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THERMAL COMFORT

OF PPC USED BY FIRE-FIGHTERS IN ITALY

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What does “thermal comfort” exactly mean ?

In UNI-ENISO 7730 it is defined as:

“ that condition of mind that expresses *satisfaction* with the thermal environment”

It is a definition many people can agree upon, but it cannot be easily translated into physical parameters

For example:
In a working place general assessment, other factors need also to be taken into account:

1. air temperature
2. air quality
3. light
4. noise

in case of outdoor environments, wind and its influence on temperature perception must also be considered.

HUMAN BODY THERMOREGULATORY SYSTEM

It maintains inner body temperature at around 37 °C. When temperature decreases or increases too much, two different processes are activated:

1. dilation of blood vessels (increased blood flow in skin)
2. sweat (energy used to evaporate is taken from skin surface)

If inner temperature increases even by a few tenths of a degree, sweating may induce a fourfold increase in body heat dissipation.

If inner temperature decreases too much, the first reaction is a vasoconstriction with a reduction of blood flow in the skin, the second reaction is an increase of energy inside the body, affecting muscles and giving rise to shudder.

The two main sensor groups of the control system are placed:

1. in the skin (when it is cold < 34 °C)
2. in hypothalamus (when it is hot > 37 °C)

If heat and cold sensors send signals simultaneously, human brain will inhibit one or both defence reactions.

Hypothalamus is a structure of the central nervous system located in a central area between the two cerebral hemispheres. It forms the ventral part of the diencephalon and contains a number of small nuclei which activate, monitor and integrate peripheral mechanisms, the endocrine activity and many somatic functions such as body temperature, sleep, the balance between water and mineral salts, fatigue and food intake. Hypothalamus controls many activities connected with homeostasis and hypophisis.

What is textile comfort ?

It can be defined as:

“The wellbeing level offered by a tissue to the consumer”

Comfort sensation

Factors:

1. human body
2. environment
3. garment

Temperature and relative humidity determine the response magnitude to body thermal regulation, also influenced by:

- the level of practised activity
- type of garment

in order to maintain inner temperature at around 37 °C

COMPLETE FIRE TESTS AND TEMPERATURE DETECTION DEVICES

DIAGRAMMS MAX TEMPERATURES:

FRONT = 53 °c
BACK = 75 °C
INNER = 45 °C

pictures

STORED DATA - COMPARISON

3 tables

THERMAL COMFORT FOR FIRE-FIGHTERS

In spite of measurable parameters, comfort is a subjective sensation, perceived either
- at the workplace, or
- in specific work conditions

and the term is used to define the perceived “level of wellbeing”.

Considering that fire-fighters work in the most hostile of environments, the result is that the comfort or wellbeing feelings can be only provided by clothing or PPC used.

Joining “fire protection” and “comfort” is a contradiction in terms, except for the textile part of the equipment. Through fabrics, it is possible to measure the maximum perspiration, the retained or dissipated heat, R_{CT} and R_{ET}.
The evaluation of cold protection is often neglected, but it is well analysed in fire-fighters duty station jackets, which can already be certified as cold-proof gear.
An example is provided by fire rainwear, developed to protect fire-fighters against bad weather in several operational scenarios.

European Standard 343 deals with protective garments and establishes the minimum values for rain- and wind-proof outfits. Two categories are considered: the first one refers to impermeability and the second refers to humidity and breathability. In both cases the appropriate value lies between 1 and 3, where 3 represents the top material, that is the fabric providing the user with the best protection.

FIRE RAIN WEAR

Even if it is not a specific cold-proof garment, it provides an adequate thermal protection, so that fire-fighters are allowed to operate even in cold climates.

Thermal protection is ensured by coupling a rain coat with an inner thermal jacket.

The latter is manufactured with laminated fabric sealed to windproof lining, with a special cotton wool on the chest (offering high thermal insulation) and fleece in the sleeves.

The windproof lining is designed to prevent the so-called “windchill” effect (that is, the perception of temperatures lower than real ones, as consequence of wind).

Moreover, the outfit is completely rainproof

FIRE RAINWEAR

Body parts covered by the rainwear:

CHEST

- R_{CT} cotton wool = 0.159 m^2K/W (measured)
- R_{CT} compound (outer shell jacket + inner jacket) = 0.185 m^2K/W (estimated in) (outer shell + cotton wool + lining)
- R_{CT} complete outfit = 0.198 m^2K/W (measured) (outer shell jacket + inner jacket + winter uniform + wool/aramid/viscose sweater)

SLEEVES

- R_{CT} fleece = 0.039 m^2K/W (measured)
- R_{CT} compound (jacket) = 0.081 m^2K/W (estimated in) (outer shell jacket + fleece + lining)
- R_{CT} complete outfit = 0.103 m^2K/W (measured) (outer shell jacket + inner jacket + winter uniform + wool/aramid/viscose sweater)

TROUSERS

- R_{CT} complete outfit = 0.029 m^2K/W (partially measured and partially estimated) (rain pants + winter uniform)

- Each layer has a thermal protection which depends on fabric thermal conductivity and its thickness
- Each fabric layer dissipates a given heat amount

R thermal resistance = m^2K/W calculated dividing thickness by thermal conductivity m/(W/mK)

INSULATION PERFORMANCE

In order to correlate insulation performances with operational scenarios, it is necessary to apply to European Standard UNI 14058/2004:

“Protective clothing. Garments for protection against cool environments”

This standard defines the performance requirements of simple clothing items for the protection of the body against these climates and the relative tests (Cool climate is an environment generally characterized by a possible combination of moist and wind conditions and a temperature of -5°C and more).

REQUIREMENTS AND PERFORMANCES:

• Thermal insulation (measured): value depending on max service temperature at a given activity level and exposure time;

• Thermal resistance: class 1 to 3 depending on the thermal resistance in m^2K/W (R_{CT})

• Permeability to air: class 1 to 3 depending on the diffusion of air in mm/s (AP)

• Resistance to penetration of water: class 1 or 2 (WP).

FIRE RAINWEAR

It has been possible to set up a partial correlation using the R_{CT} value and to classify the rain wear according to the table reported in item 4.2 of the European Standard.
Such classification is as follows:

- class 3, best thermal resistance value for the whole outfit (shell jacket + inner jacket + winter uniform + sweater) for the body upper part,

- class 2, an intermediate class, for sleeves (shell jacket + inner jacket + winter uniform + sweater):

To assess possible utilization scenarios based on temperature and wearing time, it is necessary to refer to Table B.2, Annex B (informative) "Temperature ranges of utility" of the same European Standard:

ICLER Insulation m^2K/W	Moving user			
	Light activity 115 W/m^2		Intermediate activity 170 W/m^2	
	8h	1h	8h	1h
0.170	11	2	0	-9
0.230	5	-5	-8	-19
0.310	-1	-15	-19	-32

CONCLUSIONS

Indisputable data ----------→ manikin thermal tests

Following rain wear:

1. Shell jacket
2. inner jacket
3. rain pants
4. winter uniform
5. sweater (50%wool**/**25% aramid**/**25%viscose)

Icler = 0.234 m^2K/W

The RAIN GEAR worn on winter uniform + sweater is classified in the intermediate table category. Therefore, taking into account the developed metabolic energy, it can be used according to Class 2 requirements.

CONCLUSIONS

Icler = 0.234 m² K/W

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	Light activity 115 W/m²		Intermediate activity 170 W/m²	
	8h	1h	8h	1h
0.170	11	2	0	-9
0.230	***5***	***-5***	***-8***	***-19***
0.310	-1	-15	-19	-32

WEDNESDAY , JANUARY 18, 2017

10.25 First seismic wave, magnitude 5.1

17.40 An avalanche crushed the RIGOPIANO Hotel, 1200 mt a.s.l., on the Gran Sasso range

TEMPERATURES:

-6 °C by day
-10 °C by night