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Cooling vests solutions

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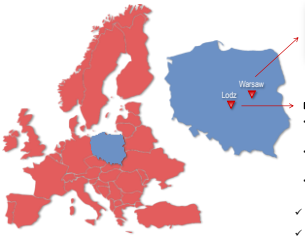

Headquarters and main research laboratories

Department of Personal Protective Equipment

- Development of new solutions including smart PPE and their integration within SWE
- Development of new testing methods of PPE components and whole structures
- Development of evaluation criteria and contribution to standardisation

- ✓ **Notified body no. 1437 within a scope of Regulation (EU) 2016/425**
- ✓ **Laboratories accredited (AB 038) by the Polish Centre for Accreditation**

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Thermal load

during work in protective clothing

Rescue operations

Constant hot environment

Barrier protective clothing

Work outside

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Prevention from overheating

during work in protective clothing

Air conditioning systems

? ? ?

Cooling clothing that comprehensively meets the needs of people experiencing heat stress while working is still sought.

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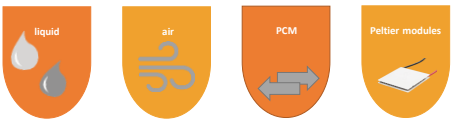
COOLING CLOTHING

division by medium



The selection of cooling method should be supported by an analysis of:

- Environmental conditions (especially temperature and relative air humidity),
- Type of activities performed by the employee (in terms of metabolism and required mobility),
- Necessary cooling time,
- Eventual additional restrictions.

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Liquid cooling clothing

Basic features

- ✓ High efficiency
- ✓ Appropriate for high RH
- ✓ Easy regulation of cooling intensity
- ✓ Tubes distributing cooling medium – required tight adjustment
- ✓ Cooling unit – limited mobility

More information:

- Bartkowiak G., Dąbrowska A., Marszałek A., 2017. Assessment of an active liquid cooling garment intended for use in a hot environment, Applied Ergonomics, 58, pp. 182-189
- Bartkowiak G., Dąbrowska A., Włodarczyk B., Construction of a garment for an integrated liquid cooling system, Textile Research Journal, 85(17), 2015, pp. 1809-1816
- Bartkowiak G., Dąbrowska A., Marszałek A., Assessment of the human responses to the influence of personal liquid cooling system in the hot environment, International Journal of Clothing Science and Technology, Vol. 26, iss. 2, 2014

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Air cooling clothing

Basic features

- ✓ Mobility
- ✓ Required source of the compressed air
- ✓ Operating time depends on the compressed air cylinder
- ✓ Tubes distributing cooled air

More information:

- Marszałek A., Bartkowiak G., Dąbrowska A., Krzemińska S., Łężak K., Makowski K., Bugajska J., Mine Rescuers' Heat Load during the Expenditure of Physical Effort in a Hot Environment, Using Ventilated Underwear and Selected Breathing Apparatus, International Journal of Occupational Safety and Ergonomics, 24:1, 1-13, 2017

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Cooling clothing with PCM

Basic features

- ✓ Doesn't require additional devices
- ✓ Ergonomics
- ✓ Full mobility
- ✓ Wide range of phase change transition temperature
- ✓ Operating time depends on phase change transition
- ✓ Cooling efficiency depends on weight

More information:

- Młynarczyk, M.; Bartkowiak, G.; Dąbrowska, A. 2022. Cooling Effect of Phase Change Materials Applied in Undergarments of Mine Rescuers in Simulated Utility Conditions on Thermal Manikin. Materials, 15, 1999.
- Bartkowiak G., Marszałek A., Dąbrowska A., 2020, Thermal Load of mine rescuers in the underwear and protective clothing with phase change materials in simulated utility conditions, Materials 13(19), 4320
- Bartkowiak G., Dąbrowska A., Marszałek A., Analysis of thermoregulation properties of PCM garments on the basis of ergonomic tests, Textile Research Journal 2013,83(2), pp. 148-159
- Bartkowiak G., Dąbrowska A., Assessment of the Thermoregulation Properties of Textiles with Fibres Containing Phase Change Materials on the Basis of Laboratory Experiments, FIBRES & TEXTILES in Eastern Europe 2012, 20, 1(90), 47-52

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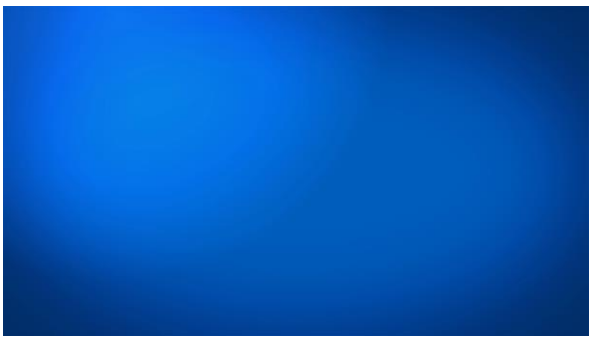
Specific requirements for outdoor workers

- Changeable weather conditions
- High visibility

A promising direction: **thermoelectric modules**

More information:

- Dąbrowska, A.; Kobus, M.; Sowiński, P.; Starzak, Ł.; Pękosławski, B. Integration of Active Clothing with a Personal Cooling System within the NGIoT Architecture for the Improved Comfort of Construction Workers. Applied Sciences 2024, 14(2), 586; https://doi.org/10.3390/app14020586
- Dąbrowska, A.; Kobus, M.; Starzak, Ł.; Pękosławski, B. Evaluation of Performance and Power Consumption of a Thermoelectric Module-Based Personal Cooling System—A Case Study. Energies 2023, 16, 4699. https://doi.org/10.3390/en16124699
- Dąbrowska, A.; Kobus, M.; Starzak, Ł.; Pękosławski, B. Analysis of Efficiency of Thermoelectric Personal Cooling System Based on Utility Tests. Materials 2022, 15, 1115
- Dąbrowska, A.; Kobus, M.; Pękosławski, B.; Starzak, Ł. A Comparative Analysis of Thermoelectric Modules for the Purpose of Ensuring Thermal Comfort in Protective Clothing. Applied Sciences, 2021, 11, 8068



Methods

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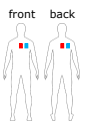
Utility tests in laboratory conditions

- **Objective**: to assess the impact of the applied cooling on the user's thermophysiological comfort
- 6 test participants – **end-users**
- Ambient temperature of 25 °C and a relative humidity of 65%
- Measured parameters:
  - Local skin temperature



Results

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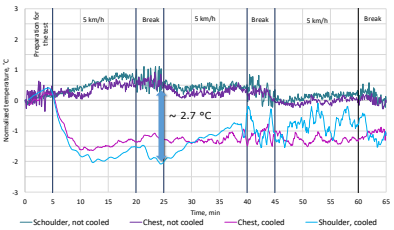

Next Generation Internet of Things

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assist-iot

ASSIST-IoT main goal was to develop a **new architectural approach to future IoT**

Address the needs of smart factories, logistics, constructions and automotive industries

Address **scalability and flexibility** of data processing and analytics

Allow **multiple streams of human and environment** collected contextual data, to benefit multiple AI-infused applications

Transform existing IoT-based solutions into **smarter, more secure, trustable, and efficient environments**

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ASSIST-IoT Pilots

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- Pilot 1: Port automation Pilot

- Pilot 3: Cohesive vehicle monitoring and diagnostics Pilot

- **Pilot 2: Smart Safety of workers Pilot**

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Smart Safety of Workers Pilot

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The Smart safety of workers Pilot was focused on the improvement of health and safety at the construction site by providing human-centric modular solutions

Trials:

- **Trial 1: Occupational safety and health monitoring**
- Trial 2: Fall-related incidents identification
- Trial 3: Health and safety inspection support

Pilot driven by the Central Institute for Labour Protection – National Research Institute and Mostostal Warszawa SA

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Trial 1: Occupational safety and health monitoring

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Detect heart rate abnormalities that are potentially threatening

Monitor use of required PPE

Prevent unwarranted access to dangerous areas

Track construction worker's location

Prevent overexposure of construction worker to UV radiation

Notify the OSH manager about incidents and life-threatening events

Reduce thermal discomfort of construction workers at the construction site

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Integration within ASSIST-IoT architecture

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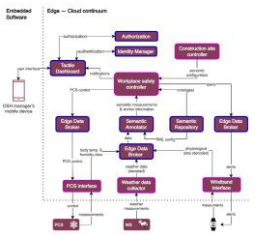

Based on the collected measurements, **Artificial intelligence** instructs the PCS about the appropriate cooling intensity at a given moment

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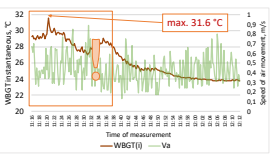
Thermal load of glassworkers



WBGT index measurement

cooperation

Cooling clothing

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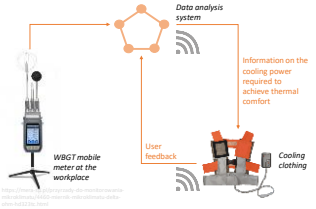
Overheating monitoring and prevention system for glassworks

- ✓ **On-site WBGT** mobile meter
  – real-time measurements of worker's thermal load
- ✓ Wearable **cooling system**
  – thermoelectric modules
- ✓ **Individual** and **automatic** adjustment of cooling intensity



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