

**FIREFIGHTER SAFETY DURING OVERHAUL AT THE MANHATTAN FIRE  
DEPARTMENT**

EXECUTIVE LEADERSHIP

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

June 2007

## Abstract

This research paper focused on the health risks associated with the removal of self contained breathing apparatus (SCBA) while firefighters conduct interior operations during the overhaul period at structure fires. The problem was the Manhattan Fire Department (MFD) had not identified the potential health risks of exposure to substances present in the atmosphere during this time period. The purpose of this research was to evaluate whether strengthening the respiratory protection policies during overhaul operations at the MFD were warranted and if implementation of a strengthened policy would meet employee resistance.

This was a descriptive and evaluative research project undertaken to address the following questions:

1. What national standards and “best practices” apply to the issue of respiratory protection during overhaul?
2. What toxic substances are typically present during the overhaul stage at structural fire scenes?
3. What are the health implications of exposure to the toxic substances present during the overhaul stage at fire scenes?
4. What respiratory protection policies would be most effective in protecting firefighters from the hazards associated with exposure to the toxic products present during the overhaul stage?

An extensive literature review revealed a list of harmful airborne substances present in actual fire scenes during overhaul operations, with numerous short-term health risks and long term cancer risk being associated with exposure. This information was

communicated to the firefighting personnel at the MFD through a process that included sharing information collected in the literature review and the collection of feedback through a departmental survey.

A majority of department members recognized the risks associated with removing SCBAs during overhaul operations and would support strengthening the respiratory protection policy applicable to the issue. The research also suggested that more information would be beneficial to reaching a consensus on the appropriate level of protection required for overhaul operations.

The recommendations arising from this study included the assignment of individuals to research options to increase monitoring capabilities, making positive pressure ventilation a priority on all fires, and continuing to involve employees in the decision-making process as the new policies were implemented. Based on the research, the author concluded that the only respiratory option available to adequately protect the employees at the MFD was full SCBA until all overhaul activities were complete.

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## INTRODUCTION

Fighting a structure fire is a very difficult task. During the early stages of a fire, firefighters work under extreme conditions wearing approximately 70 pounds of personal protective equipment (PPE). When the fire has been extinguished there is still “overhaul” work to be completed and it is understandable that firefighting personnel want relief from the burden of their PPE. Bolstad-Johnson et al. (2000) defined overhaul as “the firefighting stage in which fire suppression is complete and firefighters are searching the structure for hidden fire or hot embers, which may be found above ceilings, in between walls, or in other obscure areas” (p. 636). This research addresses the potential health risks to firefighters of removing their respiratory protection while working during the overhaul period.

This researcher has served as the Chief Training Officer (CTO) for the Manhattan Fire Department (MFD) since January of 2002. One of the primary functions of this position is serving as the incident safety officer at emergency scenes. Over the past few years this researcher has become concerned that the current MFD respiratory protection policy may allow exposure of firefighters and investigators to toxic combustion products, particularly during overhaul operations.

Upon this researcher’s completion of the Executive Leadership course in July of 2006, the problem was presented to the administrative staff at the MFD. As a result of this presentation, this researcher was assigned the task of exploring what toxic products may be present during the overhaul stage at fire scenes that are not currently detected by the department’s monitoring equipment. The assignment also included determining the potential health risks of exposure to these products. The staff expressed concern that a

primary challenge to strengthening current policies would be employee resistance if an effective process of educating the firefighting staff on the issue was not followed. The overall purpose of this assignment was to provide the administrative staff with the information necessary to make sound decisions regarding the health and safety of MFD personnel working inside a structure during the overhaul stage of firefighting.

The problem is the MFD has not identified the health risks associated with exposure to substances present in the atmosphere during overhaul operations at structure fires. The purpose of this research is to determine whether strengthening the respiratory protection policies during overhaul operations at the MFD is warranted and if implementation of strengthened policies would meet employee resistance.

A thorough examination of published research studies applicable to this topic and a survey of department personnel was conducted to provide information to assist upper management in making a sound decision regarding the level of respiratory protection necessary during the overhaul stage of firefighting.

This is a descriptive and evaluative research project undertaken to address the following questions:

1. What national standards and “best practices” apply to the issue of respiratory protection during overhaul?
2. What toxic substances are present during the overhaul stage at structural fire scenes?
3. What are the health implications of exposure to the toxic substances present during the overhaul stage at fire scenes?

4. What respiratory protection policies would be most effective in protecting firefighters from the hazards associated with exposure to the toxic products present during the overhaul stage?

### **BACKGROUND AND SIGNIFICANCE**

The MFD has existed since 1892. The department provides emergency services for the city of Manhattan, Kansas, which has an estimated population of 49,500 (O. Fourie, personal communication, May 10, 2006). Manhattan is also the home of Kansas State University, which has an enrollment of approximately 23,000 students.

The MFD is a career paid department with 93 personnel and currently responds from four fire stations. One station provides aircraft rescue and fire fighting (ARFF) services at the Manhattan Regional Airport. The MFD has a fully-qualified technical rescue team and a technician-level hazardous materials response team that is a member of the State of Kansas hazardous materials response system. The MFD provides emergency medical services at the basic life support (BLS) level on all requested emergencies, while the Riley County Emergency Medical Service provides advanced life support (ALS) and transport services. The department's budget for 2007 is \$4.1 million (City of Manhattan, 2007, p. 68).

Neglect in the use of respiratory protection by individuals during overhaul operations at fire scenes is a serious problem because firefighters may be exposed to toxic products of combustion that have serious long term health consequences. Although firefighters are taught in basic fire behavior classes that there are many toxic products of fire combustion, there inevitably comes a point at every fire scene where the desire to remove

the weight and discomfort of wearing the air pack outweighs the fear of exposure to the smoke. Commonly, this decision is made during overhaul operations.

The MFD deployed self contained breathing apparatus (SCBA) during the early 1980's. Until 1998, officers on the scene used visual inspection, experience, and their senses to determine when personnel could remove respiratory protection. In 1998 the MFD adopted the current policy, which requires the use of a "four-gas" monitor to measure the amount of oxygen (O<sub>2</sub>) and carbon monoxide (CO) in the atmosphere. When the oxygen level in a structure is adequate and the CO level is below 35 parts per million (ppm), the incident commander may allow the removal of respiratory protection. Former chief training officer (CTO) Arlen Loecker stated that the administrative staff settled on these parameters because 35 ppm of CO was the threshold limit value-time weighted average approved by the National Institute of Occupational Safety and Health (NIOSH). He also contacted several other departments that were in the process of adopting a similar policy (Loecker, personal communications, 3/30/07). Since the adoption of this policy, the challenge for the CTO has been consistent enforcement, as personnel tend to remove respiratory protection early and resist advice to keep SCBA's on until specific O<sub>2</sub> and CO levels are verified.

This researcher took the position of CTO with the MFD in January of 2001. A major area of responsibility for this position is serving as the health and safety officer for the department. This researcher also has been a hazardous materials technician for 15 years and serves as the hazardous materials operations chief and directs the activities of the regional response team. This is especially pertinent to the topic covered by this paper as knowledge of chemistry is invaluable in recognizing the hazards that may be present.



The position also involves extensive work with the fire department physician to develop and coordinate the activities of the department's health and wellness program.

Another valuable resource in the area is Kansas State University. This researcher has developed relationships with numerous professors and other experts on the campus, and when questions arise on complicated issues such as this, their expertise is a great resource to draw on. As I searched for information on this topic I spoke with experts in technical fields that included industrial engineering, industrial hygiene, microbiology, chemistry, and occupational medicine.

Many fire departments in the United States use similar policies to determine when respiratory protection can be removed after a fire has been extinguished. Rogers (2005) found that over three-fourths of the departments surveyed in DuPage County, IL used pre-planning, visual inspection or CO readings from a four-gas monitor to determine when to safely remove SCBA (p. 36). Based on the experience of this researcher, the majority of fire departments in the Midwest use similar policies, although many are currently discussing approaches to strengthen their respiratory protection policies.

Firefighters at the MFD need to have a reasonable understanding of the dangers associated with removing respiratory protection during overhaul operations and they should have a voice in any decision to strengthen the departmental policy. Wearing SCBA during overhaul has always been very difficult to enforce. This is an adaptive problem, where the problem and the solutions to it, are unclear at best and behavioral changes will be required to make meaningful improvements to firefighter safety. Leadership will be vital in this process. If the respiratory protection policy is strengthened, the job of firefighters may be more difficult and uncomfortable during

overhaul; however, the long-term protection of personnel must receive primary consideration. Departmental liability for the health of firefighters must also be considered.

A clear understanding of the questions surrounding this situation will allow the administration at the MFD to make an informed policy decision. The widespread acceptance of the enhanced policy by department members will be critical. Feedback and “buy-in” will be key on this important health and safety issue.

This applied research project relates to the Persuasion Unit of the Executive Leadership course (NFA, 2005). Unit 14 of the course focuses on improving the “influencing” skills of the executive fire officer (p. 12-2). This project specifically utilized the three elements of influencing including logical persuasion, common vision, and participation and trust (p. 12-4). The questions to ask when formulating an influencing plan were also used when planning the participatory decision-making process at the MFD on this issue (p. 12-5). As mentioned earlier, this is an example of an adaptive problem requiring behavioral changes on the part of firefighters.

This research relates directly to the USFA five-year objective to “reduce the loss of life from fire of firefighters” (NFA, 2002, p. II-2). Examination of the health risks to firefighters during overhaul will enable an educated decision to be made on adjustments to the respiratory protection policies during overhaul at the MFD. This policy change could have a profound effect on the long term health of firefighting personnel.

## **LITERATURE REVIEW**

A review of the existing information pertaining to firefighter health and safety during overhaul established the foundation for this research. The initial information review

examined whether strengthening of the policy on removal of respiratory protection after extinguishment at fire scenes was warranted. The first step in this literature review was to establish what national standards or “best practices” apply to the issue of respiratory protection during overhaul.

Numerous sources establish standards that can be applied to this issue. The U.S. Department of Labor (USDOL, 2007) hazard communication standard establishes the right for employees to know about hazardous chemicals they may be exposed to in their workplace. Section 29 CFR 1910.1200(h)(1) of the regulations states:

“Employers shall provide employees with effective information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new physical or health hazard the employees have not been trained about is introduced into their work area. Information and training may be designed to cover categories of hazards (e.g. flammability, carcinogenicity) or specific chemicals. Chemical-specific information must always be available through labels and material safety data sheets.”

The federal regulations on respiratory protection (USDOL, 2007) outline specifics for employers on the decision making process to be used during overhaul. Section 1910.134 (d)(1)(iii) states:

“The employer shall identify and evaluate the respiratory hazard(s) in the workplace; this evaluation shall include a reasonable estimate of employee exposures to respiratory hazard(s) and an identification of the contaminant’s chemical state and physical form. Where the employer cannot identify or reasonably estimate the

employee exposure, the employer shall consider the atmosphere to be immediately dangerous to life and health (IDLH).”

National Fire Protection Association (NFPA, 2007) standard 1500 titled *Fire Department Occupational Safety and Health Programs* also outline standards that can be applied to the decision making process to remove respiratory protection. Section 7.9.7 of the standard states:

“When engaged in any operation where they could encounter atmospheres that are IDLH, or where the atmosphere is unknown, the fire department shall provide and require all members to use self contained breathing apparatus (SCBA) that has been certified as being compliant with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services* (p. 20).”

Clearly, fire departments have a responsibility to identify hazards in the workplace and firefighters have a legal right to be informed of the hazards they may encounter. Further, when there is a reasonable chance that a hazard exists, or when the atmosphere is unknown, the employer should exercise extreme caution when allowing firefighters to remove self-contained breathing apparatus (SCBA).

The next research question focuses on identifying the toxic chemicals typically present during the overhaul stage at fire scenes. Four studies were found that quantified amounts of dangerous chemicals present in the atmosphere during overhaul conditions.

Kinnes and Hine (1998) conducted research on a request from the Bureau of Alcohol, Tobacco, and Firearms (ATF). The study included collecting air samples at two actual fire scenes and three simulations. The purpose of the study was to evaluate the conditions for the ATF fire investigators, but the findings can also be applied to overhaul

conditions for firefighters. The primary hazards identified were formaldehyde, with concentrations measured above the NIOSH ceiling limit of 0.1 parts per million at two of the fires (p. 8), and particulate dust matter that was measured in the respirable and inhalable range (p. 10). The study also found small amounts of three polycyclic aromatic hydrocarbons (PAHs) that are suspected human carcinogens, including benz(a)anthracene, benzo(b)fluoranthene, and benzo(a)pyrene (p. 10).

Bolstad-Johnson, Burgess, Crutchfield, Storment, Gerkin, and Wilson (2000) analyzed air samples from 25 fire scenes during overhaul operations. This study was supported by the City of Phoenix Fire Department and included researchers from the University of Arizona and Arizona State University. The purpose of this study was to “characterize exposures that firefighters may encounter during the overhaul phase at fire incidents” (p. 636). The following hazardous substances were found in quantities above published ceiling values: acrolein at one fire, carbon monoxide at five fires, formaldehyde at 22 fires, and glutaraldehyde at five fires (p. 637). Also, the following exceeded short-term exposure limits: benzene at two fires, nitrogen dioxide at two fires, and sulphur dioxide at five fires (p. 637). Concentrations of PAHs exceeded the NIOSH recommended exposure limits at two fires (p. 638).

Burgess et al. (2001) conducted research “to measure the adverse effects of exposure to products of combustion during overhaul using both spirometry and serum pneumoproteins, and to determine whether the use of cartridge respirators could decrease any adverse health effects associated with this exposure” (p. 468). Air samples were collected at seven actual fire scenes and two training fires in Phoenix and five actual fire scenes and two training fires in Tucson (pp. 469-470). Monitoring data were reported in

parts per million (ppm) as mean exposures to each firefighter active in the study and were separated by the Tucson and Phoenix locations (p. 470). Compared with the online version of the NIOSH pocket guide (Center for Disease Control [CDC], 2007), this researcher determined formaldehyde and acetaldehyde levels exceeded recommended short term exposure limits in both the Tucson and Phoenix locations. Mean benzene levels exceeded the recommended level for carcinogens in the Phoenix fire scenes (p. 470).

Austin, Wang, Ecobichon, and Dussault (2001) conducted similar research “to characterize volatile organic compounds (VOCs) found at municipal structure fires in order to identify sources of long-term health risks to firefighters, which may be contributing factors in heart disease and cancer” (p. 1). In this study, firefighters collected air samples at nine structure fires at a point when they believed some firefighters would consider it safe enough to remove their SCBA. As stated previously, this study focused on VOCs, and although a common footprint of 14 substances was found, the study noted that the VOCs found in the highest concentrations were benzene, 1,3-butadiene, and styrene (p. 2).

In summary, the typical airborne chemicals present at potentially hazardous levels during the overhaul stage at actual fire scenes included 1,3-butadiene, acetaldehyde, acrolein, benzene, formaldehyde, glutaraldehyde, nitrogen dioxide, PAHs, respirable dust, styrene, and sulfur dioxide.

The next research question concerned the health risks posed to firefighters by the chemicals found to be present during the overhaul stage of fires. The following are

published health risks of the hazardous substances found to be present in significant quantities:

#### *1,3-butadiene*

Breathing low levels of 1,3 butadiene may cause irritation of the eyes, nose, and throat (Agency for Toxic Substances and Disease Registry [ATSDR], 1995, How can 1,3-butadiene affect my health?, ¶ 3). Breathing high levels may cause central nervous system damage, blurred vision, nausea, fatigue, headache, decreased blood pressure and pulse rate, and unconsciousness (¶ 4).

#### *Acetaldehyde*

Exposure to acetaldehyde may cause eye, nose or throat irritation; coughing; conjunctivitis, central nervous system depression; eye and skin burns; dermatitis; delayed pulmonary edema; and moderate narcosis (U.S. Department of Labor [USDOL], 2006, Health effects section, ¶ 4).

#### *Acrolein*

Exposure to acrolein may cause eye, skin, or mucous membrane irritation; tightness in the chest; cough, difficulty breathing, acute pulmonary edema, chronic respiratory disease, asthma, nausea, vomiting, diarrhea, high blood pressure, and unconsciousness (USDOL, 2006, Health factors section).

#### *Benzene*

Benzene is listed as a human carcinogen by the International Agency for Research on Cancer (National Cancer Institute [NCI] , 2006, Background section, ¶ 4). Benzene has also been found to lower white blood cell counts in individuals exposed to less than 1 ppm of the chemical in air (Overview section, ¶ 1).

### *Formaldehyde*

Formaldehyde has been named a human carcinogen by the International Agency for Research on Cancer and a probable human carcinogen by the U.S. Environmental Protection Agency (EPA) (NCI, 2007, ¶ 4). The short term health effects include watery eyes, burning sensations of the eyes, nose and throat, coughing, wheezing, nausea, and skin irritation at levels at or above 0.1 ppm (¶ 3).

### *Glutaraldehyde*

Glutaraldehyde is irritating to the eyes, nose throat, and skin. Exposure to glutaraldehyde can cause asthma and allergic reactions of the skin (California Department of Health Services, 1995, Health hazard summary section, ¶ 1).

### *Nitrogen Dioxide*

Nitrogen dioxide exposure may cause irritation of the eyes, nose and throat. Other health effects include coughing, decreased pulmonary function, difficulty breathing, chest pain, pulmonary edema, cyanosis, tachypnea, and tachycardia (USDHHS, 2004, Health factors section, ¶ 2).

### *Polycyclic Aromatic Hydrocarbons*

Three polycyclic aromatic hydrocarbons identified as potentially present in the atmosphere during the overhaul period at structure fires were benz(a)anthracene, benzo(b)fluoranthene, and benzo(a)pyrene. These PAH's have been designated as probable human carcinogens by the Environmental Protection Agency (ATSDR, 1995, How can PAHs affect my health? ¶ 4).



### *Respirable Dust*

Exposure to respirable dust causes the following health hazards; irritation of the eyes, ears, nose, throat, and skin (USDL, n.d., Why is dust control necessary? ¶ 1), and respiratory disease known as pneumoconiosis (USDL, n.d., Health hazard factors section, ¶ 2).

### *Styrene*

Acute effects of styrene include irritation of the skin, eyes, and upper respiratory tract. Chronic effects include depression, headaches, fatigue, weakness, and minor effects on kidney and liver function (USDL, 2003, ¶ 1)

### *Sulfur Dioxide*

Sulfur dioxide is corrosive and irritating to the eyes, skin, and respiratory tract. Other short term health effects include headaches, and general discomfort and anxiety. Sulfur dioxide is also listed as a mutagen (BOC Gases, 2006, Hazard identification section).

Further evidence of the short term health risks of exposure to these substances were cited in two of the previously mentioned research studies. Kinnes and Hine (1998) mentioned that several of the investigators experienced coughing and tearing as a result of being in the building during the overhaul time period (p. 11).

Burgess et al. (2001) noted the researchers “observed acute changes in spirometric measurements and lung permeability following firefighter overhaul” (p. 471). Their findings provided “strong evidence that the current practice of removing SCBA prior to overhaul may result in exposure to respiratory toxicants and subsequent adverse health effects” (p. 471). The primary purpose of the study was to examine short term health effects, but the researchers also noted that repeated “acute exposures could have

persistent adverse health effects, and given that wood combustion products contain substances capable of damaging DNA, cancer from occupational exposure is also a concern” (p. 472).

Two recent studies suggest the cancer risk linked to exposure to these chemicals may be a serious concern. In a study titled, *Cancer Incidence in Florida Professional Firefighters*; Fangchao, Fleming, Lee, Trapido, and Gerace (2006) examined the records of 34,796 male and 2,017 female firefighters and concluded “male firefighters had significantly increased incidence of bladder, testicular, and thyroid cancers. Female firefighters had significantly increased rates of overall cancer, cervical, and thyroid cancer and Hodgkin disease” (p. 883). The study also noted that “firefighters are routinely exposed to various carcinogens during firefighting and overhaul” (p. 883).

LeMasters et al. (2006) reviewed 32 studies on firefighters “to quantitatively and qualitatively determine the cancer risk using a meta-analysis” (p. 1189). Their findings indicated firefighters have a “probable” cancer risk for multiple myeloma, non-Hodgkin lymphoma, prostate, and testicular cancers. Eight additional cancers were listed as having a possible association with firefighting (p.1189).

The literature on health risks suggests there are numerous identifiable symptoms and health concerns linked to the chemicals shown to be present at dangerous levels during overhaul activities at the fire scenes studied. Several of the chemicals identified are listed as known or probable human carcinogens and the cancer research studies found that firefighters are at a higher risk for cancer than the general public.

A goal of this research paper is to assist in determining an effective MFD policy on the use of respiratory equipment to protect firefighters from the hazards associated with

exposure to the toxic products present during the overhaul stage. Kinnes and Hine (1998) noted the impracticality of requiring investigators to wear full SCBA during fire scene investigations. The study noted that the recommendations would also be applicable to firefighters working during the overhaul period. They recommended “the use of half-face, air-purifying respirators (APRs) equipped with combination filter cartridges (high-efficiency particulate, VOCs, acid mists, and formaldehyde) or powered air-purifying respirators with the appropriate filter cartridges used” (p. 12). The researchers also recommended the use of eye goggles for individuals using half-face respirators, the implementation of mechanical ventilation, checking for safe oxygen and carbon monoxide levels prior to entry, and the establishment of a model respiratory protection program (p. 12).

Bolstad-Johnson et al. (2000) also concluded that respiratory protection should be worn during fire overhaul. The research noted that SCBAs “provide optimum protection with a given protection factor of approximately 10,000, but they are heavy, and for this reason may not be used by firefighters during overhaul” (p. 640). The researchers noted that full-face APRs would “provide a protection factor of 50, and their use during fire overhaul would reduce the physical burden of carrying the extra weight associated with the SCBA unit” (p. 640). The researchers recommended that firefighters utilize SCBA units when CO levels were found to be above 150 ppm and full-face APRs when CO levels were found to be below 150 ppm (p. 641). The study also concluded that more research was necessary on the effectiveness of full-face APRs and stated that “CO concentrations should not be used to predict the presence of other contaminants found in the overhaul environment” (p. 641).

As noted earlier, Burgess et al. (2001) conducted a follow-up study in Phoenix and Tucson. One of the primary purposes of this study was to measure the effectiveness of cartridge respirators in protecting the respiratory health of firefighters during the overhaul period (p. 468). The study found shortcomings in the effectiveness of full-face APRs and concluded that “because cartridge respirators do not seem to provide complete protection against changes in spirometric measurements and serum pneumoproteins, either increasing the time interval between extinguishment and overhaul or continuing the use of SCBA is recommended” (p. 473).

The studies noted in this literature review were conducted to provide information to improve the health and safety of firefighters working during the overhaul period. It is clear from this research that respiratory protection at some level is vital for these personnel. The research reaffirms that the most protection is afforded by a full SCBA and the most recent study suggests that full-face APRs may not be effective in protecting the respiratory health of firefighters working during the overhaul period. The research revealed a list of harmful substances present in actual fire scenes during the overhaul period with numerous associated short term health issues as well as the long term risk of cancer. Clearly, this information should be communicated to all firefighting personnel to comply with national regulations on hazard communication.

## **PROCEDURES**

After extensive review of the existing research findings on firefighter respiratory safety during overhaul, this researcher determined that the information on this issue should be presented to the MFD Health and Safety Committee for consideration. Initially, this researcher believed that more research studies would be needed to make the

determination that strengthened respiratory policies during overhaul were necessary. As the research progressed it became apparent that sufficient information may be available to make an informed safety decision on the issue. This information was presented at the regular quarterly meeting of the committee on February 15, 2007. The consensus of the committee members was that the information should be presented to the members of the department to gauge their understanding of the issues involved and the internal support for strengthened policies. The committee agreed that internal understanding of the issues and support for any change would be vital to the success of a stricter policy.

A survey was designed to assess the understanding of the members of the MFD toward issues surrounding respiratory protection during overhaul. The survey was developed by this researcher with input from the administrative staff, which became the *Respiratory Protection during Overhaul Survey* (Appendix A). All uniformed MFD firefighting personnel received the survey. In addition to the survey each respondent received a cover letter (Appendix B) and an information sheet (Appendix C) which included a summary of the information collected during the literature review. The information sheet was developed by this researcher with input from two on-shift hazardous materials technicians, Fire Drivers Kyle Voth and Mark Whitehair. Along with the information sheet, a notebook with copies of each research study cited in the materials was forwarded to each station to give the respondents an opportunity for a more detailed review of the material. The cover letter asked the respondents to review the information sheet and the research articles to raise their awareness of the health and safety risks associated with overhaul operations.

The survey consisted of eleven questions. The first question was included to determine the breakdown of individuals responding by rank and utilized a multiple choice format. Questions two through six used a five-point Likert scale which ranged from “strongly agree” to “strongly disagree”. Question seven asked respondents to choose the respiratory protection option they believe the MFD should utilize in a multiple choice format. Questions eight through eleven were open-ended and were designed to elicit detailed responses from the MFD employees. All of the responses were rounded to the nearest 1/10 of a percent.

After reviewing the information sheet and the articles, the respondents were asked to complete the survey and return it to the administrative offices. Surveys were distributed on March 14, 2007, to be returned by April 6, 2007. The total survey population was 75. The survey was distributed to the chief officers and fire inspectors through interoffice mail. Shift personnel received the survey through their respective battalion chiefs. No reminder notices were sent to the personnel before the due date. Forty surveys were returned in the allotted time, resulting in a 53.3% response rate.

After compiling the results of the survey, the material was presented at a special meeting of the MFD health and safety committee on April 10, 2007. The minutes of that meeting are included as Appendix D.

### *Limitations*

The response rate of 53.3% for the survey was lower than expected. Only one of seven part-time student firefighters responded, which may have been due to their sporadic work schedule. If the data were recalculated to exclude the student firefighters, the overall response rate would be 57.4%.

The author assumes all of the individuals returning the surveys followed the instructions to read the information on respiratory protection during overhaul before answering the questions to the best of their ability. There was no data collected on how many of the respondents took the time to read the research studies that were provided at the stations.

Another serious limitation of this study is, based on the research provided, respondent agreement with the statements made in questions two through six seems obvious. Still, in the opinion of the author, the process of presenting the information and gathering the feedback will be vital in strengthening the respiratory protection policies at the MFD. Unit two of the Executive Leadership course (NFA, 2005) emphasized the “gift of feedback” and the importance of using the information in the process of leading people to solve adaptive problems.

#### *Definition of terms*

Carcinogen- “An agent capable of initiating development of malignant tumours.. May be a chemical, a form of electromagnetic radiation, or an inert solid body” (Centre for Cancer Education [CCE], 1998, January 18. ¶ 1).

Conjunctivitis- “Inflammation of the conjunctiva, generally consisting of conjunctival hyperemia associated with a discharge” (CCE, 1997, November 18. ¶ 1).

Cyanosis- “A bluish discoloration, applied especially to such discoloration of skin and mucous membranes due to excessive concentration of reduced hemoglobin in the blood” (CCE, 1997, May 21. ¶ 1).

Dermatitis- “Inflammation of the skin” (CCE, 1997, November 18. ¶ 1).

Edema- “The presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body, usually applied to demonstrable accumulation of excessive fluid in the subcutaneous tissues” (CCE, 1997, November 18. ¶ 1).

Meta-analysis- “A quantitative method of combining the results of independent studies (usually drawn from the published literature) and synthesizing summaries and conclusions which may be used to evaluate therapeutic effectiveness or to plan new studies” (CCE, 1999, June 27. ¶ 1).

Mutagen- “An agent that can cause an increase in the rate of mutation, includes X-rays, ultraviolet irradiation (260 nm) and various chemicals” (CCE, 1997, November 18. ¶ 1).

Narcosis- “Privation of sense or consciousness, due to a narcotic” (CCE, 1998, March 1. ¶ 1).

Pneumoconiosis- “Fibrosis and scarring of the lungs secondary to the repeated inhalation of dust associated with some occupation. Examples include silica, asbestos and coal dust exposure” (CCE, 1998, October 29. ¶ 1).

Pulmonary- “Pertaining to the lungs” (CCE, 1997, October 6. ¶ 1).

Serum- “The clear portion of any body fluid. The clear fluid moistening serous membranes” (CCE, 1997, November 18. ¶ 1).

Spirometry- “Measurement of volume of air inhaled or exhaled by the lungs” (CCE, 1998, December 12. ¶1).

Tachycardia- “The excessive rapidity in the action of the heart, the term is usually applied to a heart rate above 100 per minute and may be qualified as atrial, junctional (nodal) or ventricular and as paroxysmal” (CCE, 1997, November 18. ¶ 1).



Tachypnea- “An abnormally rapid (usually shallow) respiratory rate. The normal resting adult respiratory rate is 12-20 breaths/minute” (CCE, 1997, September 27. ¶ 1).

Volatile organic compounds- “Emissions of non-methane hydrocarbons, measured by standard DEQ methods” (CCE, 1998, December 5. ¶ 1).

## RESULTS

### *Respiratory protection during overhaul survey*

Results of the *Respiratory Protection during Overhaul* survey were compiled and formatted for each question. A summary of the results is included in Appendix E.

Question one asked the respondents to circle their current rank at the department. . The rank classifications of those returning the survey included 14.3% of all student firefighters, 53.3% of fire drivers/firefighters, 60% of lieutenant/inspectors, and 75% of chief officers.

Question two stated, “The four-gas monitors used to determine whether it is safe to remove SCBA during interior operations during the overhaul stage of fires are limited in the relevant information they are able to provide.” The responses for this category included 32.5% that strongly agreed, 55.0% that agreed, 10.0% that were neutral, and 2.5% that disagreed. Overall, 87.5% of the department personnel survey agreed with the statement, while 2.5% disagreed.

Question three stated, “Research has shown there are numerous toxic products that may be present during interior overhaul operations at structure fires.” Employee responses to this statement included 57.5% that strongly agreed, 37.5% that agreed, 2.5% that were neutral, and 2.5% that disagreed. Overall, 95% of the department personnel surveyed agreed with the statement, while 2.5% disagreed.

Question four asked employees to respond to the statement, “Research has shown there are serious long-term health risks which have probable links to exposure to toxic products present during overhaul operations at structure fires.” The responses included 42.5% that strongly agreed, 47.5% that agreed, 7.5% that were neutral, and 2.5% that disagreed. Overall, 90% of the employees agreed with the statement, while 2.5% disagreed.

Question five stated, “The current respiratory protection policies at the Manhattan Fire Department are adequate to protect the health and safety of firefighters during interior overhaul operation at structure fires.” The responses included 27.5% that agreed, 20% that were neutral, 47.5% that disagreed, and 5% that strongly disagreed. Overall, 27.5% of the employees agreed that the current policies were adequate, while 52.5% disagreed.

Question six asked employees to respond to the statement, “The respiratory protection policies at the Manhattan Fire Department should be adjusted to protect the health and safety of firefighters during interior overhaul operations at structure fires.” The responses included 20% that strongly agreed, 60% that agreed, 17.5% that were neutral, and 2.5% that disagreed. The overall total showed 80% of the employees surveyed agreed that the policies should be strengthened, while 2.5% disagreed.

Question seven asked “What level of respiratory protection during overhaul operations should the Manhattan Fire Department require?” The choices included; “No change is necessary”, “Switch to full-face APR’s when carbon monoxide readings are less than 150 parts per million and the oxygen level is adequate”, “Wear SCBA during interior operations for the duration of each incident”, and “More information is necessary to make this determination.” The responses included 7.5% that thought no change was necessary,

27.5% that chose switching to full face APRs at when carbon monoxide readings were at acceptable levels, and 10% which thought SCBAs should be worn for the duration of each incident. Fifty per cent of the personnel responding thought that more information was necessary to make this determination. Five per cent of the employees did not give a response to this question.

Question eight was an open-ended question that asked, “What acute (short-term) health problems have you experienced after working without an SCBA during interior overhaul operations at structure fires?” Twenty-five employees responded with information on this question. The responses included 11 that reported having irritated eyes, 10 had irritated throat or lungs, 10 experienced coughing, eight reported having black mucous from sinuses, five experienced headaches, three had difficulty breathing, two reported dust particles in their respiratory system, two reported having a runny nose, one reported redness of the skin and one reported experiencing fatigue.

Question nine asked “What additional information would be helpful to you in order to participate in an informed decision-making process on respiratory protection policies during interior overhaul operations at structure fires?” Twenty eight employees responded to this question. The responses included 8 requesting more studies on what is present in the atmosphere during overhaul operations. Seven employees requested more information on APR cartridge use and their effectiveness. Five employees wanted more information on the effect of ventilation on air quality. Two employees thought studies on the effect of temperature in relation to the toxic products present would provide relevant information. Two additional employees requested more information on what other departments are doing. Other responses included requests for information on additional

monitoring equipment available. There was also a request for a discussion of the topic among department members.

Question 10 asked, “What stumbling blocks can you foresee if the Manhattan Fire Department implements a stricter respiratory protection policy during interior overhaul operations at structure fires?” Thirty three individuals responded with information on this topic. The responses included 14 individuals that thought employee resistance to change would be a stumbling block. Eight individuals believed more manpower would be necessary if the policies were strengthened. Six individuals believed longer rehabilitation periods would be needed. The need for strict enforcement was mentioned by three individuals. Other responses mentioned included; extended time on scenes, lack of compliance by chief officers, harder work necessary on the scene, more injuries during the overhaul period, difficulty conducting fire investigations, limited visibility, higher costs, and lack of compliance by fire investigators.

The final survey question asked “Please list any additional questions you have on this issue.” There were seven responses given on this question. The additional questions included:

- Will cost be a major factor in getting a lower protection option than full SCBAs?
- What is the effect of ventilation during the overhaul period on toxic gases present?
- At what point is the atmosphere clear of toxic products?
- Isn't it likely that if carbon monoxide levels are lowered, other toxic gases will be lowered in the process?

- Are there detection devices available to monitor for the toxic gases present during overhaul?
- Will employees be given a time frame for implementation of any changes to the current policy?

*MFD health and safety committee special meeting*

After the results of the survey were collected and tabulated, the results were analyzed at a special meeting of the MFD health and safety committee. This meeting was held on April 10, 2007 and the discussion was limited to the topic of firefighter safety during overhaul. The committee members reviewed the results of the study and, after discussion, a consensus was reached that the respiratory protection policies during overhaul operations at the MFD should be strengthened. The committee issued the following recommendations to Chief Snyder and the rest of the department members:

- Monitoring capabilities should be expanded. The committee members agreed that further research should be conducted into respiratory protection options.
- The time that department members spend in SCBAs should be increased until the toxic gases identified in the studies presented are at acceptable levels.
- Air purifying respirators should be available for dust producing environments and for investigators “digging out” fire scenes.
- Increased manpower should be provided during the overhaul period and rotation through rehabilitation should be mandatory.
- Powered positive pressure ventilation, starting with gas-powered and transitioning to electric fans, should be provided throughout the entire incident.

## DISCUSSION

The results of the department survey offer feedback in several important areas for the MFD administration. The literature review established a foundation of information concerning respiratory protection during overhaul including information on standards and policies, studies identifying hazardous substances present in actual test scenes, short and long term health effects, and options for increased respiratory protection. It is clear from this effort that many more questions remain, but the information gathered in the department survey answers several questions identified as critical to the MFD administration to strengthening the current policy.

The literature review clearly established the responsibility of employers to educate their employees on hazards in the workplace. The hazard communication standard (USDL, 2007) requires that employers provide initial and ongoing training on hazardous chemicals in their workplace and also when a new hazard is identified or introduced. The process involved with the department survey included introduction of the topic, education on the hazards involved, and feedback from all department firefighting personnel. This effort was critical to establishing an effort to strengthen the respiratory protection policy.

The respiratory protection regulations (USDL, 2007) also provide guidance on the decision making process that should be utilized when making respiratory protection decisions. The regulations require the employer to identify respiratory hazards in the workplace and make a reasonable estimate of potential employee exposures. Further, section 1910.134 (d)(1)(iii) of the regulation states “where the employer cannot identify or reasonably estimate the employee exposure, the employer shall consider the atmosphere to be immediately dangerous to life and health.” Additionally, Bolstad-

Johnson et al. (2000) found that “CO readings should not be used to predict the presence of other contaminants found in the overhaul environment” (p. 641). The survey results revealed that 87.5% of the department members agreed that the monitoring devices available to detect hazards in the atmosphere provide limited information that does not detect all hazards.

The literature review also revealed four research studies that identified actual hazardous substances present and quantities involved in actual and test fires. Kinnes and Hines (1998) collected air samples at five fire scenes and identified three substances present at dangerous levels; formaldehyde, respirable dust, and three polycyclic aromatic hydrocarbons.

Bolstad-Johnson et al. (2000) analyzed 25 fire scenes and identified eight substances present at dangerous levels during the normal overhaul period including; acrolein, benzene, carbon monoxide, formaldehyde, glutaraldehyde, nitrogen dioxide, polycyclic aromatic hydrocarbons, and sulfur dioxide.

Burgess et al. (2001) analyzed samples from 16 fire scenes taken during the period overhaul operations would be conducted and this researcher used the data to identify four substances at dangerous levels; acetaldehyde, benzene, formaldehyde, and respirable dust.

Austin et al. (2001) studied air samples from nine fires and identified 1,3-butadiene, benzene, and styrene to be present in the highest concentrations.

The data from these studies reveals several common substances present, but the differences highlight the fact that every fire is unique and the substances present will be unknown to some degree. This information was presented to the firefighters at the MFD

and 95% of the department members surveyed agreed that the research confirmed there may be numerous toxic substances present during the overhaul period.

The literature also showed that several of the substances present in the test samples have similar short term health effects. Exposure to eight of the ten substances identified in this research are known to cause eye, nose, or throat irritation including; 1,3 butadiene, acetaldehyde, acrolein, formaldehyde, glutaraldehyde, nitrogen dioxide, styrene, and sulfur dioxide. Further, exposure to four of the ten substances causes coughing including 1,3 butadiene, acrolein, formaldehyde and nitrogen dioxide.

The department survey asked respondents to list acute health problems they have experienced after working without an SCBA during interior overhaul operations at structure fires. A total of 25 of the 40 individuals that completed the survey reported having short term health issues. Eleven individuals reported having eye irritation, 10 reported experiencing irritations of the throat or lungs, and 10 individuals reported experiencing coughing. This research suggests the possibility that the firefighters at the MFD may be experiencing symptoms of exposure to the listed substances that we are currently unable to detect with available monitoring technology.

There were possibilities for serious long term health effects suggested by the literature reviewed. The safety data information reviewed for benzene (NCI, n.d.), formaldehyde (NCI, n.d.), and polycyclic aromatic hydrocarbons (U.S. Department of Health and Human Services, n.d. ) revealed they are all listed as potential human carcinogens. Further, the studies conducted by Fangchao et al. (2006) and LeMasters et al. (2006) found significantly higher cancer rates among firefighters than the general public. The responses from the department survey revealed that 90% of the respondents agreed that



there are serious long term health risks which have probable links to exposure to the toxic products present during overhaul operations at structure fires.

The survey also asked whether the department members believed the current respiratory protection policies at the MFD are adequate to protect the health and safety of firefighters during interior operations at structure fires. Fifty-two percent of the members surveyed believed the current policy is not adequate. Significantly, 27.5% of the members surveyed thought the current policies were adequate and 20% were neutral.

The department members were also asked whether they believed the current respiratory protection policies at the MFD should be adjusted to protect the health and safety of firefighters during interior overhaul operations. Significantly, 80% agreed that the current policies should be adjusted in some manner. This response confirms that the department members recognize the limitations of the monitoring equipment and the short and long-term health hazards of the substances that may be present.

The findings from the literature review and the employee support for a specific respiratory protection option is much less clear. Kinnes and Hine (1998) and Bolstad-Johnson et al. (2000) recommended the use of full-face APRs with support from monitoring equipment to ensure adequate oxygen levels and to ensure that carbon monoxide levels were not above listed parameters. The follow-up study by Burgess et al. (2001) found shortcomings in the effectiveness of APRs and recommended increasing the time period that full SCBAs were worn (p. 473). The department survey results showed that 50% of the department members believe that more information is needed before a decision can be made on a respiratory protection option, while 27.5% believe that APRs are the most effective choice. The author discovered the Burgess study after

administering the department survey; therefore, the information on the limitations of APRs in overhaul situations was not available to the MFD respondents. Also, only 10 department members supported the option of wearing SCBAs during interior operations for the duration of the incident. It is clear from this employee feedback that while the members support strengthening the respiratory protection policy, they believe that more information is necessary.

Additional objectives of the department survey were to identify areas where further research was necessary and to identify stumbling blocks to implementing a stricter policy. After concluding the literature review, the opinion of this researcher was the data collected from the 55 fires in the cited studies provided an adequate sampling base to estimate the substances that could possibly be present. Still, the leading requests for additional information from the survey were more studies on what is actually present in the atmosphere. Other significant requests were for information on the effectiveness of APRs and on the effect of ventilation on air quality during overhaul.

The stumbling blocks listed by the department members mirrored the initial concerns of the MFD administration as “employee resistance” was the leading response offered. Other significant responses included the need for additional manpower at fire scenes and the potential need for longer rehabilitation periods for members wearing respiratory protection for extended periods.

In summary, the department survey confirmed that after a review of the information gathered during the literature review, the majority of department members surveyed understand the risks involved in removing respiratory protection during overhaul and agree the current policies should be strengthened.

## RECOMMENDATIONS

In the opinion of this researcher, the MFD should consider the following options to address the issue of respiratory protection during overhaul activities:

- The MFD administration should consider the results of this research and the recommendations from the health and safety committee at the next available opportunity.
- Based on this research, the only respiratory option available to adequately protect firefighters is full SCBA until overhaul activities have been completed.
- Ventilation efforts should continue to be a priority at all structure fires. The current practice at the MFD of using positive pressure ventilation, starting with gas-powered and transitioning to electric fans, should be mandatory and provided throughout the overhaul period.
- The department should assign individuals from the hazardous materials team to research options to increase monitoring capabilities. This group should consider technical information from manufacturers, as well as information from other departments across the country, to find the most effective options available that fall within the MFD budget constraints.
- The MFD administration should explore the feasibility of organizing a regional research study to monitor the atmosphere during the overhaul period at structure fires. The regional element would be necessary to get an adequate sample of test fires. The author is particularly interested in testing the effectiveness of using photo-ionization capabilities available on the newest four-gas monitors and comparing the data that monitor is able to gather with full data from more

expensive, less portable air sampling equipment. This proposed research would assume that positive pressure ventilation was deployed at each fire. This research may be able to establish that monitor as an effective unit to be utilized in conjunction with the ventilation efforts.

- The employees at the MFD should continue to be engaged and involved in the process of determining future measures to be taken on this issue. Postponing the removal of SCBAs will greatly enhance the long term health and safety of firefighters, but it will also make working conditions more difficult. It is extremely important that the administration at the MFD continue to educate the workforce, listen to the feedback, and work for employee “buy-in” on any enhancements to the respiratory protection policy.
- Any departments currently relying on visual inspection or CO readings should consider evaluating their respiratory protection during overhaul policies immediately. All firefighters should be informed as soon as possible of the hazards that research has proven to be present during the overhaul stage.
- Future readers of this report should consider using the data from this report, including the information sheet on respiratory hazards, to educate the members of their department. Due to the health risks involved, all firefighters should be fully informed on the issue. More research is also needed to explore issues such as monitoring options available, respiratory protection options, and the effect of ventilation on the toxic products present. Through additional research, fire chiefs will have the information necessary to lead an informed decision making process on this adaptive problem at their departments.

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## Appendix A



## Manhattan Fire Department Respiratory Protection during Overhaul Survey Form

Please read the enclosed information sheet on respiratory protection during overhaul carefully before completing the following questions:

- 1) Please circle the rank category that applies to your position
  - a) Chief Officer
  - b) Lieutenant/Inspector
  - c) Fire Driver/Firefighter
  - d) Student Firefighter
  
- 2) The 4-gas monitors used to determine whether it is safe to remove SCBA during interior operations during the overhaul stage of fires are limited in the relevant information they are able to provide.
  - a) Strongly agree
  - b) Agree
  - c) Neutral
  - d) Disagree
  - e) Strongly disagree
  
- 3) Research has shown there are numerous toxic products that may be present during interior overhaul operations at structure fires.
  - a) Strongly Agree
  - b) Agree
  - c) Neutral
  - d) Disagree
  - e) Strongly disagree
  
- 4) Research has shown there are serious long term health risks which have probable links to exposure to toxic products present during interior overhaul operations at structure fires.
  - a) Strongly agree
  - b) Agree
  - c) Neutral
  - d) Disagree
  - e) Strongly disagree

- 5) The current respiratory protection policies at the Manhattan Fire Department are adequate to protect the health and safety of firefighters during interior overhaul operations at structure fires.
  - a) Strongly agree
  - b) Agree
  - c) Neutral
  - d) Disagree
  - e) Strongly disagree
  
- 6) The respiratory protection policies at the Manhattan Fire Department should be adjusted to protect the health and safety of firefighters during interior overhaul operations at structure fires.
  - a) Strongly agree
  - b) Agree
  - c) Neutral
  - d) Disagree
  - e) Strongly disagree
  
- 7) What level of respiratory protection during overhaul operations should the Manhattan Fire Department require?
  - a) No change is necessary
  - b) Switch to full-face APRs when carbon monoxide readings are less than 150 parts per million and the oxygen level is adequate.
  - c) Wear SCBA during interior operations for the duration of each incident.
  - d) More information is necessary to make this determination.

Short answer questions

- 8) What acute (short term) health problems have you experienced after working without an SCBA during interior overhaul operations at structure fires?
  
  
  
  
  
  
  
  
  
  
- 9) What additional information would be helpful to you in order to participate in an informed decision making process on respiratory protection policies during interior overhaul operations at structure fires?
  
  
  
  
  
  
  
  
  
  
- 10) What stumbling blocks can you foresee if the Manhattan Fire Department implements a stricter respiratory protection policy during interior overhaul operations at structure fires?

11) Please list any additional questions you have on this issue.

Please complete this form and return it as soon as possible to CTO Clark in the envelope provided. Thank you very much for your cooperation.

## Appendix B



# *Department of Fire Services*

2000 Denison Manhattan, KS 66502 785-587-4504 Code Services 785- 587-4506  
Emergency Dial 911

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March 14, 2007

All MFD Firefighting Personnel,

This is in regard to our departmental safety training assignment for March 2007, which is “firefighter health and safety during overhaul.” The primary purpose of this training is to raise your awareness of the health and safety concerns on this issue. Please review the attached information packet which provides a summary of the information I’ve found while researching the topic. The complete articles for each research study cited are also being forwarded to your station for review.

Second, please take the time to fill out the enclosed survey form. As you complete this, consider the data included in the information provided (including the complete articles) and feel free to contact me with any further questions you have. Your feedback will be taken very seriously as we determine the best course of action to take on this issue. Please forward the completed surveys to my office as soon as possible, but no later than Friday, April 6.

Enhancement of health and safety during overhaul operations at the MFD will depend on the support of our workforce. Thanks in advance for your input on this issue.

Sincerely,

Scott Clark  
Chief Training Officer

*Please return the enclosed questionnaire to CTO Clark by 1700 hours, Friday, April 6th.*

## Appendix C



## Manhattan Fire Department Respiratory Protection during Overhaul Information Sheet

**Current Manhattan Fire Department policy-** Our current policy regarding the removal of self contained breathing apparatus (SCBA) during overhaul operations at structure fires involves collecting air monitoring readings with a Drager “four-gas” monitor. A reading of 35 parts per million of carbon monoxide (CO) is used as a baseline to determine whether it is safe to remove SCBA. After removal, on-scene incident safety personnel continue to monitor the atmosphere to gather current CO readings and no respiratory protection is worn.

Please review the following material carefully prior to completing the enclosed survey. The literature used to compile this information sheet is also being made available at your station for your detailed review. If you have questions during the review of this material, please feel free to contact CTO Clark at 785-341-3753 or by email at [clark@ci.manhattan.ks.us](mailto:clark@ci.manhattan.ks.us).

**MYTH:** A four-gas monitor provides information on all of the dangerous products of combustion that may be present in the atmosphere after extinguishment in a structure fire.

**FACT:** Although research has shown that approximately 30% of fire departments use readings from a “four gas” monitor to make respiratory protection decisions during the overhaul stage at fires, these monitors are limited in the useful safety information they can provide. In order to understand the limitations of the four-gas monitor, consider the information each of the four sensors provide:

**Combustible gas sensor**- this sensor provides a number signifying a percent of the lower explosive limit (LEL) of the calibration gas used by the instrument. In order to get a precise LEL reading, a conversion factor must be used for the suspected gas in the atmosphere. This reading does not provide specific information to identify the chemical(s) involved or to easily estimate the quantity present.

**Oxygen sensor**- this sensor provides a reading of the percent of oxygen in the atmosphere. The normal level is 20.9%. For every one percent drop in the oxygen level in a structure, there is 50,000 parts per million of another gas present that has displaced it.

**Carbon Monoxide sensor**- The “four-gas” monitor provides a reading of the amount of carbon monoxide *at the detector* in parts per million.

**Hydrogen Sulfide sensor**- This sensor provides a reading of the amount of hydrogen sulfide *at the detector* in parts per million. This sensor may be replaced with another “toxic gas” sensor.

*Limitations of “four-gas” monitors:*

- a) The “four-gas” monitor does not provide specific, readily available information on quantities of any gas other than oxygen, carbon monoxide, or hydrogen sulfide.
- b) The “four-gas” monitor cannot be used to identify which toxic gases are present, other than carbon monoxide or hydrogen sulfide.
- c) The “four-gas” monitor does not provide information on particulate solid matter that may be present in the structure.

**MYTH:** Carbon Monoxide is the most dangerous toxic by-product that may be present after the fire is knocked down in a structure.

**FACT:** Research studies completed by the Bureau of Alcohol, Tobacco, and Firearms (ATF) and the Phoenix Fire Department have shown there are numerous toxic substances present after extinguishment at structure fires:

*ATF Study-* This study, which was completed in 1998, involved monitoring the atmosphere at five structural fire scenes. The research concluded that the potential for exposure existed to the following:

Formaldehyde- concentrations exceeded the NIOSH ceiling limit of 0.1 ppm.

*Formaldehyde is a suspected human carcinogen.*

Polynuclear Aromatic Hydrocarbons (PAH)- Three PAH's were detected that are on a list of industrial substances suspected to be human carcinogens. They included benz(a)anthracene, benzo(b)fluoranthene, and benzo(a)pyrene.

Total and Respirable Dust- the study showed that high levels of respirable and inhalable dust were present in short durations during some activities. The particle sizes generated during some overhaul activities were small enough to be deposited anywhere in the respiratory tract.

*Phoenix Fire Department Study-* This study involved monitoring during the overhaul period at 26 fires during 1998. This study found potentially dangerous levels of the following:

“The chemicals found to exceed occupational exposure limits in this study have the potential to cause adverse health effects in firefighters. Acrolein produces intense irritation to the eye and mucous membranes of the respiratory tract. Acute exposures may result in bronchial inflammation, resulting in bronchitis or pulmonary edema. Carbon monoxide is present in all fire environments as a product of incomplete combustion and decreases the oxygen transport of the blood, which results in an inadequate supply of oxygen to the tissues. Adverse health effects due to formaldehyde may occur after exposure by inhalation, ingestion, or skin contact. Eye irritation can occur at concentrations of 0.01-2.0 ppm, irritation of the nose and throat at 1.0-3.0 ppm, and severe respiratory symptoms at 10-20 ppm. *Formaldehyde is classified as a probable carcinogen.* Glutaraldehyde is a potent sensory irritant with the capability to



cross-link, or fix proteins. Sulphur Dioxide is irritating to the mucous membranes of the upper respiratory tract. Chronic exposures may result in fatigue, altered sense of smell, and symptoms representing chronic bronchitis (i.e., dyspnea on exertion and cough).”

The Phoenix study also concluded there were numerous chemicals present that are not easily classified and with little data available on possible health effects. The study also noted there is little data available on the combined effects of exposure to the mix of chemicals present (Bolstad-Johnson, 2000, p. 639-640).

**MYTH:** Acute symptoms that firefighters experience immediately after working without respiratory protection in an overhaul atmosphere are the most dangerous health problems that may occur.

**FACT:** Two recent studies have found an increased risk of cancer in firefighters:

*Cancer Incidence in Florida Professional Firefighters, 1981-1999*

Published in the Journal of Occupational and Environmental Medicine, September 2006

This study, which covered 34,796 male and 2,017 female firefighters, concluded that “male firefighters had significantly increased incidence of bladder, testicular, and thyroid cancers. Female firefighters had significantly increased incident rates of overall cancer, cervical, and thyroid cancer and Hodgkin disease.” The study also noted that “firefighters are routinely exposed to various carcinogens during firefighting and overhaul (i.e., time period for searching and extinguishing hidden fires after the main fire has been brought under control).

*Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 Studies*

Published in the Journal of Occupational and Environmental Medicine, November 2006.

The objective of this study was “to review 32 studies on firefighters and to quantitatively and qualitatively determine the cancer risk using a meta-analysis.”

The findings indicated that firefighters had a “probable” cancer risk for multiple myeloma, non-Hodgkin lymphoma, prostate, and testicular cancers. Eight additional cancers were listed as having a “possible” association with firefighting.

## WHAT ARE THE OPTIONS??

There are multiple options for a departmental response to this issue, including but not limited to:

- 1) **No change in policy.** Continue to monitor the post-extinguishment atmosphere and allow fire department personnel to remove SCBA protection when the carbon monoxide readings are below 35 parts per million.

- 2) **Allow personnel to switch to full-face air purifying respirators (APRs) when carbon monoxide concentrations are below 150 parts per million and the oxygen level is adequate.**

Variations on this option were chosen for the personnel at the Bureau of Alcohol, Tobacco and Firearms (ATF) and the Phoenix Fire Department based on their respective studies:

- a) The ATF study concluded that “since the use of SCBAs would most likely not be practical during most fire scene investigations, the use of half-face, air-purifying respirators equipped with combination filter cartridges (high-efficiency particulate, VOCs, acid mists, and formaldehyde) or powered air-purifying respirators with the appropriate cartridges should be used.”
- b) The Phoenix study recommended that “SCBA should be used in atmospheres with CO concentrations above 150 ppm, and APRs may be used when CO concentrations are below 150 ppm.”

*LIMITATIONS*

There are several limitations to the use of APRs:

- a) The Phoenix study noted that “additional health-based studies on the use of APRs during overhaul should be used to confirm their effectiveness.”

- 3) **Wear SCBA during interior operations for the duration of each incident.**

This option would provide the highest level of respiratory protection available to firefighting personnel.

*LIMITATIONS*

- a) The primary limitation of this option is the physical stress of wearing an SCBA.

Thank you for your detailed review of this material. Please take the time to review the individual research articles that are available at your station and feel free to call me if you have any questions. When your review is finished, please complete the enclosed survey form and return it to the administrative offices by Friday, April 6 in the envelope provided.

## Appendix D



# *Department of Fire Services*

## **Health and Safety Committee Meeting April 10, 2007**

Special meeting called to discuss results of respiratory protection survey at HQ this date at 0840. Present: Clark, French, Almes, Habbart, Whitehair, Shaffer and Wells.

Discussion was limited firefighter safety during overhaul and was in response to the survey distributed to all members that was due on 04/06/07. CTO Clark distributed compiled results from survey and discussion followed.

Survey revealed, based on information provided to fire department personnel, that strengthening of our SOGs on respiratory protection should be done.

After reviewing results and discussing options to improve the current system to promote better health and safety, the following recommendations are made:

- 1) Expanded monitoring. This issue will be researched and monitoring capabilities should be expanded to show currently undetected hazards.
- 2) Time spent wearing SCBA should be increased until gases, which research determines will be monitored, are at acceptable levels. These levels will likely be based on TVL-TWA or comparable standards.
- 3) Make Air Purifying Respirators (APRs) available for dust producing environments and digging out fires for investigation purposes.
- 4) Provide more manpower through shift personnel and callbacks for prolonged overhaul and make substitution of workers mandatory.
- 5) Require powered ventilation, starting with PPV changing to electric, throughout the entire incident including investigation.

Items committee members will continue to research include use of tethered air supply and different types of APRs.

The committee decided that members of this committee present should spread these recommendations to the shifts and accept any input to improve these procedures in the future. Meeting adjourned at 1015.

## Appendix E



## Manhattan Fire Department Respiratory Protection during Overhaul Survey results

1) Please circle the rank category that applies to your position:

a) Chief Officer	6	8 possible
b) Lieutenant/Inspector	9	15 possible
c) Fire Driver/Firefighter	24	45 possible
d) Student Firefighter	1	7 possible
<b>Total</b>	<b>40</b>	<b>75 possible</b>

53.33% of total workforce

Key to abbreviations (used on this Appendix only)

CO .Chief Officer  
 Lt/Insp .Lieutenant/Inspector  
 FD/FF .Fire Driver/Firefighter  
 SFF .Student Firefighter

2) The 4-gas monitors used to determine whether it is safe to remove SCBA during interior operations during the overhaul stage of fires are limited in the relevant information they are able to provide.

		Per cent of total responses
a) Strongly agree	13	32.5%
b) Agree	22	55.0%
c) Neutral	4	10.0%
d) Disagree	1	2.5%
e) Strongly disagree	0	0.0%
<b>Total</b>	<b>40</b>	<b>100.00%</b>

3) Research has shown there are numerous toxic products that may be present during interior overhaul operations at structure fires.

		Per cent of total responses
a) Strongly agree	23	57.5%
b) Agree	15	37.5%
c) Neutral	1	2.5%
d) Disagree	1	2.5%
e) Strongly disagree	0	0.0%
<b>Total</b>	<b>40</b>	<b>100.00%</b>

4) Research has shown there are serious long-term health risks which have probable links to exposure to toxic products present during interior overhaul operations at structure fires.

	Per cent of total responses	
a) Strongly agree	17	42.5%
b) Agree	19	47.5%
c) Neutral	3	7.5%
d) Disagree	1	2.5%
e) Strongly disagree	0	0.0%
Total	40	100%

5) The current respiratory protection policies at the Manhattan Fire Department are adequate to protect the health and safety of firefighters during interior overhaul operations at structure fires.

	Per cent of total responses	
a) Strongly agree	0	0.0%
b) Agree	11	27.5%
c) Neutral	8	20.0%
d) Disagree	19	47.5%
e) Strongly disagree	2	5.0%
Total	40	100%

6) The respiratory protection policies at the Manhattan Fire Department should be adjusted to protect the health and safety of firefighters during interior overhaul operations at structure fires.

	Per cent of total responses	
a) Strongly agree	8	20.0%
b) Agree	24	60.0%
c) Neutral	7	17.5%
d) Disagree	1	2.5%
e) Strongly disagree	0	0.0%
Total	40	100%

7) What level of respiratory protection during overhaul operations should the Manhattan Fire Department require?

	Per cent of total responses	
a) No change is necessary.	3	7.5%
b) Switch to full-face APR's when carbon monoxide readings are less than 150 parts per million and the oxygen level is adequate.	11	27.5%
c) Wear SCBA during interior operations for the duration of each incident.	4	10.0%
d) More information is necessary to make this determination.	20	50.0%
NO RESPONSE GIVEN	2	5.0%
Total	40	100%

8) What acute (short term) health problems have you experienced after working without an SCBA during interior overhaul operations at structure fires?

Total responses- 25 individuals responded with information on this question.

Total for each type of symptom given.

- 11 Irritated eyes
- 10 Irritated throat/lungs
- 10 Coughing
- 8 Black mucous from sinuses
- 5 Headache
- 3 Difficulty breathing
- 2 Dust/particles in respiratory system
- 2 Dizziness
- 2 Runny nose
- 1 Skin redness
- 1 Fatigue

9) What additional information would be helpful to you in order to participate in an informed decision-making process on respiratory protection policies during interior overhaul operations at structure fires?

Total responses- 28 individuals responded with information on this question.

Total for each category of information given.

- 8 More studies on what is present in the atmosphere
- 7 More information on air purifying respirator cartridge use and effectiveness
- 5 Effects of ventilation on air quality during overhaul operations
- 2 Temperature inside the structure and the corresponding effect on amount of toxics present
- 2 Need more firefighting experience to make a determination
- 2 Provide more information on what other departments are doing
- 1 Monitoring equipment available
- 1 Respiratory protection options not mentioned
- 1 Study on length of exposure and its effect on adverse health conditions
- 1 Medical problems at other departments
- 1 Discussion among department members

10) What stumbling blocks can you foresee if the Manhattan Fire Department implements a stricter respirator protection policy during interior overhaul operations at structure fires?

Total responses- 33 individuals responded with information on this question.

Total for each category of information given.

- 14 Employee resistance/culture change
- 8 More manpower needed
- 6 Longer rehabilitation periods needed
- 4 Strict enforcement
- 3 Extended time on the scene
- 3 Lack of compliance by chief officers
- 2 Harder work on scene for workforce
- 2 More injuries during overhaul period
- 2 Harder to conduct fire investigation
- 1 Limited visibility/mobility
- 1 Cost
- 1 Lack of compliance by fire investigators

11) Please list any additional questions you have on this issue.

Total responses- 7 individuals responded with information on this question.

Will cost be a major factor in getting a lower protection option than full SCBA's?

What is the effect of ventilation during the overhaul period?

At what point is the atmosphere clear of toxic products?

Isn't it likely that if the carbon monoxide is lowered, other toxic gases will be lowered in the process?

Are there detection devices available to monitor for the toxic gases present during overhaul?

Will employees be given a time frame for implementation of any changes to the current policy?