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Thermal conditions in mining operations. Final report on CEC Contract 6245- 11/8/049

Graves RJ, Leamon TB, Morris LA, Nicholl AGMCK, Simpson GC, Talbot CF



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I N S T I T U T E O F O C C U P A T I O N A L M E D I C I N E

THERMAL CONDITIONS IN MINING OPERATIONS

(Abstract of IOM Report TM/80/9)

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1. INTRODUCTION

This document contains a synopsis of the report on the NCB/ECSC sponsored Investigation of Thermal Conditions in Mining (Graves et al, 1981). The full report is available on request.

Project Background

It is generally accepted that adverse climatic conditions can reduce performance and lead to fatigue in an industrial workforce. Consequently, there has been considerable interest in optimal thermal conditions for industrial work and in the upper limits of tolerance.

It has been known for sometime that climates in the British mining industry range from hot and humid to cold with high air speeds. As a result of discussions within the industry the need for a comprehensive study of thermal conditions associated with mining operations and of the effects of mine climate on the workforce was identified. This project was established with the following aims:-

- a) to assess thermal conditions in the British mining industry;
- b) to measure the physiological and subjective responses of mineworkers to thermal conditions at their place of work;
- c) to evaluate means of reducing climatic stresses on the workforce.

Associated with this was the requirement to identify how effectively American Effective Temperature (ETA) served the industry's requirements as a thermal index.

2. PROJECT APPROACH

A climatic survey was carried out:-

- a) to provide up-to-date underground climatic data in order to determine the extent of hot and cold environments in a representative sample of collieries.
- b) To examine the relationship between climatic measurements taken at the statutory ventilation points and the miner's workspace.
- c) To examine any climatic changes over the working week at the miners' workspaces.

The project was divided into two major approaches after the climatic survey to deal with the hot conditions separately to the cold conditions as the physiological response mechanisms are different in each case. The first approach was the assessment of thermal indices for hot mining conditions and the second was the development of principles for the selection of clothing for use in cold conditions.

Hot Conditions

A review of the literature on thermal indices suggested that four were appropriate for use in hot conditions: Effective Temperature American (ETA), Wet Bulb Globe Temperature (WBGT), Predicted Four-Hour Sweat Rate (P4SR) and the Index of Thermal Stress (ITS).

The operator's workrate was found to be a factor in the relationships between these indices. This finding was supported by the results of an experimental study which showed that metabolic heat in combination with environmental heat produced marked increases in both heart rate and core temperature. However, a subsequent field study indicated that mining work in hot conditions was generally intermittent in nature and light to moderate in intensity. Under these conditions, metabolic heat load had little effect of the thermal load imposed on the workmen.

A final laboratory study showed that under intermittent workload conditions in ETAs up to 28°C, indices without workrate components (ETA and WBGT) could predict increased physiological strain. The practical implication for the British mining industry was that ETA, which is

already in widespread use and easily measured and understood, remains an acceptable index for predicting thermal strain, even when compared with more recently derived indices.

Cold Conditions

In developing principles for the selection of clothing for cold conditions, four main factors were found to affect heat loss from clothing assemblies:-

- a) the thermal insulation of the clothing fabric;
- b) the resistance of the fabric to wind penetration;
- c) the air exchange rate;
- d) the overall insulation characteristics of the clothing assembly.

Air exchange rate was considered to be the most important because of the high air velocity component in cold mining conditions. The available laboratory technique which involved air exchange measurement was not sufficiently sensitive to measure air exchange rate in miners' clothing assemblies due to the permeable nature of the fabrics used. A field experiment was designed, therefore, to investigate aspects of clothing materials and design in terms of subjective response.

3. MAIN FINDINGS FROM THE STUDIES OF HOT MINING CONDITIONS

The central theme underlying the studies of hot mining conditions has been the evaluation of thermal indices as a means of predicting heat strain. The main findings were:-

- a) Some faces, face-ends, developments and district roadways had hot conditions characterised by a narrow climatic envelope described by moderately high dry bulb temperatures, but the effects of these were exacerbated by high relative humidities and low air speeds.
- b) Four indices (ETA, WBGT, P4SR and ITS) which were appropriate to this envelope were highly correlated.
- c) As metabolic work is a major component of total heat stress the nature of work in mining conditions was investigated. Workrate was generally found to be light to moderate in intensity and of intermittent duration. It was shown further that in this envelope, light to moderate intermittent work had little significant effect on total thermal strain and was not therefore a significant factor in the choice of an index.
- d) It was concluded, therefore, that there was no scientific justification for using any of the indices in preference to others.
- e) The practical implication of this for the British mining industry is that Effective Temperature (American) remains an acceptable index for predicting thermal strain despite its theoretical limitations.

4. MAIN FINDINGS FROM THE STUDIES OF COLD MINING CONDITIONS

Cold conditions in mining were characterised by an envelope of conditions described by low air temperatures and high air velocities.

The investigation of the effects of these conditions centred on the evaluation of the design of clothing. The main findings were:-

- a) Clothing made from melton material provided better insulation and feelings of warmth than the existing clothing.
- b) One-piece or two-piece designs were equally acceptable in providing thermal comfort.
- c) There were less feelings of restriction obtained with the trial designs than the existing clothing.
- d) Some design features such as which affect wearer acceptability were defined during the field trials. These included factors not related to the thermal properties such as pocket provision etc.

5. REFERENCE

GRAVES R.J., LEAMON T.B., MORRIS L.A., NICHOLL A.G.McK., SIMPSON G.C., TALBOT C.F. (1981) Thermal conditions in mining operations. Final report on CEC Contract 6245-11/8/049. Edinburgh: Institute of Occupational Medicine. (IOM Report TM/80/9).

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