

The Development and Widespread Adoption of a Heat Resistant Fire Attack Hose:

A Paradigm Shift Created by Raising Social Awareness, Data Collection, Improving Standards, Understanding Manufacturing Capabilities, Uncovering the Fire Service Purchasing Process and Economic Realities, and Engaging Stakeholders

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Abstract

This research lays the foundation for a paradigm shift in how municipal fire attack hose is thought of and how it is expected to perform on the fireground. The study encompasses the enhancement of a national fire attack hose burn-through database, communication with fire departments and the fire attack hose industry, and review of national and international standards. An agenda is presented for a multi-day meeting engaging all stakeholders in the development of a next generation fire attack hose.

1.0 Introduction

The development and widespread adoption of a heat resistant fire attack hose would require a paradigm shift in the way attack hose is thought of and how it is expected to perform on the fireground. Fire attack hose is widely recognized as a piece of equipment used for fire control and extinguishment. However, it is less often recognized for its other crucial role, which is providing the last line of defense for the firefighter. Although fire hose is a critical piece of equipment throughout fireground operations, it is not designed or tested to withstand actual thermal conditions it will be exposed to on the fireground. Additionally, fire attack hoses and firefighter personal protective equipment are exposed to the same conditions on the fireground, yet personal protective equipment is tested more rigorously. Many of the differences in how fire attack hose and PPE are designed, constructed, tested, and budgeted for stem from the commonly held view that fire attack hose is “equipment” and not “personal protection”. This dichotomy can propose a life threatening situation.

On March 26, 2014, Firefighter Michael Kennedy and Lieutenant Edward Walsh of the Boston Fire Department were killed while operating in a burning structure. One of the factors that contributed to their death was the burn-through of the fire attack hose they were using to fight the fire, leaving

them without water. This high profile burn-through in Boston has resulted in questions with regard to the causes and frequency of fire hose burn-throughs.

Many of these questions involved the design and thermal performance of fire attack hose. The last major development of fire attack hose occurred decades prior, in the 1950s, when synthetic materials such as nylon 6,6 and polyester were introduced as outer jacketing material. At the time, these materials were selected because of their light-weight and mold/rot resistive properties. Nylon 6,6 and polyester have low melting points of approximately 250 °C and are not used in any other high heat environment or application. Despite this, these materials remain the standard for the outer jacket of fire hoses manufactured in the United States.

Though the current materials used in attack hoses offer one possible explanation with regard to the burn-through problem, other factors exist as well. These include the faster growing, hotter conditions of the modern fireground, as well as the codes and standards that govern the manufacturing process of attack hose. These standards fall short of requiring heat resistance testing that is representative of conditions a hose would be exposed to on an actual fireground. In addition, many members of the fire service also argue that the problem may not be with attack hose at all, but rather with the tactics used by firefighters during an incident. A common belief, for example, is that a hose charged with water will not burn-through.

Despite the many possible factors contributing to hose burn-throughs, no individuals have generated any statistical or scientific data to support their theory. This is because when a fire department experiences a burn-through, they simply replace the hose, and it is not reported. The fatal incident in Boston resulted in the initiation of the first ever fire hose burn-through database which is part of the WPI Next Generation Fire Attack Hose Project. Prior to the establishment of this database, the fire service had no means of reporting burn-throughs, thus there was little awareness of this

problem. To this day, there is still no requirement to report any such incident, and the true extent of the fire attack hose burn-through problem has only recently been realized.

Major components of firefighter PPE include boots, turnout pants and jacket, gloves, a helmet, and a hood. PPE has continually evolved, keeping pace with the introduction of newer, more heat resistant materials into the marketplace. Likewise, rigorous tests for thermal resistance for each component of PPE have been developed and incorporated into the national standard *NFPA 1971, Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*. Economic structure supporting PPE has been clearly established as a result of the development of materials of greater heat resistance, as well as the continued use of rigorous national standards. A full ensemble of PPE for one firefighter currently costs in the range of \$2,000 - \$3,000, however, since PPE is viewed as a necessity for firefighter life safety, this cost is not questioned (Dover Fire). There are also numerous grants and financing options currently accessible for fire departments to buy PPE.

The goal of this project was to contribute to the development and widespread adoption of a heat resistant fire attack hose by fostering a paradigm shift in the way fire attack hose is viewed and how it is expected to perform on the fireground. This research encompassed five important focus areas:

1. Improving and expanding the WPI burn-through database
2. Analysis of the national and international thermal performance standards.
3. Understanding manufacturing capabilities.
4. Uncovering the fire service purchasing process and economic realities.
5. Raising social awareness and engagement of stakeholders.

The methodology by which the study was conducted is presented in Section 2 of this report, with the background for and objectives of each the focus areas are presented in a subsection of Section 2. Likewise, the findings and analysis of each of the five focus areas are located in a corresponding

subsection of section 3. A set of ten recommendations from the study as a whole are presented in Section 4.

2.0 Methodology by Focus Area

Although the team worked collaboratively, each member provided leadership for and assumed ultimate responsibility of one of the five focus areas. The background and objectives of each of the five focus areas is presented in a separate subsection of the overall methodology.

2.1 Focus Area I: Improved and Expanded Data Collection

2.1.1 WPI Burn-through Database

Starting in March 2015, the first national burn-through database was created by the WPI Next Generation Fire Attack Hose team. The database, modeled after the NIOSH Fire Fighter Fatality database, serves as a repository of information regarding fire attack hose burn-throughs that have occurred across the United States. Like the NIOSH database, information will be publicly shared so that fire service employees are able to freely access data in real time. This data is collected via firefighter direct entry into a standardized survey using the software *Qualtrics*.

The survey contained twenty questions covering four main categories, each relating to a different aspect of the burn-through event. The four categories are: fire department, fire event, firefighting tactics, and the fire hose. This information is used for a better understanding of what occurred during the burn-through event being reported. Additionally, it will allow identification and analysis of any trends or patterns across all burn-through data.

The fire department section asks the responder about the location, size, and type of the department that experienced a burn-through, while the fire event section documents the type of event and its severity; for example, full involvement of a room in a house fire. The firefighting tactics category deals with methods employed by the firefighters to combat the situation. Finally, the fire hose category

allows the responder to describe the nature and extent of the burn-through suffered by the fire hose, as well as information about the size, age, and construction of the hose.

All survey responses are verified through follow-up conversations with fire departments and research into investigative reports. From March 2015 to September 2015, the previous research team collected one-hundred and seventy-two survey responses that were verified and entered into the database. A geographical map is generated where the location of each burn-through recorded in the database is represented by a tag on the map. Along with the location, the tags, when clicked on, show all the information regarding the burn-through.

The initial surge of responses followed an announcement of the database through *The Secret List*. Although an advertisement was also placed in *Fire Engineering* magazine, responses slowed due to the difficulty of maintaining an awareness of the database across the fire service. In addition to the slowing responses, the survey encountered difficulties in full data collection. Many survey responses that were recorded did not generate highly detailed accounts of the burn-through, even with follow-up communication. This was most prevalent in the lack of information regarding the actual hose that burned through. Ideally, a system will be put in place to ensure longevity of the database, full data reporting of burn-throughs, and public access to the database.

2.1.2 Objectives of this Study

The information gained from the analysis of the one hundred and seventy-two incidents documented by the previous team uncovered areas suitable for improvement and/or modification of the database. To address these concerns and move the database forward, four goals were established for this research:

1. Revise the survey instrument.
2. Strengthen the verification process.
3. Obtain more survey responses.

4. Maintain a consistent flow of information.

2.1.2.1 Revise the survey.

After an evaluation of the survey designed by the previous research team, it was noted that many of the responses were incomplete. This absence of data lead the team to evaluate how the survey might be improved. It was decided to focus on the aspects of content, user-friendliness, tone and grammar.

Content of the burn-through survey was analyzed by the team in order to find areas where adjustments could be made to increase the amount and quality of the information gathered. The team also read through each question on the survey instrument in order to revise questions that had low response rates.

Along with a way for responders to provide a sufficient amount of content, the survey needed to be user-friendly. Originally, the survey asked questions that had multiple questions within them, such as question 14 from Appendix A1. This could have created confusion from the responder, resulting with him/her not responding fully to a specific question. To resolve these issues, the team identified questions that could be confusing and restructured them for clarity and simplicity.

Once the team examined the content and user-friendliness of the survey, the focus switched towards the tone. Through close examination, the team determined that some questions on the survey could be interpreted as an attack on firefighter tactics. For example, the original survey never mentioned that the project's sole purpose was to gather informative data on modes of failure, not to undermine or critique the tactics used. To clarify the purpose of the survey, the team determined that a disclosure statement would be the most viable way to set the tone of the survey. The disclosure statement assures firefighters the purpose of the study.(Appendix A2).

The final area the team looked at was grammar. To search for grammar and spelling mistakes, the team meticulously read through each question on the survey and discovered any flaws in the

document. The grammatical errors were edited and finalized, the team was then able to make these changes to the live survey on *Qualtrics*.

After the new survey had been finalized, the team ran into a limitation. If a question on the survey was changed in *Qualtrics*, then new results could not be analyzed concurrently with older entries. Due to the editing limitation, the polished survey thus became a basis for an improved follow-up process.

2.1.2.2 Strengthen the verification process.

The goal of strengthening the follow-up process is to determine if a survey response meets the criteria for an attack hose burn-through and if there is adequate information for entry into the database. A secondary goal of the follow-up process is to obtain more information about hose burn-throughs. The new polished survey allowed the team to use simpler, more focused questions to uncover additional information about a given burn-through. Once a survey was completed via *Qualtrics*, a team member would read through the responses and gather the responder's phone number. The respondent was then contacted shortly after the initial response. Once on the phone with the fire service employee, a conversational demeanor was employed in order to make the respondent comfortable with the information needed. The phone call also explained how the information they provided would be used to increase the safety of the fire service and themselves personally. The gathered responses from the follow-up process was entered into the database and added to the burn-through map.

2.1.2.3 Obtain more survey responses.

Due to a reduction in survey responses during the summer months and early part of the school year in 2015, the team devised a strategy to increase awareness of the database. The group first researched methods used by the previous IQP team. The most successful methods of advertisement that IQP-I used were discovered by examining the previous one-hundred and seventy-two responses.

Answers to question twenty in Appendix A1, “How did you learn about the survey?”, were analyzed visually via bar graph. The most common responses, along with other social media outlets such as Facebook and Twitter, were looked at as ways to acquire more survey responses (Appendix A3).

Modes of advertisement were broken down into the cost and the amount of potential viewers that the particular method would attract. To understand how the team’s project would be displayed as an advertisement, phone calls to the magazines and social media outlets were made. A deeper understanding of the cost versus reach allowed the team to delve into the pros and cons of each system. The team weighed its options on which form of advertisement would be able to promote the Next Generation Fire Attack Hose project at the highest level for the most affordable cost.

2.1.2.4 Maintain a consistent flow of information.

Due to advertisement being a temporary method to let people in the fire service industry know about the project, the team searched for new ways to keep interested stakeholders up to date regarding information on the project. To do this, the team analyzed multiple social media outlets and determined what systems would be the most useful. This process was similar to the process used in determining the mode of advertisement. Once the team established what modes of social media would be used, the team planned what to put on the social media’s home pages. Short descriptions of the projects goals, along with a link to the burn-through survey was posted on each home page. The team then discussed what articles and pictures to post regarding the project. This was done by researching past articles that have been written about the project. The team also posted information regarding any type of burn-through incident in order to raise awareness of the problem. Fire service companies such as Fire House Magazine and Fire Engineering Magazine were contacted on the social media sites. These companies were asked to post about the Next Generation Fire Attack Hose Project in order to obtain a wider audience. The team also friended and liked pages of a couple hundred fire stations across the country.

2.2 Focus Area II: Analysis of International and Industrial Thermal Performance Standards

Previous work conducted by WPI's Next Generation Fire Attack Hose team found notable weaknesses in the fire hose heat resistant test required by *NFPA 1961: Standard on Fire Hose*. First off, the standard contains only a moderate challenge conduction heat test that is inconsistent with conditions on the fireground. Furthermore, the previous team discovered that although the firefighter and the attack hose are subjected to the same thermal environment, the heat resistant testing for firefighter personal protective equipment (PPE) is much more rigorous than those for fire attack hoses.

2.2.1 Modern Fire Ground Conditions and Existing Fire Hose Standards

Modern day fireground environments have evolved over the past several decades, resulting in more intense fire conditions. Residential structures are becoming larger, allowing for increased fuel loads. Additionally, open floor plans, which lack passive containment, are becoming more common. Newly-engineered glued beams and synthetic building materials, which ignite more easily and promote faster flame spread, have replaced traditional wood frames. Also, household items such as furniture, electronics and appliances are abundant and now constructed from more combustible synthetic materials. These new structural designs, building materials, and household commodities have led to more rapid fire growth and intense fire conditions. As a result, modern structures are reaching flashover conditions at a rate eight times faster than structures from fifty years ago ("Modern Residential Fires"). According to *Analysis of Changing Residential Fire Dynamics* published by UL, residential fire room temperatures often reach temperatures of 400°C (750°F), and can even get as hot as 1200°C (2190°F). Although fireground conditions have changed dramatically, fire attack hose construction and the heat resistant standard it is held to have remained constant for over 60 years, even with the advent of more thermally resistant materials that have been incorporated in firefighter PPE.

2.2.1.1 Standards on Fire Attack Hose

NFPA develops and publishes a set of codes and standards for public fire protection in the United States. *NFPA 1961* states the design, construction, inspection and testing requirements for all newly manufactured fire hoses. Fire attack hoses are manufactured to meet *NFPA 1961* because of its widespread adoption in jurisdictions across the country. This standard includes kink tests, burst tests, and proof tests. *NFPA 1961* does not explicitly define the testing method for heat resistance, but rather states that fire attack hoses must comply with heat resistance tests from *UL 19*, *FM 2111* or an equivalent test. The conductive heat resistance test set forth by *UL 19: Standard for Lined Fire Hose and Hose Assemblies* and *FM 2111: Fire Hose Assemblies and Fire Hose Couplings* involves heating a 2.5 x 1.5 x 8 inch steel block to 260 C (500° F) before stamping it on a water filled hose for 60 seconds. After this time, the steel block is removed, the hose is allowed to cool, and it is then pressurized to three times its service test pressure. If there is no leakage or damage that can be observed, the hose is considered to have passed the test (*NFPA 1961: Standard on Fire Hose*). This test has issues of repeatability, due to the thermal profile of the block during the duration of the test which is affected by the ambient temperature in the room.

The test for heat resistance in *NFPA 1961* does not correspond to the conditions on the fireground. Almost all the tests in *NFPA 1961* require the hose to withstand conditions far above what they experience during regular use. For example, the pressure test requires hoses to withstand a pressure three times higher than a typical service pressure. The one exception is the heat resistant test, which only subjects hoses to a temperature of 260°C even though temperatures on the fireground are hundreds of degrees higher than that. Additionally, the primary mode of heat transfer in the *UL 19* test is conduction, whereas the fireground presents modes of convection and radiation predominantly (Poremba). *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire*

Fighting requires much more rigorous thermal tests on PPE, even though turnout gear and hoses are exposed the same fireground conditions.

2.2.1.2 Standards on Firefighter PPE

Unlike standards for fire attack hoses, heat resistant tests for PPE are more representative of fireground conditions. Firefighter PPE consists of a helmet, mask, turnout coat, turnout pants, gloves, boots, and a self-contained breathing apparatus (Hasenmeier). Thermal performance requirements for the listed components are designated throughout chapter 8 of *NFPA 1971*. These eight tests include conductive, convective, radiative and flame resistance procedures where temperatures and heat fluxes generally correlate with fireground conditions. For example, helmets must withstand a flame temperature of 1200°C for fifteen seconds and a radiant flux translating to 730°C for three minutes (*NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*). Implementation of these tests have enhanced the safety of firefighters by developing PPE that is more heat resistant.

2.2.1.3 Summary of Previous Findings

Ultimately, it was concluded that attack hoses are susceptible to temperatures exceeding their minimum requirements by exposure to all modes of heat transfer. The U.S. standard for the heat resistance of fire attack hoses has been stagnant, while fireground conditions have become more severe. As seen in database results, there have been reports of hose lines burning through across the United States, causing catastrophic failure to the firefighter's last line of defense. The research conducted aimed to acquire information on fire hose standards used internationally in order to gain insight on different hose constructions and the tests they held to.

2.2.2 Objectives of this Study

The goal of the standards section was to investigate how *NFPA 1961*'s heat resistant test compares to other thermal performance requirements used internationally. By acquiring fire hose standards used throughout the globe, the team could determine whether the conduction test used in the United States meets or exceeds international expectations. In addition, the team investigated fire hoses that comply with the standard containing the most advanced thermal performance test. Furthermore, research was conducted on standards for hydraulic hoses used in other high temperature industrial applications. This information may lead to insight on potential material constructions that are more heat resistant. Lastly, the team analyzed the development of the rigorous thermal performance requirements outlined in *NFPA 1971* and the resulting impact these tests had on the manufacturing of PPE. In order to complete the specified goals, the team developed the following objectives:

1. Obtain international fire hose standards to compare with the heat resistant test outlined in *NFPA 1961*.
2. Search for fire hose products that pass more advanced heat resistant tests.
3. Search for industrial standards on hoses used in other applications that withstand high temperature heat resistant tests.
4. Analyze the development of firefighter personal protective equipment.

2.2.2.1 International Fire Hose Standards

The team sought to answer the question whether fire hose standards developed in other countries contain thermal resistant tests involving conduction, convection, radiation or flame impingement. Standards organizations from several nations in Europe and Asia were contacted for their fire hose standard. Members of the International Confederation of Fire Protection Association aided the identification of standards distributors in their respective nations. A major concern of this task was acquiring English versions of national standards, as there were limited or no translations available. This

complication arose with the Chinese and Japanese standard. Employees and alumni of the WPI Fire Protection Engineering department provided proper translations for each of these documents.

2.2.2.2 Search for Advanced Fire Hose Products

After examining various heat resistant tests used around the world, the team identified a fire hose standard that most accurately represents conditions on the fireground. Research was conducted on fire hoses that comply with the specified standard in order to find any exceeding thermal performance characteristics. The team then contacted the manufacturer who was perceived to develop the most advanced hose and requested a sample for the team's inquiry. By examining the characteristics of the hose sample, the group could solidify the correlation between standards and the performance of fire attack hoses.

2.2.2.3 Standards on Industrial Hoses used in High Temperature Applications

This objective aimed to find hydraulic hoses that endure thermal environments similar to fire hoses, and then obtain the corresponding standard the product is held to. The team focused on hydraulic hoses used in aircraft and marine technology as they are subject to high temperatures during vehicle operation. Thermal performance requirements listed in acquired standards could potentially lead to insight on more heat resistant materials used in different hose constructions.

2.2.2.4 Development of Firefighter PPE

Upon the initiation of research, it was established that attack hoses and PPE encounter the same environment, but the standards they are held to are alarmingly dissimilar. The team's objective was to investigate the driving forces in the development of firefighter PPE and the designs ability to pass various heat resistant tests required by *NFPA 1971*.

2.3 Focus Area III: Understanding Current and Potential Industrial Manufacturing Capabilities

2.3.1 Fire Hose Manufacturing and Industrial Process

The fire hose market in the United States is served by less than a dozen companies. Most of these companies are based in the United States or Canada, however, there are a few companies who operate in Europe but have locations in North America to sell to the American and Canadian markets. Many of these companies manufacture many different kinds of fire hose, from attack hose to supply hose, as well as hose for industrial use, which has much in common with fire hose.

Fire attack hose generally consists of a waterproof liner made of a synthetic rubber and one or two jackets made of a synthetic fiber such as polyester or nylon. The inner liner is made by melting down large amounts of synthetic rubber, and then extruding it into a hose. After the hose is extruded, it is then cured, which consists of adding heat and chemical additives to make the rubber stronger and more durable. This process is known as vulcanization. The cured hose is then coated with a thin layer of uncured rubber. The jacket is woven by machines and then dipped into tank to be coated or painted if specified. Once the jacket (or jackets, in the case of a double jacket hose) and the rubber liner are completed, they are joined by threading the rubber hose through the jacket(s) and curing the thin layer of rubber on the inner hose. The curing process bonds the inner and outer layer(s) of hose together. Adhesives may also be used to supplement or replace the vulcanization process when joining layers of hose together. In a special case, the rubber inner liner is extruded over the jacket as it is woven, resulting in hose that has a jacket “sandwiched” between two thin layers of rubber. This is called a “through the weave” hose. Couplings are attached placing a metal ring just inside the rubber liner and fitting a coupling over the exterior jacket at the ends of the hose. The metal rings are then mechanically expanded, squeezing the hose between the coupling and the ring and securing it to the hose. Hoses are then pressure tested to NFPA specifications or higher before going to market.

The team reached out to companies in the fire hose manufacturing industry to determine if any work was being done to develop an attack hose with advanced thermal properties, and if manufacturers believe it is feasible to bring such a hose to market. The team was specifically trying to answer the following questions:

1. Are manufacturers aware of the occurrence of attack hose burn-throughs?
2. What are manufacturer opinions on attack hose burn-throughs?
3. What is the most advanced type of hose currently on the market?
4. What research and development are manufacturers conducting?
5. What are the factors driving the development of fire attack hoses?

The information gathered was used to determine the feasibility of creating a marketable attack hose that would resist burning through using current materials and manufacturing techniques. This information was also used to provide recommendations for future research. A total of nine companies were contacted; six weave and extrude their own hose, two companies assemble pre-existing fire hose with their own couplings, and one produces fibers and advanced materials, not fire hoses. All representatives from the companies that were interviewed held senior positions, with the majority being Presidents or Vice Presidents, and all had experience serving U.S. markets.

2.3.2 Objectives of this Study

To meet these goals outlined above, the following objectives were defined and met:

1. Identify manufacturers to contact.
2. Create a series of interview questions.
3. Conduct interviews with company representatives.
4. Compile and analyze the information gathered.

2.3.2.1 Select a group of companies to contact.

The team compiled a list of companies that sell fire hose. A final selection of companies was then made using the following criteria:

1. Does the company sell attack hose? The team was only interested in companies that sell fire attack hoses.
2. Has the Next Generation Fire Attack Hose project obtained sample lengths of hose from these companies before? These companies were automatically added to the list because the project has had previous interaction with them.
3. Does the company sell to North America? Companies that sell to foreign markets may have interesting information, but in the interest of time and logistics, companies that sell to North America were prioritized.
4. Does the company sell a hose that is particularly interesting? (e.g., high heat resistance claimed) Any advanced hoses currently on the market were of particular interest to the team.
5. Has a representative of the company recently attended an *NFPA 1961* meeting? The team has presented at two *NFPA 1961* meetings and attendees of those meetings are familiar with the project and WPI's Fire Protection Engineering department.

2.3.2.2 Create a series of interview questions to ask company representatives

Once the list of companies was finalized, the industry task leader submitted a series of interview questions to the WPI Institutional Review Board for approval. The series included questions about basic company history, such as when the company was founded and where its manufacturing facilities are located. Questions about fire attack hose design and use were also included, particularly the thermal properties of the hose. Additionally, questions about research and development efforts in the industry, such as funding, driving factors, limitations, and new technologies, were incorporated into the series. Questions about manufacturer interactions with firefighters, especially throughout the purchasing process, were added as well. The complete set of interview questions can be found in Appendix B1. When approval was obtained, the industry task leader arranged interviews with a knowledgeable representative of the company. If a member of the company did not attend a recent meeting, the main company line was called and, explaining the project, the industry task leader requested an interview with someone from the company who had the appropriate knowledge and experience.

2.3.2.3 Interview company representatives

Interviews were arranged by email or via phone, usually with a secretary. Most of the interviews took place over the phone, however, several were conducted in person, and lasted on average about 50 minutes. The Industry task leader opened the interviews by briefing the company representative on the project and recent project activity. The interview questions in appendix B1 were asked by the Industry task leader and the manufacturer representative was also given the chance to ask questions about the project as well. Throughout the interview, the Industry task leader took written notes only; no recordings were made.

2.3.2.4 Compile and analyze the information gathered

After the interviews were completed, the Industry task leader compiled all of the notes from the interviews conducted an analysis. As part of this analysis, the industry task leader compared the responses of representatives to discern any industry wide opinions and to determine general awareness of fire hose burn-throughs. The industry task leader also used the compilation of representative responses to questions about research and fire hose technology to determine the driving factors of research, what technology is currently on the market, and what research is currently being conducted across the industry. The team then used this analysis to make recommendations about further research.

2.4 Focus Area IV: Fire Service Interface

2.4.1 Fire Department Equipment Ordering Procedure and Restrictions

The focus of the fire service interface sector of the project was gaining awareness of the typical fire hose and PPE ordering processes utilized by departments, including how frequently these items are ordered in various size departments, the monetary restrictions that guide their selection and purchase, the factors that influence the brands and/or specifications selected, and how fire hose and PPE are tracked within a department once they are acquired. To obtain this information, a twenty question survey was created to later be administered to fire department personnel, and a variety of departments

were invited to participate in the study. Following the administration of the survey at select departments, the results were compiled and analyzed for future use by the research team.

2.4.2 Objectives of this Study

To optimize results, the following objectives were created, to guide the fire service interface section of the project.

1. Determine the financial restrictions limiting the purchase of attack hose, and compare to the financial restrictions for PPE.
2. Determine the frequency with which attack hose is purchased, when compared to PPE.
3. Investigate methods used by departments to track their attack hose and PPE in-house.
4. Determine what factors influence the brands and/or specifications of attack hose and PPE purchased by fire departments.

2.4.2.1 Financial Restrictions

The creation of the survey, shown in Appendix D1, was paramount to obtaining meaningful information while conducting fire department field visits. An area of particular interest to the research team was the monetary constraints departments face when purchasing fire attack hose; this is because new hose materials are of little value if the fire service cannot afford to utilize them. The survey was split into two sections. The first section of the survey consisted of ten questions related to fire attack hose, including questions regarding budget constraints, inspections conducted, and desired qualities in future hose. The second section of the survey consisted of ten questions designed to obtain the same information about the PPE used by fire departments. After the survey was completed, the survey was submitted to WPI's Institutional Review Board for approval, before being administered to fire department personnel.

After the completion of the survey, the next, and equally important, component of the fire service interface sector of the project was selecting fire departments for field visits. Research was conducted upon the types of fire departments throughout the United States, and more specifically

Massachusetts. A variety of department types were selected for field visits, ranging from exclusively career departments, to combination departments, some being predominantly career and others predominantly volunteer. The fire departments visited protected populations ranging from the NFPA's 2,500 to 4,999 category to the NFPA's 50,000 to 99,999 category. Department visits were scheduled over a one month period with one to three members of the research team present at each.

Following the department visits, analysis was conducted on the survey responses obtained to determine whether there were any trends present regarding fire attack hose and PPE in various size departments. Of specific interest was any relationship between the size/type of department and the equipment utilized, including its expense and the frequency with which it was replaced. The information found was then brought back to the research team for further use and application.

2.4.2.2 Ordering Frequency

As with the financial restrictions category mentioned above, questions pertaining to the frequency with which hose and PPE are ordered, were also included in the survey. This served several purposes, including allowing the team to get a better understanding of the age of most hose fire departments use, gaging the number of years new hoses placed on the market would need to last to be most beneficial to the fire service, and determining what differences exist when it comes to the lifespan of hose versus PPE.

2.4.2.3 Brand and Specification Selection

Brand and specification selection for critical pieces of fire service equipment was an additional area of interest for the research team. Specifically, the role that finances and available product information play in the purchasing decisions made by fire department officials. For example, the team was interested in learning whether departments are forced to purchase equipment that is less than ideal, because of budgetary restrictions placed on them, and whether they are in fact able to replace all

equipment in a timely manner. Therefore, several questions pertaining to this topic were included in the survey.

2.4.2.4 Intradepartmental Tracking

Additionally, while completing department visits, the team was interested in learning what type of methods are used by the fire service to monitor their attack hose, PPE, and other equipment, once it is purchased. While speaking with departments, questions about this were asked, to enable the team to better understand how accurately the age of hose and PPE were tracked, along with its quality over time. The team was interested in this information because of the lack of databases currently present in the fire service, and the important role record keeping will likely play moving forward.

2.5 Focus Area V: Engage Stakeholders

In order to further the development and widespread adoption of a heat resistant fire attack hose, stakeholders of the project must engage in a cooperative effort. These stakeholders include the fire service, material and fire hose manufacturers, standard making organizations, approval agencies, federal agencies, and the public. The workshop will serve as an essential component to facilitate a paradigm shift. Each of the components of this research will contribute to a new perception of fire attack hose as both a tool and a form of life safety a firefighter can expect not to fail. The purpose of this part of the project is to layout the process of developing a workshop that will enable stakeholders to provide potential solutions and active participation in burn-through research.

2.5.1 Objectives of this Study

Goals of this workshop are to raise awareness of the scope and severity of the burn-through problem, share data and information pertaining to burn-throughs, and initiate a call to action among all stakeholders involved. These goals will be achieved by addressing: who will be participating, what will be covered, where this event will take place, and how interaction among stakeholders can be maximized.

This process was initiated once enough information was attained throughout the discovery phase of the project. The research and findings accumulated by the project will be utilized to stimulate discussion and conclusions drawn by the stakeholders. The following objectives identify how the above goals will be achieved:

1. Determine how the workshop will operate.
2. Create a dynamic and balanced participant list.
3. Select the host location.
4. Develop workshop content.

Achieving these objectives successfully contributes to the following potential outcomes:

- Most or all fire departments are aware of the burn-through database.
- The database is open to manufacturers, codes and standards representatives, federal agencies, law enforcement agencies, and policy makers for reference.
- The fire service, codes and standards developers, policy makers, federal agencies, law enforcement agencies, research organizations, and industry representatives work in collaboration to help solve the burn-through problem.
- Burn-through research and attack hose improvements remain a cooperative, focused effort among all involved beyond the date of the workshop.

2.5.1.1 Determine how the workshop will operate.

The first developmental stage of organizing the workshop involved background research which identified different methods to achieve information exchange and participant interaction. WPI's Career Development Center provided information communicating the different ways a workshop can be setup, with specific insight upon structure and seating arrangements. Deciding upon whether a one-day structure or a two-day structure would serve to be more effective depends on the amount of content to

be covered throughout the workshop. Different seating arrangements can be applied to achieve information exchange and participant interaction in different ways. Auditorium arrangement is appropriate for a workshop heavily dependent upon lecture. Hollow, u-shaped, and conference arrangements are most efficient for groups fewer than 40, where a group leader or panel drives plenary discussion and presentation. Classroom and banquet seating arrangements are practical for large and small group discussions, and are commonly used for a workshop including meals.

Two reports were prioritized throughout research as they provided the most useful information. “Workshop Report: Today and Tomorrow’s Fire Data” and “Smart Firefighting Workshop Summary Report” were each investigated to understand the various techniques and methodology applied to achieve their respective objectives (NFPA, NIST). Content provided by these reports included workshop overviews, explanations of topics discussed and respected results, closing summaries, workshop agendas, presentations, etc.

2.5.1.2 Create a dynamic and balanced participant list.

Participants will represent the following areas: the fire service, codes and standards development, law enforcement, federal agencies, research organizations, and attack hose industry. This cross section within the field will offer a roster of individuals that have the knowledge and willingness to move this project forward.

As the ultimate end user, the fire service will communicate hands-on attack hose experience. Codes and standards development representatives will offer knowledge of any code or standard associated with attack hose testing. Law enforcement agencies and federal agencies will share the first-hand experience they receive on the site of a burn-through incident, and throughout burn-through investigations. Federal agencies will also offer insight on incident reporting systems currently in operation. Research organizations provide the opportunity to share different research perspectives and approaches. As the manufacturers of fire attack hose products, industry will offer knowledge regarding

the steps it may take to develop and deploy an attack hose that is both a tool, and a lifeline. Once a list of specific organizations within each area listed above is established, individuals that will be able to contribute to the achievement of project outcomes will be identified. This list of individuals will represent an initial participant list.

2.5.1.3 Select the host location.

Potential locations offering a space to hold the summit will be evaluated through assessing availability, convenience, and cost. Viable options will have a space large enough to fit all participants that will be in attendance. To accommodate participants that are traveling to the workshop, the host location will be in the general vicinity of a hotel. Locations that are owned by organizations represented within the participant list will be considered potential host locations. Use of an associated organization's facilities will allow for more insight into the development of the workshop. Fire protection conferences held by associated organizations will also be considered potential host locations, as a majority of participant representation could already be in attendance. Locations within the WPI campus will also be of consideration, as these options may be more cost effective.

2.5.1.4 Develop workshop content.

The content of the workshop will be designed to result in the successful outcomes listed in 2.5.2. Content of the workshop will include the schedule of the workshop, as well as what will be covered within that schedule. This material will make up a detailed agenda for the workshop. The workshop agenda will promote information exchange and encourage interaction among participants. Generating a workshop purpose will be the first course of action within the agenda's development. Topics that will cover and achieve this purpose will be identified. These topics will draw insight from all areas represented at the workshop. The selected focus topics will help determine the length of the workshop. Timing of events will also be laid out within the workshop agenda.

3.0 Findings and Analysis by Focus Area

3.1 Focus Area I: Improved and Expanded Data Collection

3.1.1 Revision of the Survey.

The user-friendliness of the survey was enhanced using simpler and more direct questions. Some questions had multiple parts that were confusing to some respondents resulting in poor answers to the questions. For example, question 14, a complex question, originally worded “What was the company and the model number of the hose that burned-through? If unknown, please provide the jacket and liner material” was broken down and presented as four more specific questions. Question 14 was broken down into the following four questions (Appendix A1 and A2):

- Question 14: “What was the company and model number of the hose that burned through?”
- Question 15: “What is the jacket material of the hose?”
- Question 16: “What is the liner material of the hose?”
- Question 17: “Was the hose a single or double jacket?”

This separation was completed to allow the respondent to give more information about the burn-through without overwhelming him/her.

The team also reviewed the tone of the survey in order to set the tone of research on burn-throughs and not firefighter tactics. To achieve this goal a disclosure statement was added and the wording of one question was altered (Appendix A1 and A2). The disclosure statement reads, “Disclosure: None of the data collected are used to undermine fire service employees techniques, but rather to solely gather information about hose burn-throughs.” This ensures that the survey questions are only intended to acquire information on the burn-through. Additionally, question 11 altered from “Were you operating the hose that experienced the burn-through?” to “If operating the hose, please give a short description of how you originally noticed the burn-through” (Appendix A1). The revised question makes

it clear that our interest was in gathering information from the hose operator regarding what he/she observed relating to the burn-through, not their tactics during the event. After the content, user-friendliness, and tone were completed, mistakes in grammar were fixed and the result was a polished final product.

Although the survey revision was completed, the team was only able to change the grammar of the original survey on Qualtrics. If the team had changed the layout of the questions than previous results from the survey would become invalid. Because of this, the team determined that the new polished survey would be used mainly to enhance conversations with survey respondents during the follow-up process.

3.1.2 Stronger Verification Process.

A main goal of the burn-through database was to obtain better information regarding the incident through the use of a stronger survey and follow-up process. After the use of advertisement and social media outlets, the group received six responses from the burn-through survey. Using the new process, the group was able to obtain well understood details of what occurred in five out of six burn-through incidents. The verified information was collected and displayed on the burn-through map.

3.1.3 Increasing Survey Responses.

After comparing different methods of advertisement the team determined that the best methods for obtaining survey responses were Facebook and Twitter. Facebook and Twitter have the ability to reach the most amount of viewers at the most affordable price. The team decided to use Facebook's advertisement system which costs \$70.00 for 7 days of advertisement. The advertisement that the group designed reached 15,695 people in the seven days that it was on Facebook. From this advertisement three people completed the survey and the post had 601 post engagements. Post engagements is when a Facebook user clicks on the advertisement. This means that the team

successfully distributed news about our project and the burn-through survey to at least six-hundred people related to the fire service industry.

Alongside the formal advertisement constructed by Facebook, *Firehouse Magazine* and *Fire Engineering Magazine* shared The Next Generation Fire Attack Hose page to their followers. This contributed to the Facebook page receiving more likes, which translates to more exposure for the project. The team also created a message to send to fire departments on twitter. This message was used to give a short description of project. The Twitter page did not lead to any survey responses unlike the Facebook page, which led to five of the six responses gathered by the team (Three from advertisement and two from the acknowledgement of the page).

3.1.4 Spread of Constant Information Regarding the Project.

Facebook and Twitter were chosen by the team as the social media outlets that would be used to maintain a flow of information regarding the project. Facebook and Twitter were the most viable ways to get in touch with fire service employees and allow them to receive updates and information about the team's project. The creation of the Facebook and Twitter pages led to multiple fire service employees following the Next Generation Fire Attack Hose page. In total there were one hundred and fifty-seven likes on the page, meaning that all one hundred and fifty-seven people received updates and information regarding the project. Constant information, such as Facebook posts and shared links, helped the team obtain two responses on the survey. The Facebook posts and shared links consisted of articles about known hose burn-throughs, the survey, fire service news, and news on the project. Due to these posts, two Facebook followers commented on the Next Generation Fire Attack Hose page claiming to have had a burn-through experience.

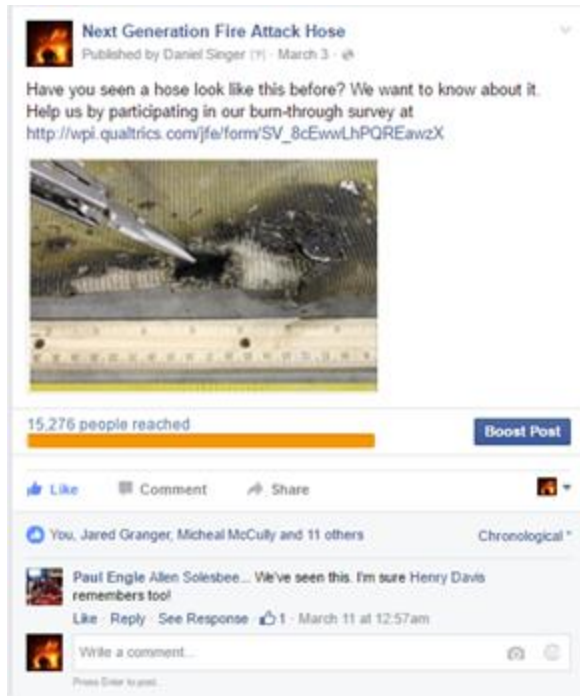


Figure 1: Facebook Comment



Figure 2: Facebook Comment

It was later found through the follow-up process that these two comments were responsible for two of the survey responses the team gathered. While Facebook was extremely successful in sustaining information and gaining followers, Twitter struggled to achieve the same success. Although multiple fire departments were followed and direct messaged on twitter, the Next Generation Attack Hose Twitter page only received eight followers. This means only eight different accounts were able to see information posted on Twitter. In the end, the group was able to determine that Facebook was a viable method for facilitating information regarding the project, while Twitter lacked success in that area.

3.2 Focus Area II: Analysis of International and Industrial Thermal Performance Standards

Thermal tests specifications required by both national and international standards governing fire attack hose were obtained and reviewed. Additionally, the improvement in heat resistance of firefighter PPE was examined in order to understand how. The rigor of each thermal test was analyzed by

comparing it to known conditions on a modern fireground. The team developed the following findings concerning fire attack hose performance:

1. International fire hose standards acquired indicate that, similar to the U.S., most countries only require a conduction test for short duration at temperatures much lower than what they would endure on the fireground. One exception was the German standard which requires hoses to resist direct flame impingement for almost thirty minutes.
2. The flame impingement test required by the German fire attack hose standard, *DIN 14811*, has spurred the manufacturing of fire hoses that are claimed to resist direct flame impingement for
3. High temperature flame tests are required in marine and aircraft hose standards, however the construction of these products contain materials that are not suitable for fireground operations.
4. Firefighter PPE was improved due to a documented series of performance failure, standards development and manufacturing research. This process is a model of how a next generation fire hose can be developed.

3.2.1 International Standards

Similar to U.S. standard on fire hose, most countries rely upon a moderate conductive heat test which requires hoses to resist hot surfaces for a period of time to be deemed compliant. Several nations throughout Europe refer to the hot surface resistant test outlined in the European National *EN 15889: Fire-fighting hoses – Test Methods*. As seen in *NFPA 1961*, the hot surface resistance test required by *EN 15889* primarily uses conduction as a measure of thermal performance. Specifically, this test loads a heated filament rod on a pressurized hose at a certain temperature for a certain period of time. Filament rod procedures vary depending upon the fire hose standard. For example, the heat resistant test described in *EN 14540: Fire-fighting hoses – Semi-rigid delivery hoses and hose assemblies for pumps and vehicles* sets the filament rod temperature to 200 °C and then applies it on the hose for two minutes.

A more rigorous test is displayed in *EN 1947: Fire-fighting hoses – Non-percolating layflat hoses for fixed systems*, which requires the filament rod to be heated to 300 °C (for double jacketed hoses) or 400 °C (for double jacketed hoses with coatings) and stamped on the test piece for one minute. The

conditions set by these European National standards do not require attack hoses to resist temperatures they may encounter. Moreover, the fire hose standards lack convective and radiative thermal performance tests, which are other modes of heat transfer present on the fireground. Although most European countries adopt the requirements listed *EN 14540* and *EN 1947*, Britain and Germany refer to their own national fire hose standards.

The fire hose standard published by the British Standards Institution, *BS 6391: Specification for non-percolating layflat delivery hoses and hose assemblies for firefighting purposes*, requires that compliant hoses pass the hot surface resistant test described in *EN 1947*. Additionally, it ensures hoses will not leak or burst within fifteen seconds while in contact with a 600°C steel cube (0.5 x 0.5 x 0.5 inch). Apart from all other conductive tests, *BS 6391* sets the apparatus to a temperature found in the flashover stage of structure fires. Since firefighter's PPE does not withstand flashover, this is above the maximum temperature a hose will function at. Although the heat resistant test in *BS 6391* is more indicative of fireground conditions than other thermal performance tests, there is still an absence of convective and radiative heat resistant tests.

In contrast to *BS 6391*'s rigorous conductive test, the German Institute for Standardization fire hose standard, *DIN 14811, Fire-fighting hoses - Non-percolating layflat delivery hoses and hose assemblies for pumps and vehicles*, requires attack hoses to pass a flame impingement test. Specifically, the hose must be able to withstand flame from a Bunsen burner for ten seconds and self-extinguish within three seconds after the test. *DIN 14811* is the only fire hose standard in the world that measures the thermal performance of fire attack hoses subject to direct flame contact. This test is unique because flame impingement covers all modes of heat transfer (Chander), a characteristic not seen in any other fire hose standard.

Continuing research of international fire hose standards, thermal performance tests were examined outside of Europe. The Russian Standards and Technical Regulations requires hoses to comply

with *GOST R 51049:2008, Fire Equipment. Pressure fire hoses. General technical requirements. Test methods*. The thermal performance test outlined in the Russian standard adopted the procedures designated in *EN 1947*. The South African fire hose standard, *ISO 4642-1: Rubber and plastic hoses, non-collapsible, for fire-fighting service – Part 1: Semi-rigid hoses for fixed systems*, follows the heat resistant test procedures found in *EN 14540*. Both the Indian standard, *IS 636-1990: Specification for non-percolating flexible fire fighting deliver hose*, and Australian standard, *AS 2792-1992: Fire hose – Delivery layflat*, refer to the heat resistant procedures outlined in *BS 6391*. Furthermore, it was found that the Chinese fire hose standard, *GB 6246:2011*, and the Japanese Fire Law do not require attack hoses to pass any heat resistant test. The table below lists all standards and their corresponding heat resistant tests.

Fire Hose Standard	Origin	Type of Test	Primary Mode of Heat Transfer	Temperature of Test (°C)	Time of Test (s)
AS 2792	Australia	Heat Resistance	Conduction	600 °C	15
BS 6391	Britain	Heat Resistance	Conduction	600 °C	15
BS 6391	Britain	Hot Surface Resistance	Conduction	300 - 400 °C	60
DIN 14811	Germany	Flame Resistance	Flame Impingement	N/A	10
EN 14540	European Nations	Hot Surface Resistance	Conduction	200 °C	120
EN 1947	European Nations	Hot Surface Resistance	Conduction	300 - 400 °C	60
GB 6426	China	N/A	N/A	N/A	N/A
GOST R 51049	Russian Standard	Hot Surface Resistance	Conduction	300 - 400 °C	60
IS 636	Indian Standard	Heat Resistance	Conduction	600 °C	15
ISO 4642	International	Hot Surface Resistance	Conduction	200 °C	60
Japanese Fire Law	Japan	N/A	N/A	N/A	N/A
NFPA 1961	United States	Heat Resistance	Conduction	260 °C	60

Figure 15: Compilation of International Fire Hose Standards

Based on the information provided in the table, it appears that heat resistance tests of fire hoses have been established based on the thermal conditions current hoses can withstand and not based on what fire attack hoses might encounter on the fireground. Many countries, including the United States, require for attack hoses to only resist a lower temperature conductive heat test. The one exception is the test developed by the German Institute of Standardization, which applies direct flame to the hose.

3.2.2 DIN 14811 Compliant Fire Hose

It was determined that Germany is the only country to develop a heat test that encompasses all modes of heat transfer present on the fireground. Although several manufactures produce fire hoses that comply with *DIN 14811*, one product found stood out among others. Eschbach, a German manufacturer of high quality layflat hoses, developed a fire attach hose referred to as the “Synthetic Dragon.” It is stated by the manufacture that this fire hose passes the *DIN 14811* thermal resistant test, and, in fact, it can be exposed to a flame temperature of 940°C for almost thirty minutes without structural failure. This is an example of how innovation is spurred when the performance requirements in standards become more rigorous. It is also proof that the technology and materials needed for a next generation fire attack hose exist.

3.2.3 Industrial Hose Standards

Hose assemblies used in aircraft and marine systems are routinely exposed to temperatures that are similar to conditions on the fireground. Fire resistance is essential in these applications because a hose failure would result in severe consequences. To analyze the thermal performance requirements of these industrial hoses, the following standards were acquired:

1. *ISO 15540: Ships and marine technology – Fire resistance of hose assemblies – Test Methods*
2. *SAE AS1055D: Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings and Similar Components*

Both standards specify thermal performance tests that required a hose assembly to pass a direct flame impingement test, however the temperature of the flame and duration of the test varies. The fire resistant test outlined in *ISO 15540* subjects' rubber, polytetrafluoroethylene, or rigid tubing to a Bunsen burner flame for a period of thirty minutes. The flame temperature during this procedure is designated as 800 °C. After completion of the test, the hose is removed from the flame and evaluated for structural integrity. The hose assembly passes the test if it is able to operate after exposure to the heat. Similarly, *SAE AS1055D* requires hose assemblies, identical to those listed in *ISO 15540*, to withstand flame from a Bunsen burner at a designated temperature of 1090 °C. The hose is deemed "fire resistant" if it continues to operate after five minutes of flame exposure, and deemed "fireproof" if it operates up to fifteen minutes. Although the flame temperature of *SAE AS1055D* exceeds that of *ISO 15540*, the SAE standard permits the use of a firesleeve. A firesleeve is applied on hydraulic hoses to shield them against high temperatures.

Hose constructions used in these industrial applications contain inner and outer layers of synthetic rubber compound, similar to the materials used in fire hoses, however, these industrial hoses also contain inserts of braided steel wire. As a result, the hoses are able to maintain structural integrity after exposure to high temperature flames. Although steel can withstand temperatures up to 1370 °C (Kross), a braided steel fire attack hose would not be accepted in the firefighting industry because the added rigidity and weight would cause difficulties in maneuvering, operating and storing the fire hose.

3.2.4 Development of Firefighter PPE

Unlike fire hose, firefighter PPE is required to be tested at temperatures that more closely represents conditions on the fireground. This research studied the factors that lead to the advancement of PPE in order to gain insight on the process its development. The development of PPE initiated in the 1950's when organizations such as the NFPA set standards for turnout gear. Specifically, the NFPA began performance testing on PPE in order to create gear that could withstand temperatures of 260 °C for

about five minutes. To accomplish this goal, heat resistant tests that involved all modes of heat transfer were implemented in the standard. The thermal performance of PPE continued to develop as higher temperatures were introduced in heat resistant tests and advanced fire resistive materials became accepted in the ensembles design (Hasenmeirer).

Today, firefighter PPE is required to pass eight thermal tests consisting all modes of heat transfer. According to Daniel Madrzykowski, these extensive and advanced requirements stem from a “documented series of line-of-duty deaths (LODDs) involving specific types of protective equipment (Madrzykowski, 2013).” Consistent reports of LODDs by the National Institute of Occupational Safety and Health (NIOSH) brought all stakeholders together to “improve the standard tests methods and requirements in order to improve the thermal resistance of the equipment and, thereby, to improve firefighter safety” (Madrzykowski, 2013). By documenting specific data regarding the performance of firefighter PPE, these organizations were able to develop more accurate methods of testing, which initiated research on more heat resistive materials.

The outer lining of PPE now contains aramid fibers and polybenzimidazole, which do not melt and have high thermal resistance. This material construction stemmed from the introduction of more rigorous thermal resistant tests. For example, the fabric flammability and thermal protective performance tests introduced in *NFPA 1971* had a significant impact on the heat resistance of firefighter PPE. These tests “resulted in the development of protective garments that resist flaming ignition” and “protect garments that reduce the rate of heat flow from a fire-fighting environment through the protective clothing” (Stroup). The advanced thermal performance standards required by *NFPA 1971* ultimately lead to PPE that drastically improved the protection of firefighters from burn injuries (Stroup, 2007).

3.3 Focus Area III: Understanding Current and Potential Industrial Manufacturing Capabilities

3.3.1 Manufacturer Opinion and Awareness

All manufacturers were generally supportive and interested in the project, however, few seemed to think that hose burn-throughs comprise a serious problem compared to other issues such as cancer and heart failure in firefighters. Nevertheless, representatives were aware of the problem of hose burn-throughs and the work WPI has been doing but their opinions and levels of engagement were quite varied. One thing representatives unanimously agreed on is that contemporary fire hoses should never be directly exposed to fire and some contend there is little need for a hose with increased thermal properties. However, while it is true that current hoses should not be exposed to fire because they will fail, the fireground has evolved over the past half century in such a way that hoses need to be able to withstand direct contact with flames. As explained in section 2.2.1, modern fires burn hotter and spread faster than fires of old.

Additionally, multiple representatives said that an advanced hose would merely delay the occurrence of a burn-through by minutes, not prevent one and that the testing of current prototypes have supported this claim. However, this should not deter the development of an advanced hose as delaying the event of a hose burn-through will allow the firefighters more time to safely exit a dangerous situation. Several others also brought up the point that if the temperatures in a room have gotten high enough to melt a fire hose, the firefighters themselves have most likely been evacuated, injured or killed. However, per NFPA 1971 PPE must pass a flame test yet it is common knowledge that attack hoses on the market today will rapidly burn through when they come into contact with flames where attack hose will fail at 260 degrees Celsius. Thus, as a result of PPE, firefighters can survive in an environment hoses cannot and thus hoses will fail far before the point that firefighters will have been evacuated or injured. Also, determining the survivability of a fire scene cannot be determined by

ambient temperature alone, as other factors such as the presence of burning debris, room size, and amount of resources available must be taken into consideration.

Some manufacturers have also claimed that burn-throughs are generally the result of freak accidents or a violation of Standard Operating Procedures (SOPs), for example dragging an unpressurized line into a building or pushing the fire toward other firefighters, and thus the development of a new hose is not worth the money. Consequently, many manufacturers do not see a pressing need to develop a fire hose with increased heat resistance. However, the data gathered by the Next Generation Fire Attack Hose survey has indicated that hose burn-throughs are not uncommon or merely freak accidents and are a more serious problem than most people think.

3.3.2 Current Technology

From the representative interviews, it was determined that the “best” type of hose on the market is a double jacketed, through the weave hose. However, the criteria for determining the “best” hose were primarily reliability, burst pressure, and abrasion resistance, not heat resistance. Thermally, all hoses are seen as more or less equal by the end users: all will fail quickly if exposed to flame or hot debris. Clearly, as of this writing, the reputation of a hose is not heavily tied to its thermal performance.

3.3.3 Research Efforts in Industry

Through the interviews with fire hose manufacturer representatives, the team has found that some companies have, within the past twenty years, conducted research on increasing the thermal properties of attack hose, with a particular focus in chemical coatings and jackets made of advanced materials. Regrettably, much of this research has been discontinued or slowed down as a result of the perceived lack of profit. One common material currently used in research and development efforts is Kevlar and other aramid fibers. Unfortunately, Kevlar’s work hardening properties, low abrasion resistance, and its tendency to tear apart nylon and polyester make it difficult and expensive to work with. Kevlar itself is also an order of magnitude more expensive than contemporary materials and

preliminary tests have demonstrated that a Kevlar outer jacket will not prevent a hose from burning through, it will merely increase the time it takes the hose to fail. Another material already being used is Hypalon, used on the exterior of a rubber hose. However, a Hypalon outer coating makes the hose thicker, heavier and less flexible. There is also very little data on the thermal properties of a Hypalon coated hose. Chemical additives, in coatings and in the rubber liner, have also been utilized, however there have been issues with the coating rigidity, cost, and toxicity. There are clearly options to develop an advanced hose, but more money will have to be spent, be it public or private, to see new technology realized.

3.3.4 Obstacles to Developing a Better Hose

The interviews also revealed that some of the manufacturers contacted were not actively engaged in research and development of a fire hose with enhanced thermal properties at the writing of this paper. Every representative that the team interviewed indicated that driving the costs down to a profitable level would be very challenging, although some conducted varying amounts research despite this. In fact, most manufacturers said that if money was not a limiting factor, current manufacturing technology could produce such a hose; for example, such a hose could be made out of Kevlar, although it would require significant working knowledge of aramid fibers and lots of money. However, many of them commented that developing an economically feasible, advanced fire hose is a very difficult task; the representatives cited the difficulties in finding and working with heat resistant materials that meet the flexibility and abrasion resistance needs of a fire hose. The primary reason given for the lack of research and development was that an advanced hose was not profitable at this time.

Additionally, all of the representatives interviewed were in agreement that finding a fire hose with increased heat resistance has to date not been a priority for the fire service. Those manufacturers that have attempted to develop and sell hoses with advanced thermal properties in the past found that the hoses sell poorly because of their high cost and lack of demand; firefighters did not see a need to

spend extra money for a hose with advanced properties. Representatives also said that in their experience, firefighters' primary concern was stretching their budget and the useful lifetime of the hoses they buy as opposed to their thermal performance. The team's conversations with firefighters supports this.

Conversations with several manufacturers in particular indicated that, in many cases, firefighters are more concerned about getting a higher volume of water on the fire than obtaining hoses with increased heat resistance. One manufacturer also said that many chiefs, especially those with volunteer departments, do not have the time or the expertise, such as a fire science degree, to critically analyze fire hoses. These chiefs repeatedly buy the same hose as a matter of habit and tradition and have little interest in acquiring improved hoses, as conventional hoses have worked just fine for over fifty years. Thus, with little demand from firefighters, many manufacturers do not see a reason to develop an advanced fire attack hose. One solution being developed by another team from WPI is hose testing apparatus to complement any new standards. Thus, fire chiefs would have the proper information to make an informed decision about the capabilities of the various hoses on the market. Additionally, if fire hose was thought of as providing life safety for the firefighter, which has radically changed over the past fifty years, as opposed to a simple tool, interest in advanced hoses could increase.

Clearly, a significant obstacle to the development of an advanced fire hose is the lack of awareness of the scope and severity of the problem and insufficient financial incentive. However, as outlined in section 3.2.4, modern turnout gear was developed and is widely used today despite the high cost of the costly, modern aramid materials. The difference between fire hose and PPE development is that PPE is seen as critical safety equipment while fire hoses are seen more as tools. However, as the data from the database shows, fire attack hose burn-throughs are a potentially deadly problem. Thus, shifting the paradigm of the way the fire service, fire hose manufacturers, and financial supporters think is critical to the implementation of an advanced fire hose.

3.4 Focus Area IV: Fire Service Interface

3.4.1 Fire Attack Hose – Purchasing and Service Life

Throughout the fire department visits, it was determined that nearly all departments have at least some attack hose that is decades old, and that very few departments know the age and location of all of their hose. *NFPA 1961* does not currently specify a maximum service life for fire attack hose and most departments claimed they were unable to routinely replace fire hose, because of the substantial expense involved. Unlike PPE, which is used on practically all calls, attack hose is not used nearly as often. This is because fire departments respond to many more fire alarm activations, car accidents, medical emergencies, and so on, than ever before, as opposed to structure fires. The recent advancements in fire protection technology have contributed largely to the decrease in structure fires. Therefore, when prioritizing items to purchase, other pieces of equipment such as radios, life safety rope, axes, halligans, and so on, are often given precedence over attack hose. Though all pieces of equipment are important to firefighting efforts, the significance of regularly inspecting and replacing fire hose will not become recognized without a paradigm shift in the fire service. Furthermore, unlike PPE, which is routinely purchased with grants, most departments fund hose purchase through their town/city budgets, which are often extremely limited. As a result, most departments will only replace hose if it fails during an annual inspection, or breaks during an incident, potentially placing firefighter, and even civilian lives, at extreme risk. In order for a next generation fire attack hose to be widely purchased and deployed, changes to code and standards to limit the maximum service life of existing hose must be put in place. Additionally, fire hose must be viewed as an essential tool for life safety. Much can be learned from a look at how the lifespan, importance, and economics of firefighter PPE works.

3.4.2 Economic Constraints and Social Views of PPE

Firefighter PPE is a critical piece of firefighter safety equipment, worn by firefighters at nearly all types of emergencies. PPE typically consists of a pair of trousers with suspenders attached, a jacket, a pair of boots, a hood, gloves, a facemask, and a helmet. The trousers and jacket consist of multiple layers to maximize protection for firefighters, and all pieces of PPE have a high thermal resistance rating. As a result, PPE is the one type of equipment that departments strive to routinely replace, above any other. All departments interviewed by the research team made substantial efforts to replace PPE at a minimum of every 10 years, as required by the NFPA, if not sooner. Additionally, the majority of career departments visited, meaning departments staffed by full-time personnel 24/7, provided firefighters with two sets of PPE. This enables firefighters to wash gear after incidents such as structure fires, without worrying about what gear they would wear if another emergency call came in. Volunteer departments, meaning departments staffed exclusively by volunteer members, and combination departments, meaning departments staffed by a combination of full-time and volunteer firefighters, tend to only have one set of PPE for each firefighter. Based on the information obtained by the research team, this is most likely because volunteer and combination departments are often found in smaller towns, with low budgets and low call volume, meaning there is less of a need for an additional set of PPE for each firefighter.

Although fire departments in the United States are required to provide firefighters with new PPE every 10 years, few departments rely exclusively on funding from their own town/city to purchase PPE. Most departments purchase a substantial amount of their PPE with the assistance of grants. Fire departments rely on these grants because PPE is a large expenditure, and it is often difficult to allocate additional money in an already tight yearly budget for the purchase of PPE. Grants for PPE replacement are widely available because, unlike fire attack hose, which is viewed as “equipment,” PPE is widely

viewed as critical for firefighter life safety and therefore for safe outcomes for building occupants and the public.

3.4.3 Brand and Specification Selection

Through the duration of fire department visits conducted by the team, an area of particular interest was the types of factors that ultimately determine the attack hose and PPE purchased. As previously mentioned, the financial restrictions faced by departments was an area of critical importance. However, the team found that nearly all fire departments use qualitative rather than quantitative evidence to select their future equipment. Rather than researching options available on the market, most purchase brands of hose or PPE they are familiar with, most often from previous use. The team's analysis determined this was most likely due to the lack of "firefighter friendly" information available with regard to the performance abilities of each item.

3.4.4 Intradepartmental Tracking

Of the departments visited, very few used a formal database to track their fire hose, PPE, or other equipment. Though a few departments utilized a database to track each piece of equipment, recording information such as age, quality, location, etc., this was extremely uncommon. The typical department used excel spreadsheets, written logs, or exclusively memory to track attack hose and PPE. As a general trend, the larger the size of the department visited, the more advanced the system used to track equipment was. Overall, however, PPE was better tracked than attack hose. The exact reason behind this is unknown, however, it is most likely because the majority of firefighters regard PPE as the most important piece of firefighter safety equipment. Moving forward, requiring departments to track all equipment in a formal database was a recommendation suggested by several fire officers.

3.5 Focus Area V: Engage Stakeholders

The formation of this workshop among stakeholders will serve as an aid to transform the perception of fire attack hose from being viewed as a tool, to being viewed a form of life safety. The determination of the operational workshop details, creation of an initial participant list, selection of a host location, and the development of an agenda for the workshop, will help execute this paradigm shift concerning attack hose.

3.5.1 Determination of operational workshop details.

Operational factors of the workshop were determined to encourage efficient information exchange and effective interaction among participants. A two-day structure was selected for the workshop to accommodate multiple needs. The two-days would provide enough time to cover all content included in the workshop agenda (Appendix D1). This structure promotes a flexible schedule that could be easily modified without any concern regarding time limitations. The two-day structure would accommodate participants looking to carry out additional work beyond workshop hours, as the schedule was designed to provide substantial downtime.

The seating arrangement that would be applied throughout the workshop is banquet style. This arrangement would offer multiple advantages. Consisting of multiple tables each seating five to eight participants, the arrangement is fit for small group discussions. Large group discussions among all tables could also take place. Each session of the workshop was planned to be initiated with a presentation or briefing identifying the major topics of discussion. Following the briefing, small group discussions were planned to take place that would eventually develop into a plenary discussion. This large discussion would allow each group to share the findings of each session. Individual tables would seat a variety of participants that represent the different stakeholders of the project. A cross-section of representation within each small group brings a variety of input and different perspectives to each topic addressed. This seating arrangement is also ideal for serving meals throughout the summit.

3.5.2 Creation of initial participant list.

The participant list includes representation from the following areas: the fire service, codes and standards development, law enforcement, federal agencies, research organizations, and attack hose industry. Specific organizations were identified within each area. These organizations include: the International Association of Fire Fighters (IAFF), the International Association of Fire Chiefs (IAFC), the National Association of State Fire Marshals (NASFM), the National Fire Protection Association (NFPA), Underwriters Laboratories (UL), the Bureau of Alcohol, Tobacco, and Firearms and Explosives (ATF), the National Institute of Occupational Safety and Health (NIOSH), the National Institute of Standards and Technology (NIST), Kocheck Co. Inc., Mercedes Textiles, and Key Fire Hose. Individuals representing these organizations were compiled into a potential participant list (Appendix D2).

3.5.3 Selection of the host location.

The host location that was chosen for the workshop was the National Fire Protection Association location in Quincy, MA, USA. NFPA offered to assist with the development and execution of the workshop, as the organization has been aware of project efforts from the initial phase until the present phase. Their office in Quincy has a space suitable for the workshop. This space is reasonable in size for the amount of people that should be involved in the summit, and will comply with the operational workshop details covered in section 3.5.1. This location can be made available for the workshop once a target date has been set, and all other developmental factors of the summit are decided upon. The location will conveniently accommodate travelers, as Quincy, MA is a city south of Boston with many hotels nearby. A partnership with the NFPA throughout the execution of this workshop may make advertising the event easier.

3.5.4 Development of an agenda.

The workshop agenda was created to communicate how the workshop would function, and what would be covered throughout its operation (Appendix D1). The agenda outlines a two day schedule for the summit, and the timing of all events is provided. Meals and breaks were incorporated into the agenda. Introductory sessions providing a welcome, introductions, background information, and workshop purpose initiate the workshop. After these events the workshop was organized by session, each assigned a topic of focus. The five focus topics incorporated into the agenda include: the fire attack hose burn-through database, the fire service experience, codes and standards, testing, and the path forward. These topics were chosen to fulfill the three-fold workshop purpose of raising the scope and severity of the burn-through problem, sharing data and information pertaining to burn-throughs, and initiating a call to action among all stakeholders involved. Each of these sessions start with a presentation, followed by small group discussions, and end with a large discussion among all groups. What should be presented throughout each presentation as well as who should present is specified in the agenda. Discussion questions that can be applied to drive discussion for each session are also provided.

4.0 Recommendations

Based off the information gathered, the team proposes the following recommendations to all stakeholders involved:

- 1. Provide output from standardized testing which results in information useful for decision making in the fire attack hose purchasing process.**

Performance data collected from standardized testing can be used to provide thermal characteristics of fire attack hoses. Published data regarding each type of fire attack hose will enable fire departments to make educated decisions with regard to their hose purchases.

- 2. Improve standards to require more rigorous testing that reflects fireground conditions.**

Modern materials have created fireground temperatures far greater than ever in the past. As a result, the standards for fire hose testing must be changed, to create hose capable of effectively fighting today's fires. As seen in the development of PPE, rigorous thermal performance testing can lead to active research on improving the material construction of fire hoses.

- 3. Increase recognition of the hose burn-through problem, to encourage the development of a more thermal resistant attack hose.**

All stakeholders must be aware that attack hoses are susceptible to burn-throughs. By establishing a need for more thermal resistant hoses, standards and manufacturing development can be addressed.

- 4. Maintain a national database and require fire departments to report fire attack hose failure to a national database.**

Although hose failures may be occurring throughout the nation, there is currently no requirement for departments to report an attack hose failure. Requiring this will better enable researchers to learn about the hose burn-throughs occurring nationwide. The creation of a national database will generate more responses directed toward the burn-through problem.

- 5. Establish funding pathways, including federal and state grants, which would enable the purchase of advanced hose.**

Though many departments recognize that they have a need for new attack hose, few departments have the financial ability to purchase new hose. There are few grants available for

the purchase of fire hose and individual departments often use their own budgets to purchase more what is viewed as more critical items, such as PPE, ahead of fire hose. Moreover, increasing fire department funding will encourage fire hose manufacturers to develop and sell advanced, but more expensive attack hose that would currently be too expensive for fire departments to purchase.

6. Require fire departments to use intradepartmental databases to track the location, age and condition of their hoses.

Currently most departments do not know the age, location, and quality of their attack hose, because of a lack of formal records. Moving forward the use of databases within departments, will enable better tracking of all equipment. Tracking equipment will simplify the process of identifying items that need to be replaced, and allow for post-incident analysis in the event of equipment failure.

7. Continue research into the use of aramid fibers in the manufacturing of attack hose.

There has been significant progress in the integration of aramid fibers into the fire hoses and preliminary testing has shown that hoses that integrate aramid fibers have increased thermal performance. The aramid fire hose concept should continue to be developed to ensure that aramid fire hoses can pass other NFPA standards, such as the abrasion standard, and to lower costs as much as possible.

8. Investigate the effectiveness of applications of different coatings.

There are many fire-retardant coatings that have been developed for rigid structures/objects. Research should be conducted to examine the possibility of creating or adapting similar coatings that can be applied to fire hoses. Using coatings in the manufacture of fire hoses may prove to be a cost effective option, especially if the coatings can be applied to existing fire hoses.

9. Conduct research on the use of chemical additives in rubber liners.

Chemical additives have been shown to increase thermal performance of rubbers, but face challenges such as toxicity and high cost. Research should be conducted to quantify the effectiveness of such mixtures and to determine if these challenges could be overcome in a cost effective manner.

10. Host a workshop to generate potential solutions and active participation among all stakeholders in order to prioritize attack hose as a form of life safety.

Joining together all stakeholders of the project involved for interaction and discussion will help establish a common ground among all involved. The summit will setup a path forward in order to facilitate the paradigm shift prioritizing fire attack hose as a form of life safety, rather than a tool.

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6.0 Appendix

Appendix A1: Original Survey Questions

1. On what date did the burn-through occur? (Dec 5, 2014)
2. What is the name of the Department that encountered the burn-through?
3. In what city and state is this Department located?
4. What best describes your department?
 - Career
 - Combined (Predominately Career)
 - Combined (Predominately Volunteer)
 - Volunteer
5. What is the size of the community that the department protects?
 - 1,000,000 or more
 - 500,000 to 999,999
 - 250,000 to 499,999
 - 100,000 to 249,999
 - 50,000 to 99,999
 - 25,000 to 49,999
 - 10,000 to 24,999
 - 5,000 to 9,999
 - 2,500 to 4,999
 - Under 2,500
6. Please provide a contact phone number for possible follow up questions
7. Please describe the type of structure involved in the fire event? (For example: Single Family Residential Structure, Industrial warehouse)
8. Please describe the fire event including the level of structural involvement
9. What's your job function during this event?
10. Was the hose inside or outside of the structure at the location of the burn-through on the hose?
 - Interior
 - Exterior
11. Were you operating the hose that experienced the burn-through?
12. Were there any civilian injuries or deaths at this fire? Please specify
13. Were there any firefighter injuries or deaths at this fire? Please specify
14. What was the company and the model number of the hose that burned-through? If unknown, please provide the jacket and liner material.
15. What year was the hose manufactured?
16. What size was the hose?
 - 1 ½"
 - 1 ¾"
 - 2"
 - 2 ½"
 - Other (Specify Size)

17. Please indicate at the time of the burn-through where the hose was:

- Uncharged
- Charged with water but not flowing
- Flowing with water
- Other

18. Was the hose in direct contact with a hot object at the location of the burn-through?

19. Does your department still have access to the hose that burned-through?

20. How did you hear about this survey?

- NFPA
- The Secret List
- Fire Engineering
- Fire House Magazine
- Other

Appendix A2: Updated Survey Questions

*new additions in red

Disclosure: None of the data collected are used to undermine fire service employees techniques, but rather solely gather information about hose burn-throughs.

1. On what date did the burn-through occur? (Dec 5, 2014)
2. What is the name of the Department that encountered the burn-through?
3. In what city and state is this Department located?
4. What best describes your department?
 - Career
 - Combined (Predominately Career)
 - Combined (Predominately Volunteer)
 - Volunteer
5. What is the size of the community that the department protects?
 - 1,000,000 or more
 - 500,000 to 999,999
 - 250,000 to 499,999
 - 100,000 to 249,999
 - 50,000 to 99,999
 - 25,000 to 49,999
 - 10,000 to 24,999
 - 5,000 to 9,999
 - 2,500 to 4,999
 - Under 2,500
6. Please provide a contact phone number for possible follow up questions.
7. Please describe the type of structure involved in the fire event. (For example: Single Family Residential Structure, Industrial warehouse)
8. Please describe the fire event including the level of structural involvement
9. What was your job function during this event?
10. If operating the hose, please give a short description of how you originally noticed the burn-through.
11. Was the hose inside or outside of the structure at the location of the burn-through on the hose?
 - Interior
 - Exterior
12. Were there any civilian injuries or deaths at this fire? Please specify
13. Were there any firefighter injuries or deaths at this fire? Please specify
14. What was the company and the model number of the hose that burned-through?
15. What is the jacket material of the hose?
16. What is the liner material of the hose?
17. Was the hose single or double jacket?
18. What year was the hose manufactured?
19. What size was the hose?
 - 1 ½"

- 1 $\frac{3}{4}$ "
 - 2"
 - 2 $\frac{1}{2}$ "
 - Other (Specify Size)
20. Please indicate at the time of the burn-through whether or if the hose was:
- Uncharged
 - Charged with water but not flowing
 - Flowing with water
21. Was the hose in direct contact with a hot object at the location of the burn-through?
22. If not, please specify what accounted for the hose burn-through.
23. Does your department still have access to the hose that burned-through?
24. How did you hear about this survey?
- NFPA
 - The Secret List
 - Fire Engineering
 - Fire House Magazine
 - Other
25. Please like our Facebook Page "Next Gen Fire Attack Hose" and send any pictures of the burned-through hose.

Appendix A3: Fire Attack Hose Phase II Advertisement Process

Purpose:

- To receive more submissions for the burn-through database.
- Spread awareness of hose burn-throughs and progress made in our project.

Goals:

- To accumulate more data for the burn-through database
 - The projected number of new entries is between 50 to 150 verified entries.
- Translate a higher level of data base participation
- Make the project and the survey more well known in the Fire Safety Service community

Location	Cost	Potential Viewers																												
NFPA Magazine	<div>2016 PRINT & DIGITAL ADVERTISING RATES</div> <div>Rates (B/W Rates 25% off color rates)</div> <table><thead><tr><th></th><th>Full Page</th><th>2/3 Page</th><th>1/2 Island</th><th>1/2 Page</th><th>1/3 Page</th><th>1/4 Page</th></tr></thead><tbody><tr><td>FULL COLOR</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>1x</td><td>\$9,200</td><td>\$8,090</td><td>\$7,650</td><td>\$6,740</td><td>\$5,960</td><td>\$5,620</td></tr><tr><td>3x</td><td>\$8,980</td><td>\$7,870</td><td>\$7,470</td><td>\$6,580</td><td>\$5,860</td><td>\$5,520</td></tr></tbody></table>		Full Page	2/3 Page	1/2 Island	1/2 Page	1/3 Page	1/4 Page	FULL COLOR							1x	\$9,200	\$8,090	\$7,650	\$6,740	\$5,960	\$5,620	3x	\$8,980	\$7,870	\$7,470	\$6,580	\$5,860	\$5,520	<ul style="list-style-type: none">•more than 65,000 members and connected with 80 national trade and professional organizations in more than 100 countries.
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Fire House Magazine	<table><thead><tr><th>Ad Size</th><th>1x</th><th>3x</th><th>6x</th></tr></thead><tbody><tr><td>Full Page</td><td>7,640</td><td>7,300</td><td>6,970</td></tr><tr><td>2/3 Page</td><td>6,645</td><td>6,135</td><td>5,880</td></tr><tr><td>1/2 Page Island</td><td>5,985</td><td>5,475</td><td>5,375</td></tr><tr><td>1/2 Page</td><td>5,840</td><td>5,350</td><td>5,240</td></tr><tr><td>1/3 Page</td><td>4,720</td><td>4,260</td><td>4,010</td></tr><tr><td>1/4 Page Vert.</td><td>4,570</td><td>3,950</td><td>3,800</td></tr></tbody></table>	Ad Size	1x	3x	6x	Full Page	7,640	7,300	6,970	2/3 Page	6,645	6,135	5,880	1/2 Page Island	5,985	5,475	5,375	1/2 Page	5,840	5,350	5,240	1/3 Page	4,720	4,260	4,010	1/4 Page Vert.	4,570	3,950	3,800	<ul style="list-style-type: none">• Over 500,000 unique monthly visitors• Over 2 million monthly page views
Ad Size	1x	3x	6x																											
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Fire Engineering Magazine, FDIC International, Fire Rescue, and Fire Apparatus	<div>\$2000 minimum for email blast</div> <div>Print:</div> <table><thead><tr><th></th><th>1x</th><th>3x</th><th>6x</th></tr></thead><tbody><tr><td>1/2 Page</td><td>\$6,840</td><td>\$6,580</td><td>\$5,990</td></tr><tr><td>1/3 Page</td><td>\$5,770</td><td>\$5,540</td><td>\$5,250</td></tr><tr><td>1/4 Page</td><td>\$4,940</td><td>\$4,740</td><td>\$4,500</td></tr><tr><td>1/6 Page</td><td>\$3,200</td><td>\$3,070</td><td>\$2,910</td></tr></tbody></table>		1x	3x	6x	1/2 Page	\$6,840	\$6,580	\$5,990	1/3 Page	\$5,770	\$5,540	\$5,250	1/4 Page	\$4,940	\$4,740	\$4,500	1/6 Page	\$3,200	\$3,070	\$2,910	<ul style="list-style-type: none">• The email blast reaches 20,000 emails which are specifically targeted.• Can chose who to target such as fire chiefs and fire deputies								
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Facebook	<ul style="list-style-type: none">• Option 1: Pay a certain amount for each display of the ad<ul style="list-style-type: none">◦ eg, pay \$50 per thousand displays◦ ad costs the same regardless of whether or not the ad is clicked	<ul style="list-style-type: none">•Potential for thousands to hundreds of thousands of visitors•Facebook advertising can be made to target as																												

	<ul style="list-style-type: none"> Option 2: Pay a certain amount of each click of the ad <ul style="list-style-type: none"> eg, pay \$0.20 for each click 	many groups/individuals as desired
Twitter	<ul style="list-style-type: none"> Free publicity 	<ul style="list-style-type: none"> Access to hundreds to thousands of twitter accounts made by fire departments and fire safety enthusiasts. There is the ability to be “retweeted”, which can allow for further reach to the fire safety community.
Secret List	<ul style="list-style-type: none"> Free Publicity, however, something new has to be achieved. This could become a possibility once the database becomes publicized. 	<ul style="list-style-type: none"> Thousands of fire safety patrons receive emails almost daily.

Methods:

NFPA Magazine:

- Before paying the normal fee for the magazine contact Jacqueline Regan Wilmot who is the *NFPA 1961* liaison.
 - There is a possibility that she has the ability to get us a spot in the magazine or website for a cheaper price than what is listed.
- If Jacqueline Regan Wilmot is not able to help, contact Kenneth Willette who has been in close correspondence with our project.
- In a final effort to receive lower advertisement costs we can contact Andrea Guamero, who is the advertising sales representative for the NFPA.
- If for some reason none of these contacts will help us lower the advertising price we still have the ability to pay the standard advertising fees.
- Before posting an ad to the NFPA magazine our group will need to create an appealing ad that promotes the burn-through database survey.


Fire House Magazine:

- An appealing ad needs to be created to promote our burn-through database survey.
- Once an Ad is created we can pay for advertising space on their website or in their paper edition of the magazine.

Fire Engineering Magazine:

- With the email blast we can specifically target certain individuals we want to see our advertisement.

- 2) The email blast reaches 20,000 people for \$2000 dollars. The more people you want to reach the more money we can spend.

		Company: <input type="text"/>
		Contact: <input type="text"/>
		Address: <input type="text"/>
EMAIL LIST RENTAL List Rental Cost: \$450/M + Selects (net) Non-Advertiser Rate: \$550/M + Selects (net) By State/SCF: +\$8/M A/B Splits \$75 each Key Coding: +\$2/M Merge/Purge: \$75 Nth Name: NIC Over 2 Tests: \$75		City: <input type="text"/> State/Province: <input type="text"/> ZIP/Postal Code: <input type="text"/> Country: <input type="text"/> Phone: <input type="text"/> Fax: <input type="text"/>
Minimum per Email: \$2,000 (net) *\$250 Rush charge for orders required within 24 hours		
PennWell Sales Rep: <input type="text"/>	E-Mail: <input type="text"/>	

1. Job Title: +\$ 10/M

- ☐ 02 Chief of Fire Dept
- ☐ 04 Deputy Chief, Asst Chief, Battalion or other Chief
- ☐ 06 Company Officer Level
- ☐ 08 Firefighter or EMT
- ☐ 10 Fire Commissioner, Director or Trustee
- ☐ 12 Executive in Fire Apparatus or Equipment Manufacturing
- ☐ 14 Manager Level in Fire Apparatus or Equipment Manufacturing
- ☐ 16 Apparatus / Equipment Sales Franchise Holder
- ☐ 18 Fire Apparatus Sales Person
- ☐ 98 Other

2. Fire Service Work: +\$ 10/M

- ☐ 01 Fire Department
- ☐ 03 Sub Station
- ☐ 05 Fire Equipment / Apparatus Mfr, Dealer or Distributor
- ☐ 07 Work Part / Full Time in Fire Service Related Field

3. Fire Department Type: +\$10/M

- ☐ 10 Volunteer
- ☐ 12 Career
- ☐ 14 Combination
- ☐ 16 Industrial

4. Population Served by Department: +\$10/M

- ☐ 11 100,000 or more
- ☐ 13 50,000 - 99,999

Notes:

- 3) They only send four email blast a day so we would need to schedule a day that we want the email to be sent out.
- 4) The print version of the advertisement has a deadline to February 3rd 2016 in order to get into the March edition of the magazine.
- a) Material is not due until February 10th 2016

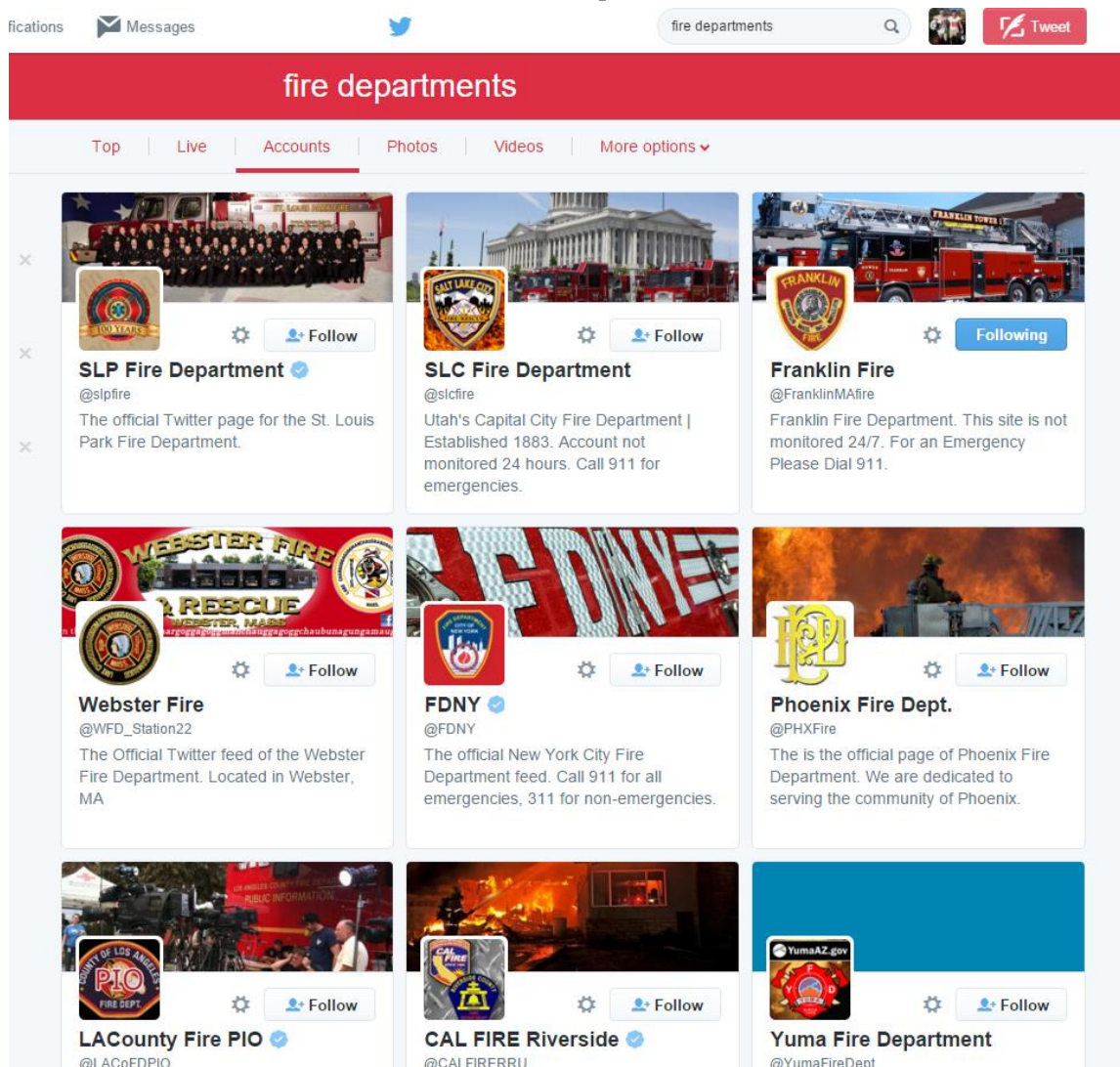
Facebook:

- 1) Completion of the Facebook page and permission to publicize the page.
- 2) Creation of an advertisement for Facebook to use.
- 3) Use Facebook's advertising program.
 - a) Allows our group to select who we want to target.
 - i) This means no wasted advertisement because everyone that sees the ad will have some sort of connection to the fire safety service.
 - b) Efficient with a low monetary price- Low risk, possible high reward.

- i) If it does not pan out to be successful the Facebook ad can be stopped completely as soon as possible.
 - ii) Only have to spend what we want to spend.
- 4) A tentative plan for Facebook advertising consist of:
 - a) Three scheduled posts per week
 - i) Sharing relevant posts, research updates, images, and encouraging survey responses.
 - b) Advertisement targeted at views for the Facebook Page
 - i) \$5 to \$10 daily budget
- 5) For more information look to our “Facebook Page Advertising” PowerPoint

Twitter:

- 1) Create a Twitter handle/page.
- 2) Once twitter “handle” is created search for “fire departments” in the search bar.



- 3) A long list of fire deparnts will appear where you are then able to click “follow”.

- 4) Once the “follow” button is clicked for a fire department, they will receive a notification that our twitter handle has followed them. At this point they have the ability to look at our twitter page (where we will have included the survey and other news about the project) and follow us back.
- 5) If the fire department follows us back they will have the ability to see each new post we make along with the opportunity to “retweet” our posts. This means that their followers will be able to see our post, generating a more widespread reach.
 - a) Large fire departments such as FDNY have the ability to retweet, Fire departments such as this have a large amount of followers, many of whom are fire service employees. If they see our information they will then be aware of our survey.
- 6) However, just because we follow a fire department or fire safety twitter handle it does not mean they need to follow us back. If they decide not to follow us back they still would have seen our page and will possibly be imprinted in their memory.
- 7) Direct messaging can also be done through twitter.
- 8) Similar to email except it will be more accessible to the admins of the twitter handle. This could result in fast response times along with extended communication to fire departments and fire safety patrons. There are also numerous fire service twitter handles that are not fire departments that have the ability to help share our survey. <http://www.firecritic.com/2009/09/14/top-100-fireems-twitter-users-are-you-included/>
- 9) Although it may be manual labor initially, twitter has an extremely high roof with little to no risk involved.
- 10) It’s FREE!
- 11) Secret List: To achieve status on the secret list again, new information on our project needs to be posted. Once the IQP I group is complete with their paper we will be able to publish the database. After the database is successfully published, requesting the Seret List to help promote the burn-through survery will be possible.

Appendix A4: Facebook Advertisement Strategy

There are three ways to advertise on Facebook.

The image displays a Facebook page for 'Next Generation Fire Attack Hose' with various sections and promotional options. Three numbered callouts are overlaid on the page:

- 1. Promote/Boost Page**: A blue arrow points from this callout to the 'Promote Page' button located in the 'Boost Your Page for \$5' section.
- 2. Promote/Boost Post**: A purple arrow points from this callout to the 'Boost Post' button located below a post by 'Fire Engineering'.
- 3. Promote/Boost Website**: A red arrow points from this callout to the 'Promote Website' button located below a link to a survey.

The Facebook page layout includes the following elements:

- Page Header**: 131 likes +92 this week, 366 post reach this week, View Pages Feed, Invite friends to like this Page.
- Boost Your Page for \$5**: Reach even more people in United States. Promote Page button.
- ABOUT**: Section for gathering data on fire hose burn-throughs. Promote Website button.
- PHOTOS**: Grid of six images showing fire scenes and firefighters.
- VISITOR POSTS**: Section for visitor posts.
- Post by Next Generation Fire Attack Hose**: Shared Fire Engineering's post. Published by Brandon Eccher 12 hrs. Have you ever had anything go wrong on the fire ground such as a hose burn-through? If so, please fill out our survey at http://wpi.qualtrics.com/jfe/form/SV_8cEwwLhPQREawzX #savelives.
- Post by Fire Engineering**: 13 hrs. Are you ready in case things go wrong on the fireground? A new blog from Kyle Sanders of Engine House Training LLC: <http://community.fireengineering.com/profiles/blog/show...> Keeping Up With When Things Go Wrong. Time to talk about the topic no one ever wants to talk about or train on. It always gets pushed off to the side or gets the classic "I'm smarter than that and won't get in that situation." This is something that no one expects to happen but can happen. COMMUNITY.FIREENGINEERING.COM. 51 people reached. Boost Post button.

Boost Page:

Advertisements for boosting a page can be viewed three different ways depending on what interface the user is using. It can viewed by the desktop and mobile news feed, which both appear on the center of one's page on a user's news feed. These methods are seen when a user is scrolling through his/her news feed.

DESKTOP NEWS FEED

**Jasper's Market**
Sponsored · 



Jasper's Market is now open downtown! We feature a large selection of organic produce to help you meet all of your family's cooking needs.



1 Like 1 Comment 2 Shares

 Like  Comment  Share

MOBILE NEWS FEED

**Jasper's Market**
Sponsored · 

Jasper's Market is now open downtown! We feature a large selection of organic produce to help you meet all of your family's cooking needs.




 Rohini Joshi 1 Comment 2 Shares

 Like  Comment  Share


[See Feature Phone Preview](#)

The third way the ads can be displayed is on the right column of the Facebook page. This way is not directly in the middle but stays in view even while scrolling down the page.

RIGHT COLUMN



Jasper's Market
Jasper's Market is now open downtown! We feature a large selection of organic produce to h...



Boost Post: We can select a post to boost it. This is extremely similar to boosting our page however information contained in the ad would be what we have in a selected post, rather than information about our page.

Boosted Page Post

Your ad will boost this Page post. You can preview your ad on the right.

Select an Existing Page Post


Have you ever had anything go wrong on... ▾

Hide Advanced Options ▴

URL Tags ⓘ

1024

Conversion Tracking ⓘ



Facebook Pixel

You can now create one pixel for tracking, optimization and remarketing. [Learn More](#)


Create a Pixel

Ad Preview

1 of 1

✓ Desktop News Feed

Remove



Next Generation Fire Attack Hose


shared Fire Engineering's post

Sponsored · 🌐

Have you ever had anything go wrong on the fire ground such as a hose burn-through? If so, please fill out our survey at

http://wpi.qualtrics.com/jfe/form/SV_8cEwwLhPQREawzX

#savelives




Fire Engineering

Sponsored · 🌐

Like Page

Are you ready in case things go wrong on the fireground? A new blog from Kyle Sanders of Engine House Training LLC:

<http://community.fireengineering.com/profiles/blog/show...>



✓ Mobile News Feed

Remove

✓ Desktop Right Column

Remove

Back

Review Order

Place Order

By clicking "Place Order", you agree to the [Facebook Statement of Rights and Responsibilities](#) including your obligation to comply with the [Self-Serve Ad Terms](#) and the [Facebook Advertising Guidelines](#). We do not use sensitive personal data for ad targeting. Topics you choose for targeting your ad don't reflect the personal beliefs, characteristics or values of

Boost Website:

Boosting a website gives direct connection to the Qualtrics site. A picture along with extra text can be added to the advertisement. The website also has the additional option of being advertised on mobile apps and mobile websites that are approved by Facebook. (Audience Network)

Enter compelling text that lets people know what you're promoting...

Images and Links

☒ Automatically show the best performing images and links first


☒ Add a card at the end with your Page profile picture

123+

Remove

Image

Change ImageCrop Image

 - 110 x 80

For questions and more information, see the [Facebook Ad Guidelines](#).

Headline40

Add an attention-grabbing headline

Description (optional)20

Describe why people should visit your site

Destination URL972

http://wpi.qualtrics.com/jfe/form/SV_8cEwwLhPQREawz

Call-to-Action Button (optional)


No Button

Show Advanced Options

Desktop News FeedRemove

Next Generation Fire Attack Hose shared a link.

Sponsored



wpi.qualtrics.comwpi.qualtrics.com

LikeCommentShare

Mobile News FeedRemove

InstagramAdd

Audience NetworkAdd

Desktop Right ColumnRemove

61

Facebook determines which location (News Feed Vs. Right Column) your ad will be placed if all placements are selected. However, we are able to disable a certain placement. For example if we only wanted to be displayed on the right column we would disable news feed and mobile news feed placement.

Ad Preview

1 of 1

✕ Desktop News Feed


Add

✕ Mobile News Feed

Add

✓ Desktop Right Column

Remove



Next Generation Fire Attack Hose

Next Generation Fire

We've created this page to gather data on fire hose burn-throughs. We need your help.

Like Page

- 131 people like this page

For example in this picture, only the Desktop Right Column is selected. Therefore our ad would only show up on the right side of a desktop browser.

Views received for Cost: The cost is the same whether you are boosting a page, website, or post.

1. Spending \$5.00 a day

How much do you want to spend?

[Help: Budgeting & Pricing](#)

Budget ⓘ

Daily Budget ▼

\$5.00

\$5.00 USD

Schedule ⓘ

☒ Run my ad set continuously starting today

☐ Set a start and end date

[Show Advanced Options ▾](#)

Estimated Daily Reach

Facebook icon

2,200 - 5,700 people on Facebook

0

of 520,000 ⓘ

This is only an estimate. Numbers shown are based on the average performance of ads targeted to your selected audience.

2. Spending \$10.00 a day

How much do you want to spend?

[Help: Budgeting & Pricing](#)

Budget ⓘ

Daily Budget ▼

\$10.00

\$10.00 USD

Schedule ⓘ

☒ Run my ad set continuously starting today

☐ Set a start and end date

[Show Advanced Options ▾](#)

Estimated Daily Reach

Facebook icon

3,500 - 9,200 people on Facebook

0

of 130,000,000 ⓘ

This is only an estimate. Numbers shown are based on the average performance of ads targeted to your selected audience.

3. The more money spent per day, the higher estimated views.

4. A Schedule can be set so you only advertise for a specific amount of days.

- Schedule ⓘ ☐ Run my ad set continuously starting today
- ☒ Set a start and end date

Start	2/29/2016 ⓘ	1:18 PM
End	3/29/2016 ⓘ (Pacific Time)	12:18 PM

Your ad will run until **Tuesday, March 29, 2016.**

You'll spend up to **\$289.58 total.**

Detailed Targeting: The ad will be shown to people who have similar interest or likes to fields that we suggest. For example I suggested Fire Protection, Fire Chief, Fire department and so on. We can make it as specific or broad as we wish.

Detailed Targeting ⓘ INCLUDE people who match at least ONE of the following ⓘ

Fire Protection

Demographics > Work > Employers

Fire department

Demographics > Work > Job Titles

Deputy Fire Chief

Fire Chief

Firefighter

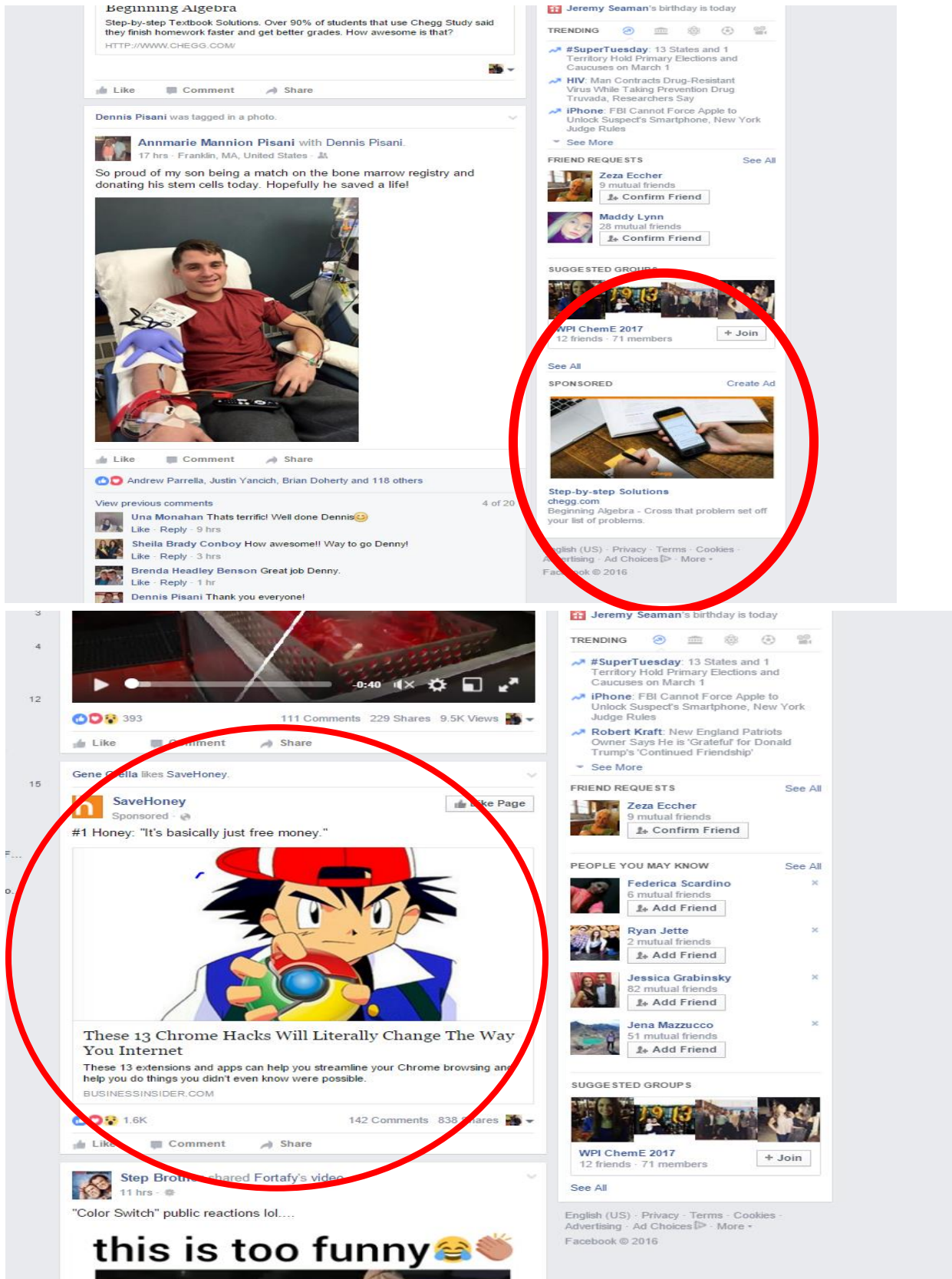
Interests > Additional Interests

Fire Engineering

Fire hose

Add demographics, interests or behaviors | Suggestions | Browse

What it looks like on a real browser:



Appendix B1: Manufacturer Interview Questions

1. How long has your company been making hoses?
2. How did your company get into the hose Industry?
3. Does your company have its own manufacturing facilities?
 - a. What parts of the hoses does your company manufacture?
 - b. Where are these facilities?
 - c. Do these facilities produce everything needed in the production of a fire hose?
4. What product is your company especially proud of?
5. Can you tell me about [insert product here]?
*ask about any hose of interest if applicable
6. Have any customers reached out to your company about hoses that exceed *NFPA 1961*?
 - a. Who was the customer?
 - b. What was the customer planning to use the hose for?
 - c. How was the hose designed to accommodate the needs of the customer?
7. Are any of the hoses your company manufactures fire-resistant?
If so:
 - a. Who buys these fire-resistant hoses and what do they use them for?
 - b. Do these fire resistant hoses cost more than other hoses?
 - c. What aspects of the hose make these hoses make them fire resistant?
 - d. Are there any obvious downsides to the fire resistant hoses, such as excessive weight or friction loss compared to other hoses?
 - e. How is the fire resistance of these hoses tested?
 - f. Is your company conducting any research on improving these hoses' fire resistance?
8. In your experience, what are the major issues with developing a fire resistant hose?
9. Do you know of any R&D going on in the Industry about burn-through?
 - a. What prompted your company to look into fire resistant hoses?
 - b. Does your company have any shelved designs of fire resistant hoses?
 - c. What is the basis of the fire resistance of those hose designs?
10. Where is most of the R&D effort going toward in the Industry?
11. Would it be possible for our team to take a tour of your facility or facilities?
12. What is the best way to get back in contact with you?

Appendix C1: Questions to Firefighters

Questions about the Fire Hose

1. Is there one specific person in your department responsible for ordering fire attack hose?
 - a. If yes, who?
 - b. If no, why?
2. What type of monetary constraints does your department face with regard to ordering hose?
 - a. Are there constraints other than monetary that your department faces when ordering hose?
3. What type of information or rankings would be beneficial to your department when ordering fire hose?
4. How often do you purchase new hose?
 - a. How is the decision to purchase new hose made? (automatically purchased every few years, inspection failure, etc.)
5. Does your department keep records of the type of hoses purchased, and/or what is done with each new hose?
 - a. Do you know how old each hose in your department is, and where each hose is located?
6. What type of testing is done on your hose to ensure its reliability over time? How often is this testing completed?
7. What characteristics do you look for when you purchase a hose?
8. Where does the information you use when deciding what hose to purchase come from?
9. How do you ultimately make the decision regarding what to purchase?
10. Is there any information not currently marked on hose, which you would like to have marked on it?
 - a. If yes, what information?
 - b. If no, why?

PPE (Personal Protective Equipment)

1. Is there one specific person in your department responsible for ordering PPE?
 - 1.1. If yes, who?
 - 1.2. If no, why?
2. What type of monetary constraints does your department face with regard to ordering PPE?
 - 2.1. Are there constraints other than monetary that your department faces when ordering PPE?
3. What type of information or rankings would be beneficial to your department when ordering PPE?
4. How often do you purchase new PPE for your firefighters?
 - 4.1. How is the decision to purchase new PPE made? (automatically purchased every few years, FF request, inspection failure, etc.)
5. Does your department keep records of the type of PPE purchased, and/or what is done with the PPE?
 - 5.1. Do you know how old each piece of PPE in your department is, and where each piece is located?
6. What type of testing is done on your PPE to ensure its reliability over time? How often is this testing completed?
7. What characteristics do you look for when purchasing PPE?

8. Where does the information you use when deciding what PPE to purchase come from?
9. How do you ultimately make the decision regarding what to purchase?
10. Is there any information not currently marked on PPE, which you would like to have marked on it?
 - 10.1. Is yes, what information?
 - 10.2. If no, why?

Appendix D1: Workshop Agenda

DAY 1	
Registration/ Breakfast, Welcome & Introductions 8:00-8:45 A.M.	
8:00-8:15 A.M.	<p>Registration/Breakfast:</p> <p>Registration will take place accompanied by a complimentary breakfast. This is a time for socialization among all, and for participants to settle in at their tables. Depending upon the catering style, breakfast will either be served by table or served buffet style.</p>
8:15-8:45 A.M.	<p>Welcome & Introductions:</p> <p>Welcome. The summit will be opened up with a brief welcome to all stakeholders/ participants. It will be stressed that each participant was invited specifically to share their wisdom and experience in order to contribute to the objectives of the workshop.</p> <p>Introductions. Primary contributors to the development and execution of the workshop will be introduced first. Following this initial introduction of personnel, remaining participants will introduce themselves.</p> <p>Agenda Check. A review of the itinerary will follow introductions. Key logistics will be covered.</p> <p>Housekeeping. Important housekeeping details will be presented; including hotel information, bathroom locations, parking details, emergency exits, etc.</p>
Purpose & Background 8:45-9:15 A.M.	
8:45-9:00 A.M.	<p>Purpose:</p> <p>The three-fold intended purpose of this summit is to raise the scope and severity of the burn-through problem, share data and information pertaining to burn-throughs, and initiate a call to action among all stakeholders involved.</p>
9:00-9:15 A.M.	<p>Background:</p> <p>A presentation regarding the evolution of the fire attack hose, and standards driving improvements and changes will be provided. The presentation will focus on the following topics to set the stage for the objectives of the summit:</p> <ul style="list-style-type: none"> -Attack Hose History. -Evolution of the NFPA fire hose standard est. 1898. -Data retrieval within the fire community.
Session I: The Fire Attack Hose Burn-Through Database 9:15-11:15 A.M.	

9:15-9:45 A.M.	Database Presentation: Former and current Next Generation Fire Attack Hose project members focusing on database creation and improvement will provide a presentation outlining the design, data collection, data collection verification, and results of the burn-through database. Participants will be informed of the results and data accumulated thus far, and some of the major conclusions reported from the database.
9:45-10:30 A.M.	Database Discussion I: Discussion will initiate in small groups. The intended setup of the summit will consume a classroom style, with multiple tables. Each table will seat either a particular organization or a mixed collection of representation. Discussion will be aimed to address the following focus questions: <ol style="list-style-type: none"> 1. Is the burn-through data base of importance to your organization? Why or why not? 2. What are some measures that could be taken in order to receive more attention towards the database? How could your organization help increase data retrieval? 3. What other data should be collected that is not currently accounted for in an organized manner? 4. How can this database be made more available to its intended audience? 5. Does this database hold enough weight to be hosted at the level of a national organization? Why or why not?
10:30-11:15 A.M.	Database Discussion II: Following the initial discussion among groups, discussion will open up among all groups and participants. Each focus question will be addressed and content discussed by each group will be exchanged. Database improvement and change will serve as the ultimate topic of discussion.
Break 11:15-11:30 A.M.	
Lunch 11:30 A.M.-1:00 P.M.	
11:30 A.M.-12:15 A.M.	Lunch Served.
12:15-1:00 P.M.	Speaker. Once everyone has gotten their meal and has had a chance to start eating, a representative from NIOSH (National Institute for Occupational Safety and Health) will provide a presentation covering the development of a successful database. The speaker is encouraged to focus on providing the specifications regarding NIOSH's <i>Fire Fighter Fatality Investigation & Prevention Program</i> , which served as inspiration throughout the creation of the <i>Burn-Through Database</i> . The content covered will be up to NIOSH and its speaker. The following focus questions are intended to be covered: <ol style="list-style-type: none"> 1. What measures are taken in order to maintain a successful database?

	<ol style="list-style-type: none"> 2. How did NIOSH create the database? 3. How does NIOSH manage quality control of their inputted data?
<p align="center">Session II: The Fire Service Experience 1:00 P.M.-3:00 P.M.</p>	
1:00-1:30 P.M.	<p>Fire Service Experience Presentation:</p> <p>A representative from the fire service will communicate the current day firefighter experience. Topics presented will be up to the representative. This is an opportunity to expose central needs and input from firefighters across the country.</p>
1:30-2:15 P.M.	<p>Fire Service Experience Discussion I:</p> <p>Discussion will initiate in small groups and will be aimed to address the following focus questions:</p> <ol style="list-style-type: none"> 1. What are some common problems related to fire hose use and maintenance? 2. What factors influence the hose selection process? 3. If someone was designing a new hose, what would you want them to know? 4. What are some other common problems on the fireground? 5. (Other Focus questions requested by presenter)
2:15-3:00 P.M.	<p>Fire Service Experience Discussion II:</p> <p>This master discussion will follow the format of the first session's second discussion. Major conclusions and significant points will be identified among all groups as the focus questions are covered by each group. Pressing needs and areas of improvement identified by the fire service will be stressed.</p>
<p align="center">Session III: Codes and Standards 3:00-5:00 P.M.</p>	
3:00-3:30 P.M.	<p>Codes and Standards Presentation:</p> <p>A representative from the NFPA and/ or another policy making organization will present important codes and standards associated this summit. Aside from an examination into these standards, the presentation may provide an overview of standards as a whole and their importance. Ultimately the content of the presentation is up to the organization involved.</p>
3:30-4:15 P.M.	<p>Codes and Standards Discussion I:</p> <p>This initial discussion will follow the structure of the opening discussion in the sessions prior. Discussion topics will ultimately be determined by those preparing the presentation. The following focus questions are suggestions to drive the discussion:</p> <ol style="list-style-type: none"> 1. What events or factors have influenced standard changes in the past? 2. How do the standards applied in the U.S. compare to International Standards? 3. What role do standards play on the fireground and within industry?

4:15-5:00 P.M.	Codes and Standards Discussion II: The master discussion will consume the focus questions among all groups. This discussion will serve as a time to identify any needs or suggestions participants have for policy makers regarding existing codes and standards, and those yet to be established.
Break 5:00-6:00 P.M.	
Dinner 6:00-8:00 P.M.	
6:00-7:00 P.M.	Cocktail Hour.
7:00-8:00 P.M.	Dinner.
DAY 2	
Breakfast 8:30-9:00 A.M.	
Session IV: Testing 9:00-11:45 A.M.	
9:00-9:45 A.M.	Testing Presentation. This presentation will consist of a culmination of organizations which practice and examine product testing. Such groups include associated WPI project groups, ATF, and NFPA. The presentation will exhibit current test requirements and research being performed to improve the status of such tests.
9:45-10:45 A.M.	Testing Discussion I: Discussions will follow the same structure as Day 1. Discussion focus questions will include: <ol style="list-style-type: none"> 1. What is the test methodology of current attack hoses? 2. What testing apparatuses are applied by organizations involved? 3. How do our test methods compare to international test methods? 4. What are some ways to improve the current hose testing criteria?
10:45-11:45 A.M.	Testing Discussion II: Discussion among all groups will take place concerning the focus topics listed in the first half of discussion for this session. Focus should be centralized upon the reality of a new testing criteria, and the next steps towards achieving change.
Break 11:45 A.M.-12:00 P.M.	

<p style="text-align: center;">Lunch 12:00-1:00 P.M.</p>	
<p style="text-align: center;">Session V: Path Forward 1:00-2:30 P.M.</p>	
1:00-1:45 P.M.	<p>Path Forward Discussion I:</p> <p>In small groups, a list of steps committed to the objectives of the summit will be created and outlined. For each step, the basic purpose/objective of the step will be identified, as well as any obstacles the may impede progress.</p>
1:45-2:30 P.M.	<p>Path Forward Discussion II:</p> <p>Each group will submit their steps of the path forward. A master list of steps identified by the majority of the groups will be formed and discussed. Following the establishment of the path forward, the summit will close with a conclusion thanking all participants for their contribution and information regarding follow-up results/ publication of proceedings.</p>

Appendix D2: Potential Participant List

<u>NAME</u>	<u>CONTACT INFORMATION</u>	<u>AFFILIATION</u>
Marty Ahrens	Phone: 617-984-7463 Email: mahrens@nfpa.org	NFPA: Manager, Fire Analysis Service
Michael Aubuchon	Phone: 805-922-7076 Email: Maubuchon@nafh.com	North American Fire Hose
Jason D. Averill	Phone: 317-975-2585 Email: Jason.averill@nist.gov	NIST: Acting Chief of the Materials and Structural Systems Division
Rick Bergeron	Phone: 704-643-5888	Superior Fire Hose
Rick Black	Phone: 817-796-1304 Email: rblack@publicsafetyexcellence.org	Center for Public Safety Excellence
Kurt Bressner	Phone: 561-436-2328 Email: kbressner@gmail.com	City Manager, City of Boynton Beach
Paul D. Brooks		Owner, Brooks Innovative Solutions
Chief Randy Bruegman	Email: rbruegman@anaheim.net	Fire Chief, Anaheim Fire Department
Christian Callsen Jr.		International Association of EMS Chiefs
Teri Caswell		First Responder Network Authority (FirstNet)
Joe Cieplak	Phone: 203-407-1201	Cieplak's Fire and Safety
Robert W. Cobb		National Director, Risk Decision Services ISO
Chief Dennis Compton		Chairman, National Fallen firefighters Foundation
Mark Donovan	Phone: 603-924-2122	President, Armored Textile
Richard K. Fagan		Technical Advisor Program Manager
Tracy Frazer		Computer Support Specialist, ITS
Daniel Gorham	Phone: Email: dgorham@nfpa.org	NFPA
Dan Greensweig		Associative Administrator, National League of Cities
Peter L. Gorman		Chief of Staff, IAFF
Jay Gunsauls		Director of Training, Emergency Reporting
John R. Hall, Jr., Ph.D.		Division Director, Fire Analysis and Research, NFPA
Elizabeth Harmen		Asst. Administrator, Grant Programs Directorate, U.S.

		Department of Homeland Security/ FEMA
Sanjay S. Kalasa		Vice President, FIREHOUSE Solutions
John Larrabee	Phone: 800-963-3377 x 16 Email: jlarrabee-@kocheck.com	Kocheck Co. Inc.
Duane Leonhardt	Phone: 514-335-4337	Mercedes Textiles
Dennis B. Light		Assistant Fire Chief, Yuma Fire Department
N. Clay Mann, Ph.D., MS		Associate Director of Research Professor, Department of Pediatrics, National EMS Information System, Technical Assistance Center
Toby Mathews	Phone: 800-447-5666 Email: tmathews@keyhose.com	Key Fire Hose
Greg Mears, MD		Associate Professor & North Carolina EMS, Medical Director, University of North Carolina- Chapel Hill
Chief William Metcalf		Treasurer, IAFC
Bruce J. Moeller, Ph.D.		City Manager, International City/ Country Management Association
Lori Moore Merrell, DrPH, MPH		Assistant to the General President, IAFF
Raj Nagaraj, Ph.D.		Vice President of Engineering, Deccan International
Jim Narva		Executive Director, National Association of State Fire Marshals
Brad Pabody		Chief, National Fire Data Center, U.S. Fire Administration
Patrick Purcell	Phone: 508-389-2300	Westborough Fire Chief
Kevin Roche		Assistant to the Fire Chief, Phoenix Fire Department
Paul Rottenburg		FireStats
Robert Santos		Senior Institute Methodologist, The Urban Institute
Stewart Smith		Product Manager, Zoll
Debbie Sobotka		Deputy Director, Center for Public Safety Excellence
Tracy Vecchiarelli	Phone: 617-984-7468 Email: tvecchiarelli@nfpa.org	NFPA

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