Firefighters
Occupational Exposure Summary Package

This package serves as a summary of CAREX Canada’s results on the known or suspected carcinogens that Canadian firefighters are exposed to at work. Assembling various CAREX Canada data, tools, and resources, it provides an overview of the exposures a worker might experience in this occupation, including polycyclic aromatic hydrocarbons (PAHs), benzene, diesel engine exhaust, ethylbenzene, solar radiation, formaldehyde, and polychlorinated biphenyls. Our aim is to provide a useful guide for those looking to better understand – and help reduce or eliminate – common exposures to carcinogens that take place during firefighting.

Firefighters in Canada

According to the 2006 Canadian census there are 27,000 professional firefighters in Canada. This sum does not include many part-time, seasonal, and volunteer firefighters; the Canadian Volunteer Fire Services Association estimates that there are more than 79,000 volunteer firefighters in Canada. Firefighters carry out firefighting and fire prevention activities, and assist in other emergencies. They are employed by municipal, provincial and federal governments and by large industrial establishments that have internal firefighting services.

Carcinogen exposures in firefighters

Firefighters can be exposed to hundreds of contaminants at work, some of which are known or suspected to cause cancer. A sample of these are summarized in Table 1.

<table>
<thead>
<tr>
<th>Asbestos</th>
<th>Formaldehyde</th>
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<tbody>
<tr>
<td>Benzene</td>
<td>Polychlorinated biphenyl</td>
</tr>
<tr>
<td>Diesel engine exhaust</td>
<td>Polycyclic aromatic hydrocarbons</td>
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<tr>
<td>Ethylbenzene</td>
<td>Solar radiation</td>
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</table>

Table 1: A sample of known or suspected carcinogens firefighters may be exposed to

Firefighters may be exposed to a number of additional carcinogens that are not listed in Table 1. Exposures to firefighters are challenging to quantify because emissions and exposure levels vary greatly depending on fire conditions. This includes ventilation, wind, and temperature, as well as time spent at the fire, firefighter tasks, and the type of fire, according to the International Agency for Research on Cancer (IARC). Even after the fire is extinguished, potentially harmful exposures may continue.

CAREX Canada classifies carcinogens based on evaluations made by IARC. Many of the agents listed in Table 1 are classified as known carcinogens (IARC 1), where there is sufficient evidence linking the agent with cancer in humans.

We offer estimates of the number of firefighters exposed for several carcinogens, including PAHs, benzene, and diesel engine exhaust, on our website. Exposures to firefighters are challenging to assess, however, so estimates of exposure are not available for all substances they may be exposed to.
Exploring the CAREX Canada estimates

Our eWORK Tool allows users to explore CAREX exposure data by carcinogen, sector, occupation, province, sex, and exposure level. We offer two versions of the eWORK Tool: eWORK Excel and eWORK Online. eWORK Excel uses a Microsoft Excel PowerPivot interface that allows users to search for – and visualize – exposures of interest. eWORK Online is for users who prefer quick, accessible, yet high-quality statistics on occupational exposures to various carcinogens.

- eWORK Excel and eWORK Online are available under the Tools tab of our website.

Carcinogen profiles

The CAREX Canada website contains detailed information on use, production and trade, exposure routes, and health effects for the top ten carcinogen exposures for firefighters listed above. A sample of these are summarized below.

More information, including regulations and guidelines for each agent, methods for calculating exposure level estimates, and a list of references, is available under the Profiles and Estimates tab of our website.

**Polycyclic Aromatic Hydrocarbons**

Multiple Classifications (IARC 1 (Known Carcinogen), IARC 2A (Probable Carcinogen), IARC 2B (Possible Carcinogen))

What are polycyclic aromatic hydrocarbons?

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 chemicals formed when wood, coal, oil, gas, garbage, and other organic substances are burned. PAHs occur naturally and generally exist as complex mixtures.

What are the main sources of PAHs for firefighters?

PAHs are primarily by-products from burning organic materials, such as wood and petrochemical products. In Canada, forest fires are the greatest natural source of PAHs in the environment.

Occupational exposure to PAHs

Inhalation and dermal contact are the main routes of exposure to PAHs.

What are their health effects?

**Cancer:**

Because PAHs are often found in complex mixtures, the carcinogenic effects of individual PAHs are difficult to assess. Evidence from workplace studies shows that exposure to PAH-containing mixtures is associated with lung and skin cancer. Animal studies also show that a number of pure PAHs are carcinogenic.

**Non-cancer:**

PAH exposure is associated with reduced lung and immune function, and skin inflammation and lesions.

Exposure level

Occupational exposure data for PAHs is limited and exposure levels are challenging to assess due to the large number of chemicals included in this group.
**Benzene**

Known Carcinogen (IARC 1)

What is benzene?

Benzene is a clear, usually colourless liquid with a gasoline-like odour. It occurs naturally in crude oil and is synthesized from coal and petroleum sources.

What are the main sources of benzene for firefighters?

Benzene is produced from burning organic materials, such as wood.

Occupational exposure to benzene

The major route of exposure to benzene is inhalation, but dermal exposure can also occur.

What are its health effects?

Cancer:

There is sufficient evidence of human carcinogenicity for acute non-lymphocytic leukaemia, and limited evidence for several lymphocytic leukaemias, multiple myeloma, and non-Hodgkin lymphoma. Benzene is considered a “non-threshold toxicant”, where adverse effects may occur at any exposure level.

Non-cancer:

Short-term exposure can cause drowsiness, headaches, and unconsciousness. The effects of long-term exposure include anaemia, neuropathies, and memory loss. Benzene is also a skin irritant.

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**Diesel Engine Exhaust**

Known Carcinogen (IARC 1)

What is diesel engine exhaust?

When diesel fuel combusts in engines it produces diesel engine exhaust, a complex mixture of gases and particulates that can contain other known and suspected carcinogens such as benzene, PAHs, metals, and particulate matter. The composition of the mixture depends on a number of factors including the type of engine (heavy or light duty), the type of fuel and oil, sulphur levels, speed and load of operation, and emission control systems.

What are the main sources of diesel exhaust for firefighters?

Most firefighting equipment in North America operates using diesel fuel. According to IARC, firefighters may be exposed to diesel engine exhaust when vehicles exit and return to the firehall, when vehicles are in operation, and when vehicles remain running at the fire scene.

Occupational exposure to diesel engine exhaust

Inhalation is the most common route of exposure. Assessing exposures to diesel engine exhaust is complex because it is difficult to separate diesel exhaust from other air contaminants with similar characteristics. There is also controversy in the best practices for measuring exposure.

(continued on page 4)
What are its health effects?

<table>
<thead>
<tr>
<th>Cancer:</th>
<th>Non-cancer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is sufficient evidence linking diesel engine exhaust to <strong>lung cancer</strong> and limited evidence for bladder cancer in humans.</td>
<td>Short-term exposure to diesel engine exhaust can irritate the eyes, throat, and bronchi, and cause light-headedness, nausea, and respiratory symptoms such as cough and phlegm. Diesel exhaust may initiate allergic reactions or increase immunological response to other allergens.</td>
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</tbody>
</table>

### Exposure reduction strategies

As outlined by the **Canadian Centre for Occupational Health and Safety (CCOHS)**, a variety of strategies can help protect workers from exposures to harmful substances such as carcinogens. These strategies are listed in order of effectiveness in controlling a risk.

1. **Engineering controls**
   - Minimize risk of exposure through strategic designs or modifications, which include process controls, enclosure/isolation of the source, and ventilation.
   - *An example of a process control is proper ventilation in firehalls to minimize exposure to diesel engine exhaust.*

2. **Administrative controls**
   - Alter the way the work is done through rules or policies.
   - *An example of an administrative control is shorter work times in areas where exposure may occur.*

3. **Personal protective equipment (PPE)**
   - Provides a barrier between the worker and the hazard.
   - *Examples of PPE include self-contained breathing apparatus (SCBA), protective clothing such as coats and pants, eye protection, helmets, gloves, and boots.*

For more information on these strategies and which one is appropriate for a situation, please visit the hazard control page of the [CCOHS website](https://www.ccohs.ca).

A compilation of exposure reduction resources, including the Canadian Partnership Against Cancer’s Prevention Policies Directory and the Canadian Cancer Society’s Cancer Information portal, is available on our website.

### Methods

The goal of the CAREX Canada project is to estimate Canadians’ potential exposures to known and suspected carcinogens in the workplace, prioritizing agents that are most relevant to Canadians. Estimates of the numbers of workers exposed to these agents are calculated by sector, occupation, province and sex for 2006 (using the 2006 Census of Population, the most recent census that includes detailed information on sector and occupation).

Where data are available, levels of exposure expected in Canadian workplaces are also estimated. CAREX Canada’s general approach to producing occupational prevalence and exposure level estimates is summarized in Figure 1.

More information on our methods is available under the Profile and Estimates tab on our website.
Data used in developing the occupational estimates for lead, nickel, hexavalent chromium, and cadmium were collected from several sources, including the Canadian Workplace Exposure Database (CWED), which contains approximately 4,200 measurements for PAHs exposure, over 1,500 measurements for benzene exposure, and over 1,500 measurements for ethylbenzene exposure. These measurements were collected between 1981 and 2004 in Ontario and British Columbia workplaces. Data for occupational exposures to diesel engine exhaust, PAHs, benzene, and ethylbenzene was also collected from scientific peer reviewed publications that addressed exposure in Canada and the United States, as well as technical reports from governments and international bodies.

More information on data sources is available under the Data Sources and Methods tab for each carcinogen on our website.

Strengths and limitations

One of the key strengths of CAREX Canada’s approach is the transparent, systematic, and scientifically rigorous methods used to develop the estimates of occupational carcinogen exposure. A challenge that we face is a general lack of current occupational exposure data. Since the 1990s, regulatory agencies across Canada have significantly decreased workplace exposure sampling. Varied record retention and archiving policies, as well as reduced accessibility to non-electronic data also limit what is available to CAREX Canada. This lack of data may affect both our estimates of prevalence and levels of exposure, especially when the use of a substance has changed substantially since the 1990s. Another limitation is the lack of information about particular work environments, which can make it difficult to determine appropriate exposure proportions for some occupations and industries. These instances are noted in our documentation.
Relevant publications and reports

OSH Answers Fact Sheets: Fire Fighter
Canadian Centre for Occupational Health and Safety, 2015.

IARC Monographs Volume 105: Diesel and Gasoline Engine Exhausts and Some Nitroarenes

IARC Monographs Volume 100F: Chemical Agents and Related Occupations

IARC Monograph Volume 92: Some Non-heterocyclic Polycyclic Aromatic Hydrocarbons and Some Related Exposures

IARC Monograph Volume 98: Painting, Firefighting, and Shiftwork

IARC Monograph Volume 77: Some Industrial Chemicals

Population health effects of air quality changes due to forest fires in British Columbia in 2003

Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts

Estimating emissions from fires in North America for air quality modeling

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