EVALUATING THE RESULTS OF A MODIFIED BUNKER GEAR POLICY

EXECUTIVE DEVELOPMENT

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An applied research project submitted to the National Fire Academy as part of the Executive Fire Officer Program

September 2002

ABSTRACT

In August 2000, Boston Fire Department (BFD) modified its mandatory bunker gear policy to permit less than full bunker gear. The problem was that no evaluation of the policy change was performed to determine whether or not firefighter safety was enhanced. The purpose of this research was to determine if modifying the BFD bunker gear policy enhanced firefighter safety. An historical and evaluative research methodology was used to answer the following questions:

1. Prior to the modification of the bunker gear policy, what was the injury rate for heat stress injuries on the fireground?

2. Did the rate of heat stress injuries go down after the modification of the policy?

3. Did any other category of injuries increase after the policy change?

4. What must BFD do to ensure optimum safety for its firefighters?

The procedures involved an examination of injury statistics before and after the change. This data was used to answer questions 1, 2, and 3. An extensive literature review and interviews with bunker gear experts provided answers to question 4.

The results of the research showed a slight increase in heat stress injuries and provided numerous options to reverse this occurrence.

Recommendations included continuing the search for less heat stress producing bunker gear, instituting a wellness/fitness program within the BFD, and training for heat stress recognition and prevention. Also, to benefit future research, the department should maintain a database of injury statistics. For the benefit of the fire service, another major study of bunker gear, similar to Project FIRES, was recommended.

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INTRODUCTION

In the late 1990s, the Boston Fire Department (BFD) noticed an increase in complaints that the bunker gear, which every member was required to wear, was causing added heat stress during emergency operations which led to more injuries. This caused considerable concern among the administration for the safety and well being of its members. In August 2000, BFD modified its policy of wearing full bunker gear to one that allows firefighters to choose from four ensemble options. This modification was implemented because BFD "determined that the use of such gear, while providing a high degree of protection against the effects of fire, may pose health and safety hazards to firefighters" (Boston Fire Department, 2000). The Special Order issued by the Department went on to say that "firefighters who have experienced discomfort in the form of high physical stress due to high body heat and difficulty of motion while using the full bunker gear ensemble may choose" (p. 1) to wear one of the other ensembles. The discomfort that this referred to is what is now commonly called heat stress.

The program was to be monitored to determine if the modified bunker gear policy was contributing to the health and safety of its firefighters. The problem is that, after 2 years, no evaluation of the modified bunker gear policy has occurred that confirms whether or not firefighter safety has been enhanced.

The full effect of heat stress on firefighter safety is becoming the basis of numerous studies. Lawson (1998), who has previously studied the thermal protection provided by bunker gear, is now turning his attention to heat stress. He states, "Heat stress has become a significant factor for the fire service. It has been identified as one of the primary challenges for fireground safety" (p. 46). The purpose of this applied research project was to determine if firefighter safety has been enhanced or reduced by this change in the bunker gear policy. Historical and evaluative research methods were employed to answer the following questions:

1. Prior to the modification of the bunker gear policy in August 2000, what was the injury rate for heat stress related injuries that occurred on the fireground?

2. Has the number of heat stress related injuries occurring on the fireground been reduced since the implementation of the modified policy?

3. Has any other category of injuries increased since the modified policy was introduced?

4. What actions are now required of the Boston Fire Department to ensure optimum safety to its firefighting force?

BACKGROUND AND SIGNIFICANCE

Prior to the arrival of bunker gear in 1995, members of the Boston Fire Department (BFD) traditionally wore a three-quarter-length rubber fire coat that included a standard moisture barrier and quilted thermal liner. With this, they wore three-quarter high rubber fire boots over their station uniform of fire resistive (FR) pants and shirt. Gloves and a leather helmet completed the personal protective equipment (PPE) worn. BFD members could also wear, as an option to the rubber boots, safety shoes with steel toes and shanks. A few firefighters chose to wear "night hitches" which consisted of turnout pants of cotton duck material with suspenders and short fire boots. Then, in June of 1995, BFD switched to full bunker gear.

Standard Operating Procedure (SOP) No. 58 was issued and full bunker gear became mandatory (BFD, 1995). This followed a 2-year evaluation and study of various styles and manufacturers of PPE. Even during this evaluation period, "one of the primary concerns was heat stress" (BFD, 1994, p. 3). Interestingly, at the time of the evaluation, 40 out of the 45 participants rated the fatigue factor and the weight of the bunker coat as better than or superior to the previously worn fire coat issued by BFD (1994, p. 1 [Coat Summary]). Furthermore, 34 out of the 45 participants of the evaluation rated the fatigue factor and weight of the bunker pants as better than or superior to the previously worn combination of station uniform pants and three-quarter high rubber boots (BFD, 1994, p. 1 [Pants Summary]).

Also, as part of the background of its willingness to accept bunker gear, BFD was directly involved with Project FIRES (Firefighters Integrated Response Equipment System) from 1976 until the release of the final report in 1985. BFD firefighters tested and evaluated PPE throughout the project. Former Fire Commissioner Leo Stapleton, who was a member of the Users Requirements/Technical Advisory Committee (UR/TAC), recalls that heat stress was a significant concern at the very beginning of the project. He noted that because they listened to the firefighters, Project FIRES was a success. Citing one specific test at FDNY Squad 1, Stapleton said, "they were young and enthusiastic and they wanted to make it work" (L.D. Stapleton, personal communication, August 27, 2002).

Complaints of heat stress caused by the full bunker gear policy increased over the years following its implementation. A joint safety committee was formed to investigate the complaints. The committee consisted of members appointed by the department and members appointed by the firefighter's union, Local 718. Their recommendations were forwarded to the Chief of Department. On August 3, 2000, a modified bunker gear policy was implemented (BFD, 2000). Firefighters could now choose from four PPE ensembles.

Noteworthy to the background of this research, is the tactics and deployment strategies used by BFD. They are well known for aggressive interior fire attack and for routinely using multiple ground and aerial ladders. They effect rapid vertical and horizontal ventilation through the use of functionally defined ladder companies and SOPs. They also maintain minimum staffing that allows for the deployment of 27 firefighters on the first alarm for a reported structure fire. This includes 6 company officers, at least one chief officer, and a chief's aide.

This research project is significant to the BFD in three ways. First, an analysis of injury data will provide guidance for future bunker gear decisions that will directly impact the safety of current and future firefighters. Second, the examination of the findings of recent heat stress studies will support those decisions. Third, the research can be a catalyst for further heat stress studies.

This applied research project is related to the National Fire Academy's (NFA) *Executive Development* course goal that is to prepare the participant to "lead effectively and efficiently within a dynamic and complex organization by … the application of action research" (NFA, 1998, p. SM 0-3). Achieving this goal will enhance the participant's personal development by acquiring research skills. Examining a policy change through research can lead the organization to understand the policy more clearly. This can lead to a paradigm shift for the good of the organization.

This research project also relates to and supports one of the U.S. Fire Administration's (USFA) operational objectives, which is to "reduce the loss of life from fire of firefighters," (U.S. Fire Administration, 2001, p. II-2).

LITERATURE REVIEW

A literature review was conducted to analyze the existing body of knowledge on heat stress and its effects on firefighters. Various studies of protective ensembles were examined. This led to the identification of new concepts, such as Total Heat Loss (THL), and to more recent studies, such as the Indianapolis study (International Association of Firefighters [IAFF], 1998) which necessitated a further literature review. The literature review included a search of both fire service and scientific journals, textbooks, fatality reports, and interviews with experts on the development and evolution of bunker gear, and other related issues surrounding heat stress. This extensive literature review added considerable support to understanding the heat stress injury problem. This section will discuss critical findings in the areas of:

1. Heat Stress
2. Available Data
3. Studies
4. Tactical Considerations, Rehabilitation, and Hydration
5. Fitness
6. Interviews

Heat Stress

"It has long been recognized that heat stress is a significant safety factor for firefighters" (Phoenix Fire Department (PFD), n.d.). McDowell (1993) points to bunker gear as the cause of heat stress when he says, "With the development of new materials, the cost of improved thermal protection has been, at least to some degree, heavier clothing. This increased weight, combined with more aggressive firefighting tactics and nearly universal use of SCBA (self-contained breathing apparatus), has caused firefighters to experience significantly higher levels of physical stress than in the past" (p. 31). Lawson (1996) describes the mechanics of heat stress with the following scenario:

> An alarm comes into the station, and firefighters don their turn-out gear (protective clothing including helmet, hood, turn-out coat and pants, and boots). As soon as they don their gear, normal heat loss from the body is slowed…. After arriving at the scene, putting on SCBAs and gloves, pulling hose lines and carrying out other duties required before attacking the fire, sweat may already be soaking clothing next to the skin. The firefighters enter the building and climb a flight of stairs. As the firefighters move down a corridor looking for the fire, their protective clothing and bodies become heated from the outside by thermal radiation and hot convective flows from the fire. This heating not only affects an individual's fire fighting performance, but also alters the protective performance of the individual's turn-out gear. Liquid sweat is absorbed by the firefighter's clothing. Sweat vapors, which fill the protective clothing air spaces, may be absorbed by fabric fibers. The heat capacity and thermal conductivity of the protective clothing starts to change. As increased quantities of sweat are absorbed into the fabric more and more heat can be stored in the firefighter's clothing, and the thermal conductivity of the turn-out gear increases. Upon heating the garments, moisture evaporation rates tend to increase. This increased evaporation rate helps to keep the firefighter comfortable but hot as work continues. The firefighter with the nozzle begins the attack and water spray splashes back from the wall and ceiling. If the protective clothing becomes saturated with sweat and water spray from the hose line, the protective clothing's thermal conductivity may approach that of water, and decrease the insulating properties. The firefighter feels heat increasing on the body and senses that the attack is working but the temperature is still increasing within the protective clothing. (p. 9)

Lawson (1996) further explains the heat stress phenomenon,

> Although protective clothing is designed to reduce the flow of heat and moisture from the firefighting environment to the firefighter, it also reduces the flow of heat and moisture away from the firefighter to the environment. Because of this, the wearer cannot easily lose body heat, which may result in a rise in body core temperature. The body may become heat stressed, which activates the sweating process in an attempt to restore a normal body temperature. Since the protective clothing is resistant to liquid flow, sweat cannot easily evaporate from the skin's surface and evaporative cooling is limited. The protective clothing insulation may absorb this sweat, which potentially could reduce its insulating properties. (p. 6)

The USFA (1992) warns that "if the sweat is not evaporated for any reason, the body's core temperature can rise to 103.4°F or 40°C" (p. 10). Data from Huck (as cited in Lawson, 1996) shows that a body core temperature of 102°F or 39°C is commonly considered to be the limit where the body begins to lose efficiency and medical problems may occur. A core temperature of about 109°F or 43°C may be fatal.

It follows that heat stress can have serious consequences. Shamadan in the video *Managing Heat Stress in the Fire Service* (PFD, n.d.) agrees that what is designed to protect firefighters can also harm them. By putting on bunker gear, firefighters block the principal method by which they exchange heat to the outside environment. "We have to remember that once you put turnouts on someone, especially with an SCBA, you markedly diminish their ability to exchange heat normally with the outside world" (PFD, n.d.). The fact that heat stress can lead to core temperatures in firefighters, which may be fatal, cannot be overlooked. About the same time as the complaints of heat stress rose among BFD firefighters, Fahey and LeBlanc (2000) reported, "Stress and overexertion, usually resulting in heart attacks, continue to be the leading cause of fatal injury [in 1999], as they have been in almost all of the years of this study" (p. 48).

The physical demands of firefighting are recognized. Melius (1995) wrote about the strenuous nature of actual firefighting activities and the high aerobic capacity required of firefighters:

> These activities often require firefighters to work at near maximal heart rates for long times. Heat is another important determinant of the physical requirements for firefighting. Studies of stimulated firefighting activities document the increased physiologic stress from the combination of exertion and high environmental temperatures, including a significant rise in core body temperature even with rest breaks. In addition to the stress from firefighting tasks and high temperatures, the use [of] protective equipment creates an additional burden. Firefighters typically wear about 35 pounds of protective equipment. In addition to the additional weight, the typical equipment may interfere with the thoracic mechanics of breathing and leads to a greater retention of body heat under exercise and simulated firefighting activities. (p. 822)

In summary, physicians and scientists as well as the firefighters who wear PPE daily recognize heat stress as a significant by-product of bunker gear. The protection from death by burns cannot outweigh the need to reduce the debilitating effects of heat stress caused by the constant protection from its lesser and, many times, preventable occurrence (P.A. Christian, personal communication, August 28, 2002; Fornell, 1992).

Available Data

In order to research the incidence of heat stress among BFD firefighters, it was necessary to compile information from injury reporting forms submitted after an injury occurred. This became extremely difficult for a number of reasons. First, no data was available. No statistics are routinely compiled anywhere in the department. All injury reports are filed in a firefighter's personal medical folder in the Office of the Medical Examiner for the BFD who has sole access

to it. There is no compilation of any information from these reports into a database for analysis of any kind. The present Medical Examiner for the BFD has expressed his intention to begin to collect data for statistical analysis but is limited by resources (M.G. Hamrock, personal communication, July 31, 2002).

A similar situation faced the Fire Department of the City of New York (FDNY) (Von Essen, 1998). Von Essen cited prior administrations as doing nothing to document trends in injuries or diseases of its firefighters. This crucial information hindered the advancement of medical benefit programs directed to firefighters. He credits the FDNY for taking "a more proactive role in the physical health and well being of [its] firefighters" (Von Essen, 1998). Furthermore, the FDNY has adopted *The Fire Service Joint Labor Management Wellness-Fitness Initiative* (IAFF, 2000) developed by the IAFF and the International Association of Fire Chiefs (IAFC). An important part of this program is to establish a computerized record of medical data for analysis and reporting (Von Essen, 1998).

This first difficulty necessitated that all data for analysis be collected from reviewing every injury report individually. This created the second and third impediment to the research: Only medically authorized persons could examine the injury reports due to medical confidentiality requirements; since there were no resources to enter the data routinely, there were no resources to examine the thousands of injury reports submitted since bunker gear was made mandatory in 1995. However, there was an alternative method for anonymously gathering the data needed. Approved staff personnel examined indemnification records. This produced limited raw data for analysis (BFD, 2002). National Fire Protection Association (NFPA) injury statistics (Karter & Badger, 2000, 2001; Karter & LeBlanc, 1997, 1998, 1999) were examined to help support the findings gathered from the BFD data.

In summary, the literature review for data proved quite challenging and eye opening. When data is not collected routinely, its subsequent analysis will be an enormous task. When data is compared on different levels and from differing perspectives, it can be the proverbial comparison of apples and oranges.

Studies

There were many studies to review. Project FIRES (Duffy, Sawicki & Beer, 1985) was the one most frequently referred to.

> The objective of Project FIRES was to design, fabricate, laboratory test and field test an integrated protective clothing ensemble for firefighters that would address the known limitations of then available equipment, including severe heat stress, interference with movement and inadequate protection, especially from the heat experienced during flashovers and backdrafts. (p. 1)

The IAFF, which was instrumental in seeing Project FIRES through to completion (Duffy et al., 1985), also funded a study (IAFF, 1998) to evaluate bunker gear for its ability to release heat away from the firefighter and out of the protective ensemble. This study, known as the

Indianapolis study, has introduced the term total heat loss into the discussion of heat stress and bunker gear performance standards (Bove, 2002; Ross, 2000). It was due to particular concern for heat stress that the latest edition of NFPA Standard 1971 (NFPA, 2000) includes a Total Heat Loss test and requires a breathable or permeable moisture barrier (Peterson, 2002).

The research of Duncan, Gardner, and Barnard (1979), Gavhed and Holmer (1989), Veghte (1989), and White, Vercruyssen, and Hodous (1989), studied heat tolerance and acclimatization of firefighters to heat while wearing PPE. The literature review also examined studies of firefighters in bunker gear and their responses to the resultant elevated core temperature and heart rate (Manning & Griggs, 1983; Romet & Frim, 1987). Although these studies are somewhat dated. They are all referenced in later studies and contributed to the research. Therefore, they could not be overlooked. The work of Smith et al. (1992) focused on the physiological and psychological stress of full bunker gear as opposed to traditional fire fighting gear. Prezant et al. (2002) studied the effect of full bunker gear on burn injuries for FDNY firefighters. This study identified a dramatic reduction of burn injuries without any significant increase in reported cases of heat exhaustion.

The BFD commissioned Dr. Richard Gonzalez of the U.S. Army Medical Research & Materiel Command to test and evaluate the various ensembles permitted by the modified bunker gear policy of the BFD. These tests (Gonzalez, 2002), using the DuPont Thermo-Man®, were conducted at the DuPont testing center in Richmond, Virginia. The modeling by Gonzalez resulting from the flame testing of the different configurations introduced age and fitness as factors to be considered. The BFD Medical Examiner (M.G. Hamrock, personal communication, July 31, 2002) expressed his opinion that based on the findings of Gonzalez, any firefighter over the age of 55 should be medically cleared for underlying cardiac conditions and level of fitness. Gonzalez further suggested that military research be leveraged with current civilian research efforts.

In summary, there have been many studies conducted over the past 25 years on bunker gear, heat stress, and the firefighter's tolerance of both. All have made a contribution to this research project. Many identify the critical need to recognize the "tradeoff between providing increased thermal protection from the fire and increasing heat stress from heat generated by the firefighter" (Walton, Bryner, Madrzykowski, Lawson & Jason, 2000, p. 25).

Tactical Considerations, Rehabilitation, and Hydration

The literature review identified reports that called for changes in the management of an emergency incident. The presence of bunker gear on the fireground or at any emergency incident may require a change in SOPs. It definitely requires the attention of the Incident Commander (IC). King, Rotanz, Malley and Prezant (1997) call for proper management of personnel by company and chief officers. "This doesn't only apply to close supervision of the use of PPE, but also to the proper use of the Incident Command System (ICS) and department procedures" (p. 7). King et al. refer to Teele (n.d.) as saying,

> It is not the purpose of advanced protective clothing to permit firefighters to go 'deeper and deeper' into involved structures, but rather to provide increased protection for the 'normal' operating positions and give an additional margin of safety if conditions unexpectedly deteriorate. (p. 7)

Calderone (1998) adds, "Incident Commanders must incorporate the bunker gear fatigue factor into their firefighting plan and adjust operations accordingly" (p. 30). Additionally, the rehabilitation of firefighters on the fireground must be part of this adjustment. The NFPA will be issuing a recommended practice for on-scene rehabilitation (NFPA [1584], in press) in the fall of 2002. This new document specifically addresses heat stress, hydration, and acclimatization. The National Institute for Occupational Safety and Health (NIOSH) issued an alert in 1994 that warned fire departments to review their emergency operating procedures in order to guard against heat stress at fire scenes. They further recommended that fire departments provide cool water supplies, rest areas, and access to emergency personnel to protect firefighters from injury and death. Melius (1995) concurs by saying, " Appropriate medical care, including ensuring proper fluid replacement, must be provided at the fire scene to recognize and care for firefighters at risk of heat stroke or overexertion" (p. 825). Davis (1995) recognized the "loss of fluid during hard physical work as one of the greatest threats to performance" (p. 28). Pagels (1987) claims that most fireground injuries can be "reduced by the use of full protective clothing and better supervision on the emergency scene." He further states, "The chief and/or company officer has the moral and legal responsibility for the safety and survival of his/her firefighters. The chief or officer must instill the proper safety attitudes" (p. 9).

In summary, the use of full bunker gear by firefighters at emergency incidents requires the IC to increase the level of awareness for safe operations and to guard against heat stress with on-scene rehabilitation and frequent rotation of fatigued units. For example, heat stress injuries for the Phoenix Fire Department are extremely rare due to short work cycles and a culture of rehabilitation at all levels of the incident organization (K.M. Roche, personal communication, September 6, 2002).

Fitness

It is widely recognized that being fit makes strenuous work less tiring. The literature review found numerous reports that bunker gear added significantly to the fatigue caused by even moderate work. The work of Davis and Santa Maria (as cited in Davis, Dotson & Santa Maria, 1982) "found that the energy cost of moderate work while wearing firefighting clothing and protective equipment was elevated 33 percent over that required to perform the same work without protective clothing and equipment" (p. 65). Malley (1996) also points to heavier and more restrictive bunker gear as driving up the energy cost of firefighting. "This promotes heat stress, which hinders oxygen use and energy production. Therefore firefighters with a low aerobic capacity will be inclined to fatigue more rapidly and recover from work much more slowly" (p. 35). Davis (1995) lists predictors of the ability of a person to sustain a hard level of work, such as firefighting. The most important factor is the fitness level of the individual. Fahy and LeBlanc (2000) put it bluntly, "The jump in the number of heart attack deaths in 1999 should raise concerns regarding the health and fitness of some members of the U.S. fire service" (p. 49).

In summary, fitness is a key component of a person's ability to tolerate the heat stress and elevated core temperature caused by bunker gear. "Ensuring a high level of fitness is the best way to reduce heat-related injuries. Placing unfit personnel in the hostile environments routinely found at many emergency incidents is an invitation to disaster" (Davis, 1995, p. 28).

Interviews

To supplement the literature review, 12 experts in the field of PPE and bunker gear were interviewed. Each was carefully chosen for their unique perspective on bunker gear issues. Two interviewees were members of Project FIRES. The BFD Commissioner/Chief of Department, who ultimately made the decision to modify the bunker gear policy, and the BFD Medical Examiner who examines every injured BFD firefighter were also interviewed. Since the NFPA is the organization that issues the most widely recognized consensus standard on protective clothing (NFPA Standard 1971), two staff senior specialists employed by the NFPA and a current member of the technical committee on PPE were interviewed. Three researchers were interviewed. All have conducted widely referenced studies on bunker gear, heat stress, and their effects on firefighter performance. The member in charge of implementing a bunker gear program for the Chicago Fire Department (CFD) was interviewed. CFD has resisted the change to bunker gear until this year. Finally, a nationally recognized fire service liability attorney was contacted for his opinions on mandating bunker gear. The credentials of each interviewee are listed in Appendix A.

In summary, the opportunity to interview bunker gear experts of such a caliber was a tremendous bonus for the literature review process. The logistical effort of conducting interviews was far exceeded by the rare insight that they provided. The addition of both internal and external viewpoints helped balance the research effort.

PROCEDURES

Research Methodology

The desired outcome of this research project was to foster recommendations that would promote firefighter safety and reduce future injuries and deaths of firefighters. The research methodology used to answer the research questions was both historical and evaluative.

The research was historical in that a literature review was used to explain and understand how past trends and injury statistics have influenced the present situation and may affect future events.

The research was also evaluative in that the results could be used to facilitate future decisions regarding the use of bunker gear. Analysis of the data collected and the findings of recent research could also lead to improvements in firefighter health and safety.

Process

A five-step process was used to conduct this historical and evaluative research project. The first step was to conduct a thorough search of the existing literature regarding heat stress, bunker gear, and personal protective equipment (PPE). By reviewing articles and reports from journals and periodicals, a better understanding of the issues related to the research questions could be gained. Various published studies relating to firefighting in bunker gear were read to see what others were saying about the research topic. There were two searches conducted at the Learning Resource Center (LRC) of the National Fire Academy in Emmitsburg, Maryland. Another search for data and reference material was conducted at the Charles S. Morgan Technical Library at the NFPA headquarters in Quincy, Massachusetts. More studies and reports were obtained through the Training and Research Division of the BFD.

The second step was to gather all the written documents that pertained to the modified bunker gear policy from the BFD. Special Orders, memos, and SOPs were collected to get a historical perspective of the evolution of the full bunker gear policy since the 1993 trial period. These documents were organized in chronological order through the most recent policy change in July 2002 (Appendix B).

The third step was to gather heat stress injury data from the office of the Medical Examiner of BFD. This led to a lengthy and frank discussion with Dr. Michael Hamrock regarding data collection in the medical section. The gathering of accurate heat stress injury statistics would prove to be very difficult (personal communication, July 31, 2002). Two periods would need to be studied to answer the research questions. The first would be from the beginning of mandatory bunker gear in June of 1995 through the date of the modified bunker gear policy, August 3, 2000. The second period to study would be from August 3, 2000 until the present. The heat stress injuries from these two periods could be analyzed to determine what affect the modified bunker gear policy had on these types of injuries. To answer research question 3, further analysis would be required to recognize any upward trends for other categories of injuries (BFD, 2002). BFD injury statistics could be compared to national data from NFPA to identify any other trends or similarities.

The fourth step was to visit the U.S. Army Medical Research & Materiel Command in Natick, MA, known as the Natick Labs. Dr. Richard Gonzalez had been commissioned to compare the various bunker gear ensembles of BFD. A newly released report on these tests using the DuPont Thermo-Man® manikin was provided for this research project (Dupont Advanced Fibers System, 2002).

The fifth step was to conduct the interviews with the bunker gear experts. Six interviews were conducted by telephone and six were conducted in person. The details of each interview are included in Appendix A. None of the interviews were recorded. Notes from the interviews were handwritten. Key points and significant comments resulting from the questions have been included. Although the answer to research question 4 was obtained from numerous reference sources. The interviews provided valuable assistance in making recommendations for further actions.

Limitations and Assumptions

The results of this research project were limited by several factors and should be noted. There was no database of injury statistics from which to gather facts for analysis. The only source of specific injury data was from injury report forms submitted at the time of the injury.

Another limitation of the research was the way injuries are categorized. The medical payment process drives the system. Thus, injuries are categorized by the body part injured, not what happened to the body part.

Since individual medical records were needed to obtain the necessary data, medical confidentiality became a limitation. Only an authorized medical staff member could examine these records. Staff scarcity severely hindered this process.

As stated in the limitations, injuries were categorized by body part not by cause. However, heat stress, heat exhaustion, and overexertion was considered a multiple system injury by medical staff. Therefore, it was necessary to make the assumption that the category Multiple Injuries would represent the heat stress injuries.

Terms Defined

Core Temperature: Core temperature equates to rectal temperature. Normal is 99.2°F or 37.5°C. "The rectal or core temperature of the body is one of the most meaningful physiological parameters reflecting strain on the body in a work/temperature environment" (Veghte, 1989, p. 59).

Thermal Protective Performance (TPP): "A test method used to quantitatively evaluate fabrics for thermal protection. This test method measures the amount of protection from heat transfer through protective ensembles exposed to [flashover] conditions. A TPP of 35 represents 17.5 seconds of protection [under these conditions]" (Duffy et al., 1985, p.5).

Total Heat Loss (THL): "The amount of conductive (dry) and evaporative (wet) heat loss that occurs through the three layers of a turnout ensemble--outer shell, moisture barrier, and thermal liner" (Bove, 2002, p. 130).

RESULTS

The results of this research were used to answer the four research questions. Pertinent injury statistics are shown in Tables 1 and 2.

Question 1. Prior to the modification of the BFD bunker gear policy in August 2000, what was the rate of heat stress related injuries that occurred on the fireground? During the period from January 1996 through July 2000, 9.4 percent (556) of the reported injuries related to heat stress (Table 1). Annually, the year 1996 (the first year of mandatory bunker gear) had the

highest rate of heat stress (15.7 percent) of all years studied. Conversely, 1996 had the lowest total number of injuries of all years studied (BFD, 2002). Interestingly, the USFA (1999) reported that "firefighter injuries trended down by 12 percent" (p. 8) in 1996. Heat stress injuries rose to 13.1 percent in the 8 months prior to the bunker gear modification in August 2000. There were also 31 heart attacks (1.5 percent) in the 19 months preceding the policy change (BFD, 2002).

Question 2. Has the rate of heat stress related injuries occurring on the fireground been reduced since the implementation of the modified bunker gear policy? No, during the period from August 2000 through August 2002, 12.0 percent (297) of the reported injuries were related to heat stress (Table 2). This is an increase of 2.6 percent from the period before the policy change.

Question 3. Has the injury rate in any other category increased since the modified bunker gear policy was introduced? During both periods studied, the one constant with the ensemble worn was the coat. Only what was worn below the waist (bunker pants and boots) changed. Thus, the research examined the data that represented those areas of the body that were affected by that part of the ensemble. Comparing Table 1 to Table 2 shows that the rate of injuries to knees and feet increased after the bunker gear policy was modified. The data was not specific about whether any of these injuries were from burns or other thermal insult. The rate of back injuries was included in both Tables as an example of a decrease in injuries after the policy modification. This could be possibly attributed to better stability and balance without bunker pants (Adams, 2000).

Table 1
Injury Data--Before Modified Bunker Gear Policy

Body Part Injured	Period from 1/1/1996 through 8/02/2000	
	Number	Percent
Back	831	14.1
Hips/Pelvis	108	1.8
Legs (exc. Knees)	130	2.2
Knees	542	9.2
Ankles	210	3.6
Feet	141	2.4
Toes	23	0.4
Heart	35	0.6
Multiple Injuries	556	9.4
TOTAL INJURIES	5889	100%

Note: Certain categories (head, eyes, face, etc.) that are obviously not affected by bunker gear were not included. Thus, the percentages and totals do not add up to 100 percent.

Table 2
Injury Data--After Modified Bunker Gear Policy

Body Part Injured	Period from 8/03/2000 through 8/31/2000	
	Number	Percent
Back	339	13.7
Hips/Pelvis	37	1.5
Legs (exc. Knees)	52	2.1
Knees	252	10.2
Ankles	89	3.6
Feet	95	3.8
Toes	9	0.4
Heart	46	1.9
Multiple Injuries	297	12.0
TOTAL INJURIES	2469	100%

Note: Certain categories (head, eyes, face, etc.) that are obviously not affected by bunker gear were not included. Thus, the percentages and totals do not add up to 100 percent.

Question 4. What actions are now required of the BFD to ensure optimum safety for its firefighting force? It is clear that heat stress injuries are occurring in the BFD at a rate above 10 percent (Table 2). Shorter work cycles, aggressive on-scene rehabilitation, and pre-incident hydration will have a direct and immediate impact on firefighters (Davis, 1995; Malley, 1998; PFD, n.d.). Raising the awareness level among firefighters as to the benefits of fitness as a way to better tolerate heat stress (P.O. Davis, personal communication, August 19, 2002). BFD should conduct training for firefighters in heat stress related topics such as recognizing the signs and symptoms of heat related illnesses (Shults, Noonan, Turner & Ronk, 1992). "Too much time has evolved since Project FIRES. There needs to be another study of bunker gear and SCBA modeled after Project FIRES" (L.D. Stapleton, personal communication, August 27, 2002).

Interview Results

The benefits to the research project that the interviews provided were significant. Being able to discuss bunker gear issues with both pioneers and visionaries contributed valuable insight to the results of this research. Two interviewees were participants in the Project FIRES study. One represented the Boston Fire Department (L.D. Stapleton, personal communication, August 27, 2002); the other represented the Phoenix Fire Department (B. Varner, personal communication, August 30, 2002). Although they represented two different environments, they agreed that heat stress was a major concern from the start and that there needs to be a Project FIRES II.

The BFD Commissioner/Chief of Department, who ultimately made the decision to modify the bunker gear policy, was very straightforward in asking, "How many firefighters are we willing to sacrifice with heart attacks in order to save one from fatal burns?" (P.A. Christian, personal communication, August 28, 2002). He credited BFDs fireground tactics and staffing with virtually eliminating flashovers from BFDs fire problem. The BFD Medical Examiner who examines every injured BFD firefighter was also interviewed. He stated that BFD members are at risk from bunker gear. He questioned, however, whether it was "the bunker gear or the conditioning of firefighters" (M.G. Hamrock, personal communication, July 31, 2002) that was the cause?

Since the NFPA is the organization that issues the most widely recognized consensus standard on protective clothing (NFPA Standard 1971), it made sense to contact Bruce Teele and Stephen Foley of the NFPA and discuss bunker gear and its contribution to heat stress. Since there have been major changes to the standard on PPE, including the addition of a total heat loss test requirement, a current member of the NFPA 1971 technical committee was also interviewed. In that he was from Phoenix, he contributed greatly to the research on heat stress tolerance.

Three researchers who have conducted studies on bunker gear, heat stress, and their effects on firefighter performance were interviewed. These studies were part of the literature review for this project. Their scientific expertise led to a better understanding of ensemble testing and the role of fitness in a firefighter's ability to tolerate heat. Dr. David Prezant commented very openly on the success of the FDNY bunker gear program in reducing injuries to its members.

The member in charge of implementing a bunker gear program for the Chicago Fire Department (CFD) was interviewed. CFD has become notable for resisting the change to bunker gear until this year. Finally, a nationally recognized fire service liability attorney was contacted for his opinions on mandating bunker gear. He contributed to a better understanding of the liability issue in non-compliance with consensus standards such as NFPA 1971. He warned, "Ignore it at your legal peril" (N. Rossman, personal communication, August 29, 2002). The credentials and comments of each interviewee are listed in Appendix A.

In summary, the results of this research has shown that prior to August 2000, there were a significant number (9.4 percent) of injuries attributed to heat stress from bunker gear (Table 1); injuries related to heat stress to BFD firefighters have not decreased since the modification of the

bunker gear policy in August 2000 (Table 2); there has been a slight increase in two categories of injuries since the policy change occurred. Whether this is due to the change cannot be accurately determined. The research has identified a number of actions that BFD may take to ensure the future health and safety of its members, especially in regards to heat stress tolerance.

DISCUSSION

It is generally accepted that bunker gear causes heat stress (Lawson, 1998; McDowell, 1993; Smith et al., 1992). Wearing firefighter's protective clothing can cause "significant thermoregulatory and cardiovascular stress to the wearer, even at low to moderate work intensities in a neutral environment" (White et al., 1989, p. 1119). Research data shows that nearly 10 percent of the reported injuries of BFD prior to the modified bunker gear policy were attributed to the heat stress caused by bunker gear (BFD, 2002). This same data also shows that the rate of heat stress injuries from bunker gear did not decrease after the bunker gear policy was modified to allow for 3/4 boots or work shoes and FR pants to be worn in place of bunker pants. Table 2 shows this increase. Also evident when Table 2 is compared to Table 1 is that hip and back injuries decreased after the policy change. This may have been due to better stability and balance without the bunker pants (Adams, 2000). There were increased injury rates for feet and knees. There was no data to show any impact on burn injuries.

There is much to discuss about what can be done by BFD to ensure optimum safety for its firefighters. Reducing heat stress in whatever ways possible must be the top priority. Schoondermark (2001) proposed developing improved bunker gear, which releases more heat from the inside to the outside. Teele (1999) contends, "Heat stress can not be addressed only by the garment but must be approached from several factors that equally affect it. The total factors affecting stress and heat stress must be evaluated including firefighters' age, physical condition, individual metabolism; as well as how firefighters are managed during incident operations…" (p. 4). Firefighters who responded to the World Trade Center on September 11, 2001 stressed that bunker gear "must be practical enough in its design and the demands it places on its users to make it possible for them to do their jobs effectively on a day-to-day basis" (Rand Science and Technology Policy Institute, 2002). NIOSH (2000), in one particular fatality report, recommends lighter weight PPE to reduce the physical demands placed on firefighters.

What a firefighter wears under bunker gear must be addressed. Wearing a completely fire resistant (FR) station uniform will greatly improve the TPP of the full ensemble but not without significant added weight and loss of mobility (Jarboe, 1997). His study, to determine the combined TPP of turnout gear worn with a station uniform underneath, found that the average TPP could be over 81. This is over twice the TPP required by NFPA Standard 1971. With this extra protection from a flashover comes the extra weight of the garment, increased sweating from exertion, reduced breathability due to the extra clothing layers, and a higher level of fatigue and heat stress. "Fire chiefs must weigh the benefit of reduced heat stress and lower TPP against higher heat stress potential and higher TPP" (Jarboe).

Cotton shorts under bunker gear have been shown to be beneficial to firefighters in regards to heat stress tolerance. Prezant et al. (2002) demonstrated that shorts under full bunker gear provided more comfort and tolerance to heat stress than a station uniform. Shorts also improved work capacity and provided better ergonomics to the wearer.

Fitness is by far the best way to develop a tolerance for the heat stress caused by bunker gear (P.O. Davis, personal communication, August 19, 2002). Gavhed and Holmer (1989) studied firefighters and their physiological responses while exercising in the heat. They concluded:

> Heat tolerance may be achieved by heat acclimation and may be further increased by physical training. Physical training in itself may to some extent improve heat tolerance as endurance-type physical training enhances sweating and improves cardiovascular functions, which are of great value for heat tolerance. (p. 115 and p. 120)

Current research indicates that aerobic training can increase the efficiency, effectiveness, and absolute capacity of the body's cooling mechanisms (Malley, 1998). When Dr. Hamrock (personal communication, July 31, 2002) spoke of wanting to increase the fitness level of the BFD, he was referring to the organizational level. This requires a successful fitness program within the department. In the video *Managing Heat Stress in the Fire Service* (PFD, n.d.), one of the key components of any heat stress management program was a strength and fitness program, with organizational support from the top. Dr. Hamrock encouraged the adoption of the IAFF/IAFC Wellness-Fitness Initiative within BFD.

The research conducted for this project included the examination of 130 NIOSH fatality reports (NIOSH, 2002) released from 1984 through 2000. Cardiovascular was listed as the cause of death in 44 of these reports. One particular study (NIOSH, 1998) cites cardiovascular stress from wearing firefighter protective gear in its discussion of causal factors. In 41 of those 44 fatality reports, NIOSH recommended that the department initiate a wellness/fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity. This recommendation may seem like an understatement at first. However, what it is saying is that, of the 44 firefighters who died of job-related injuries caused by cardiovascular disease, the fire departments of 41 of those firefighters chose not to actively promote fitness in the workplace. The fact that so many fireground cardiovascular related fatalities occur in departments that do not have wellness-fitness programs is testimony to the benefits of a fit department.

In response to ongoing concerns about heat stress and its relationship to bunker gear, BFD has issued a revised SOP 58 (Appendix C) that includes new information on the use and care of each member's bunker gear. In July 2002, BFD issued a Special Order (Appendix B) that eliminated one of the approved ensembles, authorized the use of cotton shorts under bunker pants, and set forth revised guidelines for the modified bunker gear policy. BFD is also actively searching for new PPE that will reduce the heat stress it causes to firefighters. One option being explored is bunker gear conforming to the international standard EN 469 rather than NFPA 1971.

There are four organizational implications for the BFD as a result of this research. First, it has listened to the firefighters. It recognized that there was (and still is) a high level of heat stress related injuries occurring. BFD acted out of concern for those unable to tolerate the heat stress. It acknowledges the high average age of the department of 45 (BFD, 2002) and the resultant fitness level. Secondly, the modified policy was a result of a joint labor/management process. It is expected that this joint process will enable the initiation of a Wellness-Fitness program within the department. Thirdly, the relentless search for better bunker gear has been recognized as an ongoing program. Forcing the manufacturers to do more to solve the heat stress problem will benefit the entire fire service. Finally, as a result of this research, BFD sees the importance of collecting injury data for statistical analysis. Factual representation of what causes the injuries is vitally important.

RECOMMENDATIONS

The results of this research clearly show that there needs to be more progress made towards reducing the occurrence of heat stress related injuries. In order to effectively address this problem, the following recommendations should be carefully considered.

BFD needs to continuously search for better and more technologically advanced bunker gear. Studies and standards will drive the continued development of firefighter clothing with improvements that will provide greater protection and comfort (Stull, 2001). NFPA 1851 (2001) recommends, "organizations continuously review and document how their specifications and ensembles and ensemble elements meet there needs and applicable standards" (p. 1851-17). BFD should investigate DuPont's new "smart" fiber, part of the Nomex Omega® system (Campbell, 1998; Dahl, 1998).

BFD should carefully review the evaluations of the various BFD ensembles by Dr. Richard Gonzalez (2002). The test data and burn injury predictions provided by DuPont following the Thermo-Man® tests (DuPont Advanced Fibers System, 2002) require careful analysis. A shorter coat with less weight and less mobility impairment should be offered to those who wear bunker pants.

A training program should be implemented that focuses on heat stress recognition, as recommended in the new NFPA 1584 (NFPA, in press), and other key areas, such as hydration and rehabilitation. Similar training for command officers should include topics such as the benefits of shorter work cycles (Beckett, Davis, Vroman, Nadig & Fortney, 1986) and the decision-making impairment that is brought about by increased core temperature and dehydration (Bove, 2002; Lawson, 1996; Malley, 1996).

BFD needs to follow the recommendations of NIOSH (2002) and Hamrock (personal communication, July 31, 2002) to implement a wellness-fitness initiative such as that of the IAFF (2000). While many firefighters may think that they get plenty of exercise at fires and other incidents, the daily exertion of responding to incidents is not enough (Law, 2000). Melius (1995) strongly recommends "medical programs that include appropriate screening for

cardiovascular disease risk factors…as well as programs to help firefighters maintain good physical fitness" (p. 825).

BFD must also institute a procedure for compiling injury statistics for future analysis. The lack of specific injury data was an impediment to this research and will continue to be unless rectified. The resources to enter injury data into a medical database should be provided to the Medical Examiners office. This is a basic necessity for any risk management program.

Recommendations for the future include the development of a selectively permeable membrane (Campbell, 1996; R.R. Gonzalez, personal communication, August 7, 2002) and new studies of bunker gear and SCBA technology in the spirit of Project FIRES.

It is important to remember that, although bunker gear gets blamed for causing heat stress in firefighters, fitness, age, hydration, acclimatization, and a host of other factors contribute to the fatigue equation. Bunker gear protects firefighters from numerous catastrophic fireground hazards. Just because it's the last thing to enter the equation, don't blame bunker gear for the entire problem (D.J. Prezant, personal communication, September 16, 2002).

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Appendix A

Interviews

Paul A. Christian
Boston Fire Department (BFD)
Fire Commissioner/Chief of Department
Instituted the modified bunker gear policy.

Interviewed: August 28, 2002
Boston, MA
30 minutes

Question 1. Was the BFD bunker gear manufacturer asked to conduct any research to solve the problem of high heat stress and mobility limitations? No.

Question 2. Since the first purchase of bunker gear in 1995, how has the bunker gear been improved to account for changes in protective clothing technology and the changing needs of firefighters? The outer shell is now Delta T® rip stop, whereas before it was Nomex® Delta T. The moisture barrier is now Cross-Tech for blood borne pathogen protection. The face cloth on the thermal barrier is a smoother material for greater ease of mobility. And we've added pockets to the pants.

Question 3. Who is monitoring the program? The BFD/Local 718 joint safety committee. Two years ago, with the rise in complaints of heat stress, BFD started looking at alternatives. Securitech® (brand) was evaluated with mixed reviews. We're now considering PPE that meets the requirements of EN 469, the worldwide standard. That bunker gear is lightweight. This will allow us to configure the ensemble that meets our needs. Our fire problem does not include flashovers because of the way we fight fires. We do early and aggressive venting. Our engine companies and ladder companies coordinate their attack. The average age of our department is 45 years old. Heart attacks are what are killing us, not burns. "How many firefighters are we willing to sacrifice with heart attacks in order to save one from fatal burns?"

Interviews

Paul O. Davis, Ph.D.
President, On-Target Communications
Founder of Firefighter Combat Challenge
Fitness and exercise physiology expert
Author and researcher

Interviewed: August 19, 2002
By telephone
20 minutes

Question 1. Does bunker gear cause heat stress? Yes, all bunker gear will cause some heat stress. Heat cannot be totally dissipated out of the bunker gear. The fitness of the wearer is the key. There's an irony to the safety aspect of bunker gear versus heat stress. We create an environment inside bunker gear to protect against the outer environment. This, by design, keeps the wearer's environment inside. Again, fitness is the key.

Dr. Davis referred me to some of his many past articles and reports in physiology journals. He went on to discuss other aspects of bunker gear and heat stress. He noted that aggressive fireground tactics mandate state-of-the-art PPE.

Question 2. What actions can a fire department take to protect its firefighters from heat stress? Fitness. It's all about fitness. "Bunker gear is about as good as it's going to get. It's a mistaken belief that the gear is causing the problem."

Interviews

Stephen N. Foley
National Fire Protection Association
Senior Fire Service Specialist
Public Fire Protection Division
Executive Secretary of NFPA Fire Service Section
Staff Liaison to NFPA 1500, NFPA 1971, and others.
Author

Interviewed: August 13, 2002
Quincy, MA
30 minutes

Question 1. What studies do you know of that indicate that bunker gear is too stressful? None that I know of.

Question 2. Why are firefighters naturally resistant to bunker gear? They are cumbersome and ill fitting. There is a lack of education on the need for a high level of protection. There is the lack of understanding about the "system approach" to bunker gear.

Question 3. What do you think is the most influential factor in a firefighter's resistance to wearing bunker gear? Heat stress. Today's environment of firefighting causes a high level of heat stress.

Question 4. What should be done to decrease the heat stress to firefighters caused by bunker gear? Improve the fabric. Make it lighter yet with the same TPP. Educate firefighters on the limits of PPE. "Fitness is a personal choice until it affects the rest of your company." Use better rehab procedures. Configure and design PPE with flexibility in mind. Give every firefighter two sets of bunker gear and enforce alternating between the two sets.

Mr. Foley also provided an advance copy of NFPA 1584--Recommended practice on firefighter rehabilitation and the latest revision of NFPA 1582--Standard on occupational medical programs for fire departments. Both were helpful to the research project.

Interviews

Richard R. Gonzalez, Ph.D.
Chief, Biophysics and Biomedical Modeling Division
U.S. Army Medical Research & Materiel Command
Natick Soldier Center (NSC)

Interviewed: August 7, 2002
Natick, MA
90 minutes

At this interview, Dr. Gonzalez and William E. Haskell, the technical program development manager for the Center, discussed the evaluations of BFD bunker gear ensembles that were tested using the DuPont Thermo-Man®. The NSC derived heat transfer coefficients for the three ensembles tested and developed predictive modeling of physiological results. The three ensembles were also subjected to flame burn tests using the Thermo-Man®. They explained the tests, the results, and made some professional observations on the bunker gear options. Data from the testing and evaluation was made available to the applied research project.

Dr. Gonzalez and Mr. Haskell provided an abundant amount of reference material to the research project. This led to more studies, journal reports, and experts in the field of heat stress and bunker gear. Thank you.

Interviews

Michael G. Hamrock, M.D.
Boston Fire Department (BFD)
Medical Examiner/Director, BFD Medical Section
Former Boston firefighter

Interviewed: July 31, 2002
Boston, MA
30 minutes

Dr. Hamrock's position as Medical Examiner affords him the opportunity to examine all injured firefighters. He places them on injured leave and determines their ability to return to duty (in conjunction with their personal physician). He advocates a mandatory fitness program and annual physicals for all firefighters. He spoke candidly during our conversation about heat stress and bunker gear. He questions whether it is the bunker gear or the conditioning of the firefighters that is causing the injuries. He acknowledged, "Our members are at risk from bunker gear." He notes that many of the orthopedic injuries are due to the limited mobility of the bunker gear.

He stated that our members are required to perform like professional athletes but firefighters are not afforded the opportunity to stretch out or warm-up before each performance. "Nor can they retire at age 35." He recommended that BFD follow OSHA fitness standards and NFPA 1500. He also supports the adoption of the IAFF Wellness/Fitness program.

Interviews

David J. Prezant, M.D.
Fire Department of New York (FDNY)
Physician--Montefiore Medical Center, Bronx, NY
Deputy Chief Medical Officer-FDNY
Author and researcher of bunker gear

Interviewed: September 16, 2002
By telephone
30 minutes

Question 1. What are the debilitating effects of bunker gear that impact the performance of firefighters? I've written many articles on the subject. I discuss burns and heat stress and how fitness, hydration (both pre- and post-), rotation of companies, etc.

Question 2. How does age and fitness level affect the impact of heat stress on a firefighter in full bunker gear? Yes it does in many ways. I don't want to put a particular age on it but I will say that any analysis as to what puts people over the edge, the straw that breaks the camel's back, whether it's an MI, heat stress, dehydration, etc., if the bunker gear tips you over, it gets blamed. It's a myopic approach.

Question 3. What do you recommend that a fire department do to reduce the effects of heat stress caused by bunker gear while maintaining an optimum level of safety for its firefighting force? I recommend shorts be worn under the pants. They improve flexibility greatly. Our studies with FDNY show an 80 percent reduction of burns with full bunker gear. We also found that there was no increase in MIs or cardiovascular events among firefighters. The occasional one may be caused by other factors. You have to view the problem in the context of how many burns you have. Any serious burn (one that requires any sort of grafting) is not only debilitating and painful for the firefighter but also could cost millions of dollars in hospital care per year for rehabilitation.

Dr. Prezant went on to compare the optional use of bunker gear, knowing the hazards encountered, to making the evacuation of a building optional knowing that it's about to collapse. He recommended a lower TPP for firefighters on ladder companies. His studies have noted fewer burns on members of ladder companies. Conversely, firefighters on engine companies need a higher level of leg protection.

He concluded by relating his first-hand experience with bunker gear. He first tried bunker gear and found it heavy and recommended to the firefighters around him, "Let's just make it lighter." But then they put an SCBA on him. He found that heavy. His immediate reaction was to say, "It's not the bunker gear. It's the SCBA that affects firefighters performance. Make the SCBA lighter." Then they gave him the tools that they have to carry. He said, "It's the tools. Make them lighter." He summarized that we have to look at the whole equation. We naturally want to get rid of the last thing that's come along. Firefighters have been wearing SCBAs longer than they've been wearing bunker gear. He advises us not to blame the last thing to come on the scene as the cause of a problem that has many factors.

Interviews

Kevin M. Roche
Phoenix Fire Department (PFD)
Resource Management Administrator
Protective Clothing and Equipment Specialist
Member NFPA Technical Committee on Protective Ensemble for Structural Fire Fighting--NFPA 1971

Interviewed: September 6, 2002
Phoenix, AZ
20 minutes

Question 1. What about heat stress injuries in PFD? Do they occur? No, they are extremely rare. The secret is short work cycles and a rehabilitation culture.

Question 2. What can be done with future bunker gear to reduce heat stress? Improve the breathability of the vapor barrier. Phoenix uses lighter fabric in the outer shell of the pants (6.0-oz/sq yd), except in the knees. The coat uses 7.5-oz/sq yd. They also issue Warrington leather work boots.

Question 3. What makes the PFD firefighters readily accept bunker gear? When it was introduced in 1985, they resisted it. But now, for most of the department, bunker gear is all they've known. It also has a lot to do with their wellness/fitness program, regular medical exams, and acclimatization.

Interviews

Neil Rossman
Rossman, Rossman & Eschelbacher
Attorney
Member NFPA Technical Committee on Fire Department Occupational Safety and Health Program--NFPA 1500
Fire service liability expert

Interviewed: August 29, 2002
By telephone
15 minutes

Question 1. If I'm ordered to wear full bunker gear and I get injured because of it, is the department or city liable? No, the fellow servant rule would apply. But the spouse could.

Question 2. If I'm allowed not to wear it and get injured because I chose not to, is the department or city liable? No, it was your choice.

Question 3. Do OSHA standards apply to firefighters in a non-OSHA State? Yes they can.

Question 4. Do NFPA standards compel a fire department to follow that standard if they don't adopt it? No, it's only a consensus standard. But, it can be used as evidence. So "ignore it at your legal peril."

Interviews

Michael Scianna
Chicago Fire Department (CFD)
Commander, Bureau of Operations
Protective Clothing and Equipment Specialist

Interviewed: August 25, 2002
By telephone
20 minutes

Question 1. What is the status of bunker gear in the CFD? It's in the request for proposal stage. We will be evaluating many manufacturers and conducting field tests.

Question 2. Why has CFD resisted bunker gear up to this point? Tradition. It was hard to let go of the past. Cost was also a factor. We have 4200 people to outfit at a cost of about $13 million.

Question 3. What is your biggest concern about going to full bunker gear? It's the need for formal rehabilitation at incidents. We plan on changing our tactics to include fans for cooling. We also intend to formally train the wearers to look for signs of heat stress.

Question 4. What options, if any, will you give your members regarding what they wear and when? Bunker gear will only be optional at EMS calls. However our gear will be biohazard compliant.

Question 5. What about heat stress? We'll manage it through rehab and training.

Question 6. You haven't mentioned fitness. Why? In CFD, it's hard to implement any fitness awareness. The department has supplied weights and exercise cycles. We are granted a one hour exercise period every shift and there are handball courts in some firehouses.

Interviews

Leo D. Stapleton
Boston Fire Department (BFD)
Former Fire Commissioner/Chief of Department
Former member Project FIRES Committee
Author, visionary, pioneer

Interviewed: August 27, 2002
By telephone
30 minutes

Question 1. What was your involvement with Project FIRES? Involved from the start in 1976. The SCBA project was done and it was now on to Project Fires.

Question 2. Was your interest in just SCBA or did you get involved with the development of bunker gear? I was involved with the bunker gear portion of the project even though I was not dissatisfied with the bunker gear of that time. My interest was in better foot protection, improvements in firefighter personal lights, and better communication capabilities and portable radios.

Question 3. Was heat stress a concern from the start? Yes, there was a great deal of testing done by Dr. John Clougherty, the BFD chemist at the time, and Harvard University. These "Harvard Studies" never recorded temperatures over 200°F around the firefighter. By then, "the firefighter got out." There was a significant amount of influence by the manufacturers on the committee. Boston, New York and Chicago was against the end result, "but it was a committee."

Question 4. Do you believe that not accepting the SCBAs that the manufacturers presented as "the best we can do" led to the development of better SCBA equipment and improvements? The success with the SCBA project was because they listened to the firefighters. When testing and evaluating any firefighter equipment, it is very important to pay attention to what the firefighter tells you. Use your leverage with the manufacturers to your advantage. Improvements come from listening to firefighters.

Former Commissioner Stapleton also spoke of early tests of bunker gear with FDNY Squad 1. "They were young, enthusiastic and they wanted it to work." He mentioned that, in his opinion, the best outcomes of the project were the long wristlets on the coat and better gloves. He suggested that it should be the government doing the studies not the manufacturers. He also stated that too much time has evolved since Project FIRES. Their needs to be another study done on bunker gear and SCBA.

Interviews

Bruce W. Teele
National Fire Protection Association
Senior Fire Service Safety Specialist
Staff Liaison to NFPA 1500 and NFPA 1971
Author
Interviewed: August 13, 2002
Quincy, MA
20 minutes

A general discussion ensued about the effects that bunker gear causes. We discussed heat stress being caused by bunker gear. He also spoke of the significant protection from serious burns provided by bunker gear. We discussed a recent fire in Massachusetts in which two firefighters were involved in a flashover and escaped with only minor burns.

Question 1. Does bunker gear contribute to firefighter injuries? If bunker gear contributes to injuries, at least they are survivable injuries.

Question 2. What can be done to protect firefighters from heat stress rather than not requiring full bunker gear? Use ICS and provide for effective firefighter rehabilitation.

Interviews

Bruce Varner
Carrollton (TX) Fire Department
Fire Chief (former Asst. Chief Phoenix Fire Dept.)
Former member of Project FIRES committee
Past-Member NFPA Technical Committee on Protective Ensemble for Structural Fire Fighting--NFPA 1971

Interviewed: August 30, 2002
By telephone
30 minutes

Question 1. What was your involvement with Project FIRES? Represented Phoenix Fire Department. Had previously seen firefighters who had received severe burns from wearing "hopsack" pants and had seen many burn injuries due to wearing 3/4 rubber boots.

Question 2. What made bunker gear accepted in Phoenix in the beginning? Given to chief officers first to "lead by example." All had used "night hitches" previously. They were issued in January during cooler weather. Everyone was trained to recognized signs of heat stress. Active on-scene rehabilitation was provided from the start.

Question 3. Was the synergistic ensemble approach of Project FIRES the best solution? It was the best at the time, given the materials that were available. I recommend another Project FIRES-type study.

Question 4. Were protective clothing manufacturers too influential in Project FIRES? No, there was a balanced approach.

Question 5. How do you reduce heat stress and still adequately protect your firefighters? Through aggressive rehabilitation, better design of PPE, use sector officers as the eyes and ears of the Incident Commander, proper reports on conditions from the interior. "Reading" the heat with hands and ears is not necessarily the best way.

Appendix B

SPECIAL ORDER **JULY 24, 2002**
No. 22

From: Chiefs of Operations

To: Deputy Fire Chiefs, All Divisions

Subject: **I. BUNKER GEAR**

Effective with this order, the Boston Fire Department will implement the following policy relative to the use of Bunker Gear during periods of high temperature and humidity. This policy is based on the recommendation of the joint BFD/Local 718 Safety Committee. Members may choose from the following fire fighting ensemble options:

1. Bunker Coat, Bunker Pant, Bunker Boot

2. Bunker Coat, FR Pant, Approved Safety Work Boot (steel shank/steel toe)

3. Bunker Coat, FR Pant, 3/4 Fire Boot

Members who choose to wear option 1 may purchase 100 percent cotton navy blue shorts. Shorts will be hemmed no more than one inch above the knee. Members wearing shorts must don Bunker Pants before responding, or leaving quarters for any reason. Chief Officers and Company Officers will be held strictly accountable for the compliance of members Bunker Gear Ensemble Options. Members electing options 2 or 3 shall carry their Bunker Pants on apparatus during their tour of duty.

Incident Commanders may use their discretion to order full Bunker Gear ensembles at incidents.

The Boston Fire Department, as part of a continuing commitment to the health and safety of its firefighters, and after much consideration and review of the use of the full Bunker Gear ensemble and related injuries, has determined that the use of such gear, while providing a high degree of protection against the effects of fire, may pose health and safety hazards to firefighters. Firefighters who have experienced discomfort in the form of high physical stress due to high body heat and difficulty of motion while using the full Bunker Gear ensemble may choose from the above options.

The Boston Fire Department is not abandoning Bunker Gear policy, but considers temporary implementation of these options as progressive until a full evaluation can be made of the potential long-term health problems associated with such usage. The department will continue its program of evaluating and researching all new developments in this area.

The department will monitor this program closely to determine if such policy is contributing to the health and safety of Boston Firefighters. The type, frequency and severity of injury will be studied.

All Form 5Ds submitted will specify which ensemble option number was being worn at the time of injury.

This policy change is possible because of the high caliber response capabilities of the Boston Fire Department, particularly in interior fire fighting. Namely, the rapid response of an adequate number of properly staffed and trained units, capable of rapid deployment, properly placed hose streams of sufficient volume and number, and prompt and thorough ventilation, in effect, taking measures that minimize the likelihood of backdraft or flashover.

This policy position is intended only for the Boston Fire Department and is not a recommendation to other fire service organizations.

Members are encouraged to make suggestions, comments, etc., on a Form 5A and send it to Deputy Chief David Granara, Training Division.

Per Order:

Kevin J. Mochen
Chief of Operations
Field Operations

William F. Hitchcock
Chief of Operations
Support Operations

Appendix C

Standard Operating Procedure #58 (Revised April 22, 2002)

Personal Protective Clothing

1. Scope

The following procedures governing Personal Protective Clothing are established for the guidance of members of the Boston Fire Department.

2. Purpose

The purpose of this SOP is to establish guidelines for the use and maintenance of Personal Protective Clothing, particularly Bunker Gear.

3. Personal Protective Clothing

Personal Protective Clothing refers to the following various components of protective gear that, in combination, provide complete thermal and physical protection to the wearer. To effectively provide the desired level of protection, all elements **must** be in place.

- Bunker Gear (Turnout Coat and Pants)
- Bunker Boots
- Station Work Uniform
- Gloves
- Helmet

4. Bunker Gear--Overview

Bunker Gear is an important part of the PPE and, when worn in conjunction with station uniform, will provide superior thermal protection.

A. Protective Rating

Properly used and maintained Bunker Gear affords a limited period of protection to exit an area that has become, or is about to become, untenable due to heat. It is not a close proximity suit. All protective clothing has an assigned Thermal Protective Performance (TPP) rating as mandated by the National Fire Protection Association (NFPA). The Bunker Gear provided has a TPP of 40, or 47 when worn with the station work uniform.

B. Bunker Gear is Comprised of Three Layers:

1. **Outer shell:** The outer shell forms the exterior barrier between the firefighter and the environment, creating a flame and heat resistant barrier that also protects the moisture barrier and thermal liner from physical damage. The outer shell on our Bunker Gear is Nomex Delta "T", which is a blend of 75 percent Nomex, 23 percent Kevlar, and 2 percent P140 which is an anti-static feature.

2. **Moisture barrier:** The moisture barrier membrane, Tetratex, is waterproof but breathable, allowing water vapor and some excess body heat to escape while preventing moisture from entering from the outside through the clothing.

3. **Thermal liner:** The thermal liner is constructed from an inherently non-flammable thermal felt, quilted to a Nomex FR Viscose cloth. The Thermal liner shall be permanently attached to the outer shell of both coat and pants.

5. Bunker Gear Use Guidelines

A. All members will be issued two (2) sets of Bunker Gear.

B. For identification, all members shall mark their Bunker Gear using indelible marker with their last name and the last four digits of their social security number.
- Bunker coats shall be marked on the inside on the label under the collar.
- Bunker pants shall be marked on the label inside.

C. Responding From Quarters

Response Situation	**Members Shall:**
Reported Structural Fire or Transmitted Box Alarm	Don all Personal Protective Clothing prior to responding
Reported Non-Structural Fire (outside, auto, dumpster, etc)	Don all Personal Protective Clothing prior to responding
Emergency Scene (auto accident, gas leak, alarm investigation, etc.)	Don all Personal Protective Clothing prior to responding
EMS Activities	Bunker Gear not required, but take all universal EMS precautions
Apparatus Chauffeurs	Not required to wear Bunker Gear while driving apparatus, but shall don all Personal Protective Clothing prior to engaging in any firefighting or rescue work.

D. Responding From Out of Quarters

1. Bunker Gear must be carried on the apparatus and be available for immediate donning at all times.

2. When responding to an incident from out of quarters, members shall follow the above guidelines.

3. When notified to respond to an incident requiring all protective equipment to be worn, the officer shall direct the chauffeur to stop the apparatus. When all members have donned all personal protective clothing, then the apparatus may respond to the alarm.

4. Wearing of Bunker Gear is not required while members are out of quarters for any reason not related to fire or emergency duty.

E. Operating at Fires and Emergencies

1. Members must be constantly aware of the fire environment to detect elevated heat levels. The practice of carefully removing a glove and cautiously raising the hand is time proven and can be used to detect dangerously high temperatures.

2. Wet Bunker Gear transmits heat to the wearer more readily than when dry. Trapped moisture (even perspiration) reduces thermal insulating ability and can turn into steam, which can burn the wearer.

3. When Bunker Gear becomes wet, the wearer shall rotate into his/her alternate set of Bunker Gear and dry the wet set. Wet Bunker Gear must not be machine dried, but should be hung and allowed to air dry, out of direct sunlight.

F. Operational Considerations

1. The Incident Commander may authorize the removal of the bunker coat during overhauling operations when he/she determines removal would not jeopardize injury to a member.

2. The Incident Commander may authorize the removal of the bunker pants during long standing brush fires, provided the member is wearing FR cotton station work uniform pants, when he/she determines that such removal would not jeopardize any member to an injury.

3. Firefighters wearing Bunker Gear retain more body heat and are subjected to heat stress and exhaustion. Incident commanders, Company Commanders and members shall be watchful for signs of fatigue or heat stress in members and shall:
   a. Be keenly aware of the need for relief of units that have been engaged in firefighting operations.
   b. Monitor members under their command and ensure that they receive appropriate rehabilitation when needed.
   c. Enforce the Standby Company rule to ensure that enough relief will be available to rotate members needing rehabilitation.

d. Consider calling additional units or transmitting additional alarms to allow for early rotation of fatigued units.
e. Be aware that a debilitating buildup of heat from a series of minor incidents may occur.
f. Ensure that the Boston EMS has an ambulance standing by when conditions dictate that members could be affected by heat stress.

6. Bunker Gear Care Guidelines

A. Inspection

Bunker Gear shall be regularly inspected to check for tears and rips at the seams.

B. Contamination

Bunker Gear that is contaminated shall be left at the incident. The Incident Commander shall call for W-12 to deliver jump suits to the scene for the firefighters to wear until arrival back at quarters. The Training Division shall be contacted to issue a loaner set of Bunker Gear.

Bio-hazards: Bunker Gear that has been exposed to blood or bodily fluids will be bagged in red bio-hazard bags which shall be carried on the apparatus and on W-25. The laundry section will be notified for pick-up and laundering.

Haz-Mat: Bunker Gear that has been exposed to hazardous materials will be left on scene. The Haz-Mat officer, Haz-Mat team leader or department chemist on scene will determine if the Bunker Gear can be cleaned professionally or condemned. Bunker Gear that has been exposed to hazardous materials will not be sent to the laundry section for cleaning.

C. Repair

Any Bunker Gear that needs repair shall be turned into the Training Division, while a loaner set issued to the firefighter. The officer in charge of clothing will be responsible for the inspection of all ripped or damaged Bunker Gear to determine if Bunker Gear will be repaired or replaced.

D. Cleaning and Laundering

Bunker Gear shall be kept clean. Dirty Bunker Gear absorbs more heat, lessening the degree of protection and possibly causing the gear to ignite. Firefighter clothing is often contaminated with hydrocarbons produced by the fires they are exposed to every day, which are flammable and therefore a health hazard.

1. A Laundry Section has been set up in the Training Division and will be under the direction of the Deputy Chief in charge of the Training Division.

2. The Company Commander shall ensure that all Bunker Gear is kept clean. Records shall be kept by the Company Captain to ensure that every member's Bunker Gear (two sets) is laundered at least every six months, or more often if needed, depending on the exposure. Ideally, these launderings will be done when the member is on vacation. A member going on vacation shall place his/her Bunker Gear in company laundry bags provided for pick up.

3. The Laundry Section will be responsible for the pick-up, laundering and delivery of all Bunker Gear and will report to the officer in charge of clothing.

4. When Bunker Gear has been washed and dried, it will be returned to the company in time for use by the member returning from vacation. The on duty company officer or senior man will sign for receipt of the gear.

Bunker Gear will be laundered using biodegradable detergent purchased for this purpose.