
E·COOLINE

Heat stress measurement at the workplace

Glass manufacturer

Workplace: “furnace”

Contents

I. Definitions

Hot workplace

When working in hot environments, the combined burden of heat, physical work, and, if applicable, clothing leads to warming of the body and therefore a rise in body temperature. An increase of 1-2° C in body temperature can already result in fever-like temperature of 38-39° C*. As a result, the regulation of body temperature is of the utmost importance. As a result of vigorous and frequent work in hot environments, damage to health can occur. Even brief activity in hot environments can be a health risk.

By producing sweat on the skin, the body tries to cool itself, but this process requires energy too. This energy is then no longer available for work anymore. Scientific studies have shown (sports) 5-10% performance reserves by cooling. The Kiel Institute for the World Economy (IfW) also predicts loss in performance of up to 12% during hot days.

Thermal image

The technique of making images using a thermal imaging camera is called thermography. Being invisible to the human eye, thermal radiation (medium infrared) of an object or body is made visible by the thermography imaging technique. Temperature distributions on surfaces and objects are recorded and displayed by thermography. Thermography is a non-contact measurement method, i.e. far away objects can be displayed too. The sun's radiation as well as artificial light sources do not interfere.

When working in hot environments, the body's core temperature and skin temperature** are important indications of the body's thermoregulation. Both temperatures influence one another. The thermal imaging camera just has to capture the surface temperature of the body, while the stored images can be analyzed afterwards***.

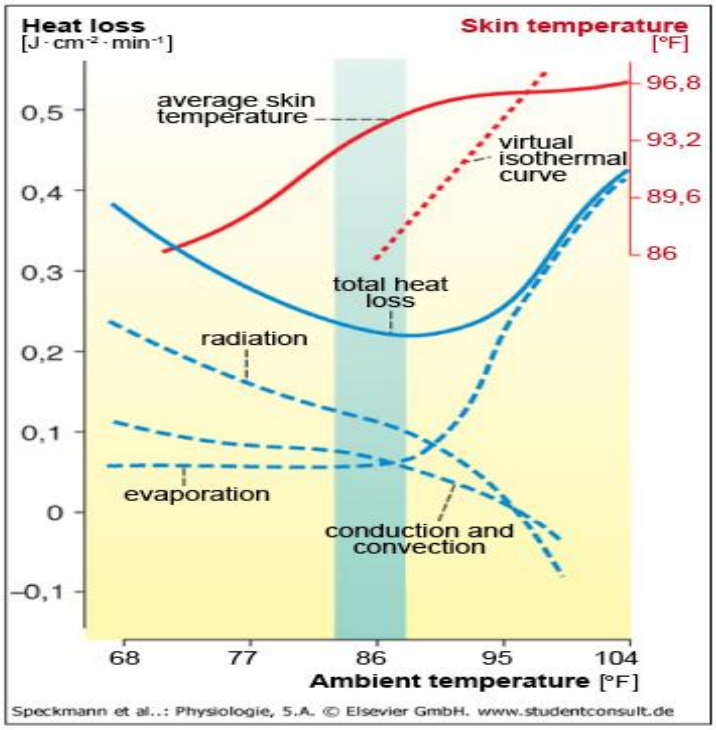


Figure 1: Unimpaired effect of outdoor temperature on energy and skin temperature, of which the latter influences body temperature via thermo receptors. High evaporation rate influences skin temperature positively and increases energy demand.

II. Situation

Description of workplace:
The glass manufacturer is an international technology company, developing and manufacturing special glass, special materials, components and systems for more than 125 years.
When making glass, very high temperatures occur especially near the “glass furnace”.

During an inspection of a factory of the glass manufacturer the work conditions at the furnace were to be assessed.
Temperatures of 304,1°C radiation temperature were measured with the thermal imaging camera in a passage next to the furnace, which is an integral part of the facility.

The facility is checked regularly. For this, the employees must inspect and conduct maintenance work in the passage as well as around the entire facility. Surveillance work and sometimes minor maintenance work are performed. Immense heat stress is the result. The furnace is located in the middle of the factory. The ambient temperature of the entire area was 28-31° C. The factory building was built in the thirties, is not air-conditioned and has lateral windows that can be opened.

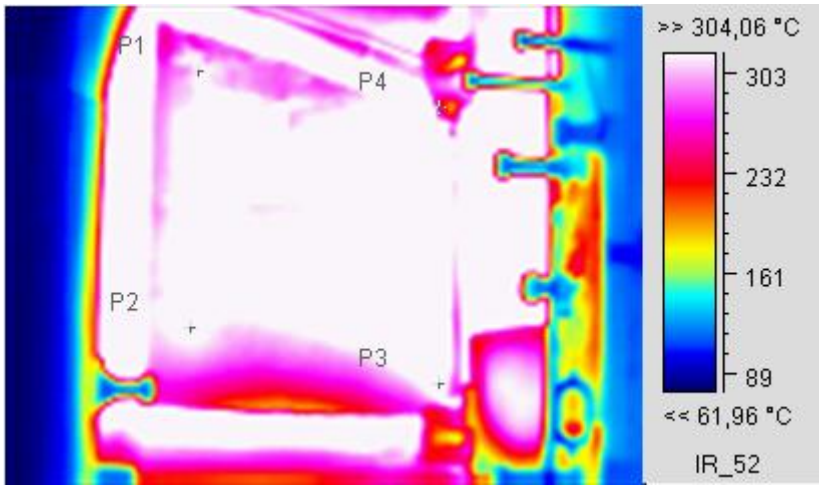


IMAGE1 Passage

IMAGE 2 Passage as seen with thermal imaging camera

Chart 1	Value
P1: Temp.	304.10°C
P2: Temp.	304.10 °C
P3: Temp.	304.10 °C
P4: Temp.	251.60 °C

Work clothing:
Work clothing for rent, heavy cotton material, not flame-retardant.
Outfit consisted of pants and jacket. Underneath a normal T-shirt made of cotton.
Due to heat stress the subject was wearing a protective hood and a “silver jacket” over his normal clothes together with gloves.



Image 2: Subject with clothing

Bandana was worn underneath the protective hood. The vest was worn over the working jacket, but underneath the silver jacket.

Classification of subject:
Employee (called subject from now on)
Man, ca. 180 cm tall, in his mid-forties, muscular physique, former strength athlete, not acclimatized.

43°C at the workplace
Conducted on: 04.16.2010, 11:49 am - 12:54 pm
Place: facility location
Type of work:
Assumed energy turnover class 1 when working in the room

Identification of potential dangers (special situations/locations/machines, etc.):
Increased heat stress in the passage because of thermal radiation of the furnace.

Deviations of measurement during seasonal changes, especially in summer (in case they exist):
Yes.

III. Utilization of COOLINE products during test

Vest	☒
Bandana	☒
Helmet inlay	☐

Comment:
Vest (clothing) and bandana (head covering) were loaded with tap water according to the instructions for each product.

IV. Thermal images

Background of the images taken by the thermal imaging camera: door leading to adjoining room (ca. 26° C).

Thermal images with temperature data for measuring surface temperature:
During the test, the subject's upper body was photographed with the thermal imaging camera at the location before and after work assignments, before and after entering the passage and the images were compared with one another. Images are compared on the next pages.

ORDER OF SEQUENCE:

1. Thermal image before usage
2. Thermal image after usage
3. Thermal image after usage and after having taken off the vest (only when vest was included in test)

1. First run with cooling

- Subject **is wearing** E.Cooline cooling vest/bandana
- Subject stays in the passage for 10 minutes, performing minor activity
- Subject: photographed with the thermal imaging camera right after leaving the passage

A. Image taken before entering the passage, without heat stress, without cooling vest:
Image 1, subject

Chart	Value
P1: Temp.	33.40 °C
P2 :Temp.	30.70 °C
P3: Temp.	35.00 °C
P4: Temp.	31.10 °C
Average temp. BS*	**31.7 °C**

*BS = Average temperature body surface

CONCLUSION: The temperature on the subject's body surface was 31,7° C before first measurement.

B. Implementation of test: 10 minute stay in the passage with cooling

Image 1.2, subject

Image with vest/bandana:

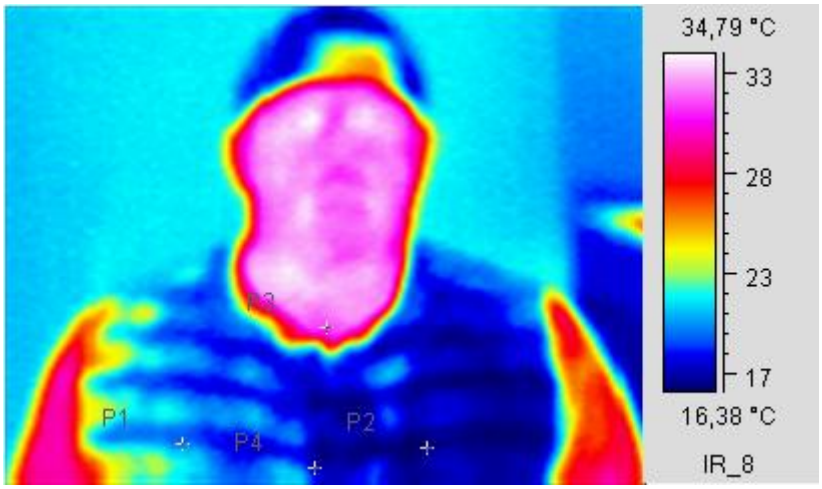


Chart	Value
P1: Temp.	20.00 °C
P2 :Temp.	16.80 °C
P3: Temp.	32.50 °C
P4: Temp.	18.20 °C
Average temp. BS*	**18.3 °C**

The thermal image shows the effectiveness of cooling vest and bandana. Because of the enormous radiation heat of the passage's environment, the surface of the cooling clothing reaches a temperature of 18,3° C .

C. Image after leaving the passage and taking off the vest

After having taken off the cooling vest, the subject was measured thermographically once more.
- Subject: after having taken off the cooling vest

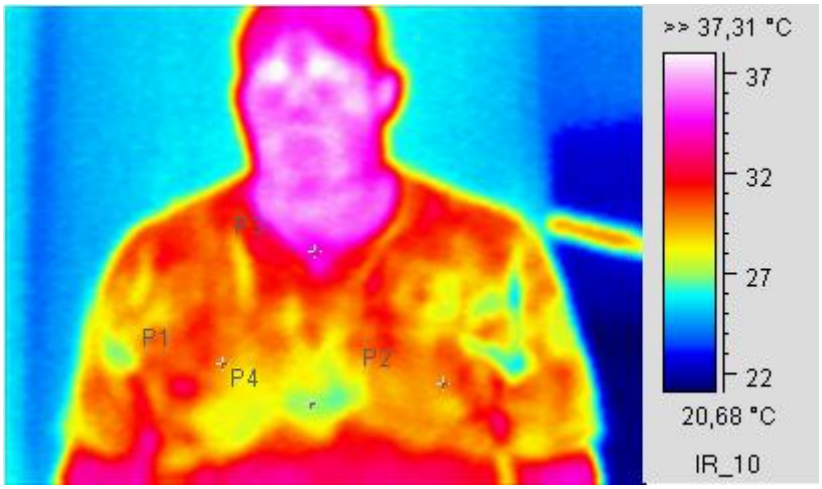


Chart	Value
P1: Temp.	30.20 °C
P2 :Temp.	30.40 °C
P3: Temp.	34.20 °C
P4: Temp.	27.20 °C
Average temp. BS*	**29.30 °C (-2.4 °C))**

Result:
After taking off vest/bandana, the temperature of the body surface was 29,3° C and therefore even lower than without cooling vest before the test.
Relief of the body by cooling is thereby clearly illustrated.

A rest period followed:
- Duration of recovery: 20 minutes

2. Second run
Subject without cooling

- Subject stays for 7.25 minutes (due to heat-related discontinuation), performing minor activity.
- Subject: photographed with thermal imaging camera right after leaving the passage

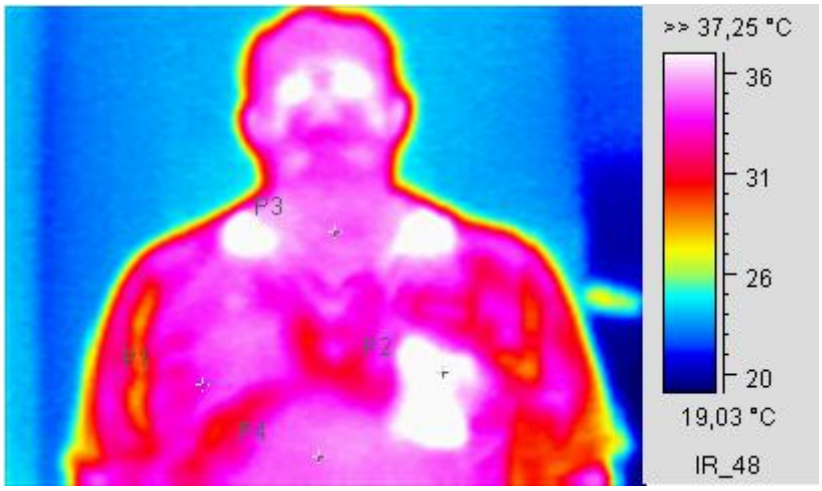


Chart	Value
P1: Temp.	34.20 °C
P2 :Temp.	37.90 °C
P3: Temp.	35.50 °C
P4: Temp.	35.50 °C
Average temp. BS*	**35.9 °C (+ 4,2° C)**

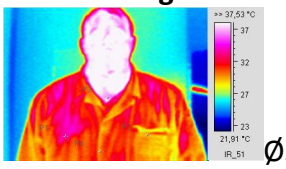
Without cooling, the body surface temperature in the chest area was +4,2° C higher than during measurement before heat stress

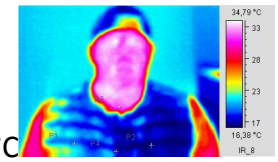
Summary of measurements:

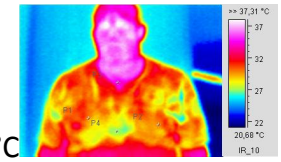
	Subject	
Before measurement **without** cooling vest (T_1)	ca. 31,7° C	
First run BS after leaving the passage **wearing** cooling vest (T_2)	ca. 18,3° C	-13,4° C cooler on vest
BS after leaving the passage **without** cooling vest (T_3)	ca. 29,3° C	-2,4° C cooler than before
Second run BS after leaving the passage **without** cooling vest (T_4)	ca. 35,9° C	+4,2° C warmer than before

Decrease of body surface temperature (BS) with cooling vest compared to no cooling (T_4 / T_3)	**ca. - 6,6° C cooler**	**than without cooling**

With cooling



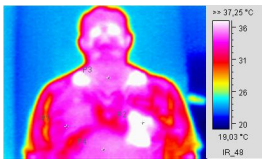
Ø31,7°C 

Ø18,3°C 

Ø29,3°C(-2,4°C)

Subject at test begin with cooling vest/bandana after taking off cooling vest/bandana

Without cooling

Ø 31,7°C 

Ø35,9°C (+4,2°C)

Subject at test begin without cooling

By using the cooling vest, the temperature of the body surface in the chest and head area (cardiovascular system) did not increase, despite an increased temperature.
By using the cooling vest and the bandana, the temperature of the body surface in the chest area (cardiovascular system) was even kept below the baseline values, despite the very high temperature, without causing any heat stress.

In comparison, the temperature of the body surface clearly increased by 4° C without cooling, which was confirmed by the subject's reports regarding heat stress and discontinuation of the test after 7 minutes.

Therefore, the E.COOLINE cooling vest is capable of considerably relieving the employee and contributes to the performance preservation within the measured temperature range.

V. Overall assessment of workplace

In warm environments over 26°C, the standard requires that a continuous exposition of employees must be avoided or other appropriate measures be taken. Dependent of the temperature, it must be examined whether technical or organizational measures are capable of reducing exposure. Usually these measures are already exhausted due to the unique work situation.

The current studies show that a simple and very effective relief of employees can be the utilization of cooling clothing (vest, bandana).

The temperature on the subjects' body surface increased by 4° C without cooling.

When using the cooling products, the increase in temperature in the chest area was kept at physiological levels and even decreased slightly, resulting in considerably relieving the employee.

Sports sciences studies involving cooling vests of the E.COOLINE brand show that cooling the body increases the ability to call upon physical performance as well as endurance considerably when compared to subjects without cooling. During rest periods at work, a faster regeneration using cooling products is achieved between work assignments.

These results can be applied to the current work situation as the rest period intervals at work are comparable to the sports sciences study.

Using the cooling clothing at the workplace investigated is therefore recommended.

“At last I can enjoy my free time after work again”

(Employee quoted at hot workplace after being relieved by E.COOLINE cooling vest)