Fire Fighter Exposure to Carcinogens

During fire suppression and overhaul activities, fire fighters encounter combustion products of modern residential and commercial fires which contain many hazardous substances.[1,2,3,4,5,6,7,8,9] Fire fighters are also exposed to diesel engine exhaust at fires and in many fire stations as well.[10, 11]

Smoke is a complex mixture of cancer causing chemicals. Combustion products of wood, coal, and diesel fuel are considered known or probable human carcinogens by the International Agency for Research on Cancer (IARC). [12] **IARC** is part of the World Health Organization and is the authoritative international agency on cancer causation. Occupational health experts rely on the IARC to categorize chemicals for their potential to cause cancer in humans. Studies have revealed that fire fighters are commonly exposed to numerous agents that IARC considers known or probable cancer causing agents in humans. The following two lists contain the carcinogens commonly found in smoke, organized by IARC Classification:[12,13]

IARC Group 1 agents (*known* to cause cancer in humans)	**IARC Group 2A agents** (*probable* human carcinogens)
• arsenic • asbestos • benzene • benzo[a]pyrene • 1,3-butadiene • diesel engine exhaust • formaldehyde • soot • Shift work affecting circadian rhythm • dioxin	• creosote • polychlorinated biphenyls

The listing below summarizes conclusions by other authoritative organizations, regarding some of carcinogens, listed in the previous table and others that fire fighters encounter. The Environmental Protection Agency (**EPA**) is the agency charged with regulating chemicals in the environment to protect human health and our natural

resources. The National Toxicology Program (**NTP**) operates under the Department of Health and Human Services to evaluate agents/chemicals of public health concern. The Agency for Toxic Substances and Disease Registry (**ATSDR**) is a public health agency under the Department of Health and Human Services that evaluates the potential toxicity of substances and publishes toxicological profiles based on the latest research.[14]

Acetaldehyde

- EPA Category B2 (Probable human carcinogen)
- http://www.epa.gov/ncea/iris/subst/0290.htm

Formaldehyde

- EPA Category B1 (Probable human carcinogen)
- http://www.epa.gov/iris/subst/0419.htm

Dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD))

- U.S.A. NTP: "Known to be a human carcinogen"[15]

Benzene

- EPA Category A ("known" human carcinogen)

Polycyclic Aromatic Hydrocarbons (PAH)

- PAHs (polycyclic aromatic hydrocarbons) are a group of chemicals that are formed during the incomplete burning of coal, oil, wood, garbage, or other organic substances. According to the ATSDR, vehicle exhausts, wildfires, agricultural burning, residential wood burning, and waste incineration (situations similar to those encountered during fire fighting activities), all generate PAHs. There are more than 100 different PAHs, and IARC has classified several polycyclic aromatic hydrocarbons as known, probable or possible human carcinogens.
- IARC, EPA – Most authorities don't discuss PAH as a whole; rather, they review each chemical separately although, as noted above, soot, which contains multiple PAHs, is considered Group 1 by IARC as is the individual PAH, benzo[a]pyrene
- ATSDR - "The Department of Health and Human Services (DHHS) has determined that some PAHs may reasonably be expected to be carcinogens" http://www.atsdr.cdc.gov/tfacts69.html#bookmark06

Diesel Engine Exhaust

- A recent NIOSH/NCI study evaluated > 12,000 participants exposed to diesel exhaust in non-metal mining facilities and observed increased rates of lung and esophageal cancer.[16]

A wide range of other chemicals have been detected in smoke, few of which have had their potential for carcinogenicity assessed. For example, Lowry and colleagues studied fire fighters' exposures at nearly 100 structural fires.[2] They detected the presence of

more than 70 different chemicals in smoke from monitored fire scenes regardless of whether synthetic materials were a major part of the materials burned.

In contrast to almost every other workforce in the US where occupational controls in the last 40 years have reduced exposures, **firefighters continue to be exposed to high levels of carcinogens in smoke because fire suppression and overhaul activities occur in uncontrolled, hazardous environments.** Further, smoke has become *more* complex rather than less due to the increased number of synthetic products in US homes and businesses.

The risk for exposure to carcinogens is apparent in measurements taken at both simulated and spontaneous fires. A Harvard study that examined levels of a number of air contaminants at more than 200 structural fires provided an excellent example of the uncontrolled, hazardous nature of fire fighter exposures.[17] In that study, the carcinogen, benzene was detected in 181 of 197 (92%) of samples taken at fire scenes with air sampling units placed on the chests of fire fighters; half were over 1 part per million (ppm), which is the current Occupational Safety and Health Administration (OSHA) permissible exposure level in factories.[18] Approximately 5% of the samples were above 10 ppm benzene which is 10 times the current OSHA limit. Almost 15% of the samples were found to be at or above the Short Term Exposure Limit (STEL) of 5 ppm benzene.

One study reported benzene levels more than 200 times the OSHA limit.[3] The authors noted: “Furthermore, in many cases of the worst exposure to these materials respiratory protective equipment was not used owing to the visual impression of low smoke intensity, and thus these levels represent actual direct exposure of the firefighters.” This was a common practice as recently as 10-15 years ago due to lack of knowledge regarding the hazards and awkwardness of the protective equipment. Recent studies continue to confirm ongoing exposures during the overhaul phase.[7, 8]

Fire houses, where fire fighters spend long hours, also pose a significant exposure hazard. Froines and colleagues studied the concentration of diesel exhaust particulates in the air inside firehouses in New York, Boston, and Los Angeles and detected elevated levels of airborne particulates from diesel exhaust.[10]

Asbestos is also of concern because firefighters are actively involved in building demolition during the overhaul phase of a fire. This results in potential for asbestos exposure.

IARC lists polychlorinated biphenyl (PCB) as a probable human carcinogen. In its monograph on PCB, IARC lists “first responders to incidents where a transformer has exploded” as one of the potential occupational exposures to PCBs. [19,20] A study of fire fighters involved in response to a transformer fire in Staten Island, NY detected serum PCB levels that declined over time. This post-exposure decline pattern suggests acute exposure to PCBs in the first responders.[20] Fire fighters who responded to a

transformer fire in Binghamton, NY in 1981 showed similar post-exposure declining serum PCB levels.[21]

Incomplete Protection from Hazards Due to Limitations of Protective Equipment

Fire fighters have only their personal protective equipment (PPE), e.g. respirators and turn out gear, to protect them from these toxic exposures. PPE is the least effective of the established workplace controls for exposure reduction (termed the hierarchy of controls which includes more protective options such as substitution with a safer chemical, enclosure of the hazard, and ventilation). PPE does not completely eliminate exposure. This becomes a particular problem in work environments where exposure levels are high, such as fire fighting. In this case, the proportion of the inhaled toxicants that PPE cannot prevent is higher as well leaving the fire fighter exposed to the toxicants in the smoke. Also, in order to avoid interference with overhaul activities, fire fighters may take off their PPE when the situation is no longer immediately hazardous to life, but while many carcinogens are still present in the air at the fire scene. This practice was particularly common in the past. Further, fire fighters do not wear PPE in the fire house where exposure to diesel exhaust takes place. Moreover, PPE may be ill-fitting or sometimes defective. The primary route of toxic exposures is through inhalation, but exposure can also occur through dermal absorption and ingestion of contaminated nasopharyngeal secretions and fluids. Thus, dermal absorption of carcinogens in the soot that fire fighters often notice on their skin despite turn out gear is another route of exposure for them.
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