# PASSIVE COOLING FOR ENCAPSULATING GARMENTS

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## INTRODUCTION

Personnel wearing encapsulating clothing ensembles will suffer heat stress under certain conditions due to the added insulation and reduced vapor permeability of such ensembles (1,2). Passive cooling vests (e.g. the Steelevest) are useful for reducing heat stress when worn with general utility clothing (3) and have found widespread use in both the military and industry. These vests are not practical for use with encapsulating ensembles since wearing the vest over the ensemble reduces the cooling effect, and wearing the vest under the ensemble prevents changing of the cooling packs. Increasing the number of cooling packs and incorporating the pockets for the packs directly into the ensemble may be a relatively easy way to provide cooling in encapsulating clothing. The purpose of this study was to test this concept on a Thermal Manikin (TM).

## METHODS

TM testing was conducted on a prototype U.S. Navy Chemical Protective Overgarment (CPO) and the Toxicological Agent Protective suit (TAP). The CPO is a semi-permeable ensemble whereas the TAP is impermeable. Both ensembles were tested with three cooling variations: the Steelevest under the ensemble (U), over the ensemble (O), and the ensemble modified by adding exterior pockets for the cooling packs to the torso and thigh surfaces (M). The M-CPO and M-TAP contained 29 cooling packs (7.4 kg of gel) compared to 18 (4.6 kg) in the Steelevest. The gel packs were frozen at approximately -15°C prior to the test. Tests were run at 35°C, 60% relative humidity, 0.9 m/s wind speed, and 35°C TM temperature. TM power was measured without cooling packs (baseline) and at 1-min intervals after the cooling packs were inserted. Cooling results equal the average of 120 consecutive power readings less baseline. The results were analyzed using one-way analysis of variance (ANOVA). Since the CPO and TAP ensembles were not being compared to each other, separate ANOVA's were conducted on each ensemble. Statistical significance was accepted at $p<0.05$.

## RESULTS

The test results are summarized in Table 1. The cooling provided by M-CPO (137 watts) was significantly greater than U-CPO (112 W) and 0-CPO (75 W). The cooling provided by M-TAP (151 W) was equivalent to U-TAP (142 W), and significantly greater than 0-TAP (86 W).

## CONCLUSIONS

These results demonstrate that external passive cooling packs may be a viable solution to heat stress problems in both semi-permeable and impermeable encapsulating clothing ensembles. If 29 external packs (7.4 kg gel) are used, the cooling provided is at least equal to the use of the Steelevest under the ensemble.

Table 1. Thermal Manikin Test Results

| Configuration | Gel weight kg | Cooling rate watts ± std dev |
|---|---|---|
| M-CPO | 7.4 | 137 ± 6.9 |
| u-CPO | 4.6 | 112 ± 2.6 |
| 0-CPO | 4.6 | 75 ± 3.7 |
| M-TAP | 7.4 | 151 ± 10.1 |
| U-TAP | 4.6 | 142 ± 3.8. |
| 0-TAP | 4.6 | 86 ± 9.8 |

REFERENCES

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