Minimising firefighters' exposure to toxic fire effluents

An independent report by UCLAN, commissioned by Fire Brigades Union (FBU)

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Full report (in English) available https://www.fbu.org.uk/campaigns/decon-fire-contaminants

Introduction

Chemical and building regulations are designed to ensure that exposure to materials within residential, commercial and industrial buildings are safe. However, there are currently no requirements to consider how the safety of those materials might change in the event of a fire – i.e. **there are no requirements to measure and quantify the toxic fire effluents produced by burning materials**. There are no restrictions on the use of products capable of emitting lethal quantities of toxic effluents during a fire. Compared with natural materials (wood, wool, cotton, leather, etc.), widely used synthetic polymers (derived from oil) burn more quickly, have faster flame spread, generate more heat and produce not only higher numbers of hazardous gases and particulates, but also much higher concentrations of toxic chemicals. Firefighters are therefore at an increased risk of exposure to toxic fire effluents and subsequently at an increased risk of suffering adverse health outcomes.

Firefighters' exposure to toxic fire effluents will depend on:

- Fire Scenario (fire conditions)
- Fuel (materials involved in the fire)
- Specific toxicants released during and post fire
- Contamination from fire debris/residues
- Type, frequency and duration of fires attended
- The tactics employed at the incident
- The extinguishing medium used
- Use of Personal Protection Equipment
- Hygiene facilities and practices
- Time between contamination and the use of hygiene facilities and practices

Contaminants, Toxicity and Exposure Pathways

*Harm to health depends on the **toxicity** of the contaminant, but also on the **exposure pathways** via which an individual is exposed to the contaminant, and the **dose** (amount) of the contaminant an individual is exposed to (Duffus & Worth, 2006).*

Fires produce a cocktail of toxic, irritant and carcinogenic chemicals – the composition of which varies depending on the specific materials burning and the fire conditions. They can be released in the form of particulates which will include aerosols, dusts, fibres, smoke and fumes or gases and vapours.

Some of these fire effluents (e.g. carbon monoxide, hydrogen cyanide and acid gases) have immediate adverse effects on health after only a single or short exposure (e.g. asphyxiation). This is known as **acute toxicity**.

However, most other fire effluents (e.g. volatile organic compounds, or polycyclic aromatic hydrocarbons) have much longer-term adverse effects on health, causing conditions which are more complex and can develop more slowly e.g. cancer, cardiovascular (related to the circulatory system which comprises the heart and blood vessels) and neurological (nervous system) diseases. This is known as **chronic toxicity**. Repeated exposure to even very small amounts of chronic toxicants over time increases the likelihood of developing long-term health conditions.

Acute and chronic toxicants can be then further classified according to the specific types of adverse effects they have on health. These classifications are referenced throughout this guide, and include:

- **Carcinogens**; substances which cause cancer (e.g. benzene, PAHs etc.).
- **Teratogens**; substances that can harm the foetus if exposure occurs during pregnancy (e.g. lead compounds, ethylene oxide, formamide etc.).
- **Sensitisers**; substances which result in an allergic type hypersensitivity reaction (e.g. of skin or lungs) (e.g. chromium, formaldehyde, isocyanates etc.).
- **Irritants**; substances which react in contact with moisture on/within the body and cause an inflammatory response (e.g. hydrogen chloride, hydrogen bromide, sulphur dioxide, nitrogen oxides etc.).

It has been proven that combinations of different chemicals which are not particularly harmful individually can give rise to entirely new hazardous effects. Moreover, the effects of chronic toxicants may be cumulative, and can remain latent for a long time before any symptoms arise or are even measurable. *(Heys et al., 2016)*

Firefighters may be exposed to toxic contaminants via multiple **exposure pathways**:

Inhalation. Many gases, vapours, mists, dusts and fibres released during fires can be inhaled through the lungs. The amount of contaminant inhaled by a person is directly linked to the volume of air inspired and expired, which increases with physical exertion. Normal breathing frequency at rest is 12-20 breaths per minute (approx. 7-14 litres of air). However, under extreme stress, firefighters with normal lung capacity can metabolise up to 100 litres of air per minute (Swedish Civil Contingencies Agency, 2015).

Dermal Absorption occurs when a toxicant comes into contact with an individual's skin. There are many situations in which firefighters' skin comes into contact with harmful substances e.g. through direct contact with soot (touching the skin with contaminated hands or with gloves that have been in contact with fire debris) or when an area of skin is exposed in a smoky environment. Absorption of toxicants via the skin will vary depending on exposure time, the quantity and type of substance, location and the surface area of the skin. The physical demands of firefighting (wearing breathing apparatus, performing rescues, post fire activities etc.) and the high temperatures in which firefighters operate increases their blood flow, sweating rates and body temperature. Together with the body's reduced water content, this leads to increased dermal absorption of fire effluents.

Ingestion (through the gastro-intestinal tract) occurs when a toxicant is swallowed. Exposure to contaminants via ingestion may occur when food or drink is contaminated with fire effluents, e.g. if eating/drinking with soiled hands. In addition, when fire gases or particulates have entered the upper respiratory tract via inhalation, they may be carried via mucous and saliva into the digestive system and absorbed into the body.

Key Recommendations

Key recommendations are divided into two subgroups:

For Fire Personnel:

- Respiratory protective equipment (e.g. SCBA) should be worn at all times whilst firefighting This should also include during salvage and turning over activities and other activities undertaken by FRS personnel (and/or others) after firefighting has been completed, but whilst the building contents are still 'gassing off'. Respiratory protective equipment should be one of the last items of PPE removed during de-robing (after decontamination).

- PPE that is suspected of being contaminated should be transported back to the station or workplace in an air-tight container to prevent cross-contamination.

- Avoid eating, drinking or smoking with unwashed hands whilst wearing, or after de-robing PPE that may be contaminated.

- After attending a fire incident, all personnel should change into a set of clean, dry clothes as soon as possible, ideally before re-entering the appliance (or FDS vehicle).

- PPE should be clean and should be thoroughly decontaminated after every incident to avoid a build-up of toxic contaminants. PPE should be inspected for wear and damage on a regular basis, and replaced as necessary.

- It is important to protect areas of exposed skin and airways when cleaning soiled PPE/equipment. This requires appropriate respiratory protection (e.g. face masks or face coverings) and gloves.

- "Shower within an hour" when returning to the station from an incident, or following a live fire training exercise.

- Regular health screening and recording attendance at fire incidents over the course of a firefighter's career is strongly advised and will be key to the longer-term monitoring and management of health.

For Fire and Rescue Services:

- Every Fire and Rescue Service (FRS) must have fully risk-assessed decontamination procedures (en-route to, during and after fire incidents), and ensure all relevant staff are trained in implementing these procedures.

- All FRS personnel should receive regular and up-to-date training on the harmful health effects of exposure to toxic fire effluents, and how these exposures can be reduced, minimised or eliminated.

- All FRSs should have policies in place for the routine care, maintenance, inspection and professional cleaning of PPE.

- Establishing and strictly maintaining "designated zones" within the fire station must be a priority for preventing cross-contamination. PPE should never be worn in areas of the station designated a clean zone (e.g. kitchens, living quarters etc.) and should be stored away from personal items.

- To reduce secondary exposures, appliance cabs and equipment from emergency response vehicles should be cleaned and decontaminated on a regular basis, especially after incidents where exposure to any combustion products occurred.