Design and Testing of a 3D-Printed Skin Simulant for Thermal Radiation Protection Studies

The application of modern technologies to the production and testing of an instrumented skin simulant that has application to fabric and protective shielding from nuclear weapon thermal radiation.

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The evaluation of materials used to protect soldiers and civilians from burns induced by nuclear weapon thermal radiation and fire is a critical research area for all countries. Testing of materials and material designs is often done by measuring temperatures on or in a manakin or skin simulant located below the protective equipment. The time-temperature record is evaluated to determine if the heat load into skin would be low enough to protect a human from burning.

With the advent of a new flashlamp thermal source (FTS) and the restored Large Blast Thermal Simulator (LBTS) at White Sands Missile Range, the potential to use these simulators for skin protection studies warranted an investigation into the development of a low-cost precision-instrumented skin simulant for future thermal and thermal-blast testing.

Thermal properties of materials used in 3D printing were investigated. The thermal diffusivity of UV hardened acrylic resin was found to be very close to that of human skin and was selected for prototype skin simulant development. A 100 cm2 prototype skin simulant with thermocouple placement wells that correspond to epidermis, mid-dermis, and sub-dermis depths was printed and instrumented.

The foundational research into the time-temperature relationship to burns was conducted by F.C. Henriques (Ph.D.) and A.R. Moritz (MD) of Harvard Medical School. The Henriques and Moritz (H&M) experiments were repeated with the 3D printed skin simulant.

The results of the H&M skin simulant tests contradict conventional concepts of the time-temperature relationships for skin burns. The simulator results are supported by *in vivo* instrumented experimental data. The contradiction is addressed in the paper. New concepts for the time-temperature relationship to skin burns are presented.