Comparison of Bench-Scale and Manikin Tests of Protective Clothing Systems During Low-Level Radiation

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Abstract

A bench-scale apparatus producing the liquid droplets and a sweating manikin were used to study the heat and moisture transfer through the multilayer protective clothing system during the low-level radiation of 2.5 kW/m^2. The results show the cooling effect of the absorbed liquid transfer and the heating effect of condensation at the bench-scale test. In addition, the wicking effect from sweating water with the stored thermal energy influences the heat transfer of the clothing system during the exposure and cooldown periods at the manikin test. Although the comparison of the bench- and full-scale tests with some differences during the moisture condition, both methods can be used to investigate heat and moisture transfer through protective ensemble exposed to and after ending the low-level thermal radiation.

Keywords

Protective clothing • Thermal protective performance • Thermal radiation • Manikin • Bench-scale test

49.1 Introduction

Thermal protective clothing is designed to protect firefighters during firefighting or exposed to other thermal radiation. Heat from the fire or thermal radiation and moisture from the perspiration can be transferred within the clothing, through the solid fabric layer and gaseous air [1].

The exposure conditions of firefighters have been classified as emergency, routine, and hazardous conditions by the different levels of air temperature and radiant flux. Skin burn injuries most frequently occur when firefighters are exposed to routine and hazardous conditions, with low-level thermal radiation less than 12 kW/m^2 [2].

There are few studies on the comparison of the manikin and bench-scale tests to study the effect of multiple air gaps on the protective performance of protective clothing [3, 4]. Lee et al. [3] compared thermal performance of a single-layer clothing with the manikin test and the bench-scale test during flash fire exposure. It was shown that the bench-scale test could predict the full-scale manikin test if the air gap distribution was measured. Many burn injuries could occur under lower thermal exposure than under flash fire exposure [5]. A bench-scale test and a full-scale manikin test were conducted by Stroup et al. [4], to evaluate the thermal performance of firefighter protective clothing exposed to low-level heat flux. The differences of the fabric layers between the two scale tests indicated that the air gaps had great influence on the heat transmission through the protective clothing. However, those two studies were studied at the dry test and did not consider the moisture transfer within the clothing. The effect of air gap was affected by the

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