BRING ON THE HEAT: VENTILATION IN STRUCTURAL FIREFIGHTER SUITS

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INTRODUCTION:

When working on the fireground, firefighters rely on their protective clothing to provide both protection and thermal comfort to ventilate and keep body temperatures regulated. Without adequate breathability in structural firefighter turnout suits, heat exhaustion and suboptimal performance become a prevalent risk for firefighters. The human body at its core is homoeothermic, meaning equilibrium is required between the heat absorption and heat loss of an individual. To prevent heat stress and heat related illness, it is essential that turnout gear has proper ventilation for metabolic heat to escape. (McQuerry et al., 2015, pg.86(7)). Performance wear can hold either active or passive vents. Active vents can be manipulated by the user, while passive vents are always in place. Through these various ventilation techniques, body heat may be reduced while deployed on common goodwill calls. ***Therefore, the purpose of this research was to develop a protocol to assess ventilation and highly evaporative material placement within structural firefighter turnout suits for simulating real world conditions.***

METHODS:

During our work in the ThermaNOLE Comfort Lab®, we tested multiple protocols for the assessment of five turnout suits with a variety of ventilation techniques. The suits that will be tested include:

1. Control (standard turnout suit with no ventilation or modification)
2. MBTLWV (moisture barrier and thermal liner with ventilation)
3. MB2TLWV (moisture barrier type 2 with ventilation)
4. MBTLNV (moisture barrier and thermal liner with no ventilation)
5. OS2TL2 (outer shell type 2 and single layer thermal liner with vents)

To test the ventilation placement in these suits, we developed a protocol by testing MBTLWV at both 6.8 Mets and 8 Mets using a sweating thermal manikin (ANDI) with an integrated human thermoregulation model (ManikinPC). The suit underwent three 20/5 minute work/rest cycles at a sampling rate of 30 seconds. Results will determine the most realistic testing protocol for all five suits, each with different evaporative cooling techniques which allow for different amounts of heat transfer, thus predicting the physiological performance of firefighters.

ANDI Manikin in the FSU ThermaNOLE Comfort Lab®

ANDI dressed in turnout suit

RESULTS:

Mets Setting	Thy°C	TSkin°C	Sweat (g/mL/min)	Comfort (-4 to 4)	Sensation (-4 to 4)
6.8 Mets	**41.05**	**40.388**	**30**	**-3.9**	**3.1**
8 Mets	**41.587**	**40.889**	**30**	**-3.9**	**2.9**

After collecting and reviewing the pilot protocol, the data indicated that tests run at a metabolic rate of 6.8 Mets led to more realistic physiological outcomes throughout the duration of the protocol. The endpoint data after 75 minutes of testing showed both Thy and Tsa were meaningfully different between the two protocols. A 0.5°C increase in Thy at 8.0 Mets reflects fatal levels for core temperature. The Swa (sweat) rate reached the maximum modeled amount of 30 g/mL/min during both the protocols. The manikin indicates extreme discomfort in both protocols at a predicted rate of -3.9 and very warm/hot sensations around 3.0.

DISCUSSION:

Findings indicate the 6.8 Mets protocol is most appropriate to analyze the ventilation placement of each turnout suit design without succumbing to fatal levels of heat exhaustion. This protocol will realistically predict active firefighting scenarios. As all ventilation, active cooling and heat stress relief materials and designs cannot be individually assessed on the human wear level, it is important that protocols utilizing sweating thermal manikins and human thermal modeling are developed to enable promising results for real world implementation. Through utilizing the ThermDAC model, researchers can determine how particular materials and garment designs will likely perform when worn by the end user and influence wearer safety and health.

CONCLUSIONS:

This work further demonstrates the benefits of sweating thermal manikin and human thermoregulation modeling tools to assess the thermal and physiological comfort of various types of personal protective clothing and equipment. Following testing using the protocol developed in this project, future research should continue exploring the performance of firefighting PPE with alternative ventilation placement using live firefighter subjects.

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