HIGH INSPIRED AIR TEMPERATURES SUPPLIED BY BREATHING APPARATUS DURING FIREFIGHTING MAY LIMIT HEAT EXPOSURE

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INTRODUCTION

Fires produce many thousands of different irritant, harmful and toxic substances, of which carbon monoxide is one of the most common. Carbon monoxide poisoning is the most immediate cause of death from fire[1] and thus firefighters wear breathing apparatus (**BA**) to avoid inhaling any of the toxic products of fire. **BA** is also thought to provide the wearer with a cool compressed air source in hot compartments, therefore protecting personnel from the danger of thermal inhalation injuries such as those described by Herndon[2]. However during firefighting trials carried out by the Royal Navy (RN), subjects reported that the air supplied by the **BA** during 10 minutes exposure to 160°C became uncomfortably hot[3], suggesting that they may be at risk of thermal injuries to their lungs during exposure to higher temperatures. Normally, RN firefighters are protected from high temperatures by a sea water system which produces a near vertical sheet of water, or 'water-wall', in front of the firefighting team and reduces the local ambient temperature behind the protection[3]. In the event of a failure of water supply this protection would be lost and the firefighters would have to evacuate the scene of the fire. The aim of this study was to quantify increases in inspired air temperatures resulting from the exposure of BA to dry bulb temperatures up to 180°C (measured at head height) to determine safety limits for evacuation in the event of a loss of water. A secondary aim was to assess the effectiveness of BA bottle insulation in reducing inspired air temperature.

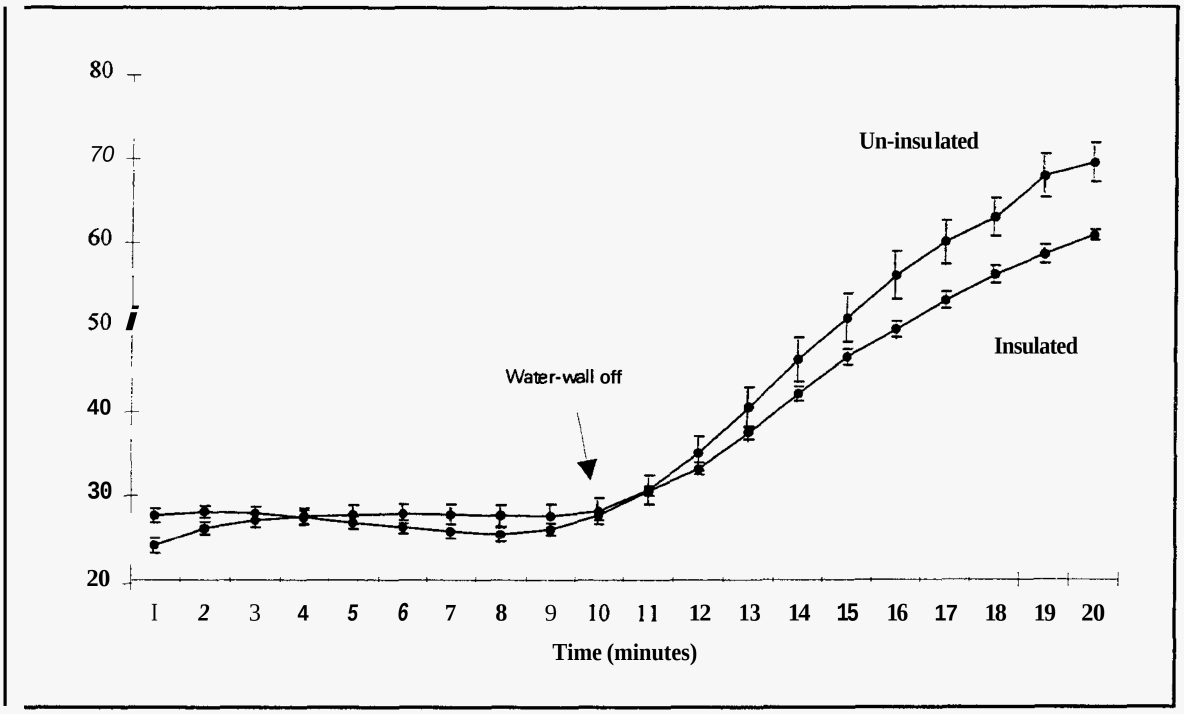
METHODS

Following local ethical approval for the study, volunteer subjects were recruited. Four subjects wearing RN firefighters protective clothing (heavy woollen Fearnought suit) and BA were exposed to dry bulb temperatures of 180°C for 10 minutes with a 'water-wall' for protection behind which, the dry bulb temperature was reduced to around 30°C. In the following 10 minutes the water supply was cut off, resulting in an increase in temperature to 180°C within 5 minutes. This procedure was repeated on a further 3 days to provide 16 data sets. One week later the experiment was repeated but with additional insulation added to the BA provided by Fearnought material: wool 4 mm thick and treated with Zirpro™ (a charring agent). Inspired air temperature was measured using thermistors placed inside the BA face-piece: one placed in the air space of the oro-nasal mask section and, the second placed in the upper air space of the face-piece in front of the eyes and forehead. Temperatures from the thermistors were recorded on an electronic data-logger at 1 minute intervals. This recording system was attached to an audible alarm which sounded if inspired air temperature exceeded 80°C (10°C below the British Standard Safety Limit[4]). Students' t-test was used to compare the two conditions, un-insulated and insulated BA, during the two experimental periods: 'water-wall' on (first 10 minutes), and 'water-wall' off (subsequent 10 minutes).

RESULTS

With 'water-wall' protection, inspired air temperatures rose during the first five minutes to a maximum of below 30°C and then fell as the local temperature was reduced. Thus inspired air temperature remained well within British Standard safety limits of 90°C *dry* bulb and would have remained so throughout the maximum possible endurance of the BA providing that 'water-wall' protection was maintained. Following the removal of 'water-wall' protection, inspired air temperatures increased rapidly: predicted mean safe exposure time, (the time to attain or exceed the British Standard limit of 90°C[4] was calculated by linear extrapolation as 14 ± 3 minutes (mean ± s.d.). Following the addition of insulation around the BA bottle, predicted mean safe exposure time was significantly increased ($P<0.05$) to 18 ± 5 minutes ($n=16$). Mean inspired air temperatures supplied by the BA, with and without insulation, calculated from all experiments are shown in Figure 1.

Figure 1. Mean increase in inspired air temperatures supplied from breathing apparatus following the removal of 'water-wall' protection during exposure to 180°C dry bulb (with and without insulation). Shown with standard error bars.



CONCLUSIONS

With 'water-wall' protection, inspired air supplied by the **BA** did not place RN firefighters at risk of a thermal inhalation injury. Following failure of 'water-wall' protection inspired air temperatures rose rapidly, although predicted safe exposure times of 10 minutes would allow adequate time for personnel to escape in the event of a failure of the water supply. If compartment temperatures were higher than 180°C then safe escape times are likely to be correspondingly reduced. In these circumstances extra insulation around the bottle may be critical to the extension of evacuation time limits.

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