"Surviving a Fire Service Career"

Understanding and Preventing Occupational Cancer

HONOR ★ DUTY ★ COURAGE

Presented by Captain Jennifer Chadwick and Lieutenant Dino Bissaro

Objectives

- Define the scope of the cancer problem in the fire service.
- Review and discuss occupational cancer research.
- Discuss the increase in toxic agents in today's fire environment.
- Identify routes of exposure to cancer-causing agents.
- Discuss common firefighter exposures to carcinogens.
- Review the steps firefighters can take to protect themselves from cancer.

Scope Of The Cancer Problem In The Fire Service

- Cancer is one of the most dangerous threats to the health and safety of firefighters everywhere.
  - 60% of LODDs are due to occupational cancer (IAFF).

- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network; IAFF -

Multiple studies have proven the link between firefighting and cancer

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

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Objective: 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. Methods: A comprehensive search of computerized databases and bibliographies from identified articles was performed. Three criteria used to assess the probable, possible, or unlikely risk for 21 cancers included pattern of meta-relative risks, study type, and heterogeneity testing. Results: The findings indicated that firefighters had a probable cancer risk for multiple myeloma with a summary risk estimate (SRE) of 1.53 and 95% confidence interval (CI) of 1.21–1.94, non-Hodgkin lymphoma (SRE = 1.51, 95% CI = 1.31–1.72), and prostate (SRE = 1.28; 95% CI = 1.15–1.43). Testicular cancer was upgraded to probable because it had the highest summary risk estimate (SRE = 2.02; 95% CI = 1.30–3.13). Eight additional cancers were listed as having a "possible" association with firefighting. Conclusions: Our results confirm previous findings of an elevated mesothelative risk for multiple myeloma among firefighters. In addition, a probable association with non-Hodgkin lymphoma, prostate, and testicular cancer was demonstrated. (J Occup Environ Med. 2006;48: 1189–1202)

During the course of their work, firefighters are exposed to harmful substances at the fire scene as well as at the firehouse. At the fire scene, firefighters are potentially exposed to various mixtures of particulates, gases, mists, fumes of an organic and/or inorganic nature, and the resultant pyrolysis products.[1,2] Specific potential exposures include metals such as lead, antimony, cadmium, uranium, chemical substances, including acrolein, benzene, methylene chloride, polyaromatic hydrocarbons, perchloroethylene, toluene, trichloroethylene, trichlorophenol, xylene, formaldehydes, minerals such as asbestos, crystalline, and noncrystalline silica, silicates, and various gases that may have acute, toxic effects.[1,2] In some situations, respiratory protection equipment may be inadequate or not felt to be needed resulting in unrecognized exposure.[3] At the firehouse where firefighters spend long hours, exposures may occur to complex mixtures that comprise diesel exhaust, particularly if trucks are run in closed houses without adequate outside venting. In light of the World Trade Center disaster, concerns have reemerged and heightened related to building debris particle exposures from pulverized cement and glass, fiberglass, asbestos, silica, heavy metals, soot, and/or organic products of combustion.[3]

To date, only one meta-analysis conducted by Howe and Burch in 1990 examined the extent of cancer risk among firefighters in 11 mortality studies.[4] They reported that there was an increased association with the occurrence of brain tumors, malignant melanoma, and multiple myeloma with the evidence in favor of

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This study was supported in part by a grant from the Ohio Bureau of Workers Compensation.

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Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950–2009)

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ABSTRACT

Objectives To examine mortality patterns and cancer incidence in a pooled cohort of 29 993 US career firefighters employed since 1950 and followed through 2009.

Methods Mortality and cancer incidence were evaluated by life table methods with the US population referent. Standardised mortality (SMR) and incidence (SIR) ratios were determined for 92 causes of death and 41 cancer incidence groupings. Analyses focused on 15 outcomes of a priori interest. Sensitivity analyses were conducted to examine the potential for significant bias.

Results Person-years at risk totalled 858 938 and 403 152 for mortality and incidence analyses, respectively. All-cause mortality was at expectation (SMR=0.99, 95% CI 0.97 to 1.01, n=12 028). There was excess cancer mortality (SMR=1.14, 95% CI 1.10 to 1.18, n=3285) and incidence (SIR=1.09, 95% CI 1.06 to 1.12, n=4641) comprised mainly of digestive (SMR=1.26, 95% CI 1.18 to 1.34, n=928; SIR=1.17, 95% CI 1.10 to 1.25, n=930) and respiratory (SMR=1.10, 95% CI 1.04 to 1.17, n=1096; SIR=1.16, 95% CI 1.08 to 1.24, n=813) cancers. Consistent with previous reports, modest elevations were observed in several solid cancers; however, evidence of excess lymphatic or haematopoietic cancers was lacking. This study is the first to report excess malignant mesothelioma (SMR=2.00, 95% CI 1.03 to 3.49, n=12; SIR=2.29, 95% CI 1.60 to 3.19, n=35) among US firefighters. Results appeared robust under differing assumptions and analytic techniques.

Conclusions Our results provide evidence of a relation between firefighting and cancer. The new finding of excess malignant mesothelioma is noteworthy, given that asbestos exposure is a known hazard of firefighting.

What this paper adds

- From previous studies, there is limited epidemiological evidence of increased risk of cancer from firefighting.
- We examined cancer in 30 000 career firefighters by pooling information from urban fire departments in three large US cities. The large sample size and long follow-up period improved risk estimates compared with previous studies.
- We report that firefighting may be associated with increased risk of solid cancers. Furthermore, we report a new finding of excess malignant mesothelioma among firefighters, suggesting the presence of an occupational disease from asbestos hazards in the workplace.

INTRODUCTION

There are approximately 1.1 million volunteer and career firefighters in the US.[1] During firefighting activities, these workers may be exposed to many known carcinogens (eg, polycyclic aromatic hydrocarbons (PAHs), formaldehyde, benzene, 1,3-butadiene, asbestos and arsenic) in volatilised combustion and pyrolysis products or debris.[2] These exposures have raised concerns of increased cancer among firefighters and have prompted a number of exposure assessment and epidemiologic investigations. Some studies have found excess cancers of the brain,[3–8] digestive tract,[4 5 7–10] genitourinary tract[4 9 11 12] and lymphohematopoietic organs.[5 6 13] In a recent meta-analysis of 32 studies, significant excess risk was reported for brain, stomach, colon, rectum, prostate, testes, multiple myeloma and non-Hodgkin lymphoma (NHL).[14] Similarly, the International Agency for Research on Cancer (IARC) reviewed 42 studies and reported significant summary risks for prostatic and testicular cancers and NHL.[2] Given limited evidence, however, IARC concluded that firefighter exposures were only possibly carcinogenic to humans (Group 2B).

Most studies have examined mortality, but not cancer incidence, among relatively few firefighters recruited from one fire department. The current study examines mortality and cancer incidence in a pooled cohort of firefighters employed in three major US cities. Malignancies of the brain, stomach, oesophagus, intestines, rectum, kidney, bladder, prostate, testes, leukaemia, multiple myeloma and NHL were of a priori interest in the current study based on possible sites identified in previous reviews.[2 14] Lung cancer and chronic obstructive pulmonary disease (COPD) were also of interest because inhalation is a major pathway for firefighter exposures, and there is evidence of

Exposure–response relationships for select cancer and non-cancer health outcomes in a cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950–2009)

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ABSTRACT

Objectives To examine exposure–response relationships between surrogates of firefighting exposure and select outcomes among previously studied US career firefighters.

Methods Eight cancer and four non-cancer outcomes were examined using conditional logistic regression. Incidence density sampling was used to match each case to 200 controls on attained age. Days accrued in firefighting assignments (exposed-days), run totals (fire-runs) and run times (fire-hours) were used as exposure surrogates. HRs comparing 75th and 25th centiles of lagged cumulative exposures were calculated using loglinear, linear, log-quadratic, power and restricted cubic spline general relative risk models. Piecewise constant models were used to examine risk differences by time since exposure, age at exposure and calendar period.

Results Among 19 309 male firefighters eligible for the study, there were 1333 cancer deaths and 2609 cancer incidence cases. Significant positive associations between fire-hours and lung cancer mortality and incidence were evident. A similar relation between leukaemia mortality and fire-runs was also found. The lung cancer associations were nearly linear in cumulative exposure, while the association with leukaemia mortality was attenuated at higher exposure levels and greater for recent exposures. Significant negative associations were evident for the exposure surrogates and colorectal and prostate cancers, suggesting a healthy worker survivor effect possibly enhanced by medical screening.

Conclusions Lung cancer and leukaemia mortality risks were modestly increasing with firefighter exposures. These findings add to evidence of a causal association between firefighting and cancer. Nevertheless, small effects merit cautious interpretation. We plan to continue to follow the occurrence of disease and injury in this cohort.

What this paper adds

- The study addresses limitations in previous research regarding exposure–response relationships by conducting internal analyses of disease rates among career firefighters in a large pooled cohort.
- Comprised of almost 20 000 career firefighters with over 1300 cancer-related deaths and 2600 cancer incidence cases, this study is among the largest assembled for the purpose of firefighter research and is the first with adequate statistical power for detailed examinations of exposure–response characteristics.
- Using department records, we derived three surrogates of exposure based on firefighter assignments and fire-run information. This is the first study to relate the time elapsed during fire-runs to cancer risk.
- We found previously unreported modest exposure–responses for lung cancer and leukaemia mortality. These findings add to evidence of a causal association between firefighting exposures and cancer.

INTRODUCTION

Firefighting has long been recognised as a high-risk profession relative to other occupations. A wide array of workplace hazards presents a serious threat of acute injury in the line of duty; therefore, much has been done by the fire service to characterise and mitigate this threat. In contrast, far less is known about latent chronic illnesses that may also be a consequence of firefighting. In particular, it is widely accepted that firefighters are potentially exposed to a number of known or suspected human carcinogens; yet the risk of cancer in the fire service is still poorly understood.

In its recent assessment of the literature, a working group of the International Agency for Research on Cancer (IARC) concluded that there was limited evidence for the carcinogenicity of exposures to firefighters.[1] Among 42 studies reviewed by IARC, there were 14 municipal fire-fighter cohort studies that evaluated cancer mortality and five that assessed cancer incidence (some with multiple reports). IARC's determination was based largely on these studies; however, only two[2 3] included 500 or more cancer cases and eight[4–11] reported fewer than 100 cases. Given small numbers of total cancers, analysis of specific cancers was limited. Most studies also lacked information on the relationship between firefighter

Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries

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Novelty & Impact

This study describes the cancer incidence pattern among over 16 000 firefighters with more than 2500 cancer cases. There was a small excess in the overall cancer incidence, but quite high and statistically significant excesses, for example, for prostate cancer in younger ages, and for multiple myeloma, adenocarcinoma of the lung, and mesothelioma in older ages. Observations from this large cohort with long and complete follow-up strengthen the International Agency for Research on Cancer classification that occupational exposure related to firefighting is possibly associated with cancer risk.

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ABSTRACT

Objectives Firefighters are potentially exposed to a wide range of known and suspected carcinogens through their work. The objective of this study were to examine the patterns of cancer among Nordic firefighters, and to compare them with the results from previous studies.

Methods Data for this study were drawn from a linkage between the census data for 15 million people from the five Nordic countries and their cancer registries for the period 1961–2005. SIR analyses were conducted with the cancer incidence rates for the entire national study populations used as reference rates.

Results A total of 16 422 male firefighters were included in the final cohort. A moderate excess risk was seen for all cancer sites combined, (SIR=1.06, 95% CI 1.02 to 1.11). There were statistically significant excesses in the age category of 30–49 years in prostate cancer (SIR=2.59, 95% CI 1.34 to 4.52) and skin melanoma (SIR=1.62, 95% CI 1.14 to 2.23), while there was almost no excess in the older ages. By contrast, an increased risk, mainly in ages of 70 years and higher, was observed for non-melanoma skin cancer (SIR=1.40, 95% CI 1.10 to 1.76), multiple myeloma (SIR=1.69, 95% CI 1.08 to 2.51), adenocarcinoma of the lung (SIR=1.90, 95% CI 1.34 to 2.62), and mesothelioma (SIR=2.59, 95% CI 1.24 to 4.77). By contrast with earlier studies, the incidence of testicular cancer was decreased (SIR=0.51, 95% CI 0.23 to 0.98).

Conclusions Some of these associations have been observed previously, and potential exposure to polycyclic aromatic hydrocarbons, asbestos and shift work involving disruption of circadian rhythms may partly explain these results.

What this paper adds

- This first study on cancer risk among Nordic firefighters indicates a small excess in the overall cancer incidence.
- There are more prostate cancer cases diagnosed in ages <50 years than in the men in the general population.
- Risk of myeloma, adenocarcinoma of the lung and mesothelioma are increased in older ages.
- By contrast with earlier studies, the incidence of testicular cancer was decreased.

INTRODUCTION

Firefighters are potentially exposed to a wide range of known and suspected carcinogens through their work. The constituents of fire smoke vary according to combusted materials and other factors, but benzene, formaldehyde, polycyclic aromatic hydrocarbons and fine particulates are common.[1] Exposures can be quite high, although usually for short periods of time. Firefighters may also be exposed to asbestos, which may be released when older structures burn, and historically, asbestos was a component of some protective equipment, such as gloves.[1 2] Last, firefighters may be exposed to diesel exhaust, recently classified as a human lung carcinogen, from firefighting vehicles.[2 3] Additionally, most firefighters work rotating or extended shifts to provide 24 h fire protection, which may involve disruption of circadian rhythms.[4]

Many cohort studies have been conducted, but the results have been inconsistent, and the risk of cancer among firefighters has been a controversial topic, especially in North America where workers' compensation has been a contentious issue. Recently, two large, comprehensive reviews of cancer in firefighters have been completed. The first was a meta-analysis of 32 studies conducted by LeMasters *et al*[5] which evaluated the risk for 21 cancers. Based on the strength of the association, consistency and study type, the authors classified multiple myeloma, non-Hodgkin lymphoma, prostate cancer and testicular cancer as probably being associated with firefighting. Additionally, cancer of the skin, brain, rectum, buccal cavity and pharynx, stomach and colon, as well as malignant melanoma and leukaemia were classified as possibly related to firefighting.

The second comprehensive review was conducted by an International Agency for Research on Cancer (IARC) monograph working group (2010) as part of its evaluation of firefighting. The group reviewed the results of 42 studies, including the results of two large epidemiology studies that had been published after the review by LeMasters *et al*.[5] Based on internal meta-analyses, consistency of the studies and limited dose-response information using duration of employment, the working group concluded that the strongest evidence was for testicular cancers, prostate cancer and non-Hodgkin lymphoma. However, the working group, as a whole, classified firefighting exposure as being only possibly associated with cancer (IARC Category 2B).[1]

Linked
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International Agency for Research on Cancer
Centre International de Recherche sur le Cancer

PRESS RELEASE
N° 180
5 December 2007

IARC Monographs Programme finds cancer hazards associated with shiftwork, painting and firefighting

After a thorough review and discussion of the published scientific evidence, an expert Working Group convened by the IARC Monographs programme has concluded that

- Shiftwork that involves circadian disruption is *probably carcinogenic to humans* (Group 2A).
- Occupational exposure as a painter is *carcinogenic to humans* (Group 1).
- Occupational exposure as a firefighter is *possibly carcinogenic to humans* (Group 2B).

These three occupations involve complex exposure patterns that make it difficult to attribute risk to specific factors. The Working Group, comprising 24 scientists from 10 countries, met at the International Agency for Research on Cancer (IARC), the cancer research agency of the World Health Organization.

A summary of these conclusions is being published in the December issue of The Lancet Oncology. Full results will be published next year as volume 98 of the IARC Monographs.

Occupational exposure as a firefighter is "possibly carcinogenic to humans"

Epidemiologic studies of firefighters have noted excess cancer risks compared with the general population. Consistent patterns are difficult to discern due to the large variations in exposure across different types of fires and different groups of firefighters. Relative risks were consistently increased, however, for three types of cancer: testicular cancer, prostate cancer, and non-Hodgkin lymphoma.

Acute and chronic inflammatory respiratory effects have been noted in firefighters, and this would provide a plausible mechanism for respiratory carcinogenesis. Firefighters are exposed to numerous toxic chemicals, including many known or suspected carcinogens. These intermittent exposures can be intense, and short-term exposure levels can be high for respirable particulate matter and for several carcinogens, notably benzene, benzo[*a*]pyrene, 1,3-butadiene, and formaldehyde.

MONASH University

Final Report
Australian Firefighters' Health Study

MONASH
Centre for Occupational and Environmental Health

School of Public Health & Preventive Medicine

Faculty of Medicine, Nursing and Health Sciences

December 2014

Scope Of The Cancer Problem In The Fire Service

"Pinpointing the exact cause of cancer is extremely difficult because firefighters are not exposed to just one agent. They are exposed to multiple cancer-causing agents. Because of the multiple exposures and the multiple routes of exposure – they inhale carcinogens and carcinogens are absorbed through the skin – it is also highly unlikely for firefighters to get only one type of cancer."

- Dr. Grace Le Masters, PhD, Department of Environmental Health at the University of Cincinnati -

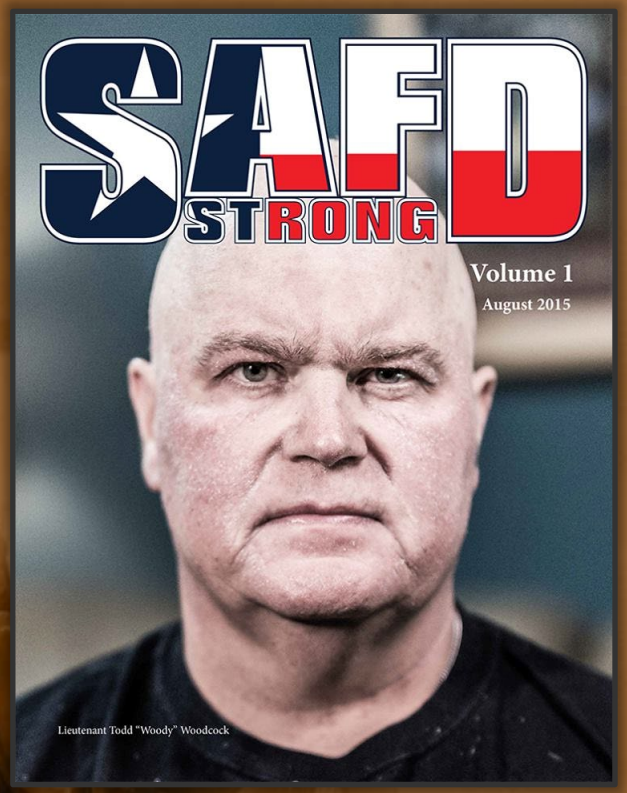
Scope Of The Cancer Problem In The Fire Service

Studies have shown higher rates of multiple types of cancers in firefighters when compared to the general population including:

- Testicular cancer (2.02 times greater risk)
- Multiple myeloma (1.53 times greater risk)
- Non-Hodgkin's lymphoma (1.51 times greater risk)
- Skin cancer (1.39 times greater risk)
- Brain cancer (1.32 times greater risk)
- Malignant melanoma (1.32 times greater risk)
- Prostate cancer (1.28 times greater risk)
- Colon cancer (1.21 times greater risk)
- Leukemia (1.14 times greater risk)

- Cancer Risk Among Firefighters: A Review and Meta-Analysis of 32 Studies; "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network -

Scope Of The Cancer Problem In The Fire Service



"Some cancer studies are also noting that firefighters are developing far more aggressive types of cancers, such as brain cancers, at a younger age than the general population, which provides further indications that the cancer could be a result of firefighting."

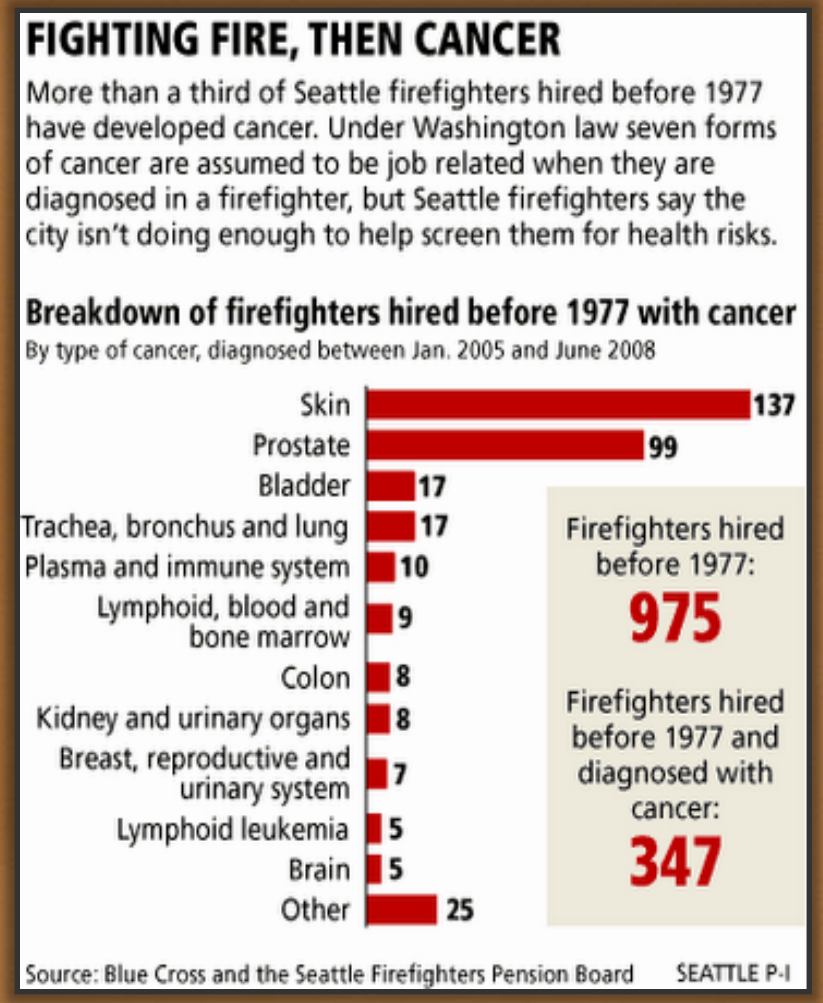
- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network -

Scope Of The Cancer Problem In The Fire Service

Boston Fire Department Cancer Video

Scope Of The Cancer Problem In The Fire Service

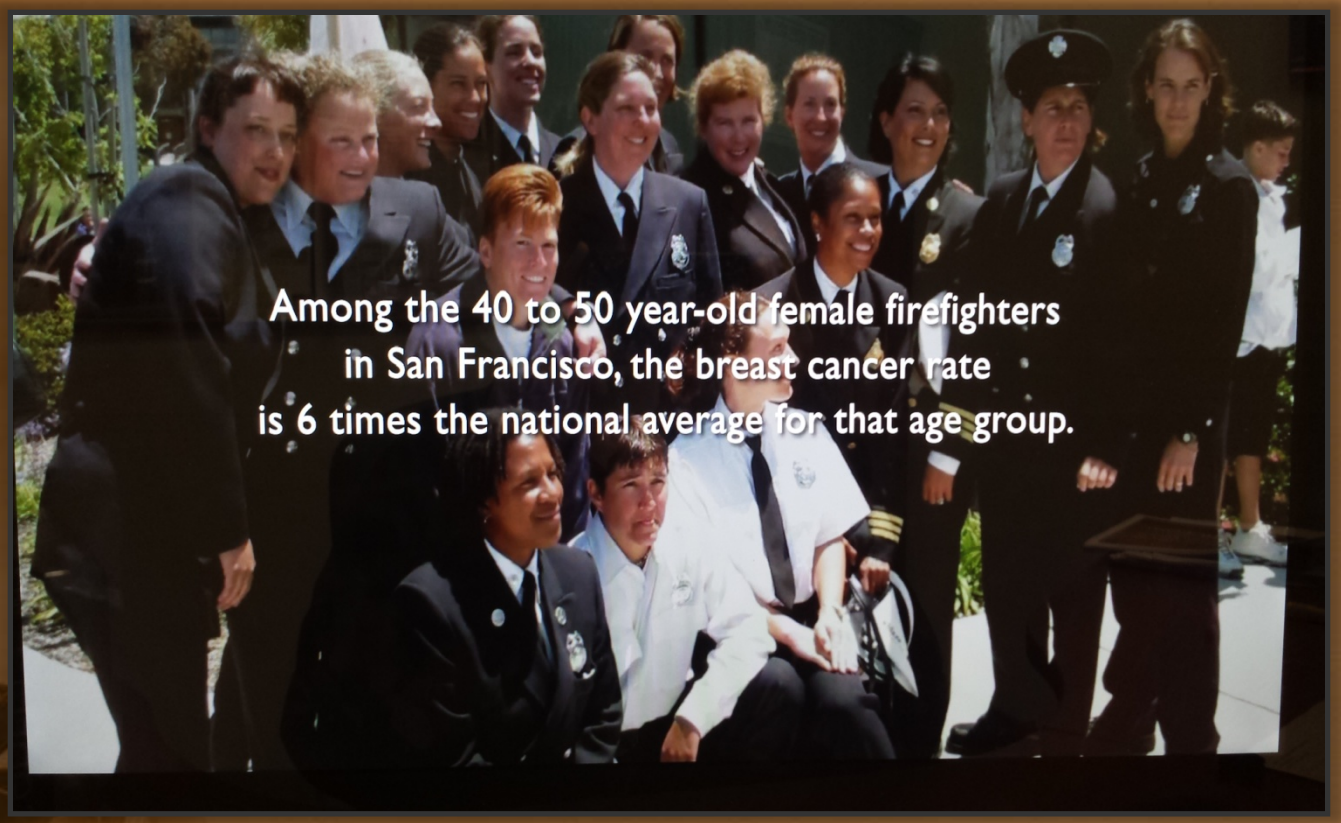
36% of the 975 firefighters have been diagnosed with cancer!!!



Scope Of The Cancer Problem In The Fire Service

- Miami-Dade Fire Rescue:
  - From 2008 to 2010, 32 percent of their firefighters (over 2000) were diagnosed with some form of cancer.
    - 1 in 3 firefighters in just 3 years.
    - Major cancer issues found:
      - Male: prostate, testicular, melanomas of the skin, brain/nervous system, head and neck (different than brain/nervous system), bladder, and colon.
      - Female: cervix, thyroid, breast, melanomas of the skin.

Scope Of The Cancer Problem In The Fire Service



- HBO Documentary Film "Toxic Hot Seat" -

Toxicity of Today's Homes

- Modern residential fires have more in common with hazmat incidents than with "legacy" house fires.
  - Contents and building materials create a "toxic soup" atmosphere.
- Approximately 84,000 chemicals being used commercially today.
  - Flame retardants in furniture.
    - HBO's *Toxic Hot Seat*.

- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network; HBO Documentary film "Toxic Hot Seat" -

Toxicity of Other Types of Fires

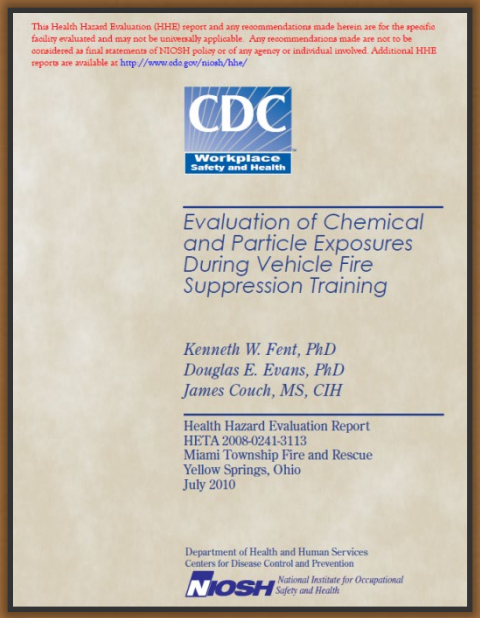
- Vehicle fires release highly concentrated toxic chemicals.
- Dumpster fires contain unknown materials and toxic substances.

- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network -

Toxicity of Other Types of Fires

Components of Vehicle Fire Smoke (present during start-up, knockdown, and overhaul):

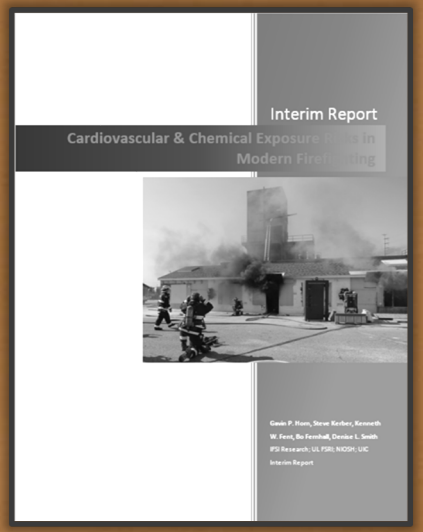
- **Acrolein - 3**
- **Methyl methacrylate - 3**
- **Acrylonitrile – 2B**
- **Ethyl benzene – 2B**
- **Benzene – 1**
- **1,3- Butadiene – 1**
- **Styrene – 2B**
- **Formaldehyde – 1**
- **Naphthalene – 2B**
- **Xylenes - 3**
- **Toluene - 3**



- Evaluation of Chemical and Particle Exposures During Vehicle Fire Suppression Training; IARC -

Routes of Exposure

- Two routes of greatest concern for exposure to carcinogens:
  1. ***The Lungs***:
     - Occurs when firefighters do not wear or remove their SCBA too soon
     - Chemicals off-gas from gear and equipment
     - Diesel exhaust
  2. ***Dermal Absorption***:
     - Soot
     - Equipment and PPE



- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network -

Routes of Exposure

- Skin can easily absorb chemicals – some areas are more permeable than others:
  - Head, neck, jaw, throat, underarms, and groin.
  - Permeability increases with temperature.
    - Skin absorption increases by 400% for every 5° increase in skin temperature.

- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network -

Routes of Exposure

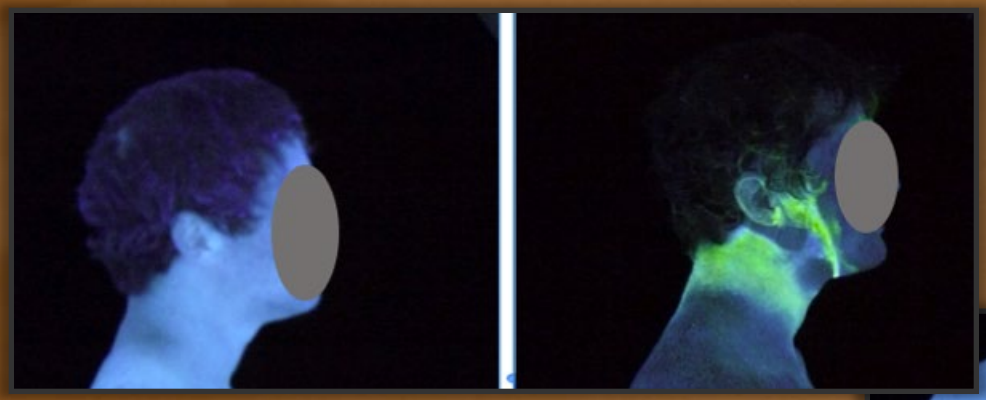
- ***<u>Most permeable piece of PPE is the hood.</u>***
  - Designed to protect the head and neck from heat.
  - Not designed to stop skin absorption through the head, jaw, neck, and throat.
    - Offers no vapor/moisture or smoke protection.
  - Liquid integrity test.

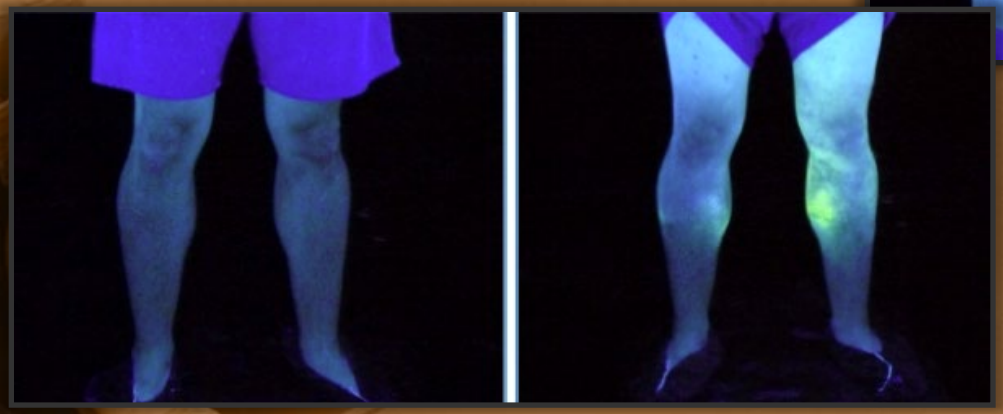
- "Taking Action Against Cancer in the Fire Service" white paper – Firefighter Cancer Support Network; Jeffrey O. and Grace G. Stull – International Personal Protection Inc.; Evaluation of Dermal Exposure to Polycyclic Aromatic Hydrocarbons in Fire Fighters -

Routes of Exposure

IAFF/RTI International Particle Infiltration Study - Video

Routes of Exposure





Particle Infiltration Study
(cont.)

Routes of Exposure

- SAFD Cancer Prevention SOP – "Summary of Required Actions" Section .03 – A, D:
  - *All firefighters will be issued a 2nd hood. This will allow firefighting personnel to be able to wash and dry one hood after every use, thus allowing a clean hood for use at all times. The areas of the scalp and angle of the jaw are among the most absorbent areas of the body. Currently, our hoods are not manufactured with a moisture barrier. It is obvious then, that the hood must be kept as free of contaminants as possible.*
  - *Exposed areas of the body (neck and face) should be wiped off during re-hab.*

Common Firefighter Exposures to Carcinogens

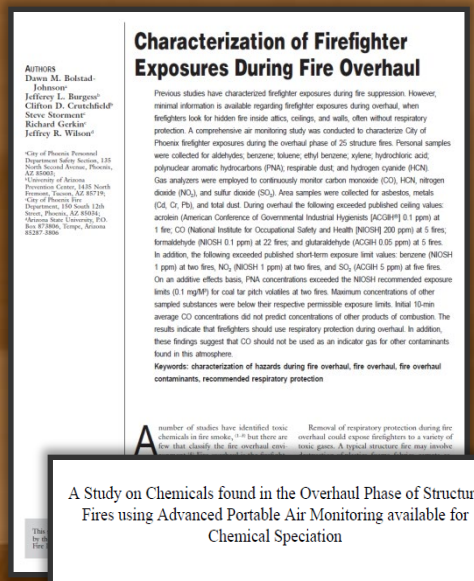
- During the overhaul process
- Soot particles
- Diesel engine exhaust

- IAFF's Working to Death: Leading Causes of Death Among First Responders – Fighting Fires. Fighting Cancer -

Characterization of Firefighter Exposures During Fire Overhaul

- Today's synthetic and plastic household items present a risk to firefighters even after the fire is out.
  - Smoldering materials release chemicals that firefighters continue to breathe.

Characterization of Firefighter Exposures During Fire Overhaul



Characterization of Firefighter Exposures During Fire Overhaul

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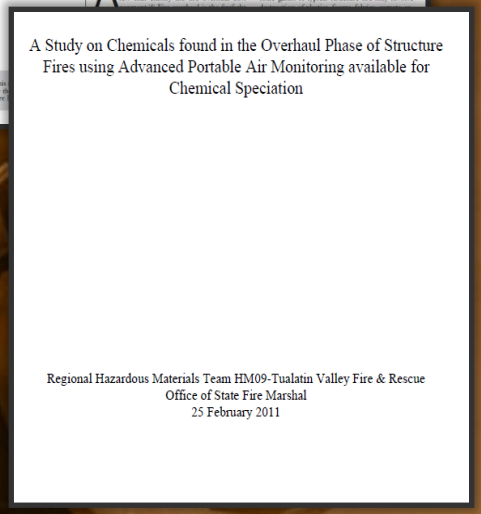
Previous studies have characterized firefighter exposures during fire suppression. However, minimal information is available regarding firefighter exposures during overhaul, when firefighters look for hidden fire inside attics, ceilings, and walls, often without respiratory protection. A comprehensive air monitoring study was conducted to characterize City of Phoenix firefighter exposures during the overhaul phase of 25 structure fires. Personal samples were collected for aldehydes; benzene; toluene; ethyl benzene; xylene; hydrochloric acid; polynuclear aromatic hydrocarbons (PNA); respirable dust; and hydrogen cyanide (HCN). Gas analyzers were employed to continuously monitor carbon monoxide (CO), HCN, nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Area samples were collected for asbestos, metals (Cd, Cr, Pb), and total dust. During overhaul the following exceeded published ceiling values: acrolein (American Conference of Governmental Industrial Hygienists [ACGIH®] 0.1 ppm) at 1 fire; CO (National Institute for Occupational Safety and Health [NIOSH] 200 ppm) at 5 fires; formaldehyde (NIOSH 0.1 ppm) at 22 fires; and glutaraldehyde (ACGIH 0.05 ppm) at 5 fires. In addition, the following exceeded published short-term exposure limit values: benzene (NIOSH 1 ppm) at two fires, NO_2 (NIOSH 1 ppm) at two fires, and SO_2 (ACGIH 5 ppm) at five fires. On an additive effects basis, PNA concentrations exceeded the NIOSH recommended exposure limits (0.1 mg/M³) for coal tar pitch volatiles at two fires. Maximum concentrations of other sampled substances were below their respective permissible exposure limits. Initial 10-min average CO concentrations did not predict concentrations of other products of combustion. The results indicate that firefighters should use respiratory protection during overhaul. In addition, these findings suggest that CO should not be used as an indicator gas for other contaminants found in this atmosphere.

Keywords: characterization of hazards during fire overhaul, fire overhaul, fire overhaul contaminants, recommended respiratory protection

A number of studies have identified toxic chemicals in fire smoke,[1–8] but there are few that classify the fire overhaul envi-

Removal of respiratory protection during fire overhaul could expose firefighters to a variety of toxic gases. A typical structure fire may involve



A Study on Chemicals found in the Overhaul Phase of Structure Fires using Advanced Portable Air Monitoring available for Chemical Speciation

Regional Hazardous Materials Team HM09-Tualatin Valley Fire & Rescue
Office of State Fire Marshal
25 February 2011

Chemicals found during the overhaul phase:

- **Formaldehyde - 1**
- **Asbestos - 1**
- **Benzene - 1**
- **Arsenic – 1**
- **Coal-Tar Pitch - 1**
- **Diesel exhaust - 1**
- **Vinyl Chloride – 1**
- **1,3-Butadiene – 1**
- **N-Nitrosodimethylamine – 2A**
- **Ethyl benzene – 2B**
- **Styrene – 2B**
- **1,2 Dichloroethane – 2B**
- **Furan – 2B**
- **Benzofuran – 2B**
- **Acetaldehyde – 2B**
- **Styrene – 2B**
- **Napthalene – 2B**
- **Lead – 2B**
- **Sulfur Dioxide – 3**
- **Mercury – 3**
- **Hydrochloric Acid – 3**
- **Toluene – 3**
- **Acrolein – 3**
- **Furfural – 3**
- **Polynuclear aromatic hydrocarbons (PNAs) ***

- Characterization of Firefighter Exposures During Fire Overhaul Study – City of Phoenix; A Study on Chemicals Found in the Overhaul Phase of Structure Fires – Oregon; IARC -

Characterization of Firefighter Exposures During Fire Overhaul

"Carbon monoxide should not be used as an indicator gas for other contaminants found in the overhaul atmosphere."

Characterization of Firefighter Exposures During Fire Overhaul

- SAFD Cancer Prevention SOP – "Summary of Required Actions" Section 02 – L:
  - *Full bunker gear and SCBAs shall be worn through overhaul operations when products of combustion and/or gases and vapors are present.*

Soot Particles

- First reported form of occupational cancer attributed to exposure to soot.
- Prolonged exposure to soot on the skin is a hazard.
  - Soot particles absorb hazardous vapors/gases and hold them in place on surfaces including a firefighter's clothing and skin.

Soot Particles

"A major cause of cancer in firefighters is Polycyclic Aromatic Hydrocarbons absorbed through the skin as a result of contact with soot, persistently and under hot conditions. The especially high permeability of the groin area results in increased testicular cancer and possibly other types of cancer."

- Dr. Stuart Baxter, PhD, Professor of Environmental Health at the University of Cincinnati -

Soot Particles

"People think soot is benign but it is not, and most firefighters coming back from a fire are covered in soot. Soot isn't just dirty, it's dangerous"

"Soot in a firefighters' hair or on their skin could leach chemicals into their bodies. Every smear on their clothes could release toxic gases long after the fire is out."

- Dr. Grace Le Masters, PhD, Department of Environmental Health at the University of Cincinnati -

Soot Particles

- If not removed, contaminated exterior surfaces and inner layers of a firefighter's PPE can result in exposure well after the fire.
- Neck area is one of the most likely areas to become contaminated.
- Children being exposed to soot particles on our gear.
  - At home
  - Demos

- Jeffrey O. and Grace G. Stull – International Personal Protection Inc.-

Soot Particles

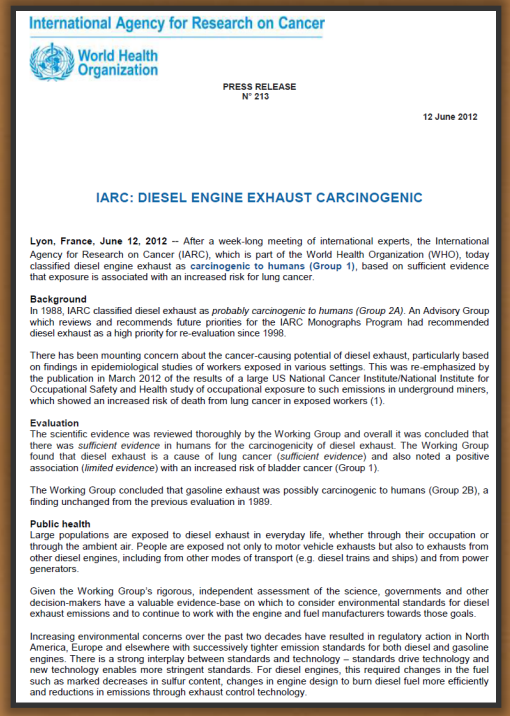
- SAFD Cancer Prevention SOP – “Summary of Required Actions” Section .03 – B:
  - *Wet Decon – Immediate wet decon is essential to reducing contaminates that may have settled on your bunker gear. Therefore, wet decon is required anytime your gear may have been exposed to products of combustion or other contaminates, or if the Company Officer, Battalion Chief or Incident Commander deems it necessary. Every effort should be made to wet decon as soon as possible, preferably while still on scene. Use a red-line, at pump pressure, with a half opened nozzle. Rinse at a downward angle from top to bottom.*

Soot Particles

- SAFD Cancer Prevention SOP – “Summary of Required Actions” Section .03 – C, D, K:
  - *Removing gear to return to the station is recommended. Additionally, at the end of each shift, if the gear was exposed to products of combustion or other contaminates, the gear will be rinsed off and hung to dry.*
  - *Shower as soon as possible after being exposed to products of combustion or other contaminates.*
  - *Apparatus seats should be cleaned and decontaminated regularly, especially after incidents where passengers were exposed to products of combustion.*

Diesel Engine Exhaust

- On June 12, 2012, the International Agency for Research on Cancer (IARC) classified diesel engine exhaust as a *Group 1* carcinogen.
  - Exposure is associated with an increased risk of lung cancer.
  - Can cause other types of cancer:
    - Bladder
    - Leukemia and other cancers of the blood (non-Hodgkin's lymphoma and multiple myeloma)
- Vented emissions can disperse up to 650 feet.



International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 213

12 June 2012

IARC: DIESEL ENGINE EXHAUST CARCINOGENIC

Lyon, France, June 12, 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as **carcinogenic to humans (Group 1)**, based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

Background
In 1988, IARC classified diesel exhaust as *probably carcinogenic to humans (Group 2A)*. An Advisory Group which reviews and recommends future priorities for the IARC Monographs Program had recommended diesel exhaust as a high priority for re-evaluation since 1998.

There has been mounting concern about the cancer-causing potential of diesel exhaust, particularly based on findings in epidemiological studies of workers exposed in various settings. This was re-emphasized by the publication in March 2012 of the results of a large US National Cancer Institute/National Institute for Occupational Safety and Health study of occupational exposure to such emissions in underground miners, which showed an increased risk of death from lung cancer in exposed workers (1).

Evaluation
The scientific evidence was reviewed thoroughly by the Working Group and overall it was concluded that there was *sufficient evidence* in humans for the carcinogenicity of diesel exhaust. The Working Group found that diesel exhaust is a cause of lung cancer (*sufficient evidence*) and also noted a positive association (*limited evidence*) with an increased risk of bladder cancer (Group 1).

The Working Group concluded that gasoline exhaust was possibly carcinogenic to humans (Group 2B), a finding unchanged from the previous evaluation in 1989.

Public health
Large populations are exposed to diesel exhaust in everyday life, whether through their occupation or through the ambient air. People are exposed not only to motor vehicle exhausts but also to exhausts from other diesel engines, including from other modes of transport (e.g. diesel trains and ships) and from power generators.

Given the Working Group's rigorous, independent assessment of the science, governments and other decision-makers have a valuable evidence-base on which to consider environmental standards for diesel exhaust emissions and to continue to work with the engine and fuel manufacturers towards those goals.

Increasing environmental concerns over the past two decades have resulted in regulatory action in North America, Europe and elsewhere with successively tighter emission standards for both diesel and gasoline engines. There is a strong interplay between standards and technology – standards drive technology and new technology enables more stringent standards. For diesel engines, this required changes in the fuel such as marked decreases in sulfur content, changes in engine design to burn diesel fuel more efficiently and reductions in emissions through exhaust control technology.

- IARC; Diesel Emissions in Fire Stations – Greg Michalak; American Cancer Society -

Diesel Engine Exhaust

- Exposure to diesel engine exhaust at the fire station:
  - Walls and furniture reveal an incredible amount of diesel exhaust particles.
  - Diesel particles are inhaled and absorbed every shift which can cause significant harm to firefighters.
    - Regulators stored in bay.
    - Bunker gear stored in bay and taken into the station.
    - Door seals.

Diesel Engine Exhaust

- SAFD Cancer Prevention SOP – “Summary of Required Actions” Section .03 - G, H, I:
  - *In order to reduce contamination by diesel exhaust, all apparatus and tools shall be started and idled outside the bay during routine checks and cleaning.*
  - *Bay doors shall be open before starting the apparatus and remain open until the apparatus is shut off; stations equipped with exhaust fans must also comply.*
  - *Bunker gear locker doors shall be closed to prevent contamination of gear by diesel exhaust.*

Actions Firefighters Can Take to Protect Themselves From Cancer

- Steps firefighters can take to protect themselves are often simple and are easily accomplished.
  - Must understand common exposures to carcinogens.
  - "SAFD Cancer Prevention SOP"

SAN ANTONIO FIRE DEPARTMENT
FIRE OPERATIONS

Cancer Prevention SOP

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.01 Background

In April of 2013, the Indianapolis Fire Department hosted a workshop on firefighter cancer. The Firefighter Cancer Support Network was the driving force behind the workshop. The information and recommendations that resulted are published in a white paper on cancer in the fire service (*Taking Action against Cancer in the Fire Service"*). The White Paper, along with two other cancer studies, will be made available on our department's SharePoint site. Please take the time to read the White Paper and the other two cancer studies (*"Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 Studies" and "Firefighter Cancer in the New Fire Environment"*).

.02 Purpose

In an effort to combat the incidence of cancer among our members, giving consideration to recommendations contained in the referenced reports, the SAFD has identified specific actions that will be required moving forward. Most of these actions are "common sense" issues that should be done routinely. Others require that we re-think how things have been done in the past. The focus of this document is the health and well-being of each member of our Fire Department. Please remember to consider your health, the health of your co-workers, and the impact that cancer can have on your family.

.03 Summary of Required Actions:

A. All firefighters will be issued a 2nd hood. This will allow firefighting personnel to be able to wash and dry one hood after every use, thus allowing a clean hood for use at all times. The areas of the scalp and angle of the jaw are among the most absorbent areas of the body. Currently, our hoods are not manufactured with a moisture barrier. It is obvious then, that the hood must be kept as free of contaminants as possible. Hoods may be washed in a washing machine on a gentle cycle setting. Laundry detergent shall be used to clean the hoods but bleach shall never be used. The hoods can be placed in a clothes dryer. Please run one additional wash cycle to clean the washing machine after washing your hood. ***(NOTE: firefighters are not allowed to wear two or more hoods at the same time under any circumstance)***

B. Wet Decon – Immediate wet decon is essential to reducing contaminates that may have settled on your bunker gear (ex: asbestos). Therefore, wet decon is required anytime your gear may have been exposed to products of combustion or other contaminates, or if the Company Officer, Battalion Chief or Incident Commander deems it necessary. Every effort should be made to wet decon as soon as possible, preferably while still on scene. Use a red-line, at pump pressure, with a half opened nozzle. Rinse at a downward angle from top to bottom.

SAN ANTONIO FIRE DEPARTMENT
FIRE OPERATIONS

Cancer Prevention SOP

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C. Removing gear to return to the station is recommended. Additionally, at the end of each shift, if the gear was exposed to products of combustion or other contaminates, the gear will be rinsed off and hung to dry.

D. Exposed areas of the body (neck and face) should be wiped off during re-hab.

E. Shower as soon as possible after being exposed to products of combustion or other contaminates.

F. No bunker gear shall be allowed in the station.

G. In order to reduce contamination by diesel exhaust, all apparatus and tools shall be started and idled outside the bay during routine checks and cleaning.

H. Bay doors shall be open before starting the apparatus and remain open until the apparatus is shut off, stations equipped with exhaust fans must also comply.

I. Bunker gear locker doors shall be closed to prevent contamination of gear by diesel exhaust.

J. Station uniforms worn under bunker gear that has been exposed to products of combustion or other contaminates, shall be changed as soon as possible.

K. Apparatus seats should be cleaned and decontaminated regularly, especially after incidents where passengers were exposed to products of combustion.

L. Full bunker gear and SCBAs shall be worn through overhaul operations when products of combustion and/or gases and vapors are present.

M. SAFD members will not use their personal vehicles to relieve companies on scene. SAFD vehicles shall be used for all relief-on-scene scenarios and shall be coordinated by on-duty leadership.

.04 REVISION

This SOP may be revised as necessary to ensure the highest level of cancer prevention.

Yours in Sevice,

Charles N. Hood, Fire Chief

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

USE WET-NAPS OR BABY WIPES TO REMOVE AS MUCH SOOT AS POSSIBLE FROM THE HEAD, NECK, JAW, THROAT, UNDER ARMS AND HANDS IMMEDIATELY AND WHILE STILL ON SCENE.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

DO NOT TAKE CONTAMINATED BUNKER GEAR OR PPE HOME.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

DO NOT STORE CONTAMINATED GEAR OR PPE IN YOUR VEHICLE EXCEPT IN AN AIR TIGHT CONTAINER.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

USE SCBA FROM INITIAL ATTACK TO FINISH AND OVERHAUL.

(NOT WEATING SCBA IN BOTH ACTIVE AND POST-FIRE ENVIRONMENTS IS THE MOST DANGEROUS VOLUNTARY ACT IN THE FIRE SERVICE TODAY.)

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

CHANGE YOUR CLOTHES & WASH THEM IMMEDIATELY AFTER A FIRE.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

STOP USING TOBACCO PRODUCTS.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

USE SUNSCREEN OR SUN BLOCK.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

GET A THOROUGH MEDICAL EXAM EVERY YEAR! EARLY DETECTION & EARLY TREATMENT ARE ESSENTIAL TO INCREASING SURVIVAL.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

WIPE DOWN AND GROSS DECON YOUR PPE IMMEDIATELY AFTER A FIRE.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

KEEP BUNKER GEAR OUT OF LIVING AND SLEEPING QUARTERS.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

DECON FIRE APPARATUS INTERIOR AFTER FIRES.

We want our firefighters to live long, healthy lives.

FIREFIGHTERMATIC
Because Your ♥ Belongs to a Hero

SHOWER THOROUGHLY AFTER A FIRE.

We want our firefighters to live long, healthy lives.

SAFD & Local 624 IAFF "Our Battle With Cancer" Video