

THERMOREGULATION OF ARMoured FIGHTING VEHICLE CREW IN HOT CLIMATES

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INTRODUCTION

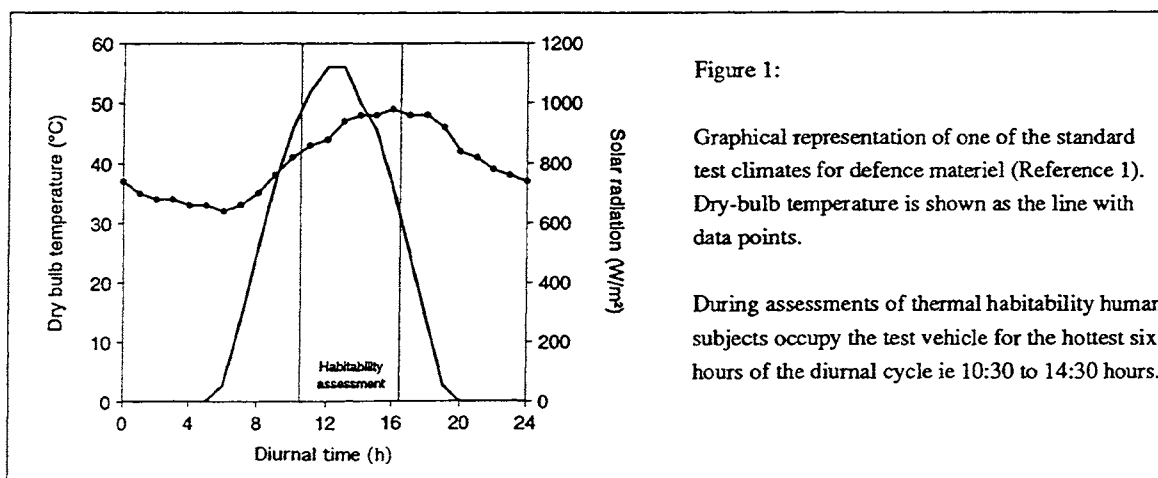
There are many work-place situations in which personnel are required to wear Personal Protective Equipment (PPE) in confined spaces. Often the PPE will be heavy, have high values of insulation and be relatively impermeable to moisture vapour transfer. In these circumstances convective and evaporative heat loss will be very restricted, and thermoregulation may be possible only at a raised deep body temperature or not at all. Management of this thermal risk is therefore essential. In principle this could be done by controlling either the work-place environment and/or the micro-climate of the PPE.

One example of a confined work-place where thermal strain is likely is in Armoured Fighting Vehicles (AFVs) deployed to hot climates. The British Army have chosen to reduce thermal strain by crew-compartment cooling rather than micro-climate cooling. Many factors have dictated this choice, including the relative fragility of micro-climate conditioning garments and the thermal burden they impose if they fail or if ice, batteries etc are not resupplied.

In many circumstances AFV crews are required to wear multi-layered chemical protective clothing which substantially reduces evaporative cooling. It is therefore essential that the effectiveness of the vehicle crew-cooling systems are assessed in realistic environmental conditions. In the UK this is typically done in manned 'thermal habitability' tests. This paper describes the methods used and some typical results.

METHODS

Reference 1 defines thermal environments in which defence materiel must function. AFVs have recently been required to operate in the most severe of these - "extreme hot" with maximum ambient dry-bulb temperature of 49°C; minimal air speed; relative humidity 6 to 8%; solar radiation of 1100 Watts/m² (Figure 1). The criterion for acceptable thermal habitability is that the deep body temperature of the crew must not exceed 37.5°C at any time during the 6 hottest hours of the diurnal cycle (2). Local Ethics Committee approval is always sought.



Before the test the AFV is heat soaked for one 24-hour diurnal cycle. The crew dress in appropriate combat and chemical protective clothing (less respirator and gloves) and remain sedentary within the AFV throughout the exposure. Whenever practicable an additional exposure is done with the cooling system switched off. Thermal strain is assessed from 4 key variables: deep body (usually rectal) temperature; mean skin temperature from 3 sites; heart rate from 3-lead chest electrodes; and total water loss from nude and clothed weights taken before and after the heat exposure, from which the ratio water evaporated : total water loss (E/P %) is also calculated. However, the only criterion of acceptable thermal habitability is that rectal temperature must not exceed 37.5°C.

RESULTS

Typical results for different AFV types are shown in Figure 2. The upper panel shows data from the 3 crew of a tracked, armoured missile launcher; the lower, mean data from a tracked armoured personnel carrier carrying 7 crew. Dry-bulb temperatures inside the vehicles varied with crew position and with diurnal time. In the missile launcher the highest single value recorded, at 13:30 hours diurnal time, was 39.0°C with the air-conditioning switched on. With it switched off the test was terminated at 11:40 hours, when the internal temperature was 46.2°C. In the personnel carrier the highest temperature recorded was 39.3°C with air conditioning and 46.5°C without. In both AFVs crew rectal temperatures rose above 37.5°C when the air conditioning system was off. However, with it on rectal temperatures stabilised below 37.5°C. Thus both AFVs met the habitability criterion.

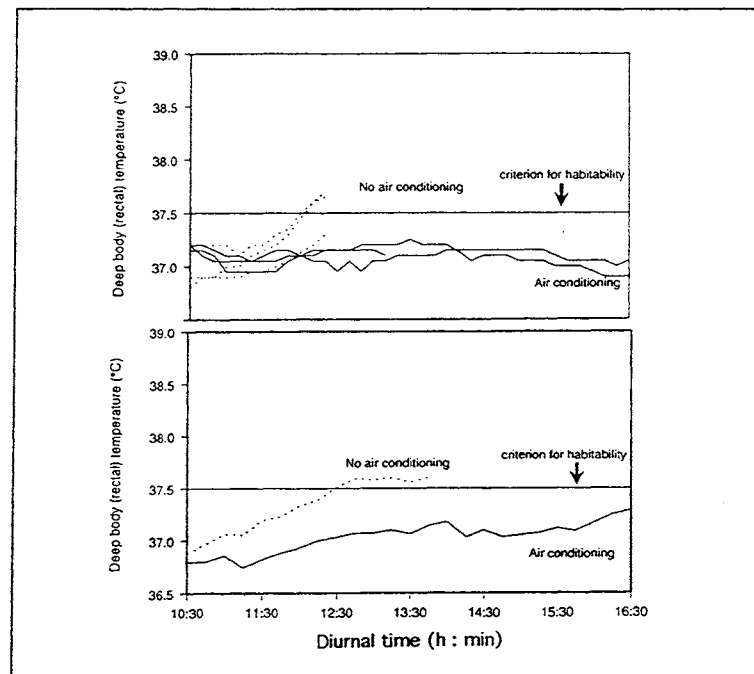


Figure 2: Rectal temperatures of AFV crews with and without air conditioning

CONCLUSIONS

Although there are limitations to this test methodology, these data show that even in extreme hot conditions in the presence of a high solar load crew-compartment air conditioning can be an effective way of managing the thermal risk in an AFV crew, despite them being dressed in PPE which reduces evaporative cooling. There are however drawbacks to the use of air conditionings such as complexity, reliability, power and thermal signature.

REFERENCES

- 1 Defence Standard 00-35 (Part 4)/1 1986. Environmental Handbook for Defence Materiel Part 4: Natural Environments, Chapter 1-01.
- 2 Turk J 1988. The environmental life support system in vehicles: an update of human factors advice. Army Personnel Research Establishment, Farnborough: Working Paper 59/87.