

Inclusive protective clothing with active cooling function - standardization needs

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Inappropriately fitted PPE and cooling clothing may lead to:

- increased risk of injuries and accidents,
- reduced mobility and work efficiency, skin irritation, blisters, and musculoskeletal pain;
- inefficient cooling, especially in case of using thermal conductivity technologies



Progressive climate change and rising air temperatures mean that people working outdoors, particularly during the summer season, are often exposed to **excessive heat stress**. At the same time, changes in the labor market can be observed that lead to an **increase in women's employment in industry**. It is therefore essential to conduct research on **individualized technical solutions** that ensure **occupational safety for both men and women** under conditions of exposure to harmful factors such as hot microclimates.



A gender-responsive PPE should:

- recognize physical, physiological and anatomical differences between women and men,
- improve workplace conditions,
- integrate diverse user needs into the design and performance of products, processes, and services,
- ensure equal usability, safety, and benefits for all users,
- avoid reinforcing existing gender inequalities.

Physiological effects of heat stress

- Intensive physical work accelerates metabolic heat production, increasing physiological burden and risk of overheating.
- Heat stress may lead to:
 - dehydration,
 - heat exhaustion,
 - dizziness and fatigue,
 - impaired cognitive and physical performance,
 - increased cardiovascular strain,
 - hyperthermia and, in severe cases, death.



Underrepresentation of women in PPE design

- Most PPE and cooling garments are designed using male or generalized anthropometric data.
- Many PPE products marketed for women are smaller versions of male designs, sometimes differentiated only by color.
- Cooling clothing and occupational heat mitigation strategies rarely consider: hormonal fluctuations, menstrual cycle phases, pregnancy and menopause, sex-specific sweating patterns, lower blood volume and cardiovascular capacity in women.
- Female-specific thermal comfort and physiological responses remain largely overlooked in standards and product development.



Inadequate sizing systems

- Current sizing standards rely on only a few body dimensions, which are insufficient to represent female body diversity.
- Existing systems fail to account for differences in: hip-to-waist ratio, chest proportions, limb length, smaller hand and foot dimensions.
- As a result, women frequently experience ill-fitting and oversized PPE, restrictive or excessively loose garments, impractical pocket placement and reduced mobility and comfort.



Standardization of PPE - protection against heat and flame. Test methods and requirements for garments with integrated smart textiles and non textile elements

- Regarding testing, assessment should cover cooling efficiency, duration of effect, performance stability over time and user safety. This applies to both cooling materials (e.g. phase change materials) and cooling systems. For electronic systems, additional tests should be included, similarly to requirements for smart PPE against heat.
- In case of requirements, minimum performance levels should be defined for cooling efficiency, operating time, and stability, to classify such solutions as PPE for protection against hot microclimate, similarly to existing standards for protection against cold.



The development of standards should:

- assume that gender differences may influence outcomes whenever people are affected;
- address gaps and biases in existing datasets;
- complement quantitative data with lived experience, research literature and qualitative evidence.

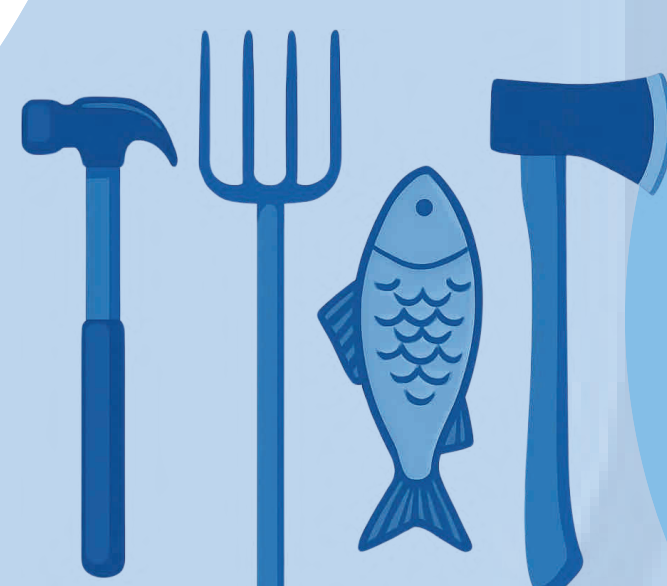
Future protective and cooling clothing systems should:

- utilize advanced technologies such as 3D body scanning,
- provide adjustable and ergonomically fitted designs,
- involve women directly in the design process,
- integrate gender-responsive occupational safety standards,
- support individualized heat stress prevention strategies.



Sectors at high risk of the heat stress

Outdoor workers in agriculture, construction, forestry and fisheries are among the most vulnerable groups to the influence of the heat stress.



Despite the increasing interest in personal cooling solutions, existing ones often based on the principle of heat conduction - **are not adapted to individual differences among potential users**. Addressing these differences is essential to ensure both the **safety** and **effectiveness** of such PPE. Undeniable support in this regard would be the development of harmonized requirements, both with respect to the performance of the **cooling function** and to the consideration of **anatomical, physiological, and even psychological differences** among potential users.