

Responding to Signs and Symptoms of Heat-Related Illness

Significant research has been conducted on the importance of quick response to an individual suffering from heat-related illness. All articles agree that rapid response and efforts to quickly cool an individual suffering heat-related illness are key in preventing permanent disability or death. Early initiation of cooling and rehydration are critical steps.[25] Delay in cooling was found to significantly contribute to permanent disabilities and even death.[26] Indeed, a study of 4 cases of heat stroke in healthy subjects found that, in 2 cases where the individuals were rapidly cooled shortly after collapse, the individuals did not experience permanent injury, while the other 2 subjects who did not receive attention for more than 3 hours after collapse both died.[27] The research also points out that severe heat illness, or heat stroke, can cause permanent irreversible damage to the heart, lungs, kidneys, and liver with a strong association between heat illness and later fatal cardiac events.[28] The research concludes that there is a limited window of opportunity within which effective cooling can influence prognosis.[29]

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[20] Cheuvront, Samuel, Robert Carter III, and Michael Sawka (2003). "Fluid Balance and Endurance Performance," Current Sports Medicine Reports, 2(4):202-208.

[21] G.C. Pitts, R.E. Johnson and F.C. Consolazio with the technical assistance of J. Poulin, A. Razoyk and J. Stachelek, Work in the Heat as Affected by Intake of Water and Salt Glucose, The Fatigue Laboratory, Harvard University, Boston, Massachusetts, June 10, 1944.

[22] Gopinathan, PM, G. Pichan, and VM Sharma (1988). "Role of Dehydration in Heat Stress Induced Variations in Mental Performance," *Archives of Environmental Health*, Vol. 43(1): 15-17.

[23] Department of the Army and Air Force (2003). "Technical Bulletin: Heat Stress Control and Heat Casualty Management." Washington, DC: Headquarters, Department of the Army and Air Force.

[24] Bonauto, David, Brian Burke, Edmund Rauser, and Robert Anderson (2006). "Heat-related Illness in Washington State, State Fund Workers' Compensation Claims, 1995-2004: Technical Report Number 59-1-2006." Olympia, WA: Washington State Department of Labor and Industries, Safety & Health Assessment & Research for Prevention (SHARP).

[25] Heled, Y., M. Rav-Acha, Y. Shani, Y. Epstein, and D. Moran (2004). "The 'Golden Hour' for Heatstroke Treatment," *Military Medicine*, Vol. 169(3): 184-186.

[26] *Id.*

[27] *Id*.

[28] Wallace, Robert, David Kriebel, Laura Punnett, David Wegman, and Paul Amoroso (2007). "Prior heat illness hospitalization and risk of early death," *Environmental Research*, 104: 290-295.

[29] Heled, Y., M. Rav-Acha, Y. Shani, Y. Epstein, and D. Moran (2004). "The 'Golden Hour' for Heatstroke Treatment," *Military Medicine*, Vol. 169(3): 184-186.

As to the method of reducing the body temperature, studies suggested that immersion in iced water is the most effective method of whole body cooling, and should be used where possible.[30] If immersion is unavailable or inappropriate, cooling may necessarily involve a combination of evaporative cooling techniques and other methods such as immersion of the extremities in cold water.[31] The emphasis is placed on reduction of core temperature as quickly as possible, as it has been suggested that the major determinant of outcome in heatstroke is the duration of hyperthermia.[32]

Based on these research articles and studies, including best practices, the Outdoor Heat Exposure rule requires employers to relieve employees showing signs or demonstrating symptoms of heat related illness from work and to provide the employee with a sufficient means to reduce the body temperature. WAC 296-62-09550(1). The rule further requires employers to monitor employees showing signs or demonstrating symptoms of heat related illness to determine whether additional medical attention is necessary. WAC 296-62-09550(2).

Information and Training

Research regarding methods necessary to prevent and control heat-related illness establishes that education and training on heat-related illness signs and symptoms are critical factors in successful management of heat stress. Studies found that, optimally, employers had a comprehensive heat stress prevention program that included engineering controls, work practices, ***employee training*** and preventive medical practices to reduce the incidence of heat-related illness in place prior to seasonal exposure.[33] The research revealed that, where workers were well informed about the cause, effects, signs, and symptoms of heat-related illness, workers did not suffer dehydration.[34] In addition, awareness of personal factors such as medical conditions, medication use alcohol or illicit drug use, and limited acclimatization, was critical for employee training.[35] Further, research found that education of workers was vital to ensure they come to work hydrated and maintain their hydration during the work shift.[36] In addition, studies showed that it is important for employees to be trained on signs and symptoms of heat-related illness so that they could monitor their co-workers (the "buddy system") and could pay attention to their own heat tolerance and needs.[37]

Based on these research articles and studies, including best practices, the Outdoor Heat Exposure rule requires employers to provide training on heat related illness to employees and supervisors prior to outdoor work and annually thereafter. WAC 296-60-09560. Consistent with the research guidance, employees must receive training on environmental factors contributing to heat related illness, general awareness of personal factors that may increase an employee's susceptibility to heat related illness, the importance of removing heat-retaining personal protective equipment during breaks, the importance of frequent consumption of water, the importance of acclimatization, and the importance of immediately reporting signs or symptoms of heat related illness in themselves or co-workers. WAC 296-62-09560(1). In addition, employers must train supervisors on elements of employee training, the procedures supervisors must follow to implement the Outdoor Heat Exposure rules, the procedures a supervisor must follow if an employee exhibits signs or symptoms of heat related illness (including emergency response

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[30] Smith, JE (2005). "Cooling methods used in the treatment of exertional heat illness," *British Journal of Sports Medicine*, Vol. 39: 503-507.
[31] *Id.*
[32] *Id.*
[33] Bonauto D, Anderson R, Rauser E, Burke B. (2007). "Occupational Heat Illness in Washington State, 1995-2005," *American Journal of Industrial Medicine* (in press).
[34] Brake, DJ and GP Bates (2003). "Fluid losses and hydration status of industrial workers under thermal stress working extended shifts," *Occupational and Environmental Medicine*, Vol. 60(2): 90-96.
[35] *Id.*; Bonauto D, Anderson R, Rauser E, Burke B. (2007). "Occupational Heat Illness in Washington State, 1995-2005," *American Journal of Industrial Medicine* (in press).
[36] Brake, DJ and GP Bates (2003). "Fluid losses and hydration status of industrial workers under thermal stress working extended shifts," *Occupational and Environmental Medicine*, Vol. 60(2): 90-96.
[37] Department of the Army and Air Force (2003). "Technical Bulletin: Heat Stress Control and Heat Casualty Management." Washington, DC: Headquarters, Department of the Army and Air Force.

procedures), and the procedures for moving or transporting an employee to a place where the employee can be reached by an emergency medical provider, if necessary. WAC 296-62-09560(2).