

TURNOUT GEAR MAINTENANCE PROGRAM

Evaluation of Turnout Gear Maintenance Program for the Oshkosh Fire Department

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and the appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The problem was the Oshkosh Fire Department does not have a comprehensive turnout gear maintenance and a replacement cycle program. The purpose was to research the components of comprehensive turnout gear maintenance and develop a draft program for maintenance and a replacement cycle of turnout gear. An action research approach was utilized to answer six research questions and create a draft standard operating policy. The questions that were answered were what maintenance and replacement was needed, and who should perform it, the type of testing indicated, and the budget impacts that a turnout gear maintenance program would have. The literature review and interviews identified what type of turnout gear maintenance was needed, and what type of a program that should be implemented. It was found that advanced inspection and testing needed to be implemented for turnout gear. Training will be provided to all members on how to perform routine inspection of turnout gear. It was indicated a review of how basic repairs are currently being provided was needed, and who should perform the advanced repairs. Training will be provided for routine cleaning and advanced cleaning, to assure they are being performed appropriately. A draft standard operating policy was created and recommended for implementation. The maintenance program was recommended to be implemented over a two year period.

Introduction

Turnout gear is a fire fighter's first line of protection from heat, smoke, toxic gases and now blood borne pathogens. The Oshkosh Fire Department (OFD) has performed annual testing and maintenance on a yearly basis at minimum of hose, ladders, breathing apparatus, and fire apparatus for decades. However, the fire fighter's first line of protection does not see the same attention. A personal observation that was made was the turnout gear of the OFD appeared to be dirty and degraded in comparison to other departments of similar size and larger.

The problem is the Oshkosh Fire Department does not have a comprehensive turnout gear maintenance and a replacement cycle program, thus placing firefighters at possible risk for serious injury or death.

The purpose is to research the components of comprehensive turnout gear maintenance in order to develop a draft program for maintenance and a replacement cycle of turnout gear for the OFD. Turnout gear for structural fire fighting will be the focus of this applied research project (ARP). For the purpose of this ARP, turnout gear will refer to the coat and trouser garment of the fire fighters turnout gear ensemble.

The action research approach has been selected to answer the following six questions: (a) what maintenance and replacement cycle is required for turnout gear, (b) who should perform maintenance on turnout gear, (c) how does turnout gear maintenance impact the life expectancy, (d) what type of testing is recommended or required for turnout gear, (e) what are the budget impacts of a comprehensive maintenance and replacement cycle program, and (f) what components should a draft standard operating policy (SOP) include for a comprehensive turnout gear maintenance program.

Background and Significance

The OFD responds to all fire and medical calls in the City of Oshkosh from six stations utilizing four engine companies, two quint companies, one rescue company, three ambulances and a command officer. The OFD has 104 personnel assigned to the operations division, assigned to three shifts with a minimum staffing of 27. Those 104 personnel responded to 1,071 calls in 2007 not including medical calls. The calls that fire fighters responded to that would require donning of turnout gear were, 217 fire calls, 8 rupture/explosions, 223 hazardous conditions, 109 service calls, and 172 good intent calls, and 342 false calls (Oshkosh Fire Department [OFD], 2007). On average, each fire fighter responded to 896 calls that required the donning of turnout gear. Each fire fighter performs, on an average, three hours of practical fire fighting training per month which requires them to don turnout gear (OFD, 2007). Some fire fighters will also wear turnout gear on the occasional cold day during the winter months on medical calls. The amount of times turnout gear is being worn by the members of the OFD may have an impact on the replacement cycle, and may need to be replaced at greater frequency than recommended.

The OFD currently has a standard operating policy (SOP) on maintenance of turnout gear. The SOP gives guidance to the firefighters how to wash their turnout gear twice a year and that it is inspected once a year by their supervisor (OFD, 2007). In the SOP there is no mention of maintenance, testing, cycle of replacement nor the qualifications or requirements of any of the personnel performing any of the functions. The OFD has not yet sustained a serious injury or death as a result of turnout gear program or failure. However with the increasing amount of incidents and training that each fire fighter's turnout gear is exposed to, and without having inspection, maintenance and replacement identified, the potential of a serious injury or death

exists currently and in the future. Without a turnout gear maintenance program in place, fire fighters may also be at increased risk of cancer in the future from continuous exposure to carcinogens trapped in turnout gear (Drainville, 2002; Jorgenson, 2002 & 2005). This ARP will also discuss the budgetary impact that a comprehensive maintenance and replacement cycle program may pose on the OFD with the future budget having only a 2.3% increase for 2009 (City of Oshkosh, 2009).

One of the objectives listed in the Executive Development student manual is “describe the role of the Executive Fire Officer (EFO) as change agent, in terms of the adaptive model” (Department of Homeland Security, 2006 p. SM 3-1). The action research method has been selected for this ARP in order to change the process on how care and maintenance of turnout gear is handled. In order to make this change occur within the OFD, the change model of analysis, planning, implementation, and evaluation (APIE) will be used. This ARP will provide the analysis and a draft SOP will be created from this ARP to assist with the planning and implementation. An evaluation of the effectiveness of the program will follow the implementation.

This ARP relates to one of the United States Fire Administrations (USFA) Operational Objectives, which is, “reduce the loss of life from fire-related hazards, particularly among these target audiences: 14 years and younger age group, 65 years and older age group, and firefighters” (USFA, 2003). This ARP will focus on the target audience of firefighters. This ARP will provide the OFD with a SOP that will assure the readiness of the turnout gear when it is exposed to an environment of heat, smoke, toxic gases, and blood borne pathogens. The goal is the protection of firefighters from injury or death that may have occurred with turnout gear that was not at its highest level of readiness.

Literature Review

The National Fire Protection Association (NFPA) reported injuries from burns 2002 8.5 percent (Karter & Molis, 2003), 2003 10.6 percent (Karter & Molis, 2004), 2004 7.8 percent (Karter & Molis, 2005), 2005 9.2 percent (Karter & Molis, 2006), and 2006 5.9 percent (Karter & Molis, 2007). This averaged out over the past five years to 8.4 percent between 2002 through 2007. Very few injuries that were reported to the National Fire Incident Reporting System (NFIRS) that reported problems with fire fighting turnout gear. Only 7 percent indicated turnout gear failures as a factor in the injury. Turnout coats and firefighter gloves with wristlets accounted for 25 percent of equipment problems. Modern equipment and equipment standards, combined with current equipment replacement cycles, may preclude protective equipment failures (USFA, 2004).

According to USFA (1998-2007), burns attributed to 31 firefighter's deaths in structural fire fighting. Only one incident had turnout gear listed as a potential cause, but the cause was listed as undetermined, and the turnout gear was sent to the manufacturer.

In reviewing the National Institute of Safety and Health (NIOSH) (1988-2008) firefighter death and injury reports, it was found nine firefighter's cause of death were from burns, burns were the secondary cause of death for 10 firefighters, and three firefighters were injured from burns. Turnout gear integrity was not listed as either the cause of death or injury. Replacement, inspection or cleaning was not listed in any of the recommendations where burns were listed as cause of death or injury.

It has been recognized for many years that proper maintenance of turnout gear needed to be accomplished to assure full benefit to the fire fighter and obtain the full life expectancy. Manufacturers have been doing an excellent job of making high quality of turnout gear. Even

the highest quality of turnout without maintenance will become unusable before its full life expectancy is seen. With a tight budget, maintenance of turnout gear can stretch the life expectancy (Schenck, 2003).

In industry a personal protective equipment program can be one of the easiest safety and health program a company can implement and maintain, but also can be one of the most beneficial (Heinlein, 2001). Even the purchasing of the highest quality of PPE can waste time and money if the equipment is not maintained or worn properly. It can only provide protection if it's maintained properly, in good condition, suitable for the task in hand, and properly fits the user. Training needs to cover how to recognize faults with the equipment, and not to use faulty items. More importantly it is critical for users to report defects with PPE and the process for doing so (Anonymous, 2006).

Drainville (2005) recommends the two primary purposes that inspection provides are to help ensure firefighter's turnout gear will provide its designated protection, and to document the service and wear life characteristics of the departments turnout gear. Information obtained from inspection could be beneficial to assist in the replacement cycle and also justification to the budgetary process of increasing or decreasing the purchase cycle.

Inspection can be broken down into two categories: routine and advanced (Haskett, 2002). The routine inspection should occur when turnout gear is first purchased and issued, on a monthly basis, after cleaning, after contamination, and following any repairs (Drainville, 2005). The routine inspection has three components, outer shell, moisture barrier, and thermal liner (Reed, 2003). Routine inspections should be performed by each member (Haskett, 2002). NFPA 1851 (2008) states turnout gear shall be inspected for soiling, contamination, physical

damage, damaged or missing reflective trim, loss of seam integrity and broken or missing stitches, and correct assembly and size compatibility of shell, liner and drag rescue device.

Haskett (2002) states trained personnel within the department should perform advanced inspections. National Fire Protection Association (NFPA) 1851 (2008) states the advanced inspection shall be performed by trained personnel within the department or by an independent service provider (ISP). These inspections shall occur once a year or sooner if routine inspections indicate (Haskett, 2002; NFPA 1851, 2008). The manufacturer of the turnout gear and or the ISP with the department shall determine the level of training required for the inspection. The advanced inspection should be in addition to the areas covered in the routine inspection. The advanced inspection includes a system fit/overlap, material integrity, including wristlets, loss of moisture barrier integrity, label integrity, hook & loop functionality, liner attachment systems, closure system functionality, and accessories (NFPA 1851, 2008).

In the construction industry webbing used for fall arrest system is susceptible to UV light damage and it can drastically reduce the strength. It is recommended that a visual inspection of the webbing is performed by properly qualified personnel (Ellis, 2002).

Repairs are broken down into two parts, basic repair and advance repair. The manufacturer, an ISP or an organization member trained by the manufacturer or an ISP can perform basic repair. Basic repairs are limited to the outer shell of the turnout gear.

Advanced repairs can be performed by the manufacturer, an ISP or a verified fire department (NFPA 1851, 2008). Advanced repairs are to larger areas than mentioned in the basic repairs, and can also perform repairs to the liner.

Proper storage of turnout gear can increase the life of turnout gear, maintain performance, and reduce the potential health risks. “UV light degradation, especially from sunlight, is the

prime cause of ‘unknown’ personal protective equipment failure.” Improper storage can be broken down into five areas: Storage in direct sunlight, wet or moist turnout gear, extreme temperatures, abrasive environments, in contact with hydrocarbons and vapors from hydrocarbons, storage in living quarters, and in the turnout pants in the collapsed position. (Drainville, 2005 p.20).

Hard hats used in the construction industry are susceptible to affects of ultraviolet light affects like turnout gear by deteriorating the outside shell. It is important that hard hats are not stored in direct sunlight. They also should be replaced every ten years. Most employers in the construction industry replace them every five years (Bacon, 2001).

On average each fire fighter on the OFD responded to 896 calls that required the donning of turnout gear. Each fire fighter performs on average three hours of practical fire fighting training per month that requires them to don turnout gear (OFD, 2007). Disposal or retirement of turnout gear shall be ten years after the manufacture date. Turnout gear beyond ten years can be used for non-live fire training, but needs to be marked as such. All other turnout gear needs to be disposed of in a manner to assure it would not be used for any fire fighting or emergencies actives, including live fire training (NFPA 1851, 2008).

The lack of having a replacement cycle affected petroleum tenninal workers. They were using gloves to protect themselves from gasoline and they were not replacing them until they became torn or the cloth backing was showing through the outer nitrile layer. The gloves were used so long t the workers and managers did not realize exposure to gasoline could be occurring. The PPE was worn so long because of frugality of and being unfamiliar with how protective materials work (Calmbacher, 1993).

The attitude of cleaning turnout gear has been an upward battle for the fire service over the years. “Don’t clean my gear! I don’t want to look like a rookie who has never been in a fire. That dirt is my badge of honor” (Haskett, 2002 p. 64).

The importance of maintaining the cleanliness of ensembles and ensemble elements should not be underestimated. Soiled or contaminated ensembles and ensemble elements are a hazard to firefighters because soils and contaminants can be flammable, toxic, or carcinogenic. Additionally, soiled or contaminated ensembles and ensemble elements can have reduced protective performance. Clean elements offer the emergency responder better protection and can add to the life of the elements. Elements should, therefore, be cleaned whenever they have become soiled (NFPA 1851, 2008 A.7.1.1).

There are a several reasons why turnout gear should be cleaned. Soiled turnout gear reflects less heat, the unburned products of combustion that saturate the turnout gear may allow it to become combustible or flammable, and turnout gear heavily contaminated with hydrocarbons can conduct electricity (Drainville, 2002; Jorgenson, 2005).

Along with the potential issues just mentioned, contaminated turnout gear has long term exposure to the firefighter wearing the turnout gear. Firefighters contaminated turnout gear can expose firefighters to life threatening chemicals, biological particulate matter, and cancer causing carcinogens (Jorgenson, 2002 & 2005). According to Schenck (2003) the “dirt” may consist of; acrylonitrile, pentane, acrolein, methacrolein, hexane, croton aldehyde, benzene, toluene, octane, 2-furfural, ethyle benzene, M/p xylene, ortho xylene, nonene, benzaldehyde, M-dichlorobenzene, limonene, PCB’s, PNA’s, chlorobenzene, polystyrene, polycarbonates, furan, dimethylfuran, fufural, styrene, n.butane, freon, PVC, and polyurethane. Chemicals can enter the body by ingestion, inhalation, and/or absorption (Drainville, 2002). Another concern is children.

With their inquisitive natures it would be not uncommon to see a child get right into some turnout gear and end up covered in dirt from it.

They may perceive this as a “badge of honor”. Extra caution needs to be exercised with the public and children to assure they are not exposed to dirty turnout gear (Haskett, 2002).

Cleaning falls into three types: routine, advanced and specialized. Routine cleaning can begin on the emergency scene or shortly after returning to the station. Advanced cleaning shall be provided twice a year if the turnout gear is soiled, or routine cleaning fails to get the turnout gear clean. Specialized cleaning is used to remove hazardous materials or biological agents (Haskett, 2002).

Barker, Bender, Fowler, and Song (1999) found that washing caused the apparent evaporative resistance of different types of turnout gear to decrease. Apparent evaporative resistance “is an indicator of the resistance of a fabric to transport heat and moisture while in contact with a wet, heated plate surface.” This study indicated that as turnout gear is washed, it loses its breathability to release the moisture that builds up on the inside potentially causing increased heat stress on the firefighter.

Testing of turnout gear is mentioned in NFPA 1971 for the construction of turnout gear. However these tests are destructive in nature, which renders the turnout gear to be out of service. Since inspection only views the visible degradation and NFPA 1971 and 1851 do not indicate quantitative description of what degradation is, quantitative analysis would be beneficial (Thorpe, 2004). Since there are three layers to turnout gear, each layer essentially could undergo its own test. According to Thorpe (2004) he states all turnout does not allow for the separation and removal of all layers. His study would focus on tests that would be performed to the outer

shell and the inner surface of the thermal liner. The inner liner only exhibited minimal damage, so his study focused on four different non-destructive tests of the outer layer.

As Thorpe (2004 p.131) indicates “more work is required to verify whether fade caused by sunlight and laundering has the same performance implications as the colour fade caused by purely radiative thermal exposure as tested in this research.”

Thorpe (2004) performed non-destructive testing on the outer shell of turnout gear, however the moisture barrier is the part of the ensemble that is subject to more NFPA tests and requirements than either the outer shell or the thermal liner. Mann (2001) stated the moisture barrier is designed to protect against many hazards faced by firefighters, however they can't feel it, touch it, or even know its there.

The moisture barrier is the most fragile protective component in turnout gear (International Association of Fire Fighters [IAFF], 1999). There are three tests that can be performed on the liner. These tests are the light test, leakage evaluation, and water penetration barrier evaluation.

For the light test, the liner should be removed from the garment if possible. The inner liner needs to be turned inside out so the thermal liner is on the outside. A light is used on the moisture barrier side, and the amount of light is examined coming through the thermal barrier (NFPA 1851, 2008).

For the leakage evaluation the moisture barrier should be removed if possible and placed over a 5-gallon bucket. This test is only performed on a liner every year for the first two years of service after its manufacture date. The inner liner shall not be turned inside out as performed in the light test. Combining 1 part rubbing alcohol with 6 parts of tap water shall make an alcohol tap water mix. The liner should be evaluated on the high abrasion areas like the shoulder area,

back and waist, knees, crotch area, and seat area. If any leak through is noticed the garment shall be taken out of service and repaired or replaced (NFPA 1851, 2008).

The International Association of Firefighters (IAFF) posted an article on their web page on December 15th, 1999 in response to the issues that were occurring with the BREATHE-TEX® brand moisture barriers. Leakage evaluation was one of the recommendations to perform that was mentioned in a joint statement that was released on November 15th, 1999, by the manufacturers of Body-Guard (Lion Apparel), Cairns Protective Clothing (Globe), Fire-Dex, Fire-Gear (Securitex), Globe firefighter Suits, Jainesville (Lion Apparel), Quaker Safety, and Securitex Brands. According to IAFF (1999), “spot checking with ½ cup of water demonstrates nothing, except when the product fails this simplistic test.” This was in comparison to the full shower test that is performed by the manufacturer to determine compliance of NFPA 1971.

An evaluation apparatus is utilized to perform the water penetration test. This will help in further evaluations. Similar to the leakage evaluation, at minimum three moisture barrier materials and three moisture barrier materials with a seam shall be evaluated. The liner should be evaluated on the high abrasion areas like the shoulder area, back and waist, knees, crotch area, and seat area. If any leak through is noticed the garment shall be taken out of service and repaired or replaced (NFPA 1851, 2008).

In summary reviewing all the injuries and deaths attributed to burns, only one had turnout gear listed as a potential factor. Less than 10 percent of burns reported listed turnout gear as contributing factor to the burns. In all of the NIOSH reports reviewed replacement, inspection, or cleaning were not mentioned as a recommendation. However, these reports do not address increase cancer or heat stress risk from degraded gear. They are limited to injuries and deaths closely related to fire ground events.

In the past years only limited tests have been performed on the separate turnout gear layers, but not as a whole garment. The inspection process is relied upon since advanced non-destructive and cost effective tests for turnout gear have not been developed.

Care and maintenance of turnout gear, is more in depth than just washing turnout gear twice a year, fixing the holes, and replacing it when the department feels its necessary. Without a maintenance program including inspection, repair, and washing of turnout gear, it may place fire fighters at risk of injury or death from burns or exposure to carcinogens. A maintenance program can also increase the life expectancy of the turnout gear protecting the investment of the department.

Procedures

Action research was used to solve the current problem of the OFD not having a comprehensive maintenance and turnout gear replacement program. From the research preformed a draft policy (Appendix A) will be created to address the current issues of the OFD not having a comprehensive maintenance and turnout gear replacement program. A literature review was performed by researching professional journals and publications from the Learning Resource Center (LRC) at the NFA, Internet sources were queried for on-line articles, and papers, and NFPA standards were used to perform the comprehensive literature review. Incident reports, training records, and SOP's, from the OFD were also reviewed. The USFA and NIOSH web pages were reviewed for fire fighter injuries and death from burns, to determine if there was any correlation between maintenance of turnout gear and firefighter deaths and injuries from burns. Parallel organizations were also researched from the University of Wisconsin-Oshkosh Polk Library.

The author attended a course delivered by C. Moelker from Globe Manufacturing Company, LLC on September 29, 2008 at the Ripon Fire Department on advanced cleaning and inspection (Appendix B). The reason this course was selected was the NFPA standard had been released within the last year and other than the standard itself, additional information was difficult to find.

An interview was performed with Tim Franz, Fire Chief, Oshkosh Fire Department on October 9, 2008 in his office in Oshkosh (Appendix B). This interview was selected to determine the budgetary situation of the OFD. A turnout gear maintenance program may have some budgetary impacts, and may restrict full implementation.

An interview was performed with Jon Fenrich, Battalion Chief in charge of protective equipment, Oshkosh Fire Department on October 9, 2008 in his office in Oshkosh (Appendix B). This interview was used to determine what type of maintenance program was in place at the OFD and what impact it might have on the current process. Also input was received on what he felt needed to be included in the program and draft SOP.

An interview was performed with Andy Oliver owner of GearWash on October 8, 2008 in Milwaukee at his company (Appendix B). He was selected by recommendation of Chris Moelker from Globe Manufacturing, LLC. Mr. Oliver is one of the few verified ISP in the mid-west and has a great deal of knowledge and experience in maintenance of turnout gear.

A phone interview was performed with Joel Sprahota of Rennert's Fire Equipment on November 3, 2008 (Appendix B). This interview was performed to determine if turnout gear purchased from his company had accommodations to facilitate the NFPA 1851 (2008) inspections and older turnout gear could be retrofitted.

To determine if there was any correlation between maintenance of turnout gear and deaths and burns, NFPA, NIOSH, and USFA reports were reviewed. Injury reports from the NFPA for the years 2002 through 2007 were accessed on the web page. The NIOSH web page was accessed to review investigative reports of firefighter injury and deaths from 1984 through 2007. The USFA web page was accessed to review the *Fire-Related Firefighter Injuries for 2004*. The USFA was contacted by email to have a report sent on firefighter injuries. A report was sent for the years of 1998 through 2007.

When looking at answering the first question about maintenance and replacement cycle requirements for turnout gear, maintenance was broken down into three parts: inspection, cleaning, and repairing. NFPA 1851 *Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting* was reviewed. Articles in professional journals and the Internet that had information on maintenance of turnout gear were reviewed. Most of the articles reviewed contained information about inspection and cleaning, but very little information about repair. The NFPA 1851 did provide the foundation, but the professional journals and the Internet provided a lot of the evidence why maintenance was important.

NFPA 1851 did have a required time frame that turnout gear can be utilized past its manufacture date, however this is the maximum in-service time but does not take into consideration how the use, maintenance and repair of turnout gear affects its service expectancy. The OFD incident and training records were reviewed to determine if turnout gear would last the full life expectancy or would the use experienced by the OFD reduce the life expectancy. Parallel organizations were researched to determine if maintenance and replacement were an issue with them. It was recommended in parallel organizations that a maintenance program and replacement cycles be in place for their PPE.

When answering the second question, who should perform maintenance of turnout gear, NFPA 1851 had information on the requirements and training needed to perform the maintenance. Professional journals were reviewed to determine how departments were performing the maintenance, and only one article found indicated trained members of the fire department could perform the inspection and cleaning portion of the maintenance, but it was not mentioned how to receive the training. All of the other articles echoed the NFPA 1851 standard, that is, who should the department have performing the inspection, cleaning and repairs. It was determined either an ISP, manufacturer, or verified fire department, but did not mention how the training levels are provided.

To find more information on what training is needed the author attended a course delivered by C. Moelker from Globe Manufacturing Company, LLC on September 29, 2008 at the Ripon Fire Department on advanced cleaning and inspection. The reason this course was selected was the NFPA standard had been released within the last year and other than the standard itself, additional information was difficult to find. At the completion of the course a person would be certified to perform routine and advanced inspection of turnout gear for their organization. Information was also provided on who can perform repairs on turnout gear and what requirements must be achieved for that ability. To determine what requirements are needed to become a verified department or an ISP, an interview with A.Oliver (personal communication, September 20, 2008).

When answering the third question, how does turnout gear maintenance impact the life expectancy, few articles indicated it should increase with maintenance. There was research completed by the National Fire Protection Research Foundation on laundering of turnout gear. It

was found, the more time's turnout gear was laundered, the more the breathability of the moisture barrier was reduced.

During an interview with A. Oliver (personal communication, September 20, 2008), in his experience maintenance does increase the life expectancy of turnout gear.

The fourth question, what type of testing is recommended or required for turnout gear was answered by reviewing a thesis paper on non-destructive testing of turnout gear. NFPA 1971 was mentioned in the thesis paper, however NFPA 1971 deals directly with destructive testing on new materials. There were four different tests performed on the outer layer of turnout gear. The first two tests did not produce the results needed. The last two tests did indicate degradation, but would be difficult to determine if it came from washing and ultraviolet exposure or radiant heat exposure. The testing process mentioned in the research paper was limited to the outer layer of the turnout gear and did not provide any testing of the moisture barrier or thermal barrier.

NFPA 1851, professional journals and the Internet indicated the use of three tests, the light test, leakage evaluation test and the water penetration test. All of the three tests focus on the moisture barrier. The water penetration test and a basic test to the outer shell were demonstrated to the author during an interview with A. Oliver (personal communication, September 20, 2008). During the course the author attended provided by C. Moelker of Globe Manufacturing Company, LLC on September 29, 2008 the light test was demonstrated and there was a basic test that could be performed on the outer shell.

To answer the fifth question, what are the budget impacts of a comprehensive maintenance and replacement cycle program? The Fire Chief of the OFD was interviewed first to determine what impact to the budget if any would an increase of inspections, repairs, and

replacement have. The Battalion Chief in charge of protective equipment was interviewed to see how an increase in workload would affect his division by adding an advanced inspection to all of the turnout gear the OFD maintains, and what his recommendations would be to implement a new program. Also, there was discussion on how the current procedures of repairs are handled and would a new vendor need to be explored.

To answer the sixth question, what components should a standard operating policy (SOP) include for a comprehensive turnout gear maintenance program? A review of the NFPA 1851 (2008) standard was performed to determine what areas and frequencies needed to be focused on for maintenance. An interview was performed with the Battalion Chief in charge of protective equipment. This person is responsible for any policy change and program implementation for the OFD. A phone interview was performed with the supplier of turnout gear for the OFD to determine if the turnout gear they provide the OFD has any accommodations for the advanced inspection, and if they could retrofit the current turnout gear they provided the OFD. Information was also obtained from the course the author attended and the conversation with the presenter after the course was completed.

One of the limitations found was the reporting of injuries. Burns was one of the categories for injuries. It indicated turnout gear as a factor, but did not indicate if it was because of the turnout gear itself or because improper use. In reviewing the data from the USFA, not all of the data was present for each event. Another limitation was the information provided for the water penetration test. The 2008 version of NFPA 1851 covers the test, but there was no literature found indicating any advantages or disadvantages. There also was not a lot of literature on how repairs should be performed and who can perform them.

Results

Research Question 1: What maintenance and replacement cycle is required for turnout gear? Maintenance can be broken down into three parts inspection, cleaning, and repairing.

Two types of inspection need to be performed on turnout gear, routine and advanced, and should be performed by each member of the department (Haskett, 2002). The routine inspection should occur when turnout gear is first purchased and issued, on a monthly basis, after cleaning, after contamination, and following any repairs (Drainville, 2005). When performing the routine inspection the outer shell, moisture barrier, and thermal liner need to be inspected (Reed, 2003). NFPA 1851 (2008) states, turnout gear shall be inspected for soiling, contamination, physical damage, damaged or missing reflective trim, loss of seam integrity and broken or missing stitches, and correct assembly and size compatibility or shell, liner and drag rescue device.

Soiling can indicate contamination of the turnout gear with foreign substances that could be flammable, toxic, and/or carcinogenic (Drainville, 2005). Contamination that fire fighters commonly are exposed to and may be present on their turnout gear are; gasoline, tar, insecticides, hydraulic fluid, diesel fuel, paint, creosote, automotive oil, pesticide, mineral spirits, asbestos, and body fluids (Schenck, 2003).

Examples of physical damage would be torn, ripped, cut, abraded or other wise damaged by wear. It also includes discoloration, and char and heat damage (Fire and Safety Blog, 2005). Dye loss can result from heat or chemical exposure. This would present differently than normal fabric fading (Drainville, 2005). Another damage that is often overlooked is UV degradation. This can occur from improper storage of turnout gear. Storage of turnout gear should be in a place that it is not in contact with UV light. This includes having it in the ready position by fire apparatus with overhead doors open. According to A. Oliver (personal communication, October

9, 2008) he stated, he has seen turnout gear destroyed from ultraviolet light in three years from storage of turnout gear by fire apparatus with the overhead door open. According to C. A. Moelker (personal communication, September 29, 2008) he has seen turnout gear damaged when firefighters have stored their turnout gear inside of their vehicles. Even though it is inside, ultraviolet light still penetrates the windows and damages the turnout gear.

Turnout gear reflective trim needs to be inspected for looseness and for burns. There also needs to be a “flashlight” test performed on the trim. Standing forty feet from the reflective trim with a flashlight, and comparing the brightness to a new piece of reflective trim performs the flashlight test. If the reflective light is substantially less than the new trim, the trim must be replaced (Fire and Safety Blog, 2005). Seams and threads need to be inspected for skipped, broken, or missing stitches. This inspection needs to be completed to all layers (Drainville, 2005).

Correct assembly and size compatibility of shell, liner, and drag rescue device (DRD). This part of the inspection is to assure that shells and liners have not been interchanged, and are not improperly fitting. Also the DRD has to be intact, and able to function so it does not bind with the liner C.A. Moelker (personal communication, September 29, 2008).

When the routine inspection is completed, it should be graded as new or as-new condition, good condition, maintenance needed, or immediate replacement (Drainville, 2005; Haskett, 2002).

The advanced inspection should be in addition to the areas covered in the routine inspection, and shall occur once a year or sooner if routine inspections indicate (Haskett, 2002; NFPA 1851 2008). The advanced inspection includes a system fit/overlap, material integrity,

including wristlets, loss of moisture barrier integrity, label integrity, hook & loop functionality, liner attachment systems, closure system functionality, and accessories.

When everything fits, the coat should overlap the front of the trousers by 4 inches and 8 inches in back. When bent over at the waist it should overlap 2 inches in the front and 4 inches in the back C.A. Moelker (personal communication, September 29, 2008).

Material integrity needs to be assessed for more than just noticing the presence of physical damage. An assessment needs to be performed on the outer layer if it appears to be discolored or weakened. This can be accomplished by using a pen without the ink cartridge engaged. Scrape underneath the discolored or weakened area of the outer shell to see if weakness is noticed by breaking through the material C. A. Moelker (personal communication, September 29, 2008). A quarter inch nut driver for its blunt tip can also be used in place of a pen A. Oliver (personal communication, October 9, 2008).

Moisture barrier integrity can be determined by stretching the moisture barrier with your hands to see if there is any compromise of the material can test physical damage, loss of seam strength, and material strength. Bubbling of the moisture barrier is an indication of delamination. This is usually caused from burning or chemical exposure. C.A. Moelker (personal communication, September 29, 2008). Discoloring of the moisture barrier also indicates heat exposure. According to A. Oliver (personal communication, October 9, 2008), if discoloring of the moisture barrier is present and the moisture barrier passes the rest of the advanced inspection, he will perform a light test and a hydrostatic test. If the moisture barrier passes the light test and the hydrostatic test, he will allow it to be used with the recommendation that it is inspected after each time the garment is exposed to heat.

Another part of the moisture barrier integrity is to access the area between the moisture barrier and the thermal layer. Separating the liner and turning it inside out with the use of the inspection port is how it is performed. Inspection ports are provided on most garments manufactured to meet the NFPA 1851 2008 edition. If the garment does not have an inspection port an opening can be made at the edge of the garment. On the coat, the opening is usually placed on the bottom where the moisture barrier and the thermal liner are sewn together. On the trousers it is around the waist where the moisture barrier and the thermal liner are sewn together. Individuals able to perform basic repairs of turnout gear can close these openings.

During a phone interview with the turnout gear supplier for the OFD, recently ordered turnout gear would have inspection ports. The company will also be checking with the manufacture to determine if the older style gear can be retrofitted to facilitate the advanced inspection (J. Sprahota, personal communication, November 3, 2008).

Label integrity is to assure the label is attached and the manufacture date is present. If the label is missing or unreadable, this usually indicates the garment is past its life expectancy of ten years. Hook & Loop functionality, liner attachment systems, closure system functionality, and accessories are inspected to be present and functioning C.A. Moelker (personal communication, September 29, 2008).

Currently the OFD performs routine inspections on a yearly basis. There would need to be some training provided so the routine inspection would meet the recommended criteria. The advanced inspection would be an added component. There would need to be training provided to an individual(s) to perform or outsource the service to an ISP.

Cleaning the turnout gear can reduce the risk of long term exposure to life threatening chemicals, biological particulate matter, and cancer causing carcinogens (Jorgenson, 2002

&2005). Soiled turnout gear is full of unburned products of combustion and may allow the turnout gear to become combustible or flammable. Soiled turnout gear also reflects less heat and can conduct electricity (Drainville, 2002; Jorgenson, 2005). Another reason turnout gear needs to be kept clean is to avoid the public and children from being exposed to dirty turnout gear, during presentations (Haskett, 2002).

Cleaning falls into three types: routine, advanced and specialized. An individual removing loose debris with a soft brush can accomplish routine cleaning. Other debris can be removed by rinsing it off gently with a water hose. Routine cleaning can begin on the emergency scene or shortly after returning to the station. This may prove to be difficult in cold climates. There is another concern, if debris is rinsed off the turnout gear, the turnout gear would be wet for the remainder of the shift increasing cold emergencies and possibly steam burns.

Advanced cleaning shall be provided twice a year if the turnout gear is soiled, or routine cleaning fails to get the turnout gear clean. The water used in the washing process should not exceed 105 degree Fahrenheit. Washing gear in water with a temperature higher than 105 may shrink and/or damage the gear. The spin cycle of the washer should not be any faster than 100G force A. Oliver (personal communication, October 9, 2008). Wash machines designed for cleaning of turnout should be used to assure the gear is not damaged. Using a top-loading home-style washer can abrade the shell and damage the turnout gear (Redler, 2005).

After the turnout gear has been cleaned, the drying process shall follow the manufacturers instructions that were provided with the turnout gear. If the manufacturer does not provide any direction, it shall be placed in an area with good ventilation and not in direct sunlight (NFPA 1851, 2008).

Specialized cleaning is used to remove hazardous materials or biological agents (Haskett, 2002). According to A. Oliver (personal communication, October 9, 2008), the most common specialize cleaning on turnout he performs is to remove hydrocarbons like diesel fuel, oils and gasoline.

Routine cleaning is currently in SOP 308.00, but will need to be reinforced it is performed after every incident when indicated. Advanced cleaning of turnout gear is being performed, however the machine used will need to be evaluated to determine if the G force is less than 100. Also the detergent that is used for cleaning will need to be evaluated to determine if it falls within manufacturers recommendations. Specialized cleaning will need to be something to look into, since there currently is no way of performing in house. In the past, and prior to specialized cleaning practices, turn out gear needed to be destroyed if it became contaminated. Repairs are broken down into two parts, basic repair and advanced repair. The manufacturer, an ISP or an organization member trained by the manufacturer or an ISP can perform basic repair. Basic repairs are limited to the outer shell of the turnout gear. When repairs are made to the outer shell of the garment, the same fabric, thread, visibility marking, hardware backing and seam construction used for original construction of the garment must be used, and is compliant with NFPA Standard 1971 *Protective Ensembles for Structural Fire Fighting*.

Repair of the outer garment is limited to patch covering damaged area with 5 square inches of fabric. The fabric has to cover the damaged area by 1 inch in all directions and the edges cannot be raw. This is the requirement for the patch on the outer surface. There also needs to be a patch installed on the inside of the garment over the damaged area to prevent it from getting larger A. Oliver (personal communication, October 9, 2008). A person can perform basic

repairs, however it is recommended they work with the turnout gear manufacturer for the gear they are repairing to assure they are using the correct stitching and materials C. A. Moelker (personal communication, September 29, 2008). The visibility marking has to cover the damaged area 1 inch in both directions, and each garment can only have two patches (NFPA 1851, 2008).

The manufacturer, an ISP or a verified fire department can perform advanced repairs. Advanced repairs are to areas larger than the 5 square inch patch considered as a basic repair. An advanced repair also involves repairs to the moisture barrier and thermal liner.

Basic repairs are currently performed by a person who provides the service to the OFD. She has been performing this service for as long as anyone in the department can remember. For advanced repairs, this will need to be outsourced to an ISP or the manufacturer.

Replacement cycle at minimum needs to be ten years after the manufactured date listed the label. Ten years is the maximum time frame turnout gear can be used for structural fire fighting. There are other factors that influence the replacement cycle and that would be the amount of use the turnout gear experiences. Turnout gear being worn for responding to emergencies is an example of wear, but training and cleaning of turnout gear also has an impact on the life expectancy. Repairs can increase the life expectancy of turnout gear. According to J. Fenrich (personal communication October 9, 2008) a set of turnout gear costs the OFD \$1235.00. According to A. Oliver (personal communication, October 9, 2008) after turnout gear reaches three years old, he estimates the yearly cost for repairs to turnout gear to be \$150.00 per garment. This would be \$300.00 for the whole ensemble.

During the course the author attended provided by C. Moelker of Globe Manufacturing Company, LLC on September 29, 2008, a sample calculator for turnout gear repair limits was given. Refer to the following table.

Table A

Sample Calculator for Turnout Gear Repair Limits

Year of Service	Year-of-Service End Date	Amount or Original Cost Cost of Repair (\$1,000.00)	Amount Allowed per Set
1 st year	01/11/05	70%	\$700.00
2 nd year	01/11/04	50%	\$500.00
3 rd year	01/11/03	40%	\$400.00
4 th year	01/11/02	25%	\$250.00
5 th year	01/11/01	20%	\$200.00
6 th year	01/11/00	15%	\$150.00
7 th year	01/11/99	10%	\$100.00
8 th year	01/11/98	5%	\$ 50.00
9 th year	01/11/97	5%	\$ 50.00
10 th year	01/11/96	0%	\$ 0.00

Replacement cycle needs to be less than ten years. The time frame may need to be less, however this information will be obtained after the first advanced inspection is performed.

When comparing the age of the turnout gear to advanced inspection results, this information will be able to assist in determining the replacement cycle. The age of the gear and the results from the advanced inspection will also need to be compared to Table A to determine if repair is indicated or replacement, is the most cost effective measures to take.

Research Question 2: Who should perform maintenance on turnout gear?

To determine what requirements are needed to become a verified department or an ISP, an interview with A. Oliver (personal communication, September 20, 2008) was performed. For his company GearWash to become an ISP it costs \$10,000 per year to become certified by

Intertek/ETL®. He also has to have the approval from all manufacturers (twelve) that he would perform repairs on their turnout gear. Each manufacturer has requirements for this approval. It also takes a minimum of seven sewing machines to perform all repairs of turnout gear, and he has to stock all types of fabric for the outer shell, moisture barrier, thermal barrier, thread and visibility marking. He also stated there is a lot of work to train and maintain his personnel competent with repairs. Manufacturers usually do not like to perform advanced repairs. They are set up for production, not for one garment repairs.

The person who performs basic repairs will need to work with the manufacturer of the turnout gear to assure the process is within their requirements, and to assure the correct fabric, thread and visible marking are being used. It will also need to be communicated what her limitations are for repairs. The advance repair would need to be performed by an ISP or the manufacturer. For the OFD to become verified, it would not be cost affective to maintain that level for the amount of repairs the department would perform.

The advanced inspection is not a difficult task, however can be very time consuming, and may be difficult for the OFD to provide this service internally. There would need to be select individuals performing the advanced inspection since there will be training involved more than what is needed for the routine inspection. Routine and advanced cleaning of turnout gear can be performed internally. Members of the OFD will need to be trained and reminded of the importance of routine cleaning. Training will need to be provided to the individuals performing the advanced cleaning to assure the correct settings on the machine and detergent are used.

The light test and leakage evaluation can be done internally with some training provided. The water penetration test could be done internally if the advanced inspection would be performed internally. The advanced inspection and water penetration could be performed at the

same time. There would need to be a purchase of the apparatus that is used for the water penetration test. The unit needed to perform the water penetration test costs approximately \$600.

Research Question 3: How does turnout gear maintenance impact the life expectancy?

With a tight budget, maintenance of turnout gear can stretch the life expectancy (Schenck, 2003). During an interview with A. Oliver (personal communication, September 20, 2008), in his experience maintenance does increase the life expectancy of turnout gear. Repairs can prolong replacement, however as the turnout gear becomes older he is very cautious to assure the cost of repairs would not be better put towards new gear.

This is where the advanced inspection, light test, water penetration test and the age of the turnout gear will need to be compared. Data gathered over multiple years should be evaluated when making the decision to repair or replace the garment. Caution will need to be exercised not exceed recommendations from Table A, and end up putting money into turnout gear that may be better off being replaced.

Research Question 4: What type of testing is recommended or required for turnout gear?

There are three tests required by (NFPA 1851, 2008), the light test, leakage evaluation, and the penetration test. During the light test the liner should be removed from the garment if possible. The inner liner needs to be turned inside out so the thermal liner is on the outside. A light is used on the moisture barrier side, and the amount of light is examined coming through the thermal barrier. Caution should be taken to assure the light is contained and does not come in contact with the moisture barrier, potentially causing heat damage, and be of size that it will fit inside the sleeves of the liner. At minimum the front and back of each garment should be examined, however specific areas where increased wear may occur should be evaluated. These areas would be the upper back, shoulders, underarms, sleeves, waist area, and crotch area. There

also should be attention to areas of damage and where loss of thermal protection is detected or expected. Areas where light shines through brighter may indicate migrating or shifting of insulation. If any of these mentioned are found an advanced inspection shall be performed (NFPA 1851, 2008).

During the leakage evaluation the moisture barrier should be removed, if possible, and placed over a five-gallon bucket. This test is only performed on a liner every year for the first two years of service after its manufacture date. The inner liner shall not be turned inside out as performed in the light test. Combining 1 part rubbing alcohol with 6 parts of tap water shall make an alcohol tap water mix (NFPA 1851, 2008). Water/alcohol mixture is poured on the cupped moisture barrier side of the liner, and allowed to sit for 3 minutes. The thermal barrier of the liner shall be inspected for leak through after the three minutes. At minimum, the front and the back shall be evaluated in three different areas. The liner should be evaluated on the high abrasion areas like the shoulder area, back and waist, knees, crotch area, and seat area. If any leak through is noticed the garment shall be taken out of service and repaired or replaced (NFPA 1851, 2008).

A majority of turnout gear manufacturers recommend using only water for the leakage evaluation “bucket test” since after this test is performed the turnout gear will need to be laundered to assure the rubbing alcohol has not contaminated the liner C. A. Moelker (personal communication, September 29, 2008).

The penetration test needs to be performed every year after year two from the manufacture date of the turnout gear. A hydrostatic tester performs the penetration test. Currently W. L. Gore & Associates, Inc. is the only manufacturer of this device A. Oliver (personal communication, October 9, 2008). The liner is clamped into the tester with the

moisture barrier side of the liner down towards the water jet. Pressure of one pound per square inch is applied. Evaluation is performed of the thermal barrier to see if leakage is detected. A mark is placed around the inside of the clamp ring with a marker to determine where the test was performed so other areas can be tested in the future.

The tests that need to be performed by the OFD would include the light test, and the hydrostatic test. The leakage test without the addition of alcohol does not meet NFPA 1851, even though most manufacturers do not advise the use of it. The water penetration test needs to be performed on year three from manufacture it could be used for year one and two also.

There are tests to evaluate the outer shell prior to seeing degradation. There were four different non-destructive test methods evaluated, optical microscopy, Raman spectroscopy, digital image analysis and colorimetry. All of these tests used light to look at the changes in the fabric of the outer shell.

The first test was optical microscopy. This test used a microscope to look for fabric degradation not visible to the naked eye. During this test, fabric was exposed to heat and initially a color change was noted of individual strands. As the exposure was increased, fibers began to melt and fuse together forming globules of polymer that were shiny and smooth. It was decided that optical microscopy would not produce quantitative results. The second test, Raman spectroscopy, was found to be very inconsistent. Digital image analysis and colorimetry were used to measure color fade of the material. This would provide an enhanced visual examination that would notice discoloration indicating degradation. The discoloration would be noticed by either method before it becomes visible to the naked eye would (Thorpe, 2004).

There is some work being performed on different types of tests other than the light test, leakage evaluation and water penetration. To date no other testing process has been developed which proves to be beneficial without damaging the turnout gear.

Research Question 5: What are the budget impacts of a comprehensive maintenance and replacement cycle program?

The budgetary issue has multiple components. The first issue was, in 2004 the State of Wisconsin enacted a levy limit tax increase. Municipalities in the State of Wisconsin would be able to raise taxes only 2% or by the growth experienced in new construction. In 2009 the City of Oshkosh would be able to increase taxes 2.3% because of the small growth experienced in the city. The 2.3% could only be applied to the levy, which only makes up 42.2% of the total budget. For the complete budget, because the 2.3% increase can only be applied to the levy limit, the total budget can only be increased .9757%. Any increase to the budget would mean a decrease in other services or programs (City of Oshkosh, 2009).

Another issue is the current turnout gear repairperson for the OFD is elderly, and may not be able to continue to provide these services to the OFD in the near future. When this occurs the OFD will need to look elsewhere for services which will likely end up costing more. The increased inspections will also create a budgetary impact to the OFD. According to an interview with the Battalion Chief in charge of protective equipment (J. Fenrich personal communication October 9, 2008), he currently has the company officers perform a routine inspection once a year and washing of the turnout gear twice a year. To add the advanced inspection would not be able to be performed by the company officers or by him, due to the added workload and the training involved. This would lead to outsourcing the advanced inspection, or bringing a person in to an

administrative position to perform the advanced inspection. Each of these options would be a significant cost to the OFD.

The OFD did receive a budget increase for 2009 in safety equipment of 16%. Replacement of turnout gear, which is a line item in the safety equipment budget, received a 59% increase in budgetary funds for 2009. This will allow a replacement cycle to be created. The increase in funding would be sufficient to purchase new gear for one fifth of the OFD (T. Franz personal communication, October 9, 2008).

Research Question 6: What components should a draft standard operating policy (SOP) include for a comprehensive turnout gear maintenance program?

An interview with the Battalion Chief in charge of protective equipment (J. Fenrich personal communication October 9, 2008) was performed. One of the areas he stated needs to be addressed is the tracking of turnout gear. At this time he does not know how many sets of turnout gear the OFD maintains. The first item that would need to be in the SOP would be a tracking system. The tracking system would assign a number to each garment. This number would be able to track who the garment was assigned to, when it was cleaned, repaired, inspected and tested. Other items that will need to be in the SOP would be the assignment of duties. Who will perform routine, advanced and specialized cleaning, and if any members of the department would perform these tasks training and equipment would also need to be identified. Who will perform routine and advanced inspection of each garment every year, and if any members of the department would perform these tasks training and equipment would need to be identified. The last items of the SOP would be who would perform basic and advanced repairs when needed. A recommended replacement cycle will also be a component of the SOP. A draft SOP was created (Appendix A) with the above recommendations.

Discussion

Even the highest quality of turnout without maintenance will become unusable before its full life expectancy is seen. With a tight budget, maintenance of turnout gear can stretch the life expectancy (Schenck 2003). Maintenance can be broken down into three sections, inspection, cleaning and repairs.

Drainville (2005), the two primary purposes that inspection provides is to help ensure firefighter's turnout gear will provide its designated protection, and to document the service and wear life characteristics of the departments turnout gear. Inspection can be broken down into two categories: routine and advanced (Haskett, 2002). There are a few reasons why turnout gear should be cleaned. Soiled turnout gear reflects less heat, the unburned products of combustion that saturate the turnout gear may allow the gear to become combustible or flammable, and heavily contaminated turnout gear with hydrocarbons can conduct electricity (Drainville, 2002; Jorgenson, 2005). There are three types of cleaning performed, routine, advanced and specialized (Haskett, 2002). Repairs are broken down into two parts, basic repair and advanced repair. The manufacturer, an ISP or an organization member trained by the manufacturer or an ISP can perform basic repair. The manufacturer, an ISP or a verified fire department can perform advanced repairs (NFPA 1851, 2008).

Barker, Bender, Fowler, and Song (1999) found washing could cause the apparent evaporative resistance of different types of turnout gear to decrease. Apparent evaporative resistance "is an indicator of the resistance of a fabric to transport heat and moisture while in contact with a wet, heated plate surface." Washing gear will have a few implications. One could be that as turnout gear is washed, it loses its breathability to release moisture that builds up on the inside, potentially causing increased heat stress on the firefighter. Just the wear and tear on

the turnout gear will require a potential shorter life expectancy. When the gear is in for cleaning, there will be a need for replacement turnout gear for the fire fighter of appropriate size. This issue can be eliminated if each fire fighter had two complete sets of turnout gear.

Testing was outlined by NFPA 1851, (2008) was of three types, light test, leakage evaluation, and water penetration test. These tests were the required tests. There are four other tests performed to the outer shell, as Thorpe (2004 p.131) indicates “more work is required to verify whether fade caused by sunlight and laundering has the same performance implications as the colour fade caused by purely radiative thermal exposure as tested in this research.”

Potential for more testing is out there as mention by testing by fire Mann (2001) asks; Would a moisture barrier be in after subjection to hundreds or even thousands of abrasion cycles where it rubs against the outer shell an thermal liner at the knees, shoulders, elbows, or back? What if it where put through two dozen wash/dry cycles instead of just then mandated by the NFPA standard? Or, if it was flexed and bend over and over and over again in extremes of heat and cold?

With the budget issues the OFD is experiencing this might have an impact on how the turnout gear maintenance program gets started. There has been a 59% increase in the budget for replacement of turnout gear for the fiscal year of 2009. Adding in the maintenance portion of the program, when everyone has relatively newer gear, some of the funds allocated for replacement could be shifted into maintenance to prolong the life expectancy of the turnout gear.

The SOP will be a good addition to the OFD, however a culture change will need to be made within the department. The attitude of cleaning turnout gear has been an upward battle for the fire service over the years. “Don’t clean my gear! I don’t want to look like a rookie who has never been in a fire. That dirt is my badge of honor” (Haskett, 2002 p. 64). A personal

observation was made when a fire fighter was noticed to have heavily soiled gear from a recent fire. When this individual was confronted about his gear, that it should be washed, his reply was “I was going to get to it”. Some of this soil could have been removed from routine cleaning.

When it comes to repairs it will be good to have the person identified who should be performing them. Another observation was during our yearly breathing apparatus competency, an individual was wearing the new turnout gear he was issued. He commented how he was going to have alterations made to collar to be more comfortable. Part of the SOP will need to have training provided to individuals about routine inspection. A personal observation that was made over the past few months as I have been working on this ARP. I have taken a closer look at the condition and age of the turnout gear of the OFD and found items in need of repair and replacement.

There is no documentation of turnout gear maintenance. There is an inspection form that is filled out by the officer performing the inspection. The form is sent into the chief in charge of protective clothing. This is only done to assure an inspection was performed. When looking at the amount of documentation the OFD performs for ladders, hose and breathing apparatus, it is puzzling why we have documentation for all these other areas, but not for something that is responsible for our direct protection from heat, toxic gases, and blood borne pathogens.

Burns are responsible for a small portion of injuries and deaths. For deaths, the burns usually occurred from becoming trapped or disorientated. Looking at care and maintenance from an observational view, it would make someone think since we do have small number of injuries and deaths from burns, that we may be taking the care and maintenance too far. However we cannot place a number on the amount of injuries and deaths prevented by turnout gear in its full state of readiness. Death and injury reports only report fire ground occurrences. There is no

reporting of cancer that was related to carcinogens that were trapped in turnout gear. We do know being exposed to these carcinogens puts a fire fighter at greater risk for cancer.

Recommendations

It was found the OFD had a practice of routine inspection, and advanced cleaning. In the policy it was mentioned about routine cleaning, however it is rarely performed. The draft policy assured these areas follow the NFPA 1851 2008 standard and recommendations found in the literature review. After the author attended the course on advanced inspection and cleaning and the interview with Mr. Oliver, this was what gave the basis for the implementation.

Advanced inspection and testing need to be added to the maintenance program. Cataloging or tracking of the turnout gear will also need to be implemented. Discussion with the fire chief and the battalion chief of protective clothing will need to take place to determine what the best option is with some of the areas, whether to perform the tasks internally or outsource them.

Based on the information gathered in this research the author recommends the implementation to be tiered over two years, with the start date of January 1st 2009. Because of the budgetary impact a two year implementation would be more advantageous for success.

Year One:

- Identify and cataloging all turnout gear owned by the OFD
- Destroy any turnout gear with a manufacture date prior to January 1999.
- Implement draft SOP (Appendix A)
- Train all members of the OFD how to perform basic inspection, basic and advanced cleaning
- Perform advanced inspection on all turnout gear

- Limit repairs to basic by the current provider, any advanced repairs to be done by the manufacturer or an ISP.
- Send out a request for formal proposal for an ISP for basic and advanced repairs.

Year Two:

- Negotiate terms with an ISP for basic and advanced repairs.
- Perform leakage evaluation or water penetration test on all turnout gear
- Implement replacement cycle of five years
- Evaluate storage of turnout gear in stations, in the ready position, and purchase turnout gear bags for each person to transport turnout gear when moving stations.
- Research a selection process for turnout gear

After the first year of implementation an evaluation will need to be performed. With tight budgetary issues experienced by the OFD, some of the recommended changes for year one may need to be moved into year two, or the program may need to be expanded to three years. Issues that could have impact on the success of the program would be the budget or a large incident that would destroy a large amount of gear.

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Appendix A

Draft SOP

- 308.00A SUBJECT: Protective Clothing for Fire Fighting – Maintenance Program
- 308.00B PURPOSE: It is the purpose of this policy to define and establish responsibilities for the cleaning, inspection, and repair of issued protective clothing and equipment.
- 308.00C RESPONSIBILITIES:
- A. It shall be the responsibility of each firefighter, equipment operator, and officer to maintain his/her issued personal protective clothing and equipment to the highest degree of cleanliness and serviceability.
 - B. It shall be the responsibility of each firefighter, equipment operator, and officer to properly mark all their issued protective clothing and equipment with ocean number.
 - C. It shall be the responsibility of each firefighter, equipment operator, and officer to report lost or damaged equipment by E-form to Duty Chief within 24 hours.
 - D. All protective clothing shall be of type and kind issued by the Oshkosh Fire Department. Items shall not be worn that have not been issued by the Oshkosh Fire Department without the Fire Chief's approval.
- 308.00D PROCEDURES: The following procedures shall be followed for cleaning, inspection, and repair of issued protective clothing and equipment.
- I. Cleaning
 - A. Helmets: All components of the helmets should be inspected periodically and following all fires for cleanliness. If dirty, the following procedures shall be followed:
 1. Rinse helmet of all gross dirt and contamination with clear, warm water.
 2. Wash shells with a mild detergent, then rinsed with clear, warm water.
 3. Headband, ear flaps, and suspension should be removed and:
 - a. Hand washed with a liquid mild detergent and thoroughly rinsed with clear, warm water.

- b. For removal of tars, paints, or other stains, contact the Chief in charge of protective clothing for instructions.
 - c. Then hang to dry inside in a well-ventilated area out of direct sunlight.
- B. Protective Coat, Bunker Pants and Hoods: The protective coat and bunker pants should be inspected monthly and after each fire for cleanliness. If dirty, one of the following procedures shall be followed:
1. Routine cleaning after fires:
 - a. Rinse exterior of any gross contamination with clear, warm water.
 - b. Heavily soiled areas should be gently scrubbing with a soft bristle brush, except hoods.
 - c. They should be thoroughly rinsed with clear, warm water.
 - d. Then hang to dry inside a well-ventilated area out of direct sunlight.
 2. Advanced Cleaning
 - a. Machine washing to be done two times per year per the schedule issued by the chief in charge of protective equipment or as needed due to heavy use or contamination. The washer at Station 18 shall be the only washer utilized for protective equipment.
 - b. Procedures:
 1. Pre-treating: Apply pre-cleaner indicated for turnout gear onto stain or heavily soiled areas, gently scrub the area with a soft bristle brush for about 1½ minutes.
 2. Add 4 oz. of liquid turnout gear detergent.
 3. Follow instructions on machine.
 4. Remove shells when done and dry by hanging to dry inside a well-ventilated area out of direct sunlight. The hose tower at Station 18 meets these requirements.
 5. If the clothing washed was contaminated with body fluids, run the washing machine through one complete cycle using one cup (8 ounces) of liquid bleach, to purge machine of any residues.

IMPORTANT!

Never use chlorine bleach

Never dry clean

Never use fabric softeners

Never dry garments in clothes dryer

Never dry garments in clothes dryer

- C. Gloves: The gloves should be inspected periodically and after each fire for cleanliness. If dirty, the following procedure shall be used:
1. Rinse gloves of all gross contamination with clear, warm water.

2. Place gloves on hands as in wearing them.
 3. Using a mild liquid detergent, wash gloves as if you were washing your hands.
 4. Rinse thoroughly with clear, warm water. Important: be sure to rinse out all detergent.
 5. Gloves should be dried by hanging in a shady, well-ventilated area.
- D. Boots: Boots should be inspected periodically and following each fire for cleanliness. If dirty, the following procedure shall be followed:
1. Rinse boots of any gross contamination with clear, warm water.
 2. Use scrub brush and mild detergent to remove dirt.
 3. Rinse with clear, warm water.

If these procedures do not adequately clean your equipment, contact the chief in charge of protective clothing for further instructions.

II. Inspection

- A. The routine inspection of protective equipment shall be performed by each individual when issued, every month, and after advanced cleaning. The company officer/acting officer shall assure his/her company performs a monthly inspection and it is documented in the daybook.
- B. Protective equipment to be inspected includes: helmet with face shield, turnout coat/pants, boots, gloves, protective hood, spanner belt, suspenders and SCBA mask. Protective clothing inspection reports will be filled out for each scheduled inspection.
 1. Turnout gear shall be inspected for soiling, contamination, physical damage, damaged or missing reflective trim, loss of seam integrity and broken or missing stitches, and correct assembly and size compatibility or shell, liner and drag rescue device.
 2. Helmets shall be inspected for visible cracks, heat damage, missing hardware, chin strap assembly broken or torn, helmet liner worn, split or cracked, suspension broken, and face shield cracked or excessively scratched

3. Protective hood shall be inspected for holes and are not stretched out-of-shape.
 4. Gloves shall be inspected for stitching worn or rotten, glove insulation is worn through, leather split, and holes in gloves.
 5. Boots shall be inspected for felt lining that has come loose from the top of the boot, boot loops broken, and any holes or cuts on the body or sole of boot.
 6. SCBA mask shall be inspected for operating heads up display, voice amplifier, stitching on head straps, and scratches on lens.
- C. The following inspection criteria to evaluate the condition of the protective equipment shall be used.
1. New Condition
 2. As-New Condition
 3. Good Condition
 4. Maintenance Needed
 5. Immediate Replacement
- D. If the routine inspection indicated maintenance needed or immediate replacement, the duty chief shall be notified. Replacement protective equipment shall be issued. The protective equipment in question shall be cleaned, bagged and tagged with problem indicated and sent to the chief in charge of protective equipment.

III. Repairs

- A. Repairs shall only be performed by the organization approved by the OFD. Repairs will only be initiated by the chief in charge of protective equipment. No alterations of protective equipment shall be performed without the approval of the chief in charge of protective equipment.

Appendix B

Interviews

Chris Moelker
Globe Manufacturing Company, LLC
Regional Sales Manager
Presented Course on Advanced Cleaning and Inspection

Attendance/Interview: September 29, 2008
Ripon, WI
Time 1830- 2130

Course outline:

- Formulation the NFPA 1851 standard committee
- Definitions of terms organization, ISP, and verified
- Record keeping and reviewing the FEMSA booklet that comes with the turnout gear.
- Inspection process of routine and advanced
- Demonstrations of routine and advanced inspection on turnout gear
- Discussion of routine, advanced and specialized cleaning.
- Discussion how and who should perform repairs are to be performed, basic and advanced.
- Storage of turnout gear
- Retirement of turnout gear
- Testing of turnout gear, light test, leakage evaluation “bucket test” and water penetration test (hydrostatic testing)

Question 1. Why does NFPA 1851 recommend alcohol be added to the water for the leakage test? Alcohol breaks down the surface tension of the water so it will leak through quicker. Most turnout gear manufacturers will tell you to use water, since you will have to wash the turnout gear if alcohol is used for testing.

Question 2. Can turnout gear manufactured before the standard was created be altered and who can perform it? Yes it can. Someone who performs basic repairs can perform opening the bottom of the moisture barrier.

Jon Fenrich
Oshkosh Fire Department
Battalion Chief of Protective Equipment

Interviewed: October 9, 2008
Oshkosh, WI
Time 0745- 0830

Question 1. Does the OFD have a SOP on maintenance of turnout gear? Yes SOP 308.00, but it only addresses cleaning.

Question 2. Does the OFD have a policy on replacement? No

Question 3. Does the OFD have a replacement cycle? No

Question 4. Has there been any training on the SOP or for you personally? No

Question 5. How many sets of turnout gear does the OFD have? Unknown

Question 6. How does a piece of turnout gear get flagged for repairs? The individual fills out a form and sends it in when there is damage to turnout gear.

Question 7. Is there any inspections being performed on turnout gear? Each company officer inspects the gear of his/her personnel and turns in an inspection form for each person. He stated in his opinion the officers do a good job while inspecting gear, he sends in a lot of gear for repairs, and has requests for replacement.

Question 8. Would you be able to perform advanced inspections on turnout gear? No, currently difficult to perform assigned duties.

Question 9. Is there any documentation of in-service dates or repairs made to an individual garment? No

Question 10. Does the OFD's turnout gear washing machine and detergent meet the requirements for washing turnout gear? Unknown

Question 11. Does the person that performs repairs on turnout gear for the OFD have training on repairs? Unknown, but she has been a seamstress for many years. The OFD purchased a special sewing machine for her years ago to perform the repairs on turnout gear. She also has been provided with the required thread, material and reflective striping for repairs.

Question 12. Is there any testing performed on turnout gear? No

Question 13. How long does a person keep a set of turnout gear? Until it is not worth repairing, or the damage is too great to repair.

Question 14. How is turnout gear disposed of? Just thrown in the dumpster. This process will change, since he caught a fire fighter in the dumpster after he had thrown out the gear looking for a pair of bunker pants to use when cutting trees down.

Question 15. How much does a current set of turnout gear cost the OFD? \$1235.00

Question 16. Does the OFD have specifications for turnout gear? Yes there is a form that was passed on by his predecessor, but it is limited to meeting the NFPA 1971 standard with the persons name on the back of the coat.

Timothy R. Franz
Oshkosh Fire Department
Fire Chief

Interviewed: October 9, 2008
Oshkosh, WI
Time 0830-0930

Question 1. What was the budgetary amount for replacement of turnout gear for 2009? \$35,000 is the budget for 2009, which was a 59% increase from 2008. In 2008 the turnout gear budget was \$22,000 which was doubled from 2007.

Question 2. Would the OFD be able to increase the budget and incorporate advanced inspections and repairs performed by a verified independent service provider? The operating budget is where the money is located for turnout gear replacement, and maintenance. Currently there is \$1,500 budgeted for maintenance of turnout gear for 2009. The OFD's operating budget was increased to \$525,000 for 2009 from \$451,873 in 2008. If there would be an increase for outside services above the \$1,500 dollars, the money would have to come from some other area of the operating budget, something else would have to go, not a lot of slack. In 2004 the State of Wisconsin mandated no more than 2% increase on the levy limit or growth experienced. The City of Oshkosh for 2009 would be able to increase the levy by 2.3%. The difficult part of this is the levy only makes up 42.4% of the budget. The increase on the total budget would only be .9757%.

Question 3. How would the OFD handle the advanced inspection, if the chief in charge of protective clothing could not perform this function? One option would be to temporary assigning a person(s) to a staff position. Train this person(s) and have them perform the inspections. If inspections would have to be outsourcing, this may reduce the amount of turnout gear replaced every year. If inspection and maintenance does increase the life span, a decrease in the amount replaced each year would work.

Question 4. The person, who performs repairs, has there been any indication of how long she will continue? Unknown, at this time she is around 75 years old, and this is something that needs to be looked at, so the OFD is not without repairs on turnout gear.

Andy Oliver
Gear Wash, PPE Safety Care Services
Owner

Interviewed: October 9, 2008
Milwaukee, WI
Time 1400-1600

Question 1. What does it take to be a verified independent service provider? A verified ISP is an independent third party that performs routine and advanced repairs. A non-verified ISP can only perform routine repairs and only on the outer shell. A non-verified ISP also does not perform water penetration testing. For Gear Wash to be in business is cost \$10,000 per year for the certification from Intertek/ETL®. This is a company similar to Underwriters Laboratory. To perform the advanced repairs all of the staff has to have manufacturer training for all types of turnout gear being repaired, which are 12 different manufacturers. It also takes seven different sewing machines that cost anywhere from \$1,800 to \$4,500 dollars each. Gear Wash also has to maintain stock on all threads including colors, all types of material, and visible marking.

Question 2. Is there a lot of competition in maintenance of turnout gear? Gear Wash is one of the few companies in the mid-west. Because of the cost for equipment and certification, Gear Wash's sole focus is on maintenance of fire fighting personal protective equipment.

Question 3. What other benefits are there to have a company like Gear Wash provides maintenance of turnout gear to a fire department? Another component is the computer tracking system that is used. Every piece of turnout gear that comes through the doors is entered into the tracking system, to track all the maintenance and cleaning. Manufacturers perform repairs, but are not set up for it. They are more set up for production. Insurance companies recently have been asking for maintenance records when fire departments have been placing claims for turnout gear that was damaged during incidents. The insurance companies are using this to prove how much the gear is worth, so they are just not replacing gear that probably does not have any life span left in it.

A tour of the facility was recommended by Mr. Oliver to see if this would help with any questions, or generate any new ones. The tour started where the turnout gear is received. Demonstration of the washing cycle used including specialized cleaning if indicated and the detergent that Gear Wash produces.

Question 4. What are some of the parameters for washing gear including G force and water temperature? G force needs to be at 100 G. Any faster the gear can be torn apart. The water temperature needs to be no higher than 105 degree Fahrenheit. Mr. Oliver received some gear from a fire department that was washed in temperatures higher than 105 degrees and it was damaged.

The next area was where the testing took place. A demonstration was performed using the WL Gore hydrostatic tester to perform the water penetration test. The area where the turnout gear is hung to dry and the light test performed was also toured. The lights had protective covers to protect from the ultraviolet light that are produced by the fluorescent lights.

Question 5. What is the layer of turnout gear that has the most problems? The moisture barrier has the biggest issues. It is susceptible to heat exposure and wear and tear. If an area of the moisture barrier is discolored from heat (brown), it will be inspected and hydrostatic tested. If it passes the inspection and hydrostatic test, it can be placed back into service, however with the recommendation it is inspected after any heat exposure.

Question 6. How does UV affect turnout gear? Turnout that has been stored by open doors has been destroyed in three years by ultraviolet light.

Mr. Oliver also performed the pen test on the outer shell of some turnout gear, however he used a device that was more blunt like a nut driver. The last area of the tour was where the repairs took place. Mr. Oliver showed the racks of turnout gear either waiting for repairs or notification from the fire departments on what to perform on the turnout gear after an estimate was given to them. All of the different sewing machines were presented showing what each one specifically did, and all of the material, thread and visible marking that was kept in stock. He also showed some of garments that were being repaired including a re-production of a moisture barrier.

Question 7. What would be the cost for cleaning and advanced inspection on a set of turnout gear? All turnout gear is washed when it arrives even if the owner states it has been washed. This is to protect the employees handling it. For advanced cleaning and inspection on a set of gear, the price is about \$75.00. This does not include any repairs. For gear that is over three years old it is recommended to budget \$150.00 per set only for the outer shell for repairs.

Joel Sprahota
Rennert's Fire Equipment
Sales Representative

Interview: November 3, 2008
Phone
10 Minutes

Question 1. Does the new Bristol turnout gear have any modifications to meet the new advanced inspection requirements of NFPA 1851? Yes, there has been some access ports installed for the coat and pants.

Question 2. Can the older Bristol turnout gear be modified to have inspection ports to meet the new NFPA 1851 standard? This is unknown, there is a company that is contracted with and they possibly could do the modifications, however the manufacturer should be consulted.