2009 BFRL Project Description

Project Title: Fire Fighter Protective Clothing Standards

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BFRL Program: Advanced Fire Service Technologies

Objective: To develop the necessary measurement science for predicting the service life performance of firefighter protective clothing as a result of the type and length scale of environmental stresses.

Problem:

What is the problem? NFPA 1971 defines the minimum safety parameters all protective clothing (PC) must meet for use in structural fire fighting. No standard, including NFPA 1971, defines how the PC should perform after exposure to different stresses and over time. Concern of the PC "aging" performance is a significant enough of a problem that the NFPA developed a minimum selection, care, and maintenance guideline (NFPA 1851) fire departments should follow to reduce the safety and health risks of firefighters caused by using poorly maintained and/or damaged PC. These NFPA 1851 inspections are predominately visual inspections, except for the 1 year and 3 year "Advanced Inspections," which include one or two pass/fail tests in addition to the routine visual inspections. However, under sufficient stress, PC performance can deteriorate within weeks and in some cases the degradation may not leave a visual identifier. Therefore, the safety and health of the firefighter may be at risk for several months before the Advanced Inspection determines the PC is not providing adequate protection. A critical problem is our lack of understanding how PC performance is impacted by different stresses and exposure time prevents the development of new PC technologies with superior protection performance, better aging performance, and/or lower cost to the fire service. The lack of this information also prevents the development of non-visual PC inspection tools to provide firefighters with immediate measure of their PC performance level. Filling this knowledge gap with a better understanding of aging performance could result in developing a PC aging performance standard where the responsibility to develop the next generation PC would be placed on the manufacturers.

Why is it hard to solve? PCs are complicated systems with multiple layers consisting of a variety of materials. One technical challenge is finding tools to simulate the variety of stress conditions and the tools/methods to measure how and which layer is being stressed. Another technical challenge is finding a measurable response which relates to performance and developing an easy to use, inexpensive, and non-destructive tool a firefighter could quickly use to measure his/her PC's current performance level. A non-technical challenge could be obtaining

manufacture buy-in since a potential result of this study is the development of a new standard for the manufacturers to meet.

How is it solved today, and by whom? There are a number of publications on measuring performance characteristics of materials and fabrics intended for PC and the PC themselves. However, these studies do not include aging the test specimens, evaluating aged test specimens, or real-time PC performance testing tools.

Why NIST? This project is perfectly aligned with BFRL's mission[1] and vision[2], the fire protection of the community portion of BFRL's "Fire protection and fire spread within buildings and communities" core competency, and BFRL's "Measurement Science for Innovative Fire Protection" strategic priority as the knowledge from this study will accelerate the development of new technologies to improve the safety of our firefighters and reduce the cost to fire service industry.

Approach:

What is the new technical idea? Combining the fiber and fabric scale testing with full scale PC testing can yield information which could enable the development of a model for predicting the aging behavior and ultimately the retirement age of PC. The inputs for developing this model and advancing our understanding of PC aging will include parameters such as thermal diffusivity, thermal shrinkage, and tear resistance. Another new technical idea is the development of the necessary technical knowledge to integrate the measurement responses of commercially available (or slightly modified) tools, such as Latest™ film tester by IBM, with the performance characteristic levels of firefighter PC.

Why can we succeed now? The development of new technologies and/or methodologies has only recently made this study possible. For example, the tools and methodologies developed in BFRL's Service Life Prediction of Nanostructured Polymeric Materials program are directly correlated with the types of activities we plan for this project. Specifically, this program has looked at the impact of UV exposure on coatings and the durability of materials used in bullet proof vests.[a,b,c] This study will be the first time the two will be combined to evaluate the impact UV exposure on PPE durability and service life. The 2007 edition of NFPA 1971 and NFPA 1851 clearly indicates UV exposure is a concern. This guideline has only recently brought attention to the need for conducting this study. Also the development of new measurement technologies, such as improved attenuation of ultrasonic wave manipulation for composites, has only recently made this study possible.

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[1] BFRL's mission is "To promote U.S. innovation and competitiveness by anticipating and meeting the measurement science, standards, and technology needs of the U.S. building and fire safety industries in ways that enhance economic security and improve the quality of life." BFRL addresses standards and technology needs through its measurement science research.

[2] BFRL's vision is "To be the source for creating critical solution-enabling tools—metrics, models, and knowledge—and promoting performance-based standards that are used by the U.S. building and fire safety industries to establish global leadership."

What is the research plan? Within the 1st quarter of the project we will, through Workshops and literature reviews, determine the magnitude and the details of the aging problem and the obstacles in conducting this study. The project will be separated into multiple phases, the exact number and details to be determined after the Workshop. Over the last couple years the fire service has been heavily concerned with the impact UV exposure has on PC performance. Therefore, unless the Workshop suggests otherwise, the focus of the 1st year is to develop the tools and methods to measure the impact UV exposure has on the basic mechanical, physical, and/or chemical properties of the PC composite. The 2nd year will focus on multilevel UV exposure and UV exposure of the individual layers, rather than the PC composite. This information is critical to developing a firefighter tool for a real-time measure of PC performance and developing solutions to prevent or significantly delay UV degradation. During the end of the 2nd year and beginning of the 3rd year we will evaluate potential firefighter tools to measure PC performance level. However, the primary focus of the 3rd is pulling together the all the necessary technical information for a UV exposure guideline. This technical information will include at least one tool suitable as an immediate measure of the PC performance level and an operating procedure for the firefighter. Solutions to improve UV resistance may also be evaluated in the 2nd and/or 3rd year.

Recent Results: None. This is a new project.

Standards and Codes: This technical information will be shared with the NFPA to develop a PC aging standard.

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[a] Chin, J.; Foster, A.; Clerici, C.; Sung, L.; Oudina, M.; Rice, K. "Temperature and humidity aging of poly(p-phenylene-2,6-benzobisoxazole) fibers: Chemical and physical characterization", *Polym. Degr. Stab.*, **2007**, 92, 1234-1246.

[b] Chin, J.; Foster, A.; Rice, K. "Field and laboratory aging effects on poly(p-phenylene-2,6-benzobisoxazole) fibers used in body armor", *Am. Chem. Soc. Preprint.*, **2008.**

[c] Chin, J.W.; Byrd, W.E.; Embree, E.; Martin, J.W. "Integrating Sphere Sources for UV Exposure", *Service Life Prediction Methodology and Metrologies*, **2002**, eds. Martin, J.W. and Bauer, D.; New York: Oxford Presses.