15 An investigation into the possibility of heat strain amongst coke oven workers wearing ventilated helmet respirators

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A review of some unpublished studies, mainly in Wales, of the Airstream ventilated helmet and thermal discomfort, found that improved theoretical protection from a dangerous hazard did not necessarily give effective protection in practice. Conversely, climatic chamber experiments at the Polytechnic of Wales indicated that the helmet could improve comfort.

On the coke ovens the Airstream respirator is worn to protect against carcinogenic dust. It had been stated that such use of the respirator could result in over exposure to the hazard of excess heat, possibly due to a change in behaviour when protected. Thus field measurements of the actual effects of hot summer conditions were required, to assess whether wearing Airstream helmets during coke oven work resulted in unacceptable heat strain.

Despite maximum weather temperatures around the 23°C to 27°C (dry bulb) range, and work temperatures up to 78°C (dry bulb) and 109°C (black globe), the WBGT's (Wet Bulb Globe Temperatures) were only in the 22°C to 24°C range, when weighted according to exposure times. The International Standard (ISO 7243, 1982) gives safe reference WBGT's of 28°C and 26°C respectively for persons acclimatised and not acclimatised to heat in such conditions. Confirmation of non-excessive heat strain was also shown by generally acceptable heart rate values during work and recovery periods, and by (ISO) reasonable body temperatures.

These acceptable average WBGT's and lower heat strain responses were probably attributable to the short work periods - 25 to 50% of each shift - and to appropriate safe exposures by workers. No evidence of unsafe behaviour while wearing the helmets was observed. Consequently heat strain under these conditions was shown to be unlikely.

Nevertheless a need remains for relevant standards and legislation to be understood and accepted before they are enforced. Both health and safety may then be enhanced as workers are confronted by a wider range of hazards in the industrial environment.

Reference

ISO 7243 (1982) Hot environments - estimation of heat stress on working man, based on the WBGT index.

16 Ventilation of garments

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The magnitude to which ventilation of clothing adds to the removal of heat and moisture from a sweating person has been investigated in a mixed theoretical and experimental setup.

The main mechanisms of ventilation are pumping due to work and motion and wind penetration. Both depend on construction and fabric of the garment. The questions emerge whether the design of the garment can be optimized and whether ventilation can cope with all the heat to be removed.

By means of an enhanced tracer gas technique absolute ventilation figures were experimentally obtained, in contrast to the relative numbers of previously published methods. By means of a harness of tubings an area weighted sample of the microclimate air underneath the garment is continuously taken. This air is enriched with tracer gas and in a similar harness redistributed under the garment. By means of a mass spectrometer both the sample and inlet tracer gas concentrations are measured.

During equilibrium, just as much of the tracer gas is removed due to ventilation as is supplied by the harness. In this case the ventilation is given by the simple formula:

$$\text{Vent} = \left(\frac{C_i}{C_s} - 1 \right) \text{flow} \quad (\text{l/min})$$

where C_i and C_s are the inlet and sample concentrations and the flow is that circulated by the harness. The method requires no other calibration than that of the flow and makes no assumptions whatsoever about the patterns of ventilation.

In a small scale experiment, using 4 subjects, the ventilation of a rainsuit, consisting of a jacket and trousers with suspenders, made out of windproof fabric, was investigated as a function of walking speed (0,2.5 and 5 km/h) and windspeed (0,2 and 6 m/s frontal). The data show that up to 2 m/s windspeed the effect of motion is relevant, but that the effect of higher windspeeds tends to overrule the motion effect.

Those high windspeeds may cause ventilation up to 300 l/min for the jacket and 200 l/min for the trousers. Since wind is not related to metabolic heat production it is unproductive in supporting thermal control, however.

The lower windspeeds show ventilation up to 60 l/min for the jacket and up to 160 l/min for the trousers, depending on the speed of walking. This causes effective support of thermal control, up to 110 W of body heat. The latter figure is based on the measured 10°C temperature gradient and 7 g/m^3 vapour concentration gradient between microclimate and surrounding air, each l/min of ventilation removing 0.5 W of body heat.

Various locations of vents have been investigated, but the general conclusion is that those seem to have a local effect only. Obtaining general ventilation, servicing major parts of the body, is far from easy. A condition is that there be enough space between body and garment to enable free circulation. Use of spacers between body and garment showed an increase of ventilation under the jacket of 30 to 100%, depending on the tightness of fit.

The often advocated chimney effect seems hardly to exist inside the garment. It is the increased internal circulation due to pumping rather than natural convection that promotes ventilation, as may be concluded from ventilation data of standing people.

The conclusion is that there are limited possibilities to ventilate with motion but not with wind, and that the cooling effect will not meet the increase in metabolic heat production due to increased activity.

17 The air exchange of foundry workers' clothing

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The design of comfortable but safe workwear for use in the iron foundry industry still remains a problem. Seven garments were constructed which included design differences: coverall, belted trousers and jacket, braced trousers and jacket; and fabric differences in terms of material, cotton and wool, air permeability, weight of fabric and flame proofing finish.

The garments were tested using a trace gas technique. Standing and five work routines were used to assess the garments and rank them in terms of air exchange rates.

Differences were found in air exchange rates which could be related to design, fabric permeability and the work routine.