



Cost of Occupational Heat Stress

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How to measure heat stress?

Combination of

- Metabolic heat-
- Environmental heat-Wet Bulb Globe Thermometer (WBGT) + clothing

Minus:

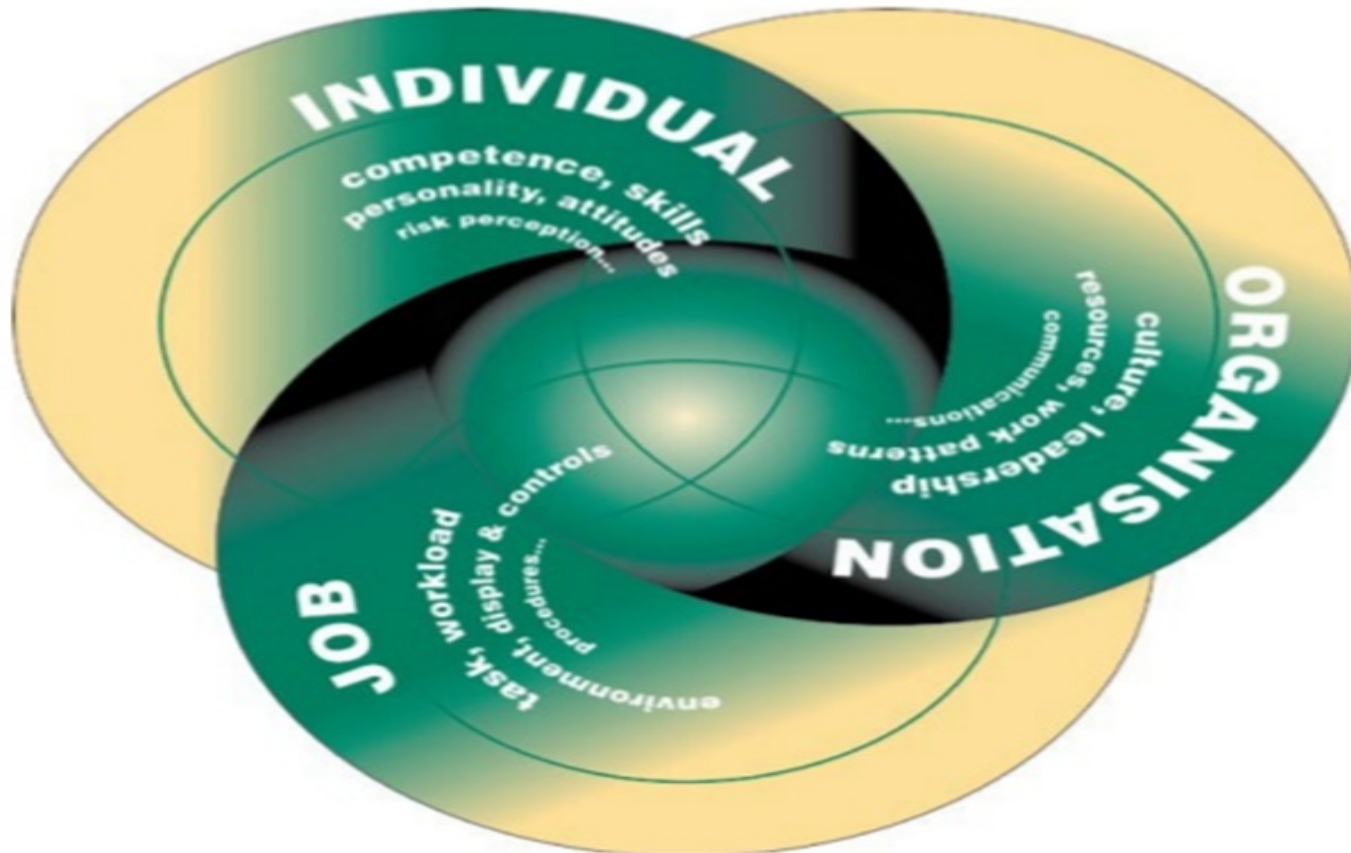
Heat lost from the body to the environment by conduction, convection, radiation and evaporation

Example assessment of metabolic heat and exposure limits

Table 5-1. Comparison of WBGT exposure limits for acclimatized workers

Workload	ACGIH	AIHA	OSHA	ISO	NIOSH
Resting		32.2°C (90°F) 100 kcal·h ⁻¹ (117 W)		33°C (91.4°F) ≤100 kcal·h ⁻¹ (117 W)	
Light	30°C (86°F) 100–200 kcal·h ⁻¹ (117–233 W)	30°C (86°F) 200 kcal·h ⁻¹ (233 W)	30.0°C* (86°F) 32.2°C† (90°F) <200 kcal·h ⁻¹ (233 W)	30°C (86°F) 100–201 kcal·h ⁻¹ (117–234 W)	30°C (86°F) <200 kcal·h ⁻¹ (233 W)
Moderate	26.7°C (80°F) 201–350 kcal·h ⁻¹ (234–407 W)	26.7°C (80°F) 300 kcal·h ⁻¹ (349 W)	27.8°C* (82°F) 30.6°C† (87.1°F) 201–300 kcal·h ⁻¹ (234–349 W)	28°C (82.4°F) 201–310 kcal·h ⁻¹ (234–360 W)	28°C (82.4°F) 201–300 kcal·h ⁻¹ (234–349 W)
Heavy			26.1°C* (79°F) 28.9°C† (84°F) >301 kcal·h ⁻¹ (350 W)	25°C* (77°F) 26°C† (78.8°F) 310–403 kcal·h ⁻¹ (360–468 W)	26°C (78.8°F) 301–400 kcal·h ⁻¹ (350–465 W)

Heat stress Vs Human factors



(HSE, 1999 HSG 48)

Heat stress Vs Human factors

- Human failures account for 75% to 95% of all industrial accidents Dr. Nancy Grugle, 2016
- Heat exposure is linked to the job and organization aspects of the human factors model

Heat Stress and Human Errors

Heat Stress is associated with:

- Increased irritability.
- Loss of concentration and ability to do mental tasks.
- Loss of ability to do skilled tasks or heavy work.

Heat Stress and Human Errors

- Increased rates of aviation accidents due to temperatures higher than 30 degrees Celsius

Froom et al, 1993

- A NASA study concluded that when the temperature is 95° F (35 Celsius) for an extended period, people can make 60 mistakes per hour without realizing it.

Safety and health magazine, 2009

Heat Stress and Human Errors

-In 2006, which is the second hottest year that has ever been recorded, **3,100 US workers had a heat-related illness that caused them to miss work**

Health research funding, 2015

- A total of **48.8% of human error can be explained by stress, repetition, fatigue and work environment.**

Safety and health magazine, 2009

Heat stress effects on physical and mental work capacity

- According to a study by Kjellstrom et al. in 2009, **work capacity is reduced significantly with the increase of Wet Bulb Globe Temperature from 26 to 30 °C.**

Heat stress effects on physical work capacity

- Another study suggest that in the absence of any compliance strategy, most countries in Southeast Asia, Central America, and the Caribbean will face a **production decline of 10% to 27% duet o occupational heat stress.**

Heat stress effects on physical work capacity

- In WBGT of higher than 25 °C, the human work capacity begins to drop.
- Moreover, in WBGT of over 40 °C, the performance of physical actions will be extremely difficult for all individuals.

Heat stress effects on physical work capacity

- Temperature slightly above comfortable temperature (slightly higher than 20°C), the human performance begins to drop from 3% to 50%.
- Furthermore, in temperatures above comfort level (35 to 37 °C), this reduction can be as high as 75%.
- For example, office workers reach their maximum work capacity at a temperature of 23 °C, while their productivity is reduced up to 70% at a temperature of 30 °C.

Heat stress effects on physical work capacity

- In Delhi the calculated Wet Bulb Globe Temperature during afternoons in May (the hottest month) reach above 30°C on average. The resulting work capacity during different hours for a person who works at a heavy work intensity is very low: on average **only 20% of work capacity remains at 12 noon.**

Cost of Heat Stress

- **Reduced GDP:** Performance loss caused by heat stress can decrease gross domestic product by up to 0.5%.

Hubler M, Klepper G, Peterson S. Costs of climate change: The effects of rising temperatures on health and productivity in Germany. *Ecol Econ* 2008;68(1-2):381-93.



Costs of Heat Stress Illnesses

- In the USA, total hospital charges for Heat Stress Illness cases were \$167.7 million (in 2014).

CDC, 2014

Indirect costs of heat stress

- Heat exposure is related to increased rates of occupational accidents and injuries, which cost the UK 4.8 billion GBP in 2014/2015, as well as 14.1 Billion GBP costs of lost work days.

Act Associates, 2017

Estimations of Occupational Heat Stress Cost in Oman

-Reduction of GDP (in light of previously discussed loss estimations)

Performance loss caused by heat stress can decrease gross domestic product (Oman GDP is estimated 66.29 Billion \$ as of 2016) up to 0.5%, hence losses could be equivalent of 33.14 million US \$.

Estimations of Occupational Heat Stress Cost in Oman

- **Reduced physical and mental capacities:**

Previous estimations of 20% physical and mental capacity reduction for temperatures higher than 30 degrees Celsius (comparable to the climate in Oman).

Beheshti MH, et al 2016.

- **Minimum wage in Oman (592 US Dollars per month approximately)**
- **Approximate heat stress-related losses per employee per year = 4000 US\$**

Recommendations

- Medical monitoring focused on heat illness detection
- Health surveillance for individual factors associated with health stress
- Acclimatization programs
- Consideration of the effects of protective clothing
- Further research to heat stress costs in Oman, and gender, age and fitness variants (little data available on the subject)

Thank you 😊