2009 BFRL Project Description

Project Title: Hose Stream Characterization and Effectiveness Modeling

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BFRL Program: Advanced Fire Service Technologies

Objective: To (1) increase understanding of the spray characteristics of various types of fire fighting water application methods, (2) determine the suppression effectiveness of different methods of water application on a fire, (3) develop a model of hose stream water spray impact on fire generated conditions, and (4) implement the hose stream model in the fire dynamics simulator (FDS).

Problem:

What is the problem? Determining the effectiveness of a range of water application methods can have impact on the tactical decisions, equipment choices and water supply requirements that affect fire departments across the country. Development of a model of the impact of fire fighting hose streams and its implementation in FDS can provide valuable tools for fire fighter training and improved safety. A better understanding of the capabilities of different water application methods could also impact Insurance Services Office (ISO) ratings for municipal fire suppression. Determining quantitative measures of effectiveness have proven extremely difficult. First, choices must be made regarding the criteria for effectiveness (amount of water, extinguishment time, energy absorption, etc.) Water is extremely effective alone; very small quantities that are applied appropriately can extinguish large fires. Previous work on fire fighting water additives conducted at NIST suggests an approach that focuses on analyzing specific characteristics (drop size, drop distribution, velocity, etc.) with some additional testing to identify overall effectiveness metrics. Recent advances in computer modeling and measurement tools make it possible at this time to begin developing a model of effectiveness and better performance metrics.

Why is it hard to solve? The interaction of water droplets, fire gases and hot surfaces is fairly well understood mathematically but there are an infinite amount of fires and hose streams that can interact and this is far from well understood. Fire Dynamic Simulator (FDS) has a number of limitations when it comes to suppression and those issues need to be identified and improved. FDS must be able to simulate a range of sprays as well as the interaction of each spray type with the fire. FDS needs to incorporate both solid streams of water from a smooth bore nozzle and the fine droplet mists from fog nozzles. A solid stream of water does not entrain air in the same way as a fog nozzle does.

How is it solved today, and by whom? There currently is no solution to incorporating manual hose streams in FDS. There have been studies done to try to quantify the effectiveness of

certain hose streams but many of them are not well characterized. The fire service chooses their hoseline based on past experiences with little scientific explanation for advantages or limitations of the available choices for hoselines or nozzle types.

Why NIST? NIST has the staff with the expertise to plan, instrument and execute these full-scale experiments. NIST has the respect of the fire community due to the continual production of good scientific, non-biased data and therefore the results are taken seriously and put into practice. We have the ability to provide the knowledge through measurement science of the use of this solution-enabling tool to the fire service worldwide. This technology increases fire protection and reduces fire spread within buildings.

Approach:

What is the new technical idea? Taking all of the measurements we have compiled from all of the experiments and organize them in a way that tells a story to the fire service. Compile the unbiased scientific results so that the fire service understands them and can apply them to their tactics and strategies. Develop a tool for FDS that allows more significant fire events to be more accurately modeled.

Why can we succeed now? Recent advances in computer modeling and measurement tools make it possible at this time to begin developing a model of effectiveness and better performance metrics.

What is the research plan? The spray measurements and data obtained from the previous full scale fire test series have been used to create a first-order hose stream model for implementation in FDS. The model is currently being refined for implementation in FDS. Once the integration is complete, the ability of FDS to predict the quantity, drop size and velocity of water delivered by hose streams under various experimental conditions will be examined.

This phase of the project would investigate three areas of importance to the fire service relative to manual hose stream applications. First, the hose stream model would be validated through comparison of the FDS results with experimental data. Large-scale fire tests with various fuels sources and compartment sizes would be conducted to develop additional model validation data. Second, the model and full scale tests would be used to investigate emerging new technologies for manual fire suppression. Specifically, the feasibility of applying water to a fully involved fire from the exterior prior to entry would be examined. Third, new instrumentation and tests would be investigated to begin quantifying the amount of manually applied water required to extinguish specific fire scenarios.

The final result from this research will provide a "manual hose line" suppression capability in FDS enabling the results to be used as a training tool for firefighters across the country. In addition, engineering predictions can be developed for hose streams and other manual water application techniques to provide guidance in the design and use of these fire fighting tools.

Recent Results:

Two series of experiments were conducted to begin characterizing the effectiveness of fire fighting hose streams. These tests examined the characteristics of selected nozzles and the impact of water spray from these nozzles on heptane burner fires in a large enclosure (7 m x 7 m x 3 m). Data from these tests need to be reviewed and reported.

During fiscal year 2006, a remotely controlled, articulating monitor with interchangeable nozzles was purchased. Unlike the first set of experiments when the nozzle remained in a fixed location, the new monitor provides the capability to move the nozzle during the test as would occur during real fire suppression activities. This articulating monitor and some nozzles were used during a series of tests conducted in the Large Fire Laboratory in May 2006. Data from these tests need to be analyzed.

Outcome: A first order fire suppression model with water has been developed and is being incorporated into FDS. Validation of this model against full scale test data is underway.

Standards and Codes: Results from this work can have significant impact on fire fighter health and safety. New metrics for specifying hose nozzle performance characteristics will be submitted to the National Fire Protection Association for changes to NFPA 1964 Standard for Spray Nozzles and any other applicable NFPA standards. Guidance on selection and use of fire fighting hose nozzles will be provided to the International Fire Service Training Association (IFSTA), NFPA, and Delmar Learning (publisher or fire fighter training materials similar to IFSTA) for inclusion in their respective fire fighting training manuals.