PROTECTION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL PROTECTION

Next Generation Technologies For Real-time Evaluation Of Protective Suits Against Toxic Chemicals

Caspar Hoyer University of Hertfordshire **Hazem Matar** University of Hertfordshire **Rustam Aryoobi** University of Hertfordshire **Robert Chilcott** University of Hertfordshire

Chemical protective equipment (CPE) is used in a variety of applications ranging from maintenance tasks in chemical plants to the protection of response teams during chemical incidents or attacks. To verify their integrity, the ensembles are tested in accordance with a set of standardized test regimes [1]. However, the current test protocols exhibit apparent weaknesses: hazardous chemicals are solely employed during the assessment of isolated material swatches (e.g. ASTM F739 [2] or ISO 6529 [3]). In contrast, a comprehensive evaluation of whole ensemble worn by human test subjects is only performed using relatively non-toxic simulants such as the man-in-simulant test (MIST [4]) or in ISO 17491 [5]. No standardized test has been established for evaluating whole ensembles against hazardous chemicals worn during anthropomorphic physical activity.

This research project aims to develop a real-time evaluation system for assessing the effectiveness of whole chemical protective ensembles against toxic chemicals and chemical warfare simulants during movement. To achieve this, a humanoid, animated mannequin was manufactured and equipped with real-time chemical sensors for the detection of chemicals penetrating a protective ensemble. A pneumatic dosing apparatus was developed to deliver precisely adjustable amounts of benzene and methyl salicylate onto the animated mannequin in form of a splash, a jet, a spray, an aerosol, or a vapour. The performance of the chemical sensors was compared to passive absorbent dosimeters (PADs) which are currently part of the MIST protocol.

Future work includes the testing of different classes of chemical protective suits worn by the animated mannequin inside a state-of-the-art exposure chamber. While wearing a full protective ensemble and performing movements such as squatting and arm raising, it will be exposed to benzene, methyl salicylate and other toxic chemicals using the different exposure techniques. The unique advantage of this system is the ability to detect ingress of toxic chemicals in real time during movement. An additional mannequin system has been developed to evaluate the ingress of particulates such as smoke and radioactive particles. The significant advantage of the latter system is the determination of particle-size specific protection factors (between 6 nm to 10 µm) that penetrate these ensembles in real-time.

[1] van Wely, E 2017, ‘Current global standards for chemical protective clothing: how to choose the right protection for the right job?’, Industrial Health, vol. 55, pp. 485 – 499.
[2] ASTM F739-20, Standard Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact (2020)
[3] ISO 6529:2013, Determination of Resistance of Protective Clothing Materials to Permeation by Liquids and Gases (2013)
[4] NFPA 1990, Standard for Protective Ensembles for Hazardous Materials and CBRN Operations (2022)
[5] ISO 17491, Test Methods for Clothing Providing Protection against Chemicals

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