

Advanced Multi-purpose Base Ensemble for Emergency Responders

Addressing first responder base protective workwear needs

The need for clothing and equipment that provides protection against “all hazards in an unpredictable response environment” was identified in the [Project Responder 3 report](#). The first responder work environment requires a multi-threat base protective ensemble that can be worn as a normal duty uniform (i.e., “Base Ensemble”) and it must be compatible with the specialized protective garments required to meet the needs of specific public safety disciplines (e.g., firefighting, EMS). Some specialty areas (e.g., explosive ordnance disposal, HAZMAT, etc.) require a different level of performance and protection than this Base Ensemble will provide. Currently no base ensembles meet this capability gap.

Designing and developing a new multi-hazard protective base ensemble

The Advanced Multi-purpose Base Ensemble for Emergency responders (AMBER) garment is being designed and developed for S&T by North Carolina State University’s Textile Protection and Comfort Center (T-PACC). T-PACC will partner with Protect the Force, Inc., a company that provides products for military and first responder applications. This team will identify and select commercially available materials that meet various protective requirements to develop a base ensemble that provides protection against multiple threats and maximizes comfort for prolonged daily wear. This effort will be further supported by input and feedback from The Department of Homeland Security (DHS) Science and Technology Directorate’s (S&T) First Responders Group to ensure the AMBER garment meets first responders’ operational requirements.

Key AMBER Base Ensemble design goals:

- Comfort and durability for daily wear;
- Provide limited protection against heat and flame, splash resistance, static dissipation, and cut, stab, and needle resistance; and
- Modular design for integration with primary protective clothing against specific hazards and to address unique design requirements of female responders

NFPA Standards for Emergency Responder and work wear personal protective equipment (PPE), as well as National



AMBER will incorporate commercial-off-the-shelf technology into a base ensemble that will increase first responder protection

Institute for Justice Standards for Law Enforcement PPE, provide guidance on testing methods for developing an ensemble prototype.

Testing to determine the garment’s ability to meet performance goals will be carried out at T-PACC’s research and testing facilities, which will enable systematic testing and evaluation of the base ensemble prototype. These will include tests for fire and heat protection, repellency and splash protection, as well as evaluation of thermal comfort and heat stress. In addition, human subject ergonomics evaluations will be performed. After the project design phase has concluded, the prototype garment will be certified to the appropriate standards. A total of 150 certified prototype garments will be delivered to DHS S&T for evaluation by responders.

Impacting the future of first responder PPE

The project has an anticipated completion date of July 2016 and will yield a new multi-threat protective base ensemble prototype that has been comprehensively developed and assessed from input from the first responder community. Based on this prototype, a technical package will be produced and made available for manufacturer production and commercialization.



Improved Firefighter Structure Glove

Current firefighter structure gloves can hamper response efforts

When responding to structural fires, firefighters wear protective gloves known as “structure gloves” to shield their hands from burns and other injuries. Because structure gloves can be bulky and limit dexterity, firefighters often need to remove the gloves to complete routine tasks, such as handling operating tools or using communications equipment. Without gloves, firefighters’ hands are at a higher risk of injury.

In addition to dexterity issues, existing structure gloves can be difficult to put on when wet and offer limited heat protection. In the field, these gloves can be very impractical and slow response time.

Final Prototype Design



Commercialized Product



Improved Firefighting Structure Glove

New glove with next-generation fabric and design offers better fit and form

The U.S. Department of Homeland Security Science and Technology Directorate (S&T) partnered with NanoSonic, Inc. and Shelby Specialty Gloves (Shelby Glove) to construct a new, improved structure glove that will provide the full range of protection firefighters need. This next-generation glove provides firefighters with enhanced dexterity, water repellency, and fire resistance.

NanoSonic has developed a durable material called HybridSil®—a Kevlar®-based fabric that is both heat and water

resistant. HybridSil® can withstand punctures and lacerations that current structure gloves may not. S&T worked with NanoSonic to ensure the final glove design meets all identified first responder requirements, standards, and certifications.

S&T addressed first responders’ needs for reduced risk and increased protection

By improving the structure glove’s technology and materials, S&T helps ensure firefighters can perform their duties while fully protected. The new material and design allows firefighters to make more precise movements without having to remove their gloves. The improved form and fit and water repellent-features ensure they provide the protection firefighters need.

The project underwent multiple stages of research and testing to ensure the durability of the selected materials in operational field conditions. To make certain the gloves truly met the needs of firefighters, S&T sent the prototypes to be tested by fire departments across the nation. Testers used the gloves in a series of rigorous exercises designed to replicate real life operational scenarios. Follow-on iterations featured improvements based on firefighter comments. In the spring of 2014 the final glove prototypes were evaluated against five categories: ease of donning and doffing, proper fit, puncture resistance, dexterity, and thermal protection and heat dissipation.

Gloves are now commercially available

After gathering feedback from responders through several rounds of testing, S&T, NanoSonic and Shelby Glove captured the final design specifications before manufacturing commenced in spring 2015, including obtaining National Fire Protection Administration (NFPA) 1971 compliance approval for structural and proximity firefighting safety and heat resistance. The finished product features NanoSonic’s HybridSil® material and is available for purchase from Shelby Glove under the name Flex-Tuff HS Glove (Model #s 5293 and 5294 at <http://www.shelbyglove.com/flexstuff/flex-tuff-hs.html>).



Smoke and Particulate Resistant Structural Turnout Ensemble

Reducing Firefighter Risk of Absorption of Fireground Toxicants and Carcinogens

In 2010, the World Health Organization's International Agency for Research on Cancer named the occupation of firefighting as possibly carcinogenic to humans. Their analyses of multiple studies concluded that firefighters experience a 50 percent increased risk of testicular cancer, a 30 percent elevated risk of prostate cancer and a 21 percent elevated risk of non-Hodgkin lymphoma, compared to the general population. Chronic exposures to toxic combustion products found in the fireground environment are believed to contribute significantly to the higher cancer occurrences in firefighters. When used during fire suppression and overhaul stages, the self-contained breathing apparatus (SCBA) protects the highly susceptible respiratory tract from toxic combustion products in smoke and soot. However, firefighters are still being exposed to hazardous vapors and particulates when smoke penetrates the interfaces in the turnout ensemble and deposits on the firefighter's skin.

Interfaces in Turnout Ensemble Designed to Limit Firefighter Exposure and Lessen Thermal Burden

North Carolina State University's (NC State) Textile Protection and Comfort Center (TPACC) and LION First Responder PPE, Inc., are collaborating to develop a structural turnout ensemble with enhanced protection from smoke and soot infiltration at the ensemble interfaces. Input and feedback from the Department of Homeland Security's First Responders Group will be used to support and guide the design and implementation of the new ensemble.

Two different approaches are being utilized in the development of this new system. The first approach focuses on using the existing moisture barrier with improved interfaces to provide the required level of protection with minimal change to the look or function of the existing turnout ensemble. In this approach, specific emphasis is placed upon improving the smoke resistance of the balaclava or hood.

The second approach, while also utilizing enhanced interface designs, will incorporate ventilation into the ensemble through staged protection configurations. The highest stage protection will have all vents sealed for fire suppression activities. The lower stage protection, intended for overhaul en-

vironments, will allow the firefighter to open vents in the ensemble to relieve thermal burden. Chemical and particulate filters to be placed in the vents are being developed to provide protection from the smoke and soot while the vents are in the open configuration.



Firefighter in overhaul environment with skin exposed to toxic combustion products (Photo: California Department of Forestry and Fire Protection [CalFire])

Prototypes developed from each approach will be evaluated as whole systems in the TPACC laboratories. The flashfire protection will be assessed using the PyroMan™ test manikin system and an instrumented physiological manikin will be used to determine the level of thermal burden for each prototype. TPACC's Man-In-Simulant-Test (MIST) facility will be critical to identifying which interfaces allow the most inward leakage as well as showing which prototype provides the best vapor/particulate protection overall. The final prototype will be submitted for certification to the NFPA 1971 requirements and appropriate requirements from NFPA 1994.

Daily Impacting the Well-Being of Firefighters

This project will be complete in early 2017 with the goal of providing firefighters with a turnout ensemble with inherent resistance to smoke and other particulates without the need to don additional equipment. Following NFPA certification, the prototype will be transitioned into a commercial product available from LION First Responder PPE, Inc.

By reducing the potential for chronic dermal exposures to toxic fireground compounds, this ensemble and the technologies developed during this research will help to improve the well-being and safety of firefighters.

