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Compliance of SCBA Training in the Lexington Fire Department

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COMPLIANCE OF SCBA TRAINING IN THE LEXINGTON FIRE DEPARTMENT

By

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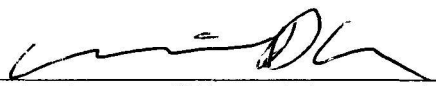

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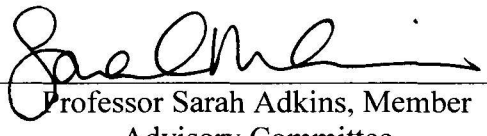

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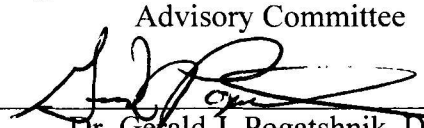

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DEDICATION

This thesis is dedicated to those who have devoted their lives to serving and protecting their communities and who have paid the ultimate sacrifice for that cause.

ACKNOWLEDGMENTS

I would like to thank my family and friends who have stood by me throughout this process. They have served as the voice of reason and encouragement during the times where self-motivation was hard to find. Additionally, they are the ones who have sacrificed right along with me, as I have had to miss numerous family gatherings and social events in order to successfully complete this process. Therefore, I would like to express my heartfelt thanks to each and every person who holds the title of family or friend because I could not have done it without you. Finally, last but most certainly not least, Ms. Leslie Valley: You are truly a saint! Thank you for going above and beyond the call of duty and consistently exhibiting the characteristics of what being an educator truly means. Your honest and timely feedback, your optimistic outlook and advice in seemingly bleak situations, and your reliability and integrity have all earned my upmost respect. Seeing as this thesis would not have reached a successful conclusion without your assistance, I am forever indebted to you.

ABSTRACT

From 2010 through 2013, an average of 90 firefighters died in the line of duty each year (USFA, 2014). Firefighters who are off-duty continue to die as well, however, it is extremely difficult to determine whether their deaths are a result of on-duty-related exposures or not. Medical and field research has consistently found associations between smoke inhalation and acute and chronic illnesses that highlight the dangers of on-duty exposure to smoke. This study investigates the early removal of the SCBA by firefighters in one fire department while operating at fire incidents. The findings indicate that firefighters are mostly aware of the dangers that smoke inhalation and exposure presents; however, they continue to remove their SCBA prematurely, particularly during overhaul operations. This points to a need for written policies and procedures that clearly define when and for how long the SCBA must be worn on fire incidents, more frequent training on the benefits and consequences of wearing or not wearing the SCBA in a contaminated environment, and a change in mentality of current firefighters who still think breathing smoke is acceptable fire ground behavior.

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CHAPTER ONE

INTRODUCTION

Background

As building construction has evolved from wood, brick, and mortar to man-made resources such as fiberglass, plastic, and metal, these new materials of construction have become firefighter killers due to their inability to withstand the high heat release rates associated with those types of fuels. This weakness causes sudden structural collapse without warning when their chemical properties change due to exposure to extreme heat, causing lethal gases to be emitted into the environment (Mittendorf, 2011). Researchers have discovered that smoke inhalation is a significant contributor to fire fatalities. For example, on November 21, 1980, the MGM Grand Hotel Fire produced 79 smoke inhalation deaths, one burn only death, three combination of burns and smoke inhalation death, and one traumatic injury death (Clark County, 1980, pp. 2-5). Another example occurred in West Warick, Rhode Island on February 20, 2003 when rapid fire advancement in a nightclub induced crowd-wide panic. The illegal use of pyrotechnics not only caused the rapid movement of fire, but it also created an uninhabitable environment within 90 seconds following the first signs of flame, ultimately leading to 99 occupant deaths (Rochford, 2008). Lastly, in March of 2006, the Providence, Rhode Island Fire Department nearly suffered multiple line of duty deaths as a result of firefighters being exposed to high levels of lethal toxins that exist in smoke (Varone, pp. 61-70).

Statement of the Problem

Firefighters continue to die as a result of their exposure to smoke and the high number of chemical carcinogens they encounter on the job. Sometimes these fatalities are immediate, but more often than not, they become more visible on a long-term scale – often in the form of cancer. Further, the respiratory, cardiac, and neurological systems of the body suffer long-term effects of smoke exposure which can be seen through respiratory illnesses such as COPD, asthma, and emphysema, cardiac events such as myocardial infarctions and narrowing of the blood vessels, and neurological deficits resulting from cerebrovascular accidents. According to Coleman (2008) and the CDC (2011), in 1988 the average life expectancy of a firefighter in the United States was 57 years while a non-firefighter maintained a life expectancy of 75 years. Additionally, a Bureau of Labor report for 1992 - 1997 revealed that the mortality rate of firefighters and law enforcement officers is almost three times higher than the national average (Clarke & Zak, 1999). For firefighters, this is attributed to their chronic exposure to smoke.

As a result of the increased exposure to toxic byproducts of smoke, LeMasters et al. (2006) concluded there is an immediate and significant need for additional protective equipment for firefighters in order to decrease the incidence rate of exposure to occupational carcinogens. Since LeMasters study, the tools, equipment, and training provided for the protection of firefighters within the fire service has improved substantially. Specifically, the recent discovery and better understanding that hydrogen cyanide is killing victims of smoke inhalation faster than any other toxic gas found in smoke (LeMasters et al., 2006) has helped propel this effort. Unfortunately, as seen through near-miss events like what happened in Providence, Rhode Island, when it comes

to maintaining respiratory protection at the scene of a fire, the actual compliance of firefighters falls well short of the ideal standard (Varone, pp. 61-70). The customary training administered to all new recruits in the Lexington Fire Department (LFD) is that they must properly use the SCBA just prior to the time of entry into an immediate dangerous to life and health (IDLH) environment until they are no longer in, around, or a part of that IDLH environment. However, actual enforcement and compliance for the entire time firefighters are within an IDLH environment has not been researched.

Purpose of the Study

The purpose of this study is to examine enforcement and compliance of firefighters wearing their SCBA throughout the entirety of a fire incident, up to and including the overhaul phase. This study takes place in one, medium-sized fire department in the state of Kentucky – the Lexington Fire Department (LFD). The current Standard Operating Procedure (SOP) 200.12 of the LFD describes when an SCBA will be worn:

> Any atmosphere that is dangerous to life or health because it is:
> - Toxic
> - Oxygen Deficient
> - Super-heated
> - Contaminated by solids
>
> An SCBA shall be provided for and shall be used by all personnel working in areas where:
> - The atmosphere is hazardous
> - The atmosphere is suspected of being hazardous
> - The atmosphere may rapidly become hazardous (LFD, 2012)

However, within that SOP, there is nothing that states how a hazardous environment is established. Therefore, the purpose of this paper is to determine if LFD firefighters are removing their SCBA prematurely and if so, to identify and analyze the

reasons for this dangerous action. This includes an investigation into the behavior of firefighters when it comes to using an SCBA compared to the training they received. Although the findings revealed no statistical significance, a detailed review of the firefighters' written responses exposed a need for change in firefighters' attitudes toward using respiratory protection. By addressing that issue, along with implementing changes to current policies, the goal of attaining better compliance while using respiratory protection in IDLH environments within the LFD and the fire service as a whole can be accomplished.

Potential Significance

In recognizing the devastating effect that smoke inhalation has on the survivability of human life, it is important to explain exactly when and why firefighters remove their SCBA. By more fully understanding the behavior of firefighters, it is possible that proactive, preventative measures might be discovered that could reduce the number of smoke related fatalities and chronic illnesses.

This study contributes to efforts to prolong the lives of those who dedicate their lives to serving their communities. The results of the survey used in this study, with emphasis placed on controlling and eliminating recognized hazards that may affect the safety and health of firefighters, could be a catalyst to creating a greater focus on safety within the LFD, national, and global firefighting communities.

Definition of Terms

Immediate Danger to Life and Health (IDLH)

Exposure to airborne contaminants that are likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such as environment (OSHA).

National Fire Protection Association (NFPA)

The world's leading advocate of fire prevention and an authoritative source on public safety, by developing, publishing and disseminating more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks (NFPA).

Occupational Safety and Health Administration (OSHA)

The government agency in the Department of Labor tasked with maintaining a safe and healthy work environment for wage earners in the United States (OSHA).

National Institute for Occupational Safety and Health (NIOSH)

The U.S. federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness (NIOSH).

Self-Contained Breathing Apparatus (SCBA)

A piece of personal protective equipment that provides breathable air in immediate danger to life and health (IDLH) atmospheres (OSHA).

Assumptions

An assumption within the context of this research is that survey responses are truthful and anonymous. As a result, the data collected is presumed to accurately portray the true behavior of firefighters within the LFD when it comes to using an SCBA compared to the training they have received. This study acknowledges that associations do not necessarily prove causation; however, the substantial amount of correlational research on the effects of smoke inhalation and chronic illness provides further evidence leading to causation.

Limitations

The findings and the significance of the work may be limited based on the fact that the LFD was the only fire department polled. There are thousands of fire departments across the nation and more than 600 in the state of Kentucky alone. Any results from the LFD may not be representative of other states or departments (full time, volunteer, etc.). Furthermore, the results may not represent the LFD as a whole since only 31% of the department responded to the survey. Lastly, since the results of the survey were gathered solely through voluntary responses, the responses have the potential to be skewed – either people who feel strongly about wearing an SCBA are more likely to respond or people who do not wear their SCBA might be less likely to respond.

Organization of the Study

Chapter 2: Literature Review

This chapter presents a detailed overview of the available medical and fire-related literature on the chronic effects of smoke exposure, specifically relating to firefighters. Additionally, applicable codes and standards have been incorporated to demonstrate the need for better compliance and enforcement.

Chapter 3: Methodology

This chapter provides an overview of the Lexington Fire Department and its training program, the selection of participants, the survey instrument, and a brief discussion of potential bias.

Chapter 4: Research Findings

This chapter analyzes and graphically displays the results of the survey instrument. The chapter's organization is broken down into five sections: demographics,

training received, current behavior and practices, perspectives on how respiratory protection can be enhanced, and a bivariate analysis involving demographic information.

Chapter 5: Discussion & Implications

This chapter provides a synopsis of the findings and their potential implications for the field of fire safety. This synopsis includes discussion of the inferences with special attention given to changing the attitudes of firefighters, recommendations for LFD policy changes specifically in the area of disciplinary sanctions, and recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

Historically, the fire service has lost an average of 100 firefighters each year as a result of line-of-duty deaths (NFPA). Over the last 10 years, however, the annual average has dropped to 88 deaths per year, with 2011 and 2012 being the two lowest years on record (Fahy, LeBlanc, & Molis, 2013). Of the 64 on-duty deaths that occurred in 2012, half were associated with stress, exertion, and other related medical issues that lead to more serious medical events such as cardiac deaths and strokes (Fahy, LeBlanc, & Molis, 2013).

Despite these numbers, on line-of-duty fatalities, it is difficult to determine the number of off-duty fire-related deaths because it remains nearly impossible to distinguish between chronic illnesses as a result of occupational exposure and chronic illnesses developed as a result of a genetic predisposition or controllable factors like diet and exercise. The NFPA acknowledges the complexity of this separation in their report of on-duty firefighter fatalities (Fahy, LeBlanc, & Molis, 2013). Despite these complexities, the IAFF's official position is that there is an increased risk to firefighters for contracting both acute and chronic respiratory diseases, though it acknowledges that more research on chronic exposure is needed (IAFF, 2014). Since firefighters are generally healthier than the average population (known as the "healthy worker effect"), the firefighter population may appear to have a lower death rate than the general population (IAFF, 2014). This phenomenon is important to investigate because the signs and symptoms of chronic diseases can potentially be masked by the reduced death rate. Another contributing factor to this phenomenon is that only healthy firefighters stay on the job

while others become ill and leave the fire service without documented disability before retirement and others leave seemingly healthy, only to suffer the long term effects long after their association with the fire service (IAFF, 2014).

Chronic Effects of Smoke Exposure

All fires, regardless of size, produce toxic smoke, thereby becoming the largest single factor in fire fatalities (Gann, 2000). The likelihood of a victim suffering a smoke-related fatality is based primary on two factors: the toxic potency of the smoke and the duration of time the victim is exposed to the smoke (Gann, 2000, p. 171). In a fire, a person's survival depends on several factors that include exposure, type of effect, the person's will to escape the fire, and the intervention taken by others (Beritić, 1990).

Fire smoke, like cigarette smoke, contains carbon monoxide, acrolein, oxides of nitrogen, and hydrogen cyanide (Minty et al., 1985, p. 633), as well as phosgene, polycyclic aromatic hydrocarbons, sulfur dioxide, and benzene (Stefanidou, Athanaselis, & Spiliopoulou, 2008; Fabian et al., 2010). These chemicals are found in and released from common, every-day materials such as plastics, carpet, foam, and synthetic fibers when they begin to burn (Mittendorf, 2011). Two of the most common gases produced as a result of a fire are carbon monoxide and hydrogen cyanide. Carbon monoxide is present in every fire. It has a triple toxic affect in that it inhibits the attachment of oxygen to hemoglobin, interrupts the transfer of oxygen from the hemoglobin to the cell, and prevents the capability to store oxygen in muscle cells, principally the cardiac muscle (Hall, 2009)

Since smoke is a mixture composed of unequal and immeasurable amounts of a variety of solids, liquids, and gaseous constituents, it is nearly impossible to evaluate or

define a dose (Beritić, 1990, p. 697). Although carbon monoxide is usually assumed to be the principal cause of death from smoke inhalation, it requires a significant amount of time and exposure to produce a lethal concentration (Hall, 2009, p. 30, 32). To apply concrete numbers to these symptoms, OSHA has established 9ppm as the maximum recommended indoor level and mandates that 50 parts per million (ppm) will not be exceeded during a normal 8-hour workday (maximum permissible exposure limit in a workplace). Once levels reach 1,600ppm, headache, nausea and dizziness present themselves after 20 minutes of exposure to carbon monoxide while immediate physiological effects, loss of consciousness and danger of death occur after a mere 1-3 minutes of exposure to levels at 12,800ppm (OSHA). J. Parow, President of the International Association of Fire Chiefs, iterates the dangers of chronic carbon monoxide exposure when he suggests that not only firefighters need to be able to recognize the significant danger of potential carbon monoxide poisoning during overhaul, but also chiefs since it is very dangerous to the health and wellness of their personnel (IAFC, 2010).

One specific concept chiefs need to be aware of is that burning plastic materials release a highly toxic gas known as hydrogen cyanide, which is so toxic that it can cause "loss of consciousness within 30 seconds, apnea in three to five minutes, and cardiac arrest in five to eight minutes" (Hall, 2009, p. 30, 32). OSHA recognizes the lethality of hydrogen cyanide, designating 5ppm as a safe environment, only allowing a 10ppm permissible exposure limit and labeling 50ppm as an IDLH atmosphere (OSHA). The properties of both carbon monoxide and cyanide complicate the determination as to whether excessive exposure has occurred or not.

Carbon monoxide and cyanide are both scientifically lighter than air, odorless and colorless gases, which make them undetectable to humans (Walsh, 2007). Signs and symptoms of potential exposure include dizziness, disorientation or confusion, and loss of consciousness (Walsh, 2007, pp. 4-8). The Fire Smoke Coalition, a nonprofit organization comprised of firefighters and medical personnel, in their 2011 resolution recognized the necessity to reduce all smoke inhalation deaths when they state that all firefighters and civilians are subjected to hydrogen cyanide which can be up to 35 times more toxic than carbon monoxide (Fire Smoke Coalition, 2011).

The dangers of carbon monoxide are so staggering that the International Association of Fire Chiefs and the International Association of Fire Fighters launched an educational campaign called "The Silent Killer" to emphasize the hazards of occupational exposure to carbon monoxide and to reduce the known risk factors that can kill or injure firefighters (Hall & Schnepp, 2011). The Fire Smoke Coalition developed firesmoke.org, which serves as an informational website about the dangers of both cyanide and carbon monoxide, which they have also dubbed as the "toxic twins" because they are released from rubbers, plastics, laminates and other synthetic materials found in modern-day residential structures (Roberts, 2011).

The concern for and awareness of the negative effects of cyanide and its relation to firefighter fatalities is still in its infancy. However, several real life examples of the lethality of smoke inhalation, measured by taking blood samples from victims following the fire event—while specifically looking at cyanide levels—are described by Varone (2006). The first incident occured in Argentina where 35 prison inmates, 90 percent of whom who had lethal levels of cyanide, died from smoke inhalation exposure of only

three to five minutes. The second incident was an aircraft fire that killed 54 people, all of whom had toxic to lethal levels of cyanide. The third incident happened at a social club in New York where most of the 87 fatalities were also found to have toxic to lethal levels of cyanide (pp. 61-70).

In March of 2006, the Providence, Rhode Island Fire Department, by chance, narrowly avoided multiple line of duty deaths due to cyanide poisoning. Shortly after a structure fire, one firefighter began experiencing symptoms that included headache, weakness, fatigue, shortness of breath, and a cough. These led to medical tests discovering cyanide levels registering at the toxic level. That firefighter was given a cyanide antidote, which will be discussed later in this report, but it also prompted all the firefighters at the structure fire to be evaluated. Three additional firefighters were found to have lethal doses of cyanide in their blood (Varone, pp. 61-70). Following two additional structure fires within the next 14 hours, four other Providence firefighters were found to have cyanide poisoning, including one who suffered a heart attack (Varone, 2006).

The lethality of smoke inhalation has been researched by both the medical community and fire safety organizations. Since the negative effects of using cigarettes have been analyzed in detail and many of the same long-term signs and symptoms apply to smoke inhalation, the effects of smoke inhalation will now be investigated. Cigarette smoking accounts for 500,000 deaths per year making it the leading cause of preventable death in the United States (Brodish, 1998). The American Lung Association found that "between 2000 and 2004, an average of 125,522 Americans (78,680 men and 46,842 women) died of smoking-attributable lung cancer each year" (ALA, 2013). Additionally,

3,400 non-smokers die each year from lung cancer caused by second-hand smoke exposure (ALA, 2013).

More than just causing lung cancer, the most likely areas of injury from first-hand smoking include the respiratory system as a whole, the heart and its ability to properly and efficiently circulate blood, the eyes and their ability to proficiently see and focus on objects, the mouth, the throat, the musculoskeletal system, the genitourinary tract, reproductive organs, digestive organs and the skin (Brodish, 1998; Stefanidou, Athanaselis, & Spiliopoulou, 2008).

Respiratory Effects

The respiratory tract must be taken care of in order to ensure adequate opportunity for oxygen to be productively used by the body (Brodish, 1998; Stefanidou, Athanaselis, & Spiliopoulou, 2008). According to the ALA (2013), the 600 ingredients in cigarettes create more than 4,000 different chemicals when burned, 50 of which are known to cause cancer. This exposure leads to many physiological symptoms, including bad breath, coughing, wheezing and increased susceptibility to respiratory infections such as bronchitis, pneumonia and emphysema (Brodish, 1998; Stefanidou, Athanaselis, & Spiliopoulou, 2008). Perhaps the most negative and longest-lasting effect of smoke exposure over a long period of time is the development of chronic obstructive pulmonary disease (COPD), which is best identified by permanent changes in the lung tissue (Brodish, 1998). NFPA 1582, Standard on Medical Requirements for Firefighters, classifies COPD as a Category B medical condition, which might prevent a person from being medically cleared to be a firefighter (NFPA 1582, 3.3.13).

Exposure to respiratory toxins—ammonia, carbon monoxide, hydrogen cyanide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, polycyclic aromatic hydrocarbons (Fabian et al., 2010)—during firefighting activities, including overhaul, expose firefighters to toxin levels that oftentimes exceed recommendations set by OSHA, NIOSH, and the American Conference of Governmental Industrial Hygienists (ACGIH) (Fabian et al., 2010). This exposure leads to increased levels of the CC16 protein, a lung surfactant protein, and a loss of respiratory cells in the distal portions of the lungs which results in decreased pulmonary function (Fabian et al., 2010). Decreased pulmonary function was noted during the peak expiratory flow period of spirometry tests administered following exposure to smoke (Fabian et al., 2010).

Decreased pulmonary function can also occur as a result of the presence of solids in smoke. The size of the particles is critically important in determining how damaging their effects may be to the human body (Roberts, 2011). Smaller particles are able to penetrate deeper into the lungs than the larger particles and during studies of simulated house and automobile fires, the levels of ultrafine particles that are invisible to the naked eye were measured at their highest point during overhaul (Roberts, 2011; Fabian et al., 2010). This can be related to the density of ultrafine particles that are present in urban air pollution, which has been shown as a relating factor to increased incidents of cardiovascular morbidity and mortality due to their reactivity, large surface area to mass ratios, and ability to transport other toxicants to target organs (Fabian et al., 2010).

Cardiovascular Effects

Not only does smoking severely affect the lungs and the respiratory tract, but it also highly impacts the heart and its ability to circulate blood (Brodish, 1998; NIOSH

2014). Premature coronary heart disease (CHD) is one of the most common diseases to strike those who smoke (Zubair, 2008) and coronary heart disease is responsible for 45 percent of the approximately 100 annual firefighter deaths while on duty (Fabian et al., 2010). A 10-year study conducted in Massachusetts revealed a direct correlation between smoking and the prevalence of CHD: when there was a 29% decline in smoking, there was a corresponding 31% decline in CHD mortality rates between 1993 and 2003 (Zubair, 2008, p. 1468). Similarly, firefighter deaths from acute cardiovascular events while on duty, secondary to chronic smoke exposure, occur 10 to 100 times more frequently than during non-emergency duties (Fabian et al., 2010). Lastly, exposure to chemical asphyxiates such as carbon monoxide, hydrogen cyanide, hydrogen sulfide, nitrogen dioxide, and sulfur dioxide could trigger a new-onset, acute cardiovascular event or precipitate an event in individuals who already have an underlying cardiovascular disease (Fabian et al., 2010).

Smoking also has the ability to cause several types of blood vessel diseases (Brodish, 1998). Smoking narrows the blood vessels, which in turn, causes poor circulation, primarily (but not exclusively) in the lower extremities and once this circulatory impairment has occurred, the only current remedy is surgical intervention (Brodish, 1998). A University of Kansas study revealed that 22 percent of 77 firefighters with an average age of 39 had arterial atherosclerosis levels typically found in people around the age of 52 (Fonarow & Moriarty, 2009). Atherosclerosis may start when factors damage the inner layers of the arteries, which includes smoking, high amounts of sugar in the blood, high blood pressure, and high amounts of certain fats and cholesterol in the blood (Department of Health and Human Services, 2011). Long-term exposure to

ultrafine particles has also been shown to enhance the long-term development of atherosclerosis, which increases the potential risk for coronary heart disease events in firefighters (Fabian et al., 2010).

Neurological Effects

Another serious health issue directly caused by smoke is cerebrovascular accident (CVA), or stroke (Brodish, 1998). Smoking cigarettes increases the odds by three times of a smoker having a stroke compared to a non-smoker (Stroke Association, 2012). Some strokes affect vital areas of the brain and leave patients with permanent disabilities, which are usually evidenced by visible symptoms such as muscle weakness on one side of the body, speech problems and changes in vision, and may be accompanied by pain (Brodish, 1998). Further, the presence of hydrogen sulfide and hydrogen cyanide within fire smoke are considered neurologic toxicants that can result in headaches, nausea, dizziness, and confusion (Fabian et al., 2010). Other strokes, called "silent strokes," also cause real brain damage but take place in less important areas of the brain. These episodes can be easier to miss since they often do not exhibit the classic physical symptoms of stroke (Brodish, 1998).

As it pertains to firefighters, an increased risk for stroke is a result of a "U-shaped association" as it pertains to the level of physical activity: both a lack of physical activity or a very heavy level of physical activity are associated with increased risk for stroke while a moderate level of physical activity is considered protective (Lee & Paffenbarger Jr., 1998). Since firefighting is a very physically demanding profession, both the heart rate and blood pressure of a firefighter rise dramatically during heavy physical exertion. These naturally occurring, pathophysiological responses may cause plaque within the

arteries to rupture or a blood vessel wall to rupture, thereby resulting in an ischemic stroke due to thrombus or a hemorrhagic stroke, respectively (Lee & Paffenbarger Jr., 1998).

Ocular Effects

The eyes are also affected by restricted blood flow. A 1996 study published in the Journal of the American Medical Association revealed that when 50,000 people were tracked over a span of 12 years, the smokers and ex-smokers in the group had a two-to-threefold increased rate of macular degeneration (Christen et al., 1996). Researchers concluded that this irreversible form of blindness is due to the lack of blood flow to the vessels in the eyes (Christen et al., 1996). Cataracts, a clouding of the eye's lens, have also been cited as an increasing problem in smokers, with levels being about 40 percent higher than non-smokers (Christen et al., 1996). These effects are not only seen in smokers; in fact, Hall (2009) further identified these same symptoms being present in firefighters following a fire event as well. Additionally, the burning of plastics that are commonly present in modern-day fires causes an immediate detrimental effect on the eyes (Hall, 2009) because of the presence of ammonia, nitrogen dioxide, and sulfur dioxide (Fabian et al., 2010).

Oral Effects

Smoke is very irritating to the delicate tissues of the throat and mouth (Brodish, 1998). The soot found within fire smoke lodges in the nasal and oral airways and can ultimately result in the degradation of cilia and alveolar surfaces (Hall, 2009). A few of the chemicals within smoke that cause these symptoms include ammonia and sulfur dioxide (Fabian et al., 2010). If superheated smoke and air are inhaled, oral tissue

swelling can be severe and cause rapid airway obstruction (Hall, 2009). Smoking causes oral tissues to be exposed to repeated swelling and thickening which eventually causes chemical changes in the gums and teeth, and can result in throat dryness, the loss of teeth, and permanent damage of the larynx, evidenced by a noticeable deepening and hoarseness of the voice (Brodish, 1998; Stefanidou, Athanaselis, & Spiliopoulou, 2008).

Musculoskeletal Effects

Smoking affects the musculoskeletal system through one serious side effect of initiating osteoporosis, which is the thinning of the bones due to the loss of bone minerals (Brodish, 1998). Osteoporosis strikes both sexes without prejudice, but makes a special target of smokers. Once the disease has claimed a portion of the bone calcium, that calcium cannot be fully recovered. Reduced bone calcium is a primary cause of increased fractures, particularly in the hip region (Brodish, 1998). Since firefighters naturally have a higher rate of smoke exposure due to their occupation, they are 3.5 times more likely to suffer a workplace injury and 3.8 times more likely to suffer a work-related musculoskeletal disorder than a private-sector worker (Seabury & McLaren, 2010). Additionally, firefighters take twice as long to return to work and take 1.8 times more days off than private-sector workers who suffer musculoskeletal injuries (Seabury & McLaren, 2010).

Fertility Effects

During pregnancy, smokers suffer higher infertility rates and miscarriages are more than two to three times more common in smokers than in non-smokers (Brodish, 1998; Stefanidou, Athanaselis, & Spiliopoulou, 2008). In addition, newborn babies of smokers have significantly lower birth weights than the babies of non-smokers, and they

are also more likely to have impaired physical, emotional and intellectual development; this syndrome has been labeled "fetal tobacco syndrome" (Brodish, 1998). In 1996, researchers found that women who smoked during pregnancy were 50 percent more likely to have a child with mental retardation of an unknown cause (Drews et al., pp. 547-553). Furthermore, a Stanford School of Medicine study on air quality monitoring indicated that toxins such as carbon monoxide, nitrogen oxide, nitrogen dioxide, and particulate matter correlated with birth defects including neural tube defects, cleft lip, cleft palate, and gastroschisis (Padula et al., 2013). As a reminder, all of these toxins are also found in and prevalent in modern-day fire smoke. On the paternal side of fertility, the offspring of male firefighters suffer high incidence rates of both ventricular and atrial septal defects (Olshan, Teschke, & Baird, 1990).

Cancer Risk

According to the often-cited 2007 study published by the University of Cincinnati encompassing 110,000 firefighters from across the country,

> Researchers believe there is a direct correlation between the chemical exposures firefighters experience on the job and their increased risk for cancer. Researchers found firefighters have a 100-percent higher risk of developing testicular cancer, a 50-percent higher risk for multiple myeloma and non-Hodgkin's lymphoma, and it is a 28-percent increased risk for prostate cancer, compared with non-firefighters. (Walker, p. 2)

Smokers tend to have a higher probability of bladder and kidney cancer since the genitourinary track is also greatly affected by smoking (Brodish, 1998; Stefanidou, Athanaselis, & Spiliopoulou, 2008). Firefighters are exposed to a wide variety of

carcinogenic agents including asbestos, benzene, styrene, polycyclic aromatic hydrocarbons, phthalate esters, and certain heavy metals (Fabian et al., 2010). This exposure has caused the World Health Organization to classify occupational exposure as a firefighter to being "possibly carcinogenic to humans (Group 2B)" (Fabian et al., 2010). This classification comes from the fact that firefighters have been shown to have higher risk to and incidence rates of several types of cancer including multiple myeloma, Non-Hodgkins lymphoma, prostate and testicular cancers, skin, brain, rectum, malignant melanoma, buccal cavity/pharynx, stomach, colon, and leukemia (Fabian et al., 2010).

Respiratory Protection Standards

Because of the correlational research on the acute and chronic effects of smoke exposure, the firefighting profession has advocated the use of respiratory protection in various consensus standards, some of which address physical qualifications for personnel who wear respiratory protection (ANSI Z88.6, 2006), fire department occupational safety and health programs (NFPA 1500), breathing air quality for emergency services respiratory protection (NFPA 1989), and standards that govern the SCBA itself (NFPA 1981) (NFPA, 2014). NFPA 1500, Chapter 7.1.1, stipulates that fire departments must take the necessary steps to ensure the protection of their members by providing them with the appropriate personal protective clothing and equipment, including respiratory protection program (specified in Chapter 7.10), to carry out their duties (2014).

The use of air monitoring should be a foundational component of the fire service's practices (OSHA, 2013). In accordance with departmental SOPs, an Incident Commander is responsible for the direction and/or controlling of resources for the safe and efficient mitigation of a hazard. Since the hazards of smoke have been well-

documented to contain carcinogens and other toxins, fire chiefs are charged with ensuring firefighters wear their SCBA through overhaul and PPE is cleaned after an incident, while also investing in atmospheric monitoring devices (Roberts, 2011).

The SCBA is a fully encompassing face piece that protects the users eyes, nose, and mouth from exposure to smoke and debris and its protection is further enhanced by its positive-pressure design. The face piece is connected to a cylinder usually made of lightweight carbon composite material and requires the use of pressure regulators that reduce the high pressure within the cylinder (4500 psi) down to a functional level.

In order to understand when it is safe to finally remove the SCBA, a definitive method of measuring the environment has been established. OSHA standard 29 CFR 1910.120(q)(3)(iv), which relates to Hazardous Waste Operations and Emergency Response stipulates that

> Employees engaged in emergency response and exposed to hazardous substances presenting an inhalation hazard or potential inhalation hazard shall wear positive pressure self-contained breathing apparatus while engaged in emergency response, until such time that the individual in charge of the ICS determines through the use of air monitoring that a decreased level of respiratory protection will not result in hazardous exposures to employees. (OSHA, 2013)

Despite these regulations, between 2001 and 2004 approximately 2,000 U.S. firefighters annually suffered fire ground injuries related to respiratory exposure (Grant, 2010). Furthermore, between 1996 and 2003, according to the NFPA, 103 firefighter deaths were directly attributed to asphyxiation (2010). Fabian et al.'s (2010) study of

smoke particulates found the respiratory toxins present in smoke exceeded OSHA regulatory exposure limits and/or recommended exposure limits from NIOSH or ACGIH.

Compliance

Due to the reduced presence of smoke and fire following initial extinguishment, regulations have not addressed SCBA usage during overhaul operations. Recent research has indicated that dangerous carcinogens actually do exist in high numbers during the post-fire environment (Jose et al., 2007). In fact, Jose et al. (2007) found that "the overhaul atmosphere exceeded occupational exposure limits and could therefore result in adverse health effects in firefighters without respiratory protection." Fabian el al. (2010) also found that specifically formaldehyde and chromium were measured at levels far above detection limits for all large-scale fire scenarios. High levels of ultrafine particles are present at all stages of fire suppression, yet during overhaul operations, firefighters usually remove their SCBA, which is worn during other activities (Fabian et al., 2010). Fabian et al. (2010) explain this tendency: "The invisibility of ultrafine particles to the human eye may create a false sense of safety that leads firefighters to remove their protective equipment in order to ameliorate the physical burden and potential heat stress associated with continued utilization of SCBA during overhaul" (p. 7-3). While exposure to both inorganic and organic carcinogens by themselves are not consistently found at levels that exceed federally regulated limits, interactions could lead to additive or synergistic effects (Fabian et al., 2010).

Additionally, budget cuts continue to condense the ranks of fire departments across the country; the demand to do more with less is relentless. Firefighting requires multiple tasks being performed simultaneously, which tends to cause extreme exertion for

firefighters in a short period of time. In fact, the energy expended while doing moderate-level work while wearing the full protective ensemble was measured at thirty-three percent more than that required to perform the same work without protective clothing and equipment (Marshall, 2003, p. 13). Therefore, being overworked without adequate relief can lead to fatigue and firefighters becoming complacent in appropriately using their personal protective equipment in hopes of reducing their level of physical exertion.

Since fire departments have yet to recover from the budget cuts and personnel shortages recently inflicted, the importance of keeping firefighters safe and healthy through sound training and education cannot be over emphasized. This is especially true with regard to the use of a self-contained breathing apparatus (SCBA), since it is one of several critical pieces of equipment that every firefighter makes sure is working 100% of the time. The SCBA is the most important and widely used tool in the fire service today because it has the most direct result in protecting a firefighter's respiratory system as he pursues the required tasks necessary to extinguish a blaze or mitigate a hazardous materials incident (Pindelski, 2013).

Research Questions

As a result of all this correlational research, the areas of focus for this case study will include investigation into the areas of SCBA compliance, firefighter behavior, and the training given to firefighters pertaining to the use of an SCBA. Because of not only the correlations between smoke exposure and chronic illnesses, but also the protection an SCBA provides to its users, firefighter compliance with an SCBA must be ensured throughout the entire duration of a fire incident. Understanding when and why

firefighters remove their SCBA will assist in developing better standards meant to protect firefighters' long-term health.

CHAPTER THREE

METHODOLOGY

Context of Study

The following observational study design made the survey available to the entire population of employees serving under the LFD. Employees were invited to answer multiple-choice questions on their training, exposure, experience, attitude, behavior and level of comfort with an SCBA. All participants were considered, by default of their present employment, to be familiar with the purpose of an SCBA and its role within the firefighter's personal protective equipment ensemble. This survey's goal was to determine trends in firefighter behavior during exposure to products of combustion, as well as their comfort level with an SCBA based on the amount of SCBA training received.

Newly hired employees with the LFD, known as recruit firefighters, are expected to complete an 18-week long training academy experience, which provides them with all applicable knowledge, certifications and qualifications to be a certified firefighter and a basic Emergency Medical Technician (EMT). Since most of the recruit firefighters have no firefighting experience, it is imperative they become familiar and comfortable with using an SCBA, to the point of donning their SCBA in 30 seconds or less. The academy also employs a rigorous physical fitness program that physically prepares the recruit firefighters for the rigors of the job. No further physical fitness requirements are currently in place once graduation from the one year probationary period has been completed.

Research Hypothesis

The hypothesis of this study is that firefighters who have received nearly identical training on the use of an SCBA should exhibit similar behavior to each other while operating on a fire scene but that their behavior is vastly different than the training they received. If the findings are significant as a result of investigating this discrepancy, identification of the potential need for more frequent training with the use of an SCBA, the need to educate firefighters regarding the hazards contained in smoke and the need to change a heavily flawed culture of traditional thinking must take place, beginning with the implementation of new policies and procedures.

Selection of Participants

Throughout the entire country, the SCBA is widely used by all types of fire departments, whether a volunteer, career or combination department. Specific departments receive different amounts of funding, which may influence the background and exposure of each subject to an SCBA. The LFD was chosen due to its large number of employees who had received identical training, implying consistency among the study subjects. The survey was administered through Qualtrics survey software. The link to the survey was distributed to sworn Lexington firefighters via email under the authority of the LFD Chief, Keith Jackson. Prior to distribution, Eastern Kentucky University's Institutional Review Board approved this survey instrument.

Data Collection

The survey administered for this research study contained 16 multiple-choice questions. Each question is represented in Appendix C with the results published later in this report. An online version of the survey listed in Appendix C was distributed via

Qualtrics survey software, a web-based survey tool. The LFD currently employs approximately 550 personnel. However, only 181 surveys were received, 10 of which were not completed. The 171 surveys used for analysis represent a 31% response rate. In accordance with the LFD's policy on computer usage, each participant who completed a survey was required to log in using his or her personalized user name and password, which is a prerequisite to visiting any website outside of the LFD intranet. This security detail ensures that the person who initiated the survey was the same person who completed the survey.

Prior to filling out the survey, participants were briefed by LFD Assistant Chief Otis Hoskins, the fire department liaison to this study, on the purpose of the research and were reassured no personal information would be divulged as a result of the analysis. Anonymity of the participants can be guaranteed since no personal identifiers were sought or posed as survey questions. Each participant was only allowed to complete and submit one survey in order to avoid duplicate responses. The demographics of the participants varied greatly and included an age range of 23 to 65 years old and included both females (4%) and males (96%).

Data Analysis

The methodology used in the research was primarily quantitative with specific instances of qualitative analysis. Frequencies and percentages were provided through Qualtrics' reporting tools, which indicated discrepancies between the training firefighters receive on the use of a SCBA and their actual performance during a fire incident. SCBA compliance was established based on participants' answer to the question pertaining to the point during a structure fire incident they remove their SCBA. The four answer

options available were: A) I don't even put an SCBA on (2%), B) After the fire is knocked down (6%), C) During overhaul operations (32%), and D) Only when I am out of and a safe distance away from the involved structure (60%). Answer options A through C signify a lack of compliance while answer option D is the compliant acceptable response; a majority (60%) of respondents indicated they are SCBA compliant while 40% indicated non-compliance

The exploratory nature of this survey was constructed to validate whether more frequent SCBA training and education for firefighters would be justified, along with potential changes in policy enforcement by the administration. In addition to exploratory univariate analysis, Chi-squared tests for association and independent sample t-tests were used as appropriate to investigate differences between firefighters that were compliant with SCBA training and those who were not. All bivariate analyses were conducted using SPSS v. 21 (SPSS IBM, Armonk, NY, U.S.A.).

Subjectivities or Bias

The author's seven years as a fire service employee working for the LFD is a potential bias. However, this has been mitigated by making the survey questions mostly quantitative in nature and by limiting the amount and ability for qualitative responses. Qualitative comments have been published in a randomly selected and unedited format to reduce/eliminate bias. Even though the research has significant personal interest to the author, constructive, honest and accurate interpretation of the data was achieved as a result of keeping the participants' identities anonymous.

CHAPTER FOUR

RESEARCH FINDINGS

The data represented is categorized into four different sections. The first covers demographic information; the second relates to training that has been received; the third relates to current behaviors and practices; and the final portion of the survey inquires about what could be done to enhance the respiratory protection of firefighters.

In total 171 participants responded to the survey; however, not all participants responded to all questions. All demographic data is summarized in Table 1. Of the 171 participants, 96% were male with a mean age of 43 years (SD=10, min=21 years, max=65). The mean years of experience in the fire service was 15 (SD=8, min=less than 1 year, max=35) and the sample included retirees who are still certified firefighters. Thirty-seven percent of participants received a high school diploma or GED, 23% held an Associate's Degree, 35% held a Bachelor's degree, and 5% possessed an advanced degree.

Forty-seven percent of participants held the rank of Firefighter while the other 53% were officers including four Assistant Chiefs (2%), eight Battalion Chiefs (6%), seventeen Majors (10%), twenty-seven Captains (16%), and thirty-two Lieutenants (19%). Thirty-three percent of participants were permanently assigned to an Engine Company, 8% were assigned to a Ladder Company, 8% were assigned to an Emergency Care Unit (ambulance), 1% were assigned to a Specialty Company such as a Heavy Rescue or Hazardous Materials Unit, 7% were considered members of the administration staff, 6% were assigned to operate within the Bureau (Training, Community Services, Communications, etc.) and 12% were retired members of the LFD. Participants were

asked to identify their most effective learning style in order to analyze whether the LFD training appeals to those learning styles. Participants were asked to mark all that apply and the majority of participants indicated their most effective learning style were actually performing a new task or skill and seeing a new task or skill.

Table 1. Demographic Information (N = 171)

Demographic factor	n (%)
Sex	
Male	165 (96%)
Female	6 (4%)
Age	
21-25	5 (3%)
26-30	11 (6%)
31-35	28 (16%)
36-40	32 (19%)
41-45	28 (16%)
46-50	28 (16%)
51-55	17 (10%)
56-60	8 (5%)
61-65	12 (7%)
No Response	2 (2%)
Education Completed	
High School Diploma/GED	64 (37%)
Associate's Degree	40 (23%)
Bachelor's Degree	59 (35%)
Advanced Degree	8 (5%)
Rank in Department	
Firefighter	80 (47%)
Lieutenant	32 (19%)
Captain	27 (16%)
Major	17 (10%)
Battalion Chief	8 (6%)
Assistant Chief	4 (2%)
Chief of Department	0 (0%)
No Response	3 (2%)

Table 1. (continued)

Demographic factor	n (%)
Years of Service	
0-10	63 (37%)
11-20	62 (36%)
21-30	39 (23%)
31-35	3 (2%)
No Response	4 (2%)
Current Assignment	
Engine Company	57 (33%)
Ladder Company	10 (8%)
Emergency Care Unit	14 (8%)
Specialty (Rescue/HazMat)	2 (1%)
Administration	12 (7%)
Bureau	10 (6%)
Retired	21 (12%)
No Response	45 (26%)
Best Learning Style	
Hearing	99 (57%)
Seeing	138 (80%)
Reading	77 (45%)
Doing	170 (98%)

All data pertaining to training received is summarized in Table 2. Of the participants, 67% were 25 years or younger when they initially received training on the selection, care and use of an SCBA. Forty-five percent of participants have received over 200 hours of SCBA training while the remaining 55% of participants noted 200 hours or less of training have been accrued. With the average years of service being 15 for the respondents, 14 hours of training per year (assuming that 200 hours of training has been received) has been devoted to appropriate SCBA usage. Since firefighters work approximately 120 days each year for a total of 2,880 hours, this equates to

approximately 0.5% of the annual work time devoted to becoming more competent using an SCBA.

Seventy-five percent of participants believed that up to 100 hours of combined classroom and hands-on training was necessary for firefighters to become confident, competent, and comfortable using an SCBA in a hazardous environment. The comfort level with using an SCBA when entrance into an IDLH environment is required was measured using a Likert Scale from 1 to 7, where 1 was "not comfortable" and 7 was "very comfortable". The average value was 6.36 with a standard deviation of 1.02, indicating that the majority of participants feel comfortable using an SCBA in an IDLH environment.

A majority (97%) of participants believed they should wear an SCBA when responding to all IDLH environments; however, less than 75% of contributors considered all structure fire incidents, hazmat incidents and/or car fire incidents dangerous enough to constitute the donning of respiratory protection. Ninety-three percent of respondents agreed that an SCBA should be used from the time they prepare to enter an IDLH environment to the time that they no longer are in an IDLH atmosphere. Lastly, participants were asked to rate the importance of an SCBA and how it related to their personal health using a Likert Scale from 1 to 7, where 1 was "not important" and 7 was "very important." The average value was 6.75 with a standard deviation of 0.79, indicating that the majority of participants recognize the importance of an SCBA for their personal health.

Table 2. Training Received (N = 171)

Training factor	n (%)
Hours of training/education received on the selection, care, & use of an SCBA	
Less than 50	22 (13%)
50-100	37 (22%)
100-200	35 (20%)
More than 200	77 (45%)
Age training/education was first received on the appropriate selection, care, & use of an SCBA	
Younger than 20	52 (30%)
20-25	63 (37%)
26-30	34 (20%)
31-35	17 (10%)
36-40	4 (2%)
Older than 40	1 (1%)
Number of hours of both hands-on and classroom training needed to become confident, competent, and comfortable with an SCBA in a hazardous environment	
Less than 50	43 (25%)
50-100	87 (51%)
100-200	27 (16%)
More than 200	14 (8%)
Why should an SCBA be used	
Provides respiratory protection	171 (100%)
Prevents burns	51 (30%)
Better vision in smoke	43 (25%)
Serves as a thermal insulator	53 (31%)
When should an SCBA used	
Responding to structure fire	123 (72%)
Responding to hazmat incident	125 (73%)
Responding to a car fire	120 (70%)
All IDLH environments	166 (97%)

Table 2. (continued)

Training factor	n (%)
Level of comfort with using an SCBA when you must enter IDLH environments	
1 (not comfortable)	1 (1%)
2	2 (1%)
3	2 (1%)
4	2 (1%)
5	15 (9%)
6	48 (28%)
7 (very comfortable)	100 (58%)
No Response	1 (1%)
How long an SCBA should be used	
From the time I get on the apparatus to the time I return to the station	1 (1%)
From the time I prepare to enter an IDLH environment to the time that I no longer am in an IDLH environment	160 (93%)
From the time my officer tells me to utilize my SCBA to the time they tell me to stop using it	5 (3%)
From the time I see the respiratory hazard to the time that I can no longer see the respiratory hazard	5 (3%)
Importance of an SCBA to overall health and safety	
1 (not important)	0 (0%)
2	0 (0%)
3	2 (1%)
4	2 (1%)
5	4 (2%)
6	15 (9%)
7 (very important)	147 (86%)
No Response	1 (1%)

The current behaviors and understanding of participants regarding SCBA usage is summarized in Table 3. When asked to select the most dangerous phase(s) of a structure

fire incident in terms of long-term respiratory protection and general health, 88% of participants replied that it was during overhaul operations, 68% said it was during the initial fire attack, 58% responded that it was during search and rescue operations, and 53% marked that it was during ventilation activities. Sixty-five percent of participants responded that more than one phase of a structure fire incident is dangerous. However, even in light of those responses, 40% of survey participants stated that they still remove their respiratory protection prior to their departure from the IDLH environment.

When asked why the respiratory protection was removed prior to leaving the IDLH environment, 23% of participants responded that the fire was knocked down and flames and/or smoke were no longer visible, 22% of participants stated that the SCBA becomes cumbersome, heavy, and uncomfortable especially when fatigued, and 6% of participants admitted that they prematurely remove their SCBA as a result of peer pressure or because everybody else was doing it. Other uncategorized responses included:

- "When the atmosphere is clear and removing it reduces fatigue."
- "When I feel it is safe to do so."
- "When I believe the environment to be safe to breathe in."
- "Habitually, I take off my mask as soon as conditions dictate. However, I now know that this is an old school way of thinking. SCBA and mask need to stay on until conditions have been cleared of all toxic gases."
- "When I am reasonably sure that the respiratory hazards have been mitigated."
- "When there are no toxic gases around me."

- "I usually removed it too soon because of the weight, awkwardness and you do not want to be the last one wearing it. People complain about having to keep getting bottles for the wimps."
- "I perceive that the environment is safe to breathe. Often, though, it was 'peer pressure'."

Table 3. Current Behavior and Understanding (N=171)

Behavior and Understanding	n (%)
Most dangerous phase of a structure fire in terms of long-term respiratory protection and overall general health	
During initial fire attack	117 (68%)
During search and rescue	100 (58%)
During ventilation activities	92 (53%)
During overhaul operations	153 (88%)
Point during the course of operating at a structure fire SCBA is removed	
I don't even put an SCBA on	3 (2%)
After fire is knocked down	11 (6%)
During overhaul operations	55 (32%)
Only when I am out of and a safe distance away from the involved structure	102 (60%)
At the point SCBA is removed, the reasoning for doing so is:	
Fire was knocked down and flames and/or smoke were no longer visible	40 (23%)
SCBA becomes cumbersome, heavy and uncomfortable, especially with fatigue	37 (22%)
Everybody else is doing it	11 (6%)
Other	80 (47%)
No Response	3 (2%)

As shown in Table 4, participants were asked what they thought was the single most important thing that could be done to reduce occurrences of death or injury to firefighters from the products of combustion. Fifty-seven percent of participants indicated the need for constant air monitoring when operating in IDLH environments, 14% thought better training on the selection, care, and use of an SCBA should be

implemented, 9% of respondents opted for the enactment of disciplinary measures for failure to appropriately wear the required respiratory protection, and 4% of contributors believe that there is nothing that can be done because the hazards are part of the job. Other uncategorized responses included:

- "Constant air monitoring as well as changing the mind set of current firemen."
- "Ensure policy reflects appropriate standards."
- "Understanding your SCBA is your friend."
- "Better, less restrictive equipment."
- "Just make guys stay masked up longer."
- It may well be part of the job, but money for masks for EVERYONE with replacement bottles is essential."
- "Understanding fire behavior and recognizing situations that may quickly change."
- "Better and more training on firefighter survival and physical training/fitness WITH SCBA training."
- "Purchase filters for the face piece that can be worn during overhaul."
- "Remove the stigma of being a smoker eater. Encourage members to wear it until it is safe. Be good role models."
- "Some hazard is always going to exist. The job still has to get done and wearing an SCBA from start to finish is not practical and results in higher rate of fatigue and inefficiency."

Additionally, participants were asked an open-ended question about what could be done to increase the level of comfort using an SCBA, assuming they were uncomfortable in the first place. The responses included:

- "Design a mask to be as sleek as possible. Peripheral vision with the mask on needs to be maximized."
- "More training and more familiarity. Spend more time on air in it."
- "Remarkably better physical fitness and a change in mentality that it is okay to wear the SCBA longer."
- "Ensuring face piece is a proper fit and knowing how and why it performs as designed."
- "More practice."
- "Training which utilizes familiarity."
- "Be less fat."

Table 4. Enhancing Respiratory Protection (N=171)

Improvement Method	n (%)
Single most important thing that can be done to reduce occurrences of death or injury to firefighters from exposure to products of combustion	
Better training on selection, care & use of an SCBA	24 (14%)
Constant air monitoring when operating in IDLH environments	98 (57%)
Enacting disciplinary measures	15 (9%)
There is nothing that can be done because it is part of the job	7 (4%)
Other	27 (16%)

Bivariate analyses were performed in order to examine if an association exists between demographic variables and compliance of SCBA training (see Table 5). No statistically significant association was found between SCBA compliance on a fire

ground and the level of education achieved (x^2 = 2.60, p = .5). It is interesting to note, however, that the compliance level of participants steadily decreases as formal education level climbs. Further, the age of participants in relation to SCBA compliance also showed no significant association (x^2 = 6.2, p = .6). One trend found in the analysis of the data is that the older participants regularly recorded a higher compliance rate than the younger members. Additionally, although there was no statistically significant association, there was a higher rate of compliance on the fire ground among participants that received SCBA training when they were older (x^2 = 4.1, p = .5).

When the rank of each participant was taken into consideration in terms of their SCBA compliance, no statistically significant association was found (x^2 = 9.0, p = .1). It was interesting to note, however, that aside from a purely command/administrative position (i.e. Assistant Chief), the two lowest compliance rates existed within the Lieutenant and Captain ranks. When comparing the importance of an SCBA to the participants overall health and safety and their compliance rate, there was no statistically significant association between the two (x^2 = 8.6, p = .1). It was found that those who indicated SCBA was very important for overall health, the higher the compliance rate registered. However, out of the high number of participants who rated SCBA as being important to overall health, 37% still indicated a lack of compliance. On a similar note, when the level of comfort with an SCBA when entering an IDLH environment was measured in relation to SCBA compliance on a fire ground, despite the lack of statistically significant data, it was found that those who indicated a higher comfort level while wearing an SCBA, the higher the compliance rate registered (x^2 = 6.1, p = .4).

Table 5. Demographics by SCBA Training Compliance (N = 171)

Demographic factor	Non-Compliant n (%)	Compliant n (%)
Age		
21-25	2 (50%)	2 (50%)
26-30	6 (46%)	7 (54%)
31-35	11 (39%)	17 (61%)
36-40	10 (31%)	22 (69%)
41-45	11 (39%)	17 (61%)
46-50	15 (58%)	11 (42%)
51-55	7 (41%)	10 (59%)
56-60	2 (22%)	7 (78%)
61-65	4 (33%)	8 (67%)
Education Completed		
High School Diploma/GED	21 (33%)	42 (67%)
Associate's Degree	16 (40%)	24 (60%)
Bachelor's Degree	28 (47%)	32 (53%)
Advanced Degree	4 (50%)	4 (50%)
Rank in Department		
Firefighter	29 (36%)	51 (64%)
Lieutenant	16 (50%)	16 (50%)
Captain	10 (39%)	16 (62%)
Major	5 (29%)	12 (71%)
Battalion Chief	2 (29%)	5 (71%)
Assistant Chief	4 (100%)	0 (0%)
Chief of Department	0 (0%)	0 (0%)
Age Training First Received		
Younger than 20	24 (47%)	27 (53%)
20-25	26 (41%)	37 (59%)
26-30	11 (32%)	23 (68%)
31-35	6 (33%)	12 (67%)
36-40	1 (25%)	3 (75%)
Older than 40	26 (41%	37 (59%)

Table 5. (continued)

Demographic factor	Non-Compliant n (%)	Compliant n (%)
Comfort Level with SCBA in IDLH		
1 (not comfortable)	0 (0%)	1 (100%)
2	2 (100%)	0 (0%)
3	0 (0%)	1 (100%)
4	1 (50%)	1 (50%)
5	8 (53%)	7 (47%)
6	20 (42%)	28 (58%)
7 (very comfortable)	36 (36%)	63 (64%)
Importance of SCBA to Health		
1 (not important)	0 (0%)	1 (100%)
2	2 (100%)	0 (0%)
3	2 (100%)	0 (0%)
4	2 (100%)	0 (0%)
5	2 (50%)	2 (50%)
6	8 (53%)	7 (47%)
7 (very important)	53 (37%)	91 (63%)

CHAPTER FIVE

DISCUSSION AND IMPLICATIONS

The overall assessment is that the importance of wearing respiratory protection throughout every phase of an IDLH-involved incident is critical. As shown in the Literature Review, the toxic elements found in smoke continue to cause chronic illnesses to form within the bodies of firefighters. These risks remain high because firefighters of all ages, genders, educational backgrounds and years of experience are removing their SCBA prior to leaving the IDLH environment created by burning materials. This unsafe habit leads to long-term and devastating effects of cancer, respiratory and cardiac illnesses, and neurological deficits.

Based on the findings listed in Chapter 4, the hypothesis of the LFD having a reduced compliance rate when it comes to wearing an SCBA in IDLH environments has been proven to be unsupported. Bivariate analysis of the demographic factors such as level of formal education received, rank within the department and comfort level with an SCBA when entering an IDLH environment revealed a couple of interesting discussion points. One interesting finding is that as the level of formal education increased, the rate of SCBA compliance decreased. This statistic stood out because one might presume that as the level of formal education increased, the higher the rate of SCBA compliance would be, yet that was not the case. One potential reason for this trend is that those with advanced degrees often find themselves in administrative roles with less opportunity to exercise SCBA compliance than other personnel who do not possess an advanced degree.

Additionally, comparing rank with SCBA compliance rates revealed that the least amount of compliance was demonstrated by the company officers—Lieutenants and

Captains. One possible reason for this statistic is that the company officers need to give direction to their firefighters while operating on a fire ground and verbal communication becomes severely muffled when attempted through an SCBA face piece. This discovery indicates that communication devices must be provided to company officers so that they will not have to subject themselves to the lethality of the products of combustion while leading their personnel on the fire ground.

Lastly, in looking at the comfort level with using an SCBA in an IDLH environment with SCBA compliance, the compliance rate among those who indicated a high level of comfort with using an SCBA (64%) was nearly double the non-compliance rate (36%). However, compliance versus non-compliance remained approximately evenly split for lower levels of comfort. This could indicate that the level of comfort with an SCBA in an IDLH environment has little bearing on whether a firefighter is compliant or not. The self-reported reasons for removing the SCBA (as quoted in Chapter 4) demonstrate Lexington firefighters' belief that they can determine when an environment is safe without the use of monitoring devices. They also indicate that firefighters remove their protective gear because of additional reasons such as peer pressure, habit, and awkwardness of the apparatus. Thus, the issue of non-compliance points directly to the need for a change in attitude when it comes to wearing an SCBA in an IDLH environment.

The research sample only included full-time, professionally certified firefighters, thereby making it difficult to formulate generalized assumptions that these viewpoints and behavior may exist in other departments. While the study revealed a majority of 60% compliance rate by LFD employees when it comes to wearing respiratory protection, the

fire department must figure out the best way(s) to protect and motivate the remaining 40% of employees to take their respiratory protection and general health more seriously. Numerous options exist to accomplish this task, such as more frequent training, better educating firefighters on the long-term hazards of inhaling the products of combustion, and the implementation of policies, procedures, and associated disciplinary sanctions that dictate and govern the professional behavior and attitudes of fire department personnel.

Currently, the LFD mandates formal SCBA training once a year during a quarterly fire in-service; however, it does not mandate that additional training be performed by individual companies (crews of three or four people assigned to individual apparatus) on a regular basis. Additional training can take the form of in-house training that consists of reviewing the standard operating procedures relating to the use of an SCBA, practicing donning the SCBA for speed, practicing search and rescue techniques with the mask blacked out, and educating personnel on the negative effects of carbon monoxide and hydrogen cyanide which includes the ineffectiveness of the human senses to detect such lethal gases. As firefighting is a profession based on completing specific tasks in time-sensitive situations when lives are in danger, firefighters must continually train on those tasks in order to perfect them; this becomes even more essential when it relates to individual firefighter health and wellness.

In addition to training, disciplinary measures should be another method of perpetrating attitudinal change within the LFD. Since the fire department's organization is based on a paramilitary structure, a written policy located in the Uniform Disciplinary Guideline portion of the SOP manual should mandate the wearing of respiratory protection until constant and measurable air monitoring determines no further threat

exists should be implemented. Additionally, verbal orders passed down through the ranks must explicitly pronounce the need for mandatory compliance with the policy. By establishing a written document that manages when an SCBA should be used, the LFD will fulfill the requirements expressed in nationally recognized standards, such as NFPA 1500. Should members of the department fail to adhere to the implemented policy, disciplinary measures should be instituted as determined by the policy guidelines. An example of a general standard operating procedure can be seen in Appendix D. While the need to ensure complete respiratory protection is evident, the LFD has not yet enacted strict regulations that better protect their members.

Therefore, additional avenues of attempting to protect non-compliant firefighters must be pursued. These include enhancing physical fitness levels throughout the department and utilizing medical advancements such as the Cyano Kit to counteract the effects of hydrogen cyanide. The role of physical fitness and the need for mandatory physical fitness requirements are currently topics of debate between the LFD administration and Union members. It is likely that improving physical fitness levels of the firefighters throughout the LFD could make a difference in some of the potential compliance issues that may be encountered with the implementation of policies extending the required duration respiratory protection is to be worn on the fire ground. Since SCBAs contain a limited air supply, better cardiovascular endurance will allow firefighters to extend the time they are able to operate while wearing respiratory protection. Furthermore, the weight of an SCBA cylinder is already considered relatively lightweight because technology has transformed their construction material from steel to that of composite, but firefighters can certainly get stronger. Increased muscular strength

will not only make firefighters more efficient with their movements as they complete their assigned fire ground tasks but will also alleviate some of the discomfort experienced with the SCBA, especially once fatigue begins to set in.

Unfortunately, an improved level of physical fitness will not protect firefighters from the lethal effects of exposure to carbon monoxide and hydrogen cyanide. Thankfully, as recognized by the International Association of Fire Chiefs (Riddle, 2004) and Fire Smoke Coalition, advances in medical technology and capabilities have improved to the point that should a firefighter succumb to smoke inhalation, a remedy with hydroxocobalamin can be administered intravenously (Uhl & Nolting, 2006, pp. 17-28). The Cyano Kit is an FDA-approved product that utilizes hydroxocobalamin to allow the cells to use oxygen again, thereby reversing the deadly effects of cyanide poisoning. The LFD has been able to purchase a limited number of sets of this antidote and is now administered to all patients who are suspected victims of smoke inhalation. At the writing of this thesis, no known cases of Cyano Kit administration had been identified in order to determine the LFD-specific successes or failures with the antidote.

Implications

Implication 1

LFD administrators should put their verbalized concerns regarding the lack of extended respiratory protection into standard operating procedures and policies that dictate when and for how long respiratory protection is needed, according to specific and measurable standards (in parts per million) per OSHA or appropriate regulatory body.

Implication 2

Constant air monitoring must become the determining factor in whether a breathable atmosphere exists or not. All ladder companies associated with the LFD carry both carbon monoxide and hydrogen cyanide monitors for when they respond to gas leaks or special rescue situations like confined space or trench collapse rescues. LFD should use these monitors during the overhaul phase of structure fires for the increased safety of department personnel operating in and around an IDLH environment. Current acceptable exposure limits, based on OSHA regulations, dictate that an environment is safe when the carbon monoxide reading is less than 50 ppm and the hydrogen cyanide reading is less than 5 ppm. Therefore, it will be recommended to the LFD administration that the environment should be deemed safe without the use of a SCBA when carbon monoxide levels and hydrogen cyanide levels measure below OSHA standards.

Implication 3

Upon adoption of these proposed policy changes, department-wide training should be performed on the new policies and all members of the department should be expected to be active participants in improving the health and safety of how the department operates on a fire scene. Additionally, 0.5% of total annual work hours is an insufficient amount of time dedicated to the specific training on SCBA selection, use and care. Therefore, increased amounts of training should be mandated and enforced on multiple fronts with emphasis placed on the frequency of the training. A recommendation to accomplish this is to administer 30 minutes of training every month rather than a yearly training session. Finally, the topic and positive effects of physical

fitness should be discussed and seriously considered to offset many of the complaints of prolonged durations wearing an SCBA.

Implication 4

A change in the mentality that defines fire department tradition must take place. The idea of being a "smoke eater" as the defining characteristic of the fire service needs to be replaced with the concept of a more conscientious and safety-driven fire professional. Construction materials and their physical properties have changed too much over recent decades that make the potential of surviving an IDLH atmosphere without adequate respiratory protection a questionable one. One way to accomplish this paradigm shift is two-fold: educate the fire service and enact disciplinary sanctions that both deter and punish a lack of compliance. Firefighters must be made aware of the negative effects of smoke inhalation, not only through the use of scientific studies but also through the actual testimonies of those who are living with the side effects of being a smoke eater.

Implication 5

Should a firefighter become a victim of smoke inhalation, advances in medical technology, such as the Cyano Kit, must be utilized immediately, in accordance with protocols established by the department's licensed medical director. Though the LFD only purchased a handful of such kits, departmental personnel should not hesitate to administer this antidote to neutralize the effects of cyanide poisoning.

Potential Areas for Future Research

Further research is necessary to continue trying to eliminate unnecessary loss of life among firefighters. Future research on this topic can potentially take many avenues.

A more in-depth look at the role and effects of physical fitness should be pursued. The effects of possibly designing, developing and implementing personal protective equipment that is more lightweight and less restrictive, yet still offers the same thermal and respiratory protection that current brands offer, should be investigated. Studies on the correlations between firefighters and the prevalence rate of contracting cancer and other chronic illnesses should continue to be documented. A study looking at firefighters who smoke cigarettes and those who do not should be developed to offer a comparison of any prospective similarities or differences to firefighters who have solely been exposed to smoke inhalation. Further, in recognizing the need to transform the attitudes and perspectives of non-compliant SCBA users, fire safety scholars should look toward research in psychology and behavioral studies. Lastly, advances in medical technology must continue to make progress in rapidly reversing the negative effects of smoke inhalation in the pre-hospital setting in order to protect firefighters.

Changing the way an organization operates does not happen overnight. However, change must be made in order to save the lives of those who willingly and sacrificially continue to expose themselves to the hazards of smoke inhalation as part of their profession and passion. Since firefighting requires a team approach, the responsibility of making the fire service a safer profession not only falls on the individual firefighter but also on the administrative staff in charge of developing, running and overseeing the health and wellness program and any policies and/or initiatives that achieve that end.

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Appendix A

Notice of IRB Exemption Status

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NOTICE OF IRB EXEMPTION STATUS
Protocol Number: 14-017
Institutional Review Board IRB00002836, DHHS FWA00003332

Principal Investigator: **Jordan Saas** Faculty Advisor**: Dr. Larry Collins**

Project Title: **Smoke Inhalation**

Exemption Date: **08/27/13**

Approved by: **Dr. Pat Litzelfelner, IRB Member**

This document confirms that the Institutional Review Board (IRB) has granted exempt status for the above referenced research project as outlined in the application submitted for IRB review with an immediate effective date. Exempt status means that your research is exempt from further review for a period of three years from the original notification date if no changes are made to the original protocol. If you plan to continue the project beyond three years, you are required to reapply for exemption.

Principal Investigator Responsibilities: It is the responsibility of the principal investigator to ensure that all investigators and staff associated with this study meet the training requirements for conducting research involving human subjects and follow the approved protocol.

Adverse Events: Any adverse or unexpected events that occur in conjunction with this study must be reported to the IRB within ten calendar days of the occurrence.

Changes to Approved Research Protocol: If changes to the approved research protocol become necessary, a description of those changes must be submitted for IRB review and approval prior to implementation. If the changes result in a change in your project's exempt status, you will be required to submit an application for expedited or full IRB review. Changes include, but are not limited to, those involving study personnel, subjects, and procedures.

Other Provisions of Approval, if applicable:

Please contact Sponsored Programs at 859-622-3636 or send email to tiffany.hamblin@eku.edu or lisa.royalty@eku.edu with questions.

Appendix B

Notice of LFD Fire Chief Approval

Lexington-Fayette Urban County Government
DIVISION OF FIRE & EMERGENCY SERVICES

Jim Gray
Mayor

Keith L. Jackson
Fire Chief

June 25. 2013

To Whom It May Concern:

While working on completing a Masters degree at EKU Lieutenant Jordan Saas has expressed interest in using the Lexington Fire Department as part of his final research project. The data he will collect for this project will involve members of the department completing a survey.

The outcome of the research Lt. Saas is involved in will also be a helpful training tool in the profession that he is in. I therefore support him in his decision in this research project.

If additional information is needed you may contact my office at 231-5660.

Keith L. Jackson
Fire Chief

200 East Main Street • Lexington, KY 40507 • (859) 425-2255 • www.lexingtonky.gov
HORSE CAPITAL OF THE WORLD

Appendix C

SCBA Respiratory Protection Survey

SCBA SURVEY

YOUR RESPONSE WILL BE TREATED CONFIDENTIALLY AND WILL NOT BE ASSOCIATED WITH YOU OR YOUR COMPANY/ASSIGNMENT IN ANY WAY!!!!

AGE: ___ SEX: ___ RANK: ___ YRS OF SERVICE: ___ STATE: ___

CURRENT COMPANY/ASSIGNMENT: _____

PLEASE PLACE AN "X" NEXT TO YOUR ANSWERS:

1.) WHAT'S THE HIGHEST LEVEL OF FORMAL EDUCATION YOU'VE COMPLETED?

___ **HIGH SCHOOL DIPLOMA OR GED EQUIVALENT**
___ **ASSOCIATES DEGREE**
___ **BACHELORS DEGREE**
___ **ADVANCED DEGREE (MASTERS OR Ph.D. OR EQUIVALENT)**

2.) HOW MANY HOURS OF TRAINING/EDUCATION HAVE YOU RECEIVED ON THE SELECTION, CARE, AND USE OF AN SCBA?

___ **LESS THAN 50**
___ **50-100**
___ **100-200**
___ **MORE THAN 200**

3.) HOW OLD WERE YOU WHEN YOU FIRST RECEIVED TRAINING/EDUCATION ON THE APPROPRIATE SELECTION, CARE, AND USE OF AN SCBA?

___ **YOUNGER THAN 20**
___ **20-25**
___ **26-30**
___ **31-35**
___ **36-40**
___ **OLDER THAN 40**

4.) HOW MANY HOURS OF COMBINED CLASSROOM AND HANDS-ON TRAINING DO YOU FEEL IS NECESSARY TO BECOME CONFIDENT, COMPETENT, AND COMFORTABLE WITH AN SCBA IN A HAZARDOUS ENVIRONMENT?

___ **LESS THAN 50**
___ **50-100**
___ **100-200**
___ **MORE THAN 200**

5.) WHICH TEACHING STYLE ALLOWS YOU TO LEARN JOB-RELATED MATERIAL THE BEST? (MARK ALL THAT APPLY)

___ **HEARING**
___ **SEEING**
___ **READING**
___ **DOING**

6.) ACCORDING TO YOUR TRAINING, WHEN SHOULD AN SCBA BE USED? (MARK ALL THAT APPLY)

___ **WHEN RESPONDING TO A STRUCTURE FIRE INCIDENT**
___ **WHEN RESPONDING TO A HAZMAT INCIDENT**
___ **WHEN RESPONDING TO A CAR FIRE INCIDENT**
___ **WHEN RESPONDING TO ALL IDLH ENVIRONMENTS**

7.) ACCORDING TO YOUR TRAINING, WHY SHOULD AN SCBA BE USED? (MARK ALL THAT APPLY)

___ **BECAUSE IT PROVIDES RESPIRATORY PROTECTION**
___ **BECAUSE IT PREVENTS ME FROM GETTING BURNED**
___ **BECAUSE IT ALLOWS ME TO SEE IN A SMOKE-FILLED ENVIRONMENT**
___ **BECAUSE IT SERVES AS A THERMAL INSULATOR**

8.) ACCORDING TO YOUR TRAINING, HOW LONG SHOULD AN SCBA BE USED?

___ **FROM THE TIME I GET ON THE APPARATUS TO THE TIME I RETURN TO THE STATION**
___ **FROM THE TIME I PREPARE TO ENTER AN IDLH ENVIRONMENT TO THE TIME THAT I NO LONGER AM IN AN IDLH ENVIRONMENT**
___ **FROM THE TIME MY OFFICER TELLS ME TO UTILIZE MY SCBA TO THE TIME THEY TELL ME TO STOP USING IT**
___ **FROM THE TIME I SEE THE RESPIRATORY HAZARD TO THE TIME THAT I CAN NO LONGER SEE THE RESPIRATORY HAZARD**

9.) CIRCLE YOUR ANSWER. RATE YOUR LEVEL OF COMFORT WITH USING YOUR SCBA WHEN YOU MUST ENTER IDLH ENVIRONMENTS.

(LOW COMFORT) 1 2 3 4 5 6 7 (HIGH COMFORT)

10.) IF YOU'RE NOT COMFORTABLE USING YOUR SCBA, PLEASE DESCRIBE WHAT COULD BE DONE TO INCREASE YOUR LEVEL OF COMFORT.

_____

_____

11.) WHAT DO YOU THINK IS THE MOST DANGEROUS PHASE OF A STRUCTURE FIRE IN TERMS OF LONG-TERM RESPIRATORY PROTECTION AND OVERALL GENERAL HEALTH? (MARK ALL THAT APPLY)

___ **DURING THE INITIAL FIRE ATTACK**

___ **DURING SEARCH AND RESCUE OPERATIONS**
___ **DURING VENTILATION ACTIVITIES**
___ **DURING OVERHAUL OPERATIONS**

12.) AT WHAT POINT DURING THE COURSE OF OPERATING AT A STRUCTURE FIRE DO YOU REMOVE YOUR SCBA?

___ **I DON'T EVEN PUT AN SCBA ON**
___ **AFTER THE FIRE HAS BEEN KNOCKED DOWN**
___ **DURING OVERHAUL OPERATIONS**
___ **ONLY WHEN I AM OUT OF AND A SAFE DISTANCE AWAY FROM THE INVOLVED STRUCTURE**

13.) AT THE POINT YOU REMOVE YOUR SCBA DURING THE COURSE OF OPERATING AT A STRUCTURE FIRE, WHAT IS YOUR REASONING FOR DOING SO?

___ **THE FIRE WAS KNOCKED DOWN AND FLAMES AND/OR SMOKE WERE NO LONGER VISIBLE**
___ **THE SCBA BECOMES CUMBERSOME, HEAVY AND UNCOMFORTABLE, ESPECIALLY WHEN I AM FATIGUED**
___ **EVERYBODY ELSE IS DOING IT**
___ **OTHER, PLEASE SPECIFY: _____**

14.) CIRCLE YOUR ANSWER. RATE THE IMPORTANCE AN SCBA IS TO YOUR HEALTH AND SAFETY.

(LOW) 1 2 3 4 5 6 7 (HIGH)

15.) WHAT SINGLE MOST IMPORTANT THING DO YOU THINK COULD BE DONE TO REDUCE OCCURENCES OF DEATH OR INJURY TO FIREFIGHTERS FROM EXPOSURE TO PRODUCTS OF COMBUSTION?

___ **BETTER TRAINING ON THE SELECTION, CARE, AND USE OF AN SCBA**
___ **CONSTANT AIR MONITORING WHEN OPERATING IN IDLH ENVIRONMENTS**
___ **ENACTING DISCIPLINARY MEASURES**
___ **THERE IS NOTHING THAT CAN BE DONE BECAUSE IT IS PART OF THE JOB**
___ **OTHER, PLEASE SPECIFY: _____**

THANK YOU FOR YOUR TIME.
SURVEY REVISED 8/21/13

Appendix D

Example Standard Operating Procedure on Overhaul Air Monitoring

SOP ABC.123: Overhaul Air Monitoring
Effective Date: 01/01/2014

Purpose: The purpose of this SOP is to provide for a safe operating environment for firefighters after initial fire knockdown and during the overhaul phase of firefighting.

Scope: This SOP shall serve as a guide for Incident Commanders (IC) and others charged with maintaining firefighter safety on fire scenes.

Command and Control: All Incident Commanders, incident safety officers, company officers and acting officers are responsible for this SOP.

Content: After initial fire knockdown the Incident Commander shall direct the air inside the structure and/or in the area to be continuously monitored for Hydrogen Cyanide (HCN) and Carbon Monoxide (CO). He shall assign monitors to company officers working in the overhaul area(s).

SCBA shall be required in any monitored area that has either an HCN reading of 4.7 ppm or higher or a CO reading of 35 ppm or higher. An IC may only order the discontinued use of SCBA, in a monitored area, when both the HCN and CO readings are below the listed levels.

When both the HCN and CO readings have fallen below the listed levels, the IC should be notified. The IC shall note the time and readings and direct that they be recorded in the NFIRS report. Monitoring shall be continued until the overhaul is complete.

Vita

Jordan P. Saas was born in Mesa, Arizona on November 18, 1983. He attended both public elementary and middle schools while in Arizona. His family moved from Arizona to Oxford, Ohio in August of 1998, where he graduated from Talawanda High School in June 2002. In August of 2002, he entered Eastern Kentucky University in Richmond, Kentucky. In 2006, he graduated with a Bachelor of Science degree in Fire Science and Engineering Technology, with an emphasis in Fire Protection Administration and a Bachelor of Science degree in Emergency Medical Care and then was hired by the LFD.

In 2012, he reentered college at Eastern Kentucky University to pursue his Master's degree in Safety, Security, and Emergency Management. In the interest of full disclosure, he presently works for the LFD as a Fire Lieutenant and Paramedic in Lexington, Kentucky. He has also obtained the LFD Fire Chief's permission to conduct this study and publish the results in order to meet the requirements of his Master of Science Thesis.