



Influence of clothing adjustment value (CAV) index on the heat load

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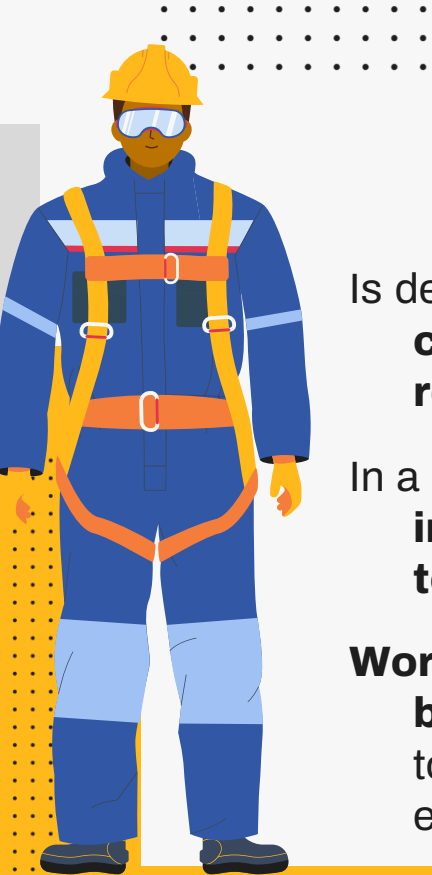
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19, 459

number of people exposed to work in a **hot microclimate** in Poland
in 2022



01. HEAT LOAD

Is defined as **the sum of the external forces** that act on an animal and **cause an increase in body temperature and a physiological response.**

In a physical sense “heat stress” **represents a heat load that tends to increase body heat storage and elevate deep body temperature.**

Worker heat stress – changes leading to, among others, **an increase in body temperature due to heat accumulation or overheating** due to physical exertion, and high temperature due to the inability to exchange it with the external environment.



Hoffmann G., et al. Animal-related, non-invasive indicators for determining heat stress in dairy cows, Biosystems Engineering, Volume 199, 2020, Pages 83-96, ISSN 1537-5110, <https://doi.org/10.1016/j.biosystemseng.2019.10.017>.

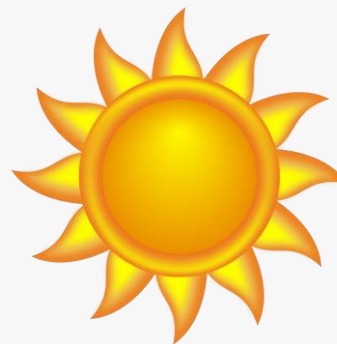
Matthew N. Cramer, Daniel Gagnon, Orlando Laitano, and Craig G. Crandall. Human temperature regulation under heat stress in health, disease, and injury. Physiological Reviews 2022 102:4, 1907-1989

Młynarczyk, M., Konarska, M. Ocena obciążenia cieplnego człowieka w środowisku gorącym poprzez wskaźnik WBGT_{eff} wg zapisów normy PN-EN ISO 7243:2018-01 Podstawy i Metody Oceny Środowiska Pracy 2021, nr 1(107), s. 5–14 DOI: 10.5604/01.3001.0014.8148

02. HEAT LOAD / WBGT

The heat load of workers in a hot environment is determined using the WBGT index.

Depending on the value of WBGT, performing 8-hour work in a hot environment may or may not be acceptable.



02. HEAT LOAD / WBGT

The Wet Bulb Globe Temperature (WBGT) is an indicator of heat related stress on the human body at work (or play) not only in direct sunlight. It takes into account multiple atmospheric variables, including: temperature, humidity, wind speed, sun angle, and cloud cover.

$$WBGT(i) = 0,7 * t_{nw} + 0,3 * t_g \quad WBGT(o) = 0,7 * t_{nw} + 0,2 * t_g + 0,1 * t_a$$

$$WBGT_{eff} = WBGT + CAV$$

WBGT(i) – indoor, without direct sunlight; WBGT(o) – outdoor, with direct sunlight; WBGT_{eff} – effective WBGT

t_{nw} – wet temperature ($t_{nw}=f(t_a, RH)$); t_g – the bulb globe temperature; t_a – air temperature.

03. CAV

CAV reflects the impact of using clothing other than standard workwear.

CAV is also affected by factors such as:

- radiant heat,
- air velocity,
- body movements and
- the humidity of clothing (indirectly).



03. CAV*

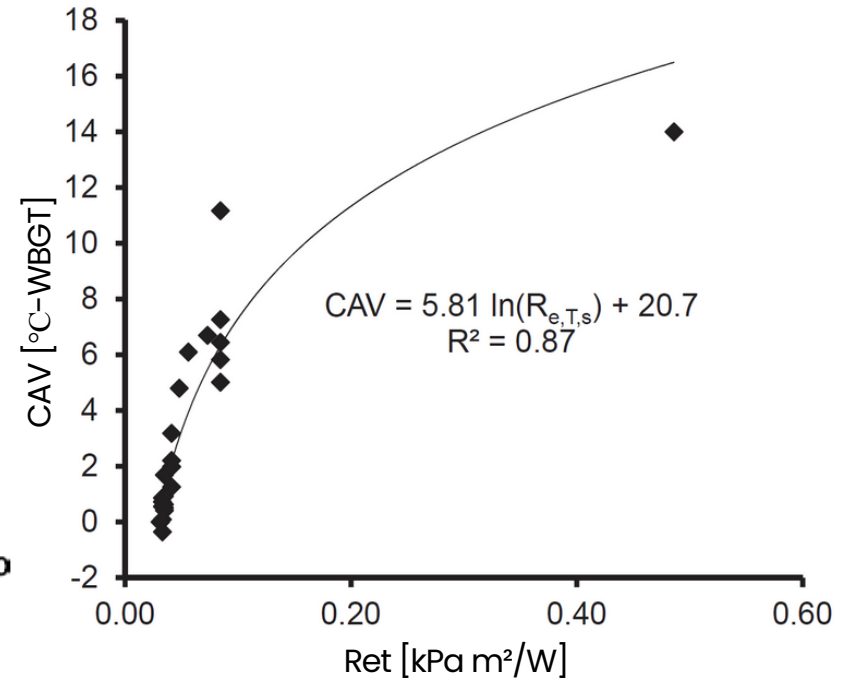
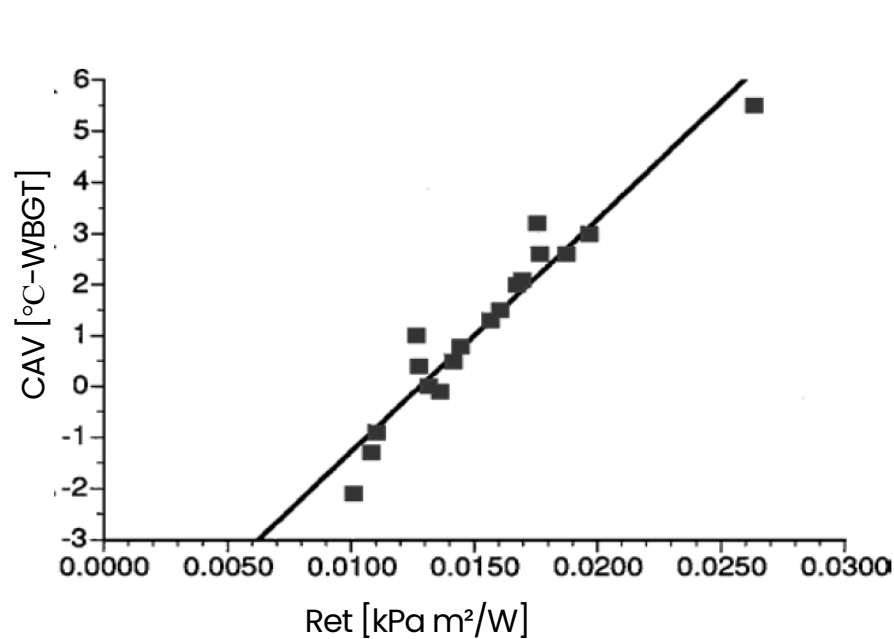
Zestaw odzieży Set of clothing	Izolacyjność cieplna zestawu odzieży, clo Thermal insulation of a set of clothing, clo	CAV, WBGT, °C
Standardowe ubranie robocze wykonane z tkaniny (zestaw referencyjny) / Standard working clothes made of fabric (reference set)	0,6	0
Kombinezon wykonany z tkaniny bawełnianej poddanej obróbce (lub z lekkiego poliestru) / Overall made of treated cotton fabric (or light polyester)	bd. / NDA	0
Kombinezon bawełniany / Cotton overall	1,0	2
Odzież wykonana z podwójnej warstwy tkaniny – często kombinezon przeznaczony do zakładania na odzież roboczą / Clothing made of a double layer of fabric – often overalls intended to be worn on top of work clothes	bd. / NDA	3
Zimowa odzież robocza / Winter work clothes	1,4	4
Kombinezon z kapturem z pojedynczej warstwy z barierą paroszczelną (np. kombinezony ochronne, kombinezony chroniące przed substancjami chemicznymi) / Single layer overall with a hood and with a vapour barrier (e.g. protective overalls, chemical protection overalls)	bd. / NDA	11

*according to:
ACGIH 2017;
Parsons 2003;
PN-EN ISO
7243; Schmoltd
2018



03. CAV

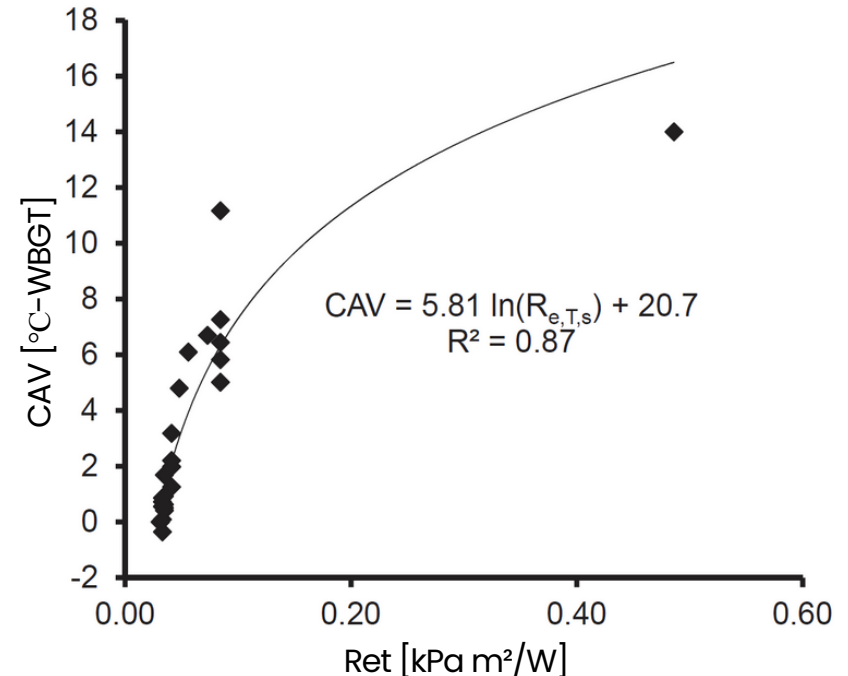
Typically, the CAV increases as water vapor resistance (R_{et}) increases; decreases with increasing air permeability coefficient (i_m).



03. CAV

Typically, the CAV increases as water vapor resistance (R_{et}) increases; decreases with increasing air permeability coefficient (i_m).

- **Single layers** of fabrics and nonwovens with adequate air permeability
- R_{et} below **0.015 kPa·m²/W** can be used to predict and rewrite CAV
- As $R_{et,s}$ increases to higher values, there is some risk of underestimating the CAV



03. CAV ?

Ensembles use in hot environment:



Measurements of: thermal insulations
and water evaporative resistances

03. Meaning of CAV

Tg	34 °C
Tnw	24 °C
Va	0,4 m/s

$$WBGT(i) = 0,7tnw + 0,3tg = 27 \text{ °C}$$

03. Meaning of CAV

Tempo metabolizmu (klasa) Metabolism rate (class)	Średnie tempo metabolizmu, W Average metabolism rate, W	Progowa wartość odniesienia WBGT, °C WBGT threshold reference value, °C	
		dla osób zaaklimatyzowanych for acclimatised persons	dla osób niezaaklimatyzowanych for non-acclimatised persons
0 (spoczynek / rest)	115 (100 ÷ 125)	33	32
1 (praca lekka / light work)	180 (125 ÷ 235)	30	29
2 (praca średnio ciężka / medium-heavy work)	300 (235 ÷ 360)	28	26
3 (praca ciężka / heavy work)	415 (360 ÷ 465)	26	20
4 (praca bardzo ciężka / very heavy work)	520 (>465)	25	20

no exceeding of the limit value

03. Meaning of CAV

Tg	34 °C
Tnw	24 °C
Va	0,4 m/s

$$WBGT(i) = 0,7t_{nw} + 0,3t_g = 27 \text{ °C}$$

$$CAV = 11 \text{ °C}$$

$$WBGT_{eff} = 27 + 11 = 38 \text{ °C}$$



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exceeding of the limit value !



04. CONCLUSION

Failure to take into account the clothing correction factor (CAV) may expose the employee to too long exposure to a hot environment, leading to disturbances in the functioning of the employee's body (heat load, heat stress).

In the worst case, hyperthermia may occur.

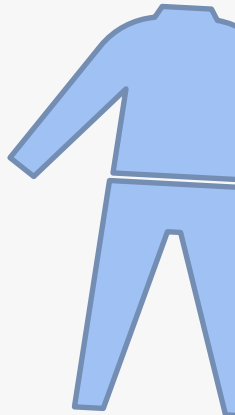
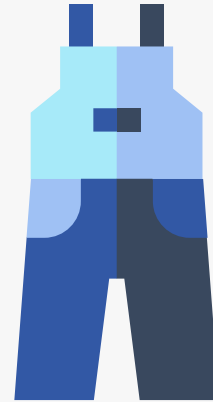


04. CONCLUSION

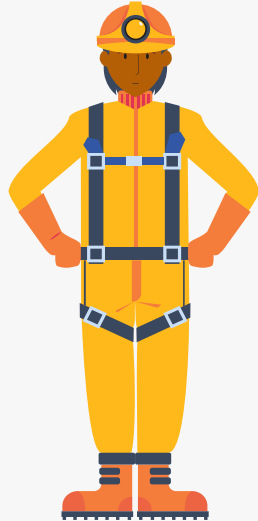


Currently, work is underway to develop summary tables for different types of clothing, taking into account the value:

- thermal insulation,
- water vapor resistance and
- air permeability.



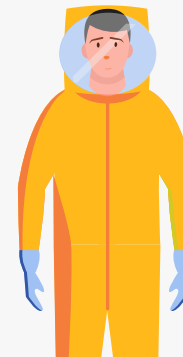
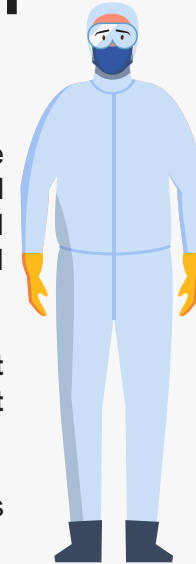
Thank you for your attention



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The Central Institute for Labour Protection – National Research Institute is the Programme’s main co-ordinator.



Do you have any questions?

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