Standard for Managing Exposure to Significant Carbon Monoxide Emissions

JULY 2015

Version 2.0

Working in conjunction with Communities, Government, Agencies and Business.
The Standard for Managing Exposure to Significant Carbon Monoxide Emissions (the Standard) including all Attachments has been approved and endorsed by the following:

**Authorised by:**

___________________________ date __________________
Craig Lapsley
Emergency Management Commissioner

___________________________ date __________________
Professor Michael Ackland
Acting Chief Health Officer
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Section 1 - Background

Context
This Standard provides direction for all agencies responding to large, extended or complex fires that produce significant levels of carbon monoxide (CO) in the outdoor environment. These may include but are not limited to fires in coal mines, peat bogs, landfill sites or large mulch piles. A large, extended or complex fire may exhibit the following characteristics:

- Risk to firefighter and emergency responder health
- Impact on communities
- Scale, scope and complexity
- Significant carbon monoxide emissions.

Purpose
This Standard has been developed to provide a framework for decision making to assist the incident controller and agency commanders to manage health and safety of all personnel and affected communities during large, complex incidents that have the capacity to produce significantly elevated levels of CO in the outdoor environment.

The Standard concerns:

- the area in immediate proximity to the fire and the protection of responder health and safety
- areas around the fire impacted by the smoke plume and the protection of community health and safety.

It is important to note that the Standard is not an operational protocol and therefore it does not provide a step-by-step guide to responding to incidents that generate significant levels of CO in the outdoor environment. Rather, this Standard should be used to inform agency-specific protocols, standard operating procedures, training procedures and decision support tools. This Standard should also be considered by industry operators in developing their arrangements.

Strategic Intent
Consistent with the Emergency Management Manual Victoria (EMMV), the Incident Controller’s priorities include the protection and preservation of life which is paramount – this includes the:

- safety of emergency services personnel
- safety of other responding agency personnel
- safety of community members, including vulnerable community members and visitors/tourists located within the incident area
- issuing of community information and community warnings.
Occupational Health & Safety

The Occupational Health and Safety Act 2004, administered by WorkSafe, states that:

- An employer must, so far as is reasonably practicable:
  - provide and maintain a working environment for employees that is safe and without risks to health
  - ensure that persons other than employees of the employer are not exposed to risks to their health and safety arising from the conduct of the undertaking of the employer.

- While at work, an employee must:
  - take reasonable care for his or her own health and safety, or that of other persons who may be affected by their acts or omissions at a workplace
  - co-operate with his or her employer with respect to any action taken by the employer to comply with a requirement imposed by or under this Act or the regulations.

This standard contains important safety provisions that will only be fully effective with the cooperation of all responders, and the willingness of the community to follow the Incident Controller’s advice.

Governance

The Standard is authorised in accordance with the statutory responsibilities of the Emergency Management Commissioner with respect to responders and community safety in line with the Emergency Management Act 2013, and the Chief Health Officer’s statutory responsibilities with respect to the protection of public health in accordance with the Public Health and Wellbeing Act 2008.

The Standard was produced by a taskforce consisting of representatives from the following agencies:

- Emergency Management Victoria (EMV)
- Department of Health & Human Services (DHHS)
- Country Fire Authority (CFA)
- Metropolitan Fire Brigade (MFB)
- Ambulance Victoria (AV)
- WorkSafe Victoria (WV)
- Environment Protection Authority (EPA).
Review of the Standard

Latest review

This Standard is an updated version of the Standard for Managing Significant Carbon Monoxide Emissions which was approved in January 2015 by the Chief Health Officer (Department of Health and Human Services) and the Emergency Management Commissioner (Emergency Management Victoria). It has been amended to reflect recommendations from an independent Expert Panel review of the Standard.

As the air quality standards for protection of responder health differ to those for protection of community health, the Standard addresses these population groups in two separate sections.

In relation to the section which is focused on protection of the community, the key amendment is initiation of responder actions and community advice at more conservative CO air concentrations than were applied in the previous version of the Standard.

Future reviews

The Standard for Managing Exposure to Significant Carbon Monoxide Emissions will be further reviewed annually or as necessary, for example following any updates to national standards or following major CO events.

Authorising Framework

The Standard is supported by the following legislation and documents:

- Emergency Management Act 1986,
- Emergency Management Act 2013,
- Public Health and Wellbeing Act 2008
- Occupational Health and Safety Act 2004
- Environment Protection Act 1970
- Emergency Management Manual Victoria (EMMV)

The Standard refers to the following documents:

- Safe Work Australia Workplace Exposure Standards For Airborne Contaminants (Safe Work Australia 18 April 2013)
- Safe Work Australia Guidance on the Interpretation of Workplace Exposure Standards for Airborne Contaminants (Safe Work Australia April 2013)
- Hazardous Substances Information System (HSIS); Exposure standard documentation: Carbon monoxide (Safe Work Australia 1996)
- A Best Practice Approach to Shelter-in-Place for Victoria (MFESB 2011)
- Protective Action Decision Guide for Emergency Services during Outdoor Hazardous Atmospheres (MFESB 2011)
- Committee on Acute Exposure Guideline Levels, Committee on Toxicology; National Research Council Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8 (2010)
Carbon Monoxide Hazard

Carbon monoxide (CO) is an odourless, colourless gas that is produced during incomplete combustion. CO exposure through inhalation of this gas can cause illness and, in some cases death. Further information regarding CO is outlined in Attachment 1 - Carbon Monoxide Specific Information.

The following are susceptible to CO exposure¹

- The developing baby prior to birth (i.e. the foetus)
- People with heart and lung disease
- People with anaemia
- Heavy smokers.

In addition to CO monitoring, when responded, fire services Hazmat Technicians and Scientific Advisors will determine the potential for significant concentrations of other atmospheric contaminants in smoke based on risk assessment of the fuel source.

The scope of fire services atmospheric contaminant monitoring is limited to real-time measurement of gases. The scope of gases includes combustible gases, oxygen, hydrogen sulphide, carbon monoxide, carbon dioxide, hydrogen cyanide, sulphur dioxide, nitrogen dioxide, total volatile organic compounds, chlorine and ammonia.

Where there is a risk of exposure to the public from other atmospheric contaminants (e.g. PM2.5), EPA may be engaged to monitor atmospheric contaminants in the adjacent community.

In the event of a long duration incident, where the use of self-contained breathing apparatus has been deemed impractical, an occupational hygiene consultant may be engaged to monitor additional atmospheric contaminants based on risk assessment.

CO Monitoring Strategy

**Principles**

The concentration of CO in the air fluctuates continuously, and spikes in elevated concentrations may occur periodically. As concentrations of CO in the air vary from moment to moment threshold exposure values are based on averaged values. Research has shown that very brief exposure to highly elevated CO concentrations during moderate overall CO exposure does not necessarily result in harmful thresholds being exceeded².

CO atmospheric monitoring results will need to be interpreted and scientific advice obtained. The trends in atmospheric concentration of CO are the most important for decision making.

Table 1 sets out the equipment and agencies involved in atmospheric monitoring for CO at the incident site for responder safety, and in the community for public health and safety.

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¹ S Bull; HPA Compendium of Chemical Hazards: Carbon monoxide (UK Health Protection Agency 2011)
² Reisen F, Mayer M, Hansen D. Carbon monoxide – hazard on the fire ground (Bushfire CRC, 2008)
Table 1: Resources for monitoring atmospheric CO at an incident

<table>
<thead>
<tr>
<th>Resources</th>
<th>Responder Safety</th>
<th>Community Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring Equipment Options</td>
<td>Atmospheric</td>
<td>Atmospheric</td>
</tr>
<tr>
<td></td>
<td>• Spot</td>
<td>• Spot</td>
</tr>
<tr>
<td></td>
<td>• Area Capable Monitors</td>
<td>• Area Capable Monitors</td>
</tr>
<tr>
<td></td>
<td>• Personal Health Monitoring (COHb)</td>
<td>• EPA Equipment</td>
</tr>
<tr>
<td>Lead Agency for Atmospheric</td>
<td>Fire Services</td>
<td>EPA</td>
</tr>
<tr>
<td>Monitoring</td>
<td>• Hazmat Specialists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Scientific Advisors</td>
<td></td>
</tr>
<tr>
<td>Support Agency</td>
<td>Industry Operator</td>
<td>Fire Services</td>
</tr>
<tr>
<td></td>
<td>BoM</td>
<td>BoM</td>
</tr>
</tbody>
</table>

*Note: This table lists monitoring strategies, agencies involved in monitoring CO and weather conditions for responder and community safety.

**CO Monitoring Options**

Based on currently available equipment the following options are available for consideration:

- **Hand-Held Atmospheric Monitoring**: atmospheric contaminant monitoring equipment used by emergency responders to survey potentially hazardous atmospheres for ‘spot’ measurements (e.g. MSA Sirius or RAE Systems MultiRAE gas detectors)

- **Fixed Atmospheric Monitoring**: atmospheric contaminant monitoring equipment deployed in locations representative of emergency responder or public exposure with the capability to be monitored remotely (e.g. RAE Systems Area-RAE Rapid Deployment Kit)

- **Personal Atmospheric Monitoring**: atmospheric monitoring equipment worn by responders in the breathing zone for the purposes of assessing personal exposure against workplace exposure standards (e.g. Drager Pac 3500 CO detector)

- **Personal Biological (Health) Monitoring**: chemical exposure assessment involving the analysis of blood, or exhaled breath samples from workers, for a hazardous substance or its metabolites (breakdown products in the body). (e.g. Pulse CO-Oximetry, CO Breath Analysis)

**Air Exposure Levels for Carbon Monoxide**

**Ambient Air Quality Values for CO**

Ambient (i.e. outdoor) air quality values exist for the air we breathe, including for CO, under normal day to day conditions. They are applied on a continuous basis at air monitoring stations operated by the EPA.

For the purpose of monitoring the general quality of a local air shed a National Environment Protection Measure 8 hour average value for CO of 9 ppm applies. Although useful to inform normal
pollution levels generally, it should not be applied to significant local emergency events where short term poor air quality will far exceed this measure.

**Occupational and community exposure air quality values for CO during incidents**

This Standard concerns responder safety and community safety during large, complex incidents that have the capacity to produce significantly elevated levels of CO in the outdoor environment.

Occupational exposure standards exist to guide emergency services in protecting personnel who may be exposed to CO during their work.

Community exposure guideline values also exist for CO exposure in the outdoor environment, for generally a one-off, short-term exposure period (e.g. from 10 minutes to 8 hours) during an emergency.

As the air quality standards for protection of responder health differ to those for protection of community health, the Standard addresses these population groups in two separate sections titled ‘Significant Carbon Monoxide Emissions – Protection of Responders’ and ‘Significant Carbon Monoxide Emissions – Protection of Community.’
Section 2 - Significant Carbon Monoxide Emissions – Protection of Responders

Occupational Exposure Standards

The Occupational Health and Safety Act 2004 and associated regulations specify that the appropriate occupational exposure standards for use in Victoria are the Safe Work Australia (SWA) Exposure Standards. Safe Work Australia has developed workplace exposure standards for airborne contaminants including CO.

These Exposure Standards are contained in the following documents:

- Workplace Exposure Standards For Airborne Contaminants (Safe Work Australia April 2013)
- Guidance on the Interpretation of Workplace Exposure Standards for Airborne Contaminants (Safe Work Australia April 2013)
- Hazardous Substances Information System (HSIS); Exposure Standard Documentation: Carbon Monoxide (Safe Work Australia 1996)

These Exposure Standards are mandatory under the Victorian Occupational Health & Safety Regulations 2007. They establish a maximum upper limit for worker exposure, therefore all reasonably practicable steps must be taken to eliminate or minimise exposure to a level well below the exposure standard.

Exposure standards are also not designed for situations outside a workplace or for exposure of people, such as bystanders or nearby residents.

The following exposure standard and associated short-term excursion levels are included in the arrangements for personnel responding to significant CO producing incidents.
Table 2: Occupational Exposure Standard for CO

<table>
<thead>
<tr>
<th>Time Weighted Average (TWA) – including short term excursion levels within an 8 hour period(^3)</th>
<th>Airborne concentration in parts per million (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 hour time weighted average (TWA)(^4)</td>
<td>30</td>
</tr>
<tr>
<td>1 hour – short term excursion level allowed within an 8 hour exposure period</td>
<td>60</td>
</tr>
<tr>
<td>30 mins – short term excursion level allowed within an 8 hour exposure period</td>
<td>100</td>
</tr>
<tr>
<td>15 minutes – short term excursion level allowed within an 8 hour exposure period</td>
<td>200</td>
</tr>
<tr>
<td><strong>Note:</strong> no short term excursion level measurement should ever exceed this value</td>
<td>400</td>
</tr>
</tbody>
</table>

When reading Table 2, note that the Exposure Standard value is an 8 hour TWA of 30 ppm with a number of possible short-term excursions over 15, 30 and 60 minutes within this 8 hour exposure period. Also, at no time should any reading exceed the value of 400 ppm.

It is important to note the following for occupational exposure standards:

- They are an airborne concentration of a substance that must not be exceeded.
- They do not identify a dividing line between a healthy or unhealthy working environment. Susceptible individuals may experience health effects, therefore these standards are not an acceptable level of exposure but a maximum upper limit.
- They are assumed to apply to healthy adult workers.
- They assume that the setting may well be enclosed, there is a possibility of repeated exposure, and there is a higher breathing rate in workers (responders). The occupational exposure standards apply to all emergency responders and industry operators.

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\(^3\) Safe Work Australia

\(^4\) 8 hour TWA exposure standards must not be adjusted upwards for shorter exposure periods or work shifts (e.g. exposure to 8 times the TWA for one hour). This is because the health effects from high exposures for short periods may not be fully understood for each airborne substance. On the other hand, the 8 hour TWA exposure standard can be adjusted for longer work shifts as per Safe Work Australia guidance.
Tactical or Operational Considerations

**Occupational**

In the occupational setting, considerations for tactical decision making include:

- reviewing the task and the time taken to complete it relative to the exposure time
- options to reduce work load and breathing rate
- options to work at a location with less atmospheric contamination
- time to don on Self-Contained Breathing Apparatus (SCBA)
- the time required to exit complex environments.

**Figure 1: Exposure to CO for Firefighters**

*Note: This diagram is not the same as that which applies to public exposure to CO. This is because firefighters will be working in shifts in which exposure times can be managed depending on the levels of CO in air, have workforce oversight, have the opportunity for monitoring personal exposure, and have access to personal protective equipment.*
Responder Safety

Arrangements to protect ESO responders and other agency personnel

- The Incident Controller has ultimate responsibility to ensure safe systems of work are in place to protect responders.
- The Incident Controller will be supported and receive advice from an Incident Safety Officer and Safety Advisors and other specialist resources as required.
- Hazmat Technicians and Scientific Advisors will undertake continuous atmospheric monitoring during the incident.
- Personal CO atmospheric monitors will be utilised by each team in potential high exposure events.
- Responders must adhere to agency Standard Operating Procedures and safety directions issued by the Incident Controller.
- Health Monitoring Teams will conduct health checks in accordance with the principles outlined in Attachment 4 – Standard Approach for CO Health Monitoring Process.
- Caches of SCBA will be deployed to strategic locations for rapid access by responders.
- Crew leaders will ensure crews are rotated on a two-hourly basis and undertake entry, exit and re-entry health monitoring protocols. Further information can be obtained in Attachment 3 – Crew Leader Instruction for Carbon Monoxide Management.
- All health and safety incidents are to be reported and this information will be shared on an ongoing basis with responders to improve their risk awareness.

There is a requirement for identified incidents and dangerous occurrences to be notified to WorkSafe Victoria.

Responder Selection

General Health Issues

Increased CO levels in the environment are more likely to cause health impact in people with pre-existing conditions:

- Individuals, who are heavy smokers, have a history of cardiovascular or respiratory conditions or anaemia should not be deployed to these incidents.
- The foetus is also very sensitive to high levels of CO. Therefore any female responder, who is known to be pregnant or may be pregnant, should not attend these incidents.

It is the responsibility of all responders to disclose all pre-existing conditions that may put them in one of the above categories.

It is the responsibility of individuals who are allocating members to this incident to ensure that the responder selection guidelines are followed PRIOR to deployment to the incident and to ensure that all personnel have been clearly briefed.

Ideally, crews previously involved in other fire incidents should have 24 hours of “clear time” prior to being deployed to a large and complex fire producing significant amounts of CO.

Frequently asked questions are referenced in Attachment 2 – Carbon Monoxide Information Sheet for Personnel.
Crew Health Management

The following principles should be applied:

- Agencies providing crews for deployment are to ensure the crew selection criteria of pre-existing conditions listed in Responder Selection section are met.
- Where any results of health observations do not meet the criteria established personnel are not to be deployed.
- Crew deployment shift times are to be monitored and recorded to ensure they do not exceed the maximum timeframes. (Attachment 3 – Crew Leader Instruction for Carbon Monoxide Management)
- There will be personal biological monitoring for carboxyhaemoglobin (COHb) pre-shift, at breaks and post-shift.
- Crew health observations are to be recorded in accordance with the Health Monitoring Process (Attachment 4 – Standard Approach for CO Health Monitoring Process). Crew Health Observations may be undertaken by an advanced first aider under the supervision of a Health Professional.
- The incident is to be deemed a non-smoking incident to reduce the impact of CO build up in individuals.
- All CO health monitoring results are to be logged, reported to communications and maintained by health monitoring team (Attachment 4 – Standard Approach for CO Health Monitoring Process). Results that exceed 8% COHb are to be investigated as an OH&S breach to ensure crew welfare is not placed at risk and appropriate control strategies are in place.
- Community engagement and public information officers when engaged will be issued personal biological COHb monitors to monitor their exposure.
- All crew with COHb >5% must have a clear 24 hour break prior to next tour to allow sufficient time for natural clearance of accumulated low levels of CO from the body.
- All crew with COHb >8% must be referred for further health assessment to a doctor or hospital and have a clear 48 hour break prior to next tour to allow sufficient time for natural clearance of accumulated low levels of CO from the body.

Personal Protective Equipment/Clothing (PPE/C)

- Personal protective clothing is to be worn at all times in accordance with agency procedures.
- Crews are to use SCBA in accordance with Attachment 4 – Standard Approach for CO Health Monitoring Process.
- Crews not wearing SCBA are to use a P2 particulate respirator for protection from particulates in smoke (not CO).

Self-Contained Breathing Apparatus

Arrangements for the maintenance, filling and supply of SCBA will be established in light of the expected incident duration and volume of SCBA being used. The Incident Controller should liaise
with CFA or MFB to enable appropriate planning. SCBA cylinders must be refilled and maintained in an area with the least amount of atmospheric CO present.

**Work Rotations**

Shift durations must be managed to prevent accumulation of CO from repeated exposure. Crews can only work for 2 hours and then must have a 2 hour break. Health monitoring, CO readings and reporting whilst on shift are outlined in Attachment 3 – Crew Leader Instruction for Carbon Monoxide Management, Crew Leader Instruction.

Shift arrangements should be regularly reviewed and modified based on additional risks identified such as:

- extreme heat, cold or wet conditions
- heavy smoke logging
- work activity
- work rate
- on the advice of the relevant Medical Officer or Health Commander.

**End of Shift**

Prior to end of shift crew members should be made aware of the symptoms of CO exposure and advised to present to hospital should these occur. Symptoms include headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion (Refer to Attachment 2 – Carbon Monoxide Information Sheet for Personnel and Attachment 4 – Standard Approach for CO Health Monitoring Process).

**Air Operations Crews**

Aircrew working overhead the defined area are subject to The Standard. The health of aircraft crew is addressed with the monitoring of cockpit CO levels and the maintenance of cockpit air quality (CO below 30 ppm – SWA Workplace Exposure Standards for Airborne Contaminants 2013).

The maximum flying time for aircrew will prevent them exceeding 8 hours and therefore the time weighted average threshold of 30 ppm – SWA Workplace Exposure Standards for Airborne Contaminants (2013) is applicable. Daily health monitoring is available to aircrew.
Section 3 - Significant Carbon Monoxide Emissions – Protection of Community

Community Exposure Guideline Values for Emergencies

The development of Acute Exposure Guideline Levels (AEGLS) is a collaborative effort of the public and private sectors worldwide. AEGLS are intended to describe the risk to humans resulting from once-in-a-lifetime, or rare, exposure to airborne chemicals. The US National Substances (AEGL Committee) is involved in developing these guidelines to help authorities, as well as private companies, deal with emergencies involving spills, or other significant emissions resulting in community exposures.


AEGLS are the preferred short-term community protection standards to be used for the community health protection based on The Protective Action Decision Guide for Emergency Services during Outdoor Hazardous Atmospheres (MFESB 2011).

There are three levels of AEGL values that are adjusted across various time periods of exposure (i.e. from 10 minutes up to 8 hours). The lowest AEGL level (i.e. AEGL 1) for an air pollutant is the most protective for community exposure. When AEGL-1 values are not available, then AEGL-2 values are used. This is the case for CO.

**AEGL-1** is the airborne concentration (expressed as ppm [parts per million] or mg/m³ [milligrams per cubic meter]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

**AEGL-2** is the airborne concentration (expressed as ppm or mg/m³) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

**AEGL-3** is the airborne concentration (expressed as ppm or mg/m³) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

AEGLS are designed to protect the general population including older people, children and other susceptible groups that are generally not considered in the development of occupational exposure levels.

It is important to note the following for community exposure guideline values during an emergency event:

- They are designed to be protective of all members of the community including susceptible individuals.
- They are levels at which health effects are generally not expected to occur over the duration of exposure specified.
- They assume a one-off, short term exposure during an emergency incident.
Community Exposure Guideline Values for CO

The AEGLs for CO are contained in Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8 (US National Academy of Sciences, 2010).

The relevant thresholds where it is predicted that the general population, including susceptible individuals, could potentially experience health effects for CO are listed in Table 3 below.

**Table 3: Emergency Community Exposure Guideline values for CO**

<table>
<thead>
<tr>
<th>Description of exposure period for monitoring CO levels</th>
<th>AEGL 1</th>
<th>AEGL-2</th>
<th>AEGL 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 hours</td>
<td>Nil</td>
<td>27 ppm</td>
<td>130 ppm</td>
</tr>
<tr>
<td>4 hours</td>
<td>Nil</td>
<td>33 ppm</td>
<td>150 ppm</td>
</tr>
<tr>
<td>1 hour</td>
<td>Nil</td>
<td>83 ppm</td>
<td>330 ppm</td>
</tr>
<tr>
<td>30 mins</td>
<td>Nil</td>
<td>150 ppm</td>
<td>600 ppm</td>
</tr>
<tr>
<td>10 mins</td>
<td>Nil</td>
<td>420 ppm</td>
<td>1700 ppm</td>
</tr>
</tbody>
</table>

- AEGL-1 effects do not exist for CO because it does not cause irritation or discomfort at airborne concentrations where effects may occur in people with coronary artery disease.

- AEGL 2 values are based on the most susceptible group. Therefore, for CO, AEGL-2 is the airborne concentration above which it is predicted that the general population, including susceptible individuals (those with coronary artery disease⁶), could potentially experience health effects.⁷ The AEGL-2 thresholds are designed to not exceed carboxyhaemoglobin levels of 4%. The exposure standard for CO aims to minimise the risk to persons with subclinical coronary artery disease as the most sensitive sub-group to the effects of CO.⁸

- AEGL 3 values are levels above which the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

The AEGL-2 values do not protect against all effects from CO exposure in the general population, including susceptible groups, however they do protect against disabling effects and are considered

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⁶ People with coronary artery disease constitute the most susceptible subpopulation. The AEGL-2 value is set at 4% COHb. At or above this exposure level, those with coronary artery disease may experience a reduced time until onset of chest pain during physical exertion. An exposure at this level of 4% COHb is unlikely to cause a significant increase in the frequency of exercise-induced arrhythmias.

⁷ Other air quality guidelines and standards, such as the National Environment Protection Measures (NEPM) and World Health Organisation (WHO) standards, are designed to be protective of populations including sensitive sub-groups over a lifetime of exposure. They have a high level of conservatism built into them and are not appropriate for use in emergency situations, including decision-making in relation to possible evacuation.

⁸ Committee on Acute Exposure Guideline Levels, Committee on Toxicology; National Research Council Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8 (2010)
to be representative of exposures that can be managed by the general community including sensitive groups. Therefore they are appropriate for use as action levels for initiation of health protection measures such as shelter indoor or temporary relocation. At concentrations below the AEGL-2, health advice may be warranted for susceptible groups, for example, advice to limit physical exertion.

For the purposes of exposure to CO in emergency situations, long-term exposure is defined as being time periods of 24 hours or longer. Therefore if fires lead to prolonged periods (e.g. days to weeks) of consistently elevated exposures to CO, the AEGLs are not appropriate as they have been derived for acute emergency situations and do not protect against effects that may occur with long-term exposure at environmentally relevant concentrations which are below the AEGL-2. If emergency events do lead to days or weeks of elevated CO concentrations, then the exposure and associated health effects become more chronic than acute. If that situation arises, then consideration should be given to the use of a CO concentration in air equivalent to 2.5% COHb which is a blood concentration at which there are no observed adverse effects on health.

Application of Community Exposure Guideline Values

Using standards to protect the community

In order to protect the community from acute health effects due to CO, air quality is monitored in communities likely to be impacted by smoke from fires with the greatest CO producing potential. Results of this monitoring are assessed continually to ensure that early preparation for appropriate community messaging and action will take place well prior to relevant thresholds being reached. CO monitoring continues until fires are sufficiently controlled to ensure that community health is protected.

The concentration of CO in the air fluctuates continuously, with frequent spikes in concentration. As concentrations of CO in the air will vary from moment to moment, averaged values are calculated. Research has shown that very brief exposure to highly elevated CO concentrations during moderate overall CO exposure does not necessarily result in harmful thresholds being exceeded. The averaged values are considered in relation to the thresholds specified in AEGL-2, along with information about the likely duration of the fire, the fire suppression strategy, and predictions about future wind and weather conditions. If the duration of exposure to elevated levels of CO is a risk to community health, a number of options to protect the community are available.

Options to protect the community

Options to protect the community from prolonged exposure to high levels of CO include:

- Advice about increased levels of CO and the need to minimise physical activity and stay aware of further alerts.
- Warning with instructions to take shelter indoors until conditions improve or further advice is received.
- Emergency Warning - to relocate or instruct to take shelter indoors.
- Evacuation ('prepare to evacuate' and 'evacuate now') – specific instructions on where to go, how to get there and what to take are provided in the warning.

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9Reisen F, Mayer M, Hansen D. Carbon monoxide – hazard on the fire ground (Bushfire CRC, 2008)
Information issued to the community is based on both observed and predictive information which includes:

- Measured results adjusted to hourly averages from monitoring
- Bureau of Meteorology forecast data
- Fire behaviour both actual and forecast
- Predicted duration of prevailing conditions and elevated levels
- Size of community impacted

Warnings are issued in anticipation of a relevant AEGL-2 threshold being exceeded, adjusted for the known effectiveness of shelter-in-place strategies. In other words, one to two hours prior to the anticipated time that the threshold will be exceeded.

**Community actions**

Members of the community must remain vigilant during the emergency so that they can receive and act on emergency warnings and information in a timely way. The community should use multiple sources to obtain emergency information.

Individuals should prepare and be ready to shelter indoors if told to do so. (See Attachment 5 – Shelter Indoors)

Shelter indoors involves:

- Move to an indoor room with the least amount of doors and windows
- Close all doors and windows
- Switch off air-conditioning or reverse-cycle heating
- Seal any gaps under doors or around windows and wall vents with towels, blankets or plastic
- Continue to monitor advice for additional protective actions to take, and for when and how to end shelter-in-place
- Avoiding other sources of CO (e.g. smoking, poorly maintained gas appliances, etc.)

In a prolonged incident, there may be several occasions where shelter indoors is advised. Between these episodes the air may clear and CO levels drop. Advice will be provided at this time to open doors and windows to air out homes.

**Tactical or Operational Considerations**

For the community tactical decisions require sufficient time to communicate and implement on a whole-of-population basis. This differs from the individual worker or command line decision-making time in the occupational context.

The tactical options to protect the health of the community include:

- Time to assess the potential risks to public health well below outdoor air concentrations at which health effects could occur.
- Informing the community of potential risk of CO exposure with advice to reduce activity and minimise exposure
- Advice to shelter indoors
• Planned evacuation of impacted community (if required).

To evacuate a community or a section of a community will take longer than 1 hour.

In these scenarios, available data is constantly monitored and preparations for appropriate community messaging and action take places well prior to relevant thresholds being reached.
Victorian CO Response Framework

Triggers for action

A staged approach to community protection from adverse effects from exposure to CO during emergency situations is described in Figure 2 and Figure 3 below.

Figure 2: Exposure to CO for the public

Exposure to CO for Public

The specified values are levels at which no health effects are generally expected. The specified actions apply when these values are predicted to be exceeded.

Harm to public health from CO is related to its concentration in the air, together with the duration of exposure. CO levels are continuously monitored. Averaged values of CO concentration are used to guide considerations of risk to public health.

The duration of exposure (plume movement) is predicted based on advice from the Bureau of Meteorology and available plume modelling, taking into account the current and forecast fire status and the size and proximity of the community to the fire. If the community is likely to be exposed to elevated CO concentrations for an extended duration, actions will be implemented to protect the health of the community.

Note: This diagram is not the same as that which applies to firefighters exposed to CO. This is because firefighters will be working in shifts in which exposure times can be managed depending on the levels of CO in air, have workforce oversight, have the opportunity for monitoring personal exposure, and have access to personal protective equipment. These management options are not available for the public.

10
Where fires are predicted to result in CO concentrations in air for more than 4 hours, requiring CO monitoring for firefighters, then the potential risk to nearby communities from exposure to CO will be assessed.

Three levels of actions are provided for each of the AEGL-2 air concentrations (i.e. 27 ppm, 33ppm and 70\(^{11}\) ppm).

- If hourly averaged CO concentrations reach the trigger level of 27ppm (i.e. the AEGL-2, 8 hour average) for 3 consecutive hours then fire status and weather conditions will be reviewed to estimate the likely duration of community exposure to this concentration. Where weather conditions and plume modelling indicate that the community may be exposed to average CO concentrations \(>27\)ppm for less than 8 consecutive hours then appropriate community advice may be issued. If the plume is predicted to extend for a period beyond 8 hours then the community may be advised to shelter indoors.

- If hourly averaged CO concentrations reach the trigger level of 33ppm (i.e. the AEGL-2, 4 hour average) then fire status and weather conditions will be reviewed to estimate the likely duration of community exposure to this concentration. Where weather conditions and plume modelling indicate that the community may be exposed to average CO concentrations \(>33\)ppm for less than 4 consecutive hours then appropriate community advice may be issued. If the plume is predicted to extend for a period of 4-10 hours then the community may be advised to shelter indoors. If the plume is predicted to extend for a period of \(>10\) hours then formal evacuation of the community will be considered.

- If the half hour average CO concentration reaches the trigger level of 70ppm (i.e. the AEGL-2, 1 hour average with a safety factor applied) then fire status and weather conditions should be reviewed to estimate the likely duration of community exposure to this concentration. Where weather conditions and plume modelling indicate that the community may be exposed to average CO concentration \(>70\)ppm for up to 4 hours, Emergency Warnings may be issued advising the community to shelter indoors. For an exposure period between 4 and 6 hours, Emergency Warnings may be issued to advise the community to relocate. If the plume is predicted to extend for a period of 6 hours (i.e. the time for indoor CO concentrations to equilibrate with outdoor CO concentrations), then formal evacuation of the community will be considered.

\(^{11}\) Note that the AEGL-2 equivalent 1 hour average CO air concentration of 83ppm has been conservatively reduced to 70ppm to ensure an extra margin of safety, beyond that already provided by the AEGLs and the use of predictive plume duration to guide public health actions.
**Figure 3: Warnings Matrix for CO Readings**

<table>
<thead>
<tr>
<th>CO Readings ppm</th>
<th>&lt;1</th>
<th>1-2</th>
<th>2-4</th>
<th>4-6</th>
<th>6-8</th>
<th>8-10</th>
<th>10-12</th>
<th>&gt;12</th>
</tr>
</thead>
<tbody>
<tr>
<td>70*</td>
<td>EW Stay</td>
<td>EW Stay</td>
<td>EW Stay</td>
<td>EW Leave</td>
<td>EVAC</td>
<td>EVAC</td>
<td>EVAC</td>
<td>EVAC</td>
</tr>
<tr>
<td>33</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>WShelter</td>
<td>WShelter</td>
<td>EVAC</td>
<td>EVAC</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>WShelter</td>
<td>WShelter</td>
<td>WShelter</td>
<td></td>
</tr>
</tbody>
</table>

**Assumptions**

- Shelter indoors provides 6 hours protection before the equalisation with the external atmosphere.
- CO based on average reading over a 30 to 60 minute period.
- BOM to provide meteorological forecast of wind speed, direction and duration.
- BoM prediction to inform the estimated time of exposure.
- Available data will be constantly monitored and action will take place well prior to thresholds being reached.

**KEY**

<table>
<thead>
<tr>
<th>Formal Evacuation</th>
<th>Advice</th>
<th>Warning</th>
<th>Emergency Warnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVAC (Prepare to Evacuate)</td>
<td>A (Advice)</td>
<td>WShelter (Shelter Indoors)</td>
<td>EWStay (Shelter indoors)</td>
</tr>
<tr>
<td>EVAC (Evacuate Now)</td>
<td>Downgrade</td>
<td>Upgrade / Update</td>
<td>EWLeave (relocate)</td>
</tr>
<tr>
<td></td>
<td>All Clear</td>
<td>Downgrade</td>
<td>Upgrade / Update</td>
</tr>
</tbody>
</table>

* Note that the AEGL-2 equivalent 1 hour average CO air concentration of 83ppm has been conservatively reduced to 70ppm to ensure an extra margin of safety, beyond that already provided by the AEGLs and the use of predictive plume duration to guide public health actions. In other words, the warnings matrix aims to ensure that the population is never exposed to CO air concentrations which will result in carboxyhaemoglobin concentrations in the blood of >4% carboxyhaemoglobin (equivalent to the AEGL-2).

**Triggers for initiating consideration of public risk**

Close monitoring of potential public health risk will be triggered by any elevation of the CO concentration at or above the National Environment Protection Measures (NEPM) of 9 ppm which is based on carboxyhaemoglobin concentrations in blood of 2.5%. This will inform the need for any ongoing public health risk assessment.

**Roles and Responsibilities to Protect the Community**

The following roles and responsibilities are in place to protect the community:

- First responders to a fire event (e.g. CFA and MFB) may have capacity to deploy mobile air monitoring equipment across the state.
- The Incident Controller will provide information to the EPA and DHHS on first responder assessment of any CO impacts from the incident. Criteria for initiating air quality monitoring are detailed in EPA’s Rapid Air Monitoring Response Guide.

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12 Based in part on the Department of Health Carbon Monoxide Response Plan
The Incident Controller will continue to provide qualitative assessment and any available data from equipment deployed by first responders to EPA for their assessment and advice back. EPA will provide assessments to DHHS.

EPA will request the Bureau of Meteorology (BoM) and other organisations (e.g. DELWP) to provide advice on predicted weather conditions for affected communities for the use by EPA and other agencies.

EPA has fixed and mobile air monitoring stations in Melbourne, Geelong and the Latrobe Valley, as well as capacity to deploy mobile air monitoring equipment in other parts of Victoria.

In the event of actual or predicted adverse conditions, EPA may undertake or be requested by the Incident Controller (or DHHS via the Incident Controller) to initiate continuous monitoring to determine CO concentrations in potentially impacted communities. EPA will provide DHHS with interpreted data for public health assessment. EPA will draw on information from a variety of sources including from the BoM to advise DHHS to ascertain relevant weather predictions advise DHHS of these predictions.

CFA and MFB may support the Incident Controller by undertaking predictive modelling of the smoke plume.

The Incident Controller will advise the Chief Health Officer (CHO) of the predicted fire duration and suppression strategies.

The CHO will assess the advice received from the EPA and the Incident Controller. The CHO will determine the risk to public health of impacted communities, and provide advice to the Incident Controller regarding appropriate actions.

The Incident Controller will lead the Emergency Management Team (EMT) in their consideration of whether an evacuation of a community or part of a community is required.

Given that the quantity and quality of information and data will generally increase over time as the incident unfolds, the CHO will form their advice based on the best available information at any point in time.

The Incident Controller will determine an appropriate strategy for protection of the community including the issuing of information to the community regarding CO as required.

Victoria Police will prepare a staged evacuation plan for communities likely to be impacted by smoke from fires with the greatest CO producing potential at the request of the Incident Controller. Such plans should be prepared as early in the emergency as feasible. Staged evacuation will remove those community members and building occupants with greatest proximity to the source of CO first.

EPA will provide advice on CO levels at locations nominated by DHHS as potential places for relocated communities.

DHHS in conjunction with Local Government will coordinate relief and recovery arrangements for relocated communities.
Section 4 - Concept of Operations

The following provides an overview of high-level steps which would occur at various stages of an incident that has the capacity to produce significantly elevated levels of CO in the outdoor environment. As this Standard is not an operational protocol, these high-level steps should be used to inform detailed agency-specific protocols, standard operating procedures, training materials and decision support tools.

- The industry operator or the first responder agency on scene evaluates potential for CO emissions (based on the risk characteristics in the Standard) and initiates monitoring for responder safety.
  - Industry should activate the appropriate technical staff
  - Hazmat specialists and fire service scientific officers should be activated
- If monitoring suggests there are negligible levels of CO, no further escalation is required. Monitoring should continue until fires are controlled.
- If the first responder agency assesses that CO levels represent a possible occupational health and safety risk but there is no nearby community, implement appropriate procedures to protect responder health and safety (see Section 3).
- First responder agency assesses whether CO levels represent health and safety risks to responders and potential impacts on community.
  - Ensure implementation of appropriate procedures to protect responder health and safety.
  - EPA should be activated and asked to initiate monitoring in the community area.
  - Bureau of Meteorology (BoM) should be requested to provide advice on local weather conditions
  - DHHS should be advised of potential risk to community health and safety.
  - Consider the use of predictive modelling of the smoke plume by fire agencies.
  - If there is a delay to the establishment of EPA community atmospheric monitoring, first responder monitoring equipment should be deployed into community areas impacted by the smoke plume to assess the extent and severity of CO risk to the community.
  - Because of rapid fluctuations of CO levels, atmospheric monitoring should be continuous to enable interpretation of results. If continuous monitoring is not available, ‘spot’ monitoring (a single reading, a “snapshot in time”) should be repeated at frequent intervals at the same monitoring point in order to provide averaged results or trends in data. The frequency of monitoring should be at not more than 5 minute intervals\(^\text{13}\).

\(^\text{13}\) Spot monitoring needs to be repeated at frequent intervals or not greater than 5 minutes apart, to develop a time series demonstrating the trends in CO levels.
CO monitoring results need to be reviewed and verified and reported as either a graph or a time series including all results with time and location of measurement.

CO monitoring results need to be interpreted with supporting information including maps of affected community specifying monitoring positions, plume modelling of smoke dispersion, and predictions of local weather for the next 12 to 24 hours. Maps should identify facilities with vulnerable people, such as childcare facilities, schools, health services, and residential aged care facilities.

CO monitoring results and supporting information should be provided to DHHS for analysis. The Chief Health Officer will assess the risk to the public health of the community and provide advice to the Incident Controller.

The Incident Controller will provide warnings and information to the community.

For long duration events consideration should be given by the Incident Controller in consultation with the Chief Health Officer and the Emergency Management Commissioner to a communications strategy to keep the community informed of the hazard of CO and potential health concerns.
Attachment 1 - Carbon Monoxide Specific Information

The purpose of this attachment is to provide relevant information to the:

- Incident Controller
- Hazmat Specialists
- Scientific Advisors
- Health monitoring team
- Safety Officer/Advisor.

Risk of exposure to carbon monoxide

Carbon monoxide (CO) is contained in smoke from all types of fires, as well as other sources. The amount of CO in smoke is greatest from fires with partial combustion of materials like coal, peat, landfill and large mulch piles. The amount of CO is greatest closest to the fire, so firefighters and other personnel responding to the fires are potentially exposed to the most hazardous levels of CO.

The likelihood that the community will be exposed to CO in smoke is influenced by the distance of the community from the fire, the size of fire, fire management strategies, and the prevailing wind direction and weather conditions. As the community is generally further from the source of the CO than firefighters and other responders, less CO will reach the community.

All people are susceptible to CO, but the risk of CO to health is greatest to people with heart and lung conditions, anaemia, and to the foetus. The likelihood of health effects relates to the concentration of CO in the air and the duration of exposure to contaminated air, as well as individual susceptibilities. In addition, physical activity increases the rate of breathing and will increase the amount of air containing CO inhaled14.

Background

CO has a high affinity for haemoglobin (Hb) in blood. Hb is the compound that transports oxygen (O₂) in the blood stream. CO is absorbed via the lungs into the blood stream where it forms carboxyhaemoglobin (COHb). This means that CO reduces the oxygen carrying capacity of the blood. Organs with a high oxygen requirement, such as the heart and the brain, are especially sensitive for this effect15.

Small quantities of CO are produced in the human body naturally. This leads to a background level of approximately 0.4 – 0.7% COHb in healthy non-smoking individuals16.

Inhalation exposure to CO concentrations within the Australian occupational exposure standard time weighted average of 30 ppm for 8 hours will result (under normal circumstances) in a COHb concentration of less than 5%.

14 S Bull; HPA Compendium of Chemical Hazards: Carbon monoxide (UK Health Protection Agency 2011)
15 Committee on Acute Exposure Guideline Levels, Committee on Toxicology; National Research Council Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8 (2010)
CO takes 10 to 30 hours to clear from the body in fresh air depending on the amount absorbed and other individual factors

**CO – Acute poisoning**

The appearance of symptoms in someone suffering from acute exposure is dependent on the following:

- The concentration of CO in air breathed
- The duration of exposure
- The degree of physical exertion
- Individual susceptibility
- Pre-inhalation COHb level.  

Susceptible individuals include:

- Pregnant women – because of potential harm to the foetus from low levels of oxygen
- People with anaemia (low blood count or Hb concentration) - because of lowered oxygen carrying capacity of the blood
- People who have cardiovascular or heart conditions, especially angina
- People who have breathing disorders and lung disease
- Smokers because they may have high levels of CO in their blood before they are exposed to contaminated air.

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17 Hazardous Substances Information System (HSIS); Exposure standard documentation: Carbon monoxide (Safe Work Australia 1996)

18 S Bull; HPA Compendium of Chemical Hazards: Carbon monoxide (UK Health Protection Agency 2011)
Table 4: Summary of acute health effects of carbon monoxide

<table>
<thead>
<tr>
<th>COHb Concentration %</th>
<th>Principal Signs and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>No significant health effects</td>
</tr>
<tr>
<td>2.5 – 5</td>
<td>Decreased exercise duration due to increased chest pain (angina) in patients with cardiovascular disease. No significant health effects expected in rest of population</td>
</tr>
<tr>
<td>5 – 10</td>
<td>Subtle neurobehavioral symptoms</td>
</tr>
<tr>
<td>10 – 20</td>
<td>Headache (&quot;frontal tightness&quot;), possible shortness of breath in healthy population. May be lethal for someone with severe heart disease.</td>
</tr>
<tr>
<td>20 – 30</td>
<td>Throbbing headache, nausea, flushing</td>
</tr>
<tr>
<td>30 – 40</td>
<td>Severe headache, dizziness, nausea, rapid breathing</td>
</tr>
<tr>
<td>&gt;40</td>
<td>Collapse, coma, convulsion, death</td>
</tr>
</tbody>
</table>

*Note: This is given as a guide only and there may be considerable variation depending on individual characteristics.

Inhalation exposure to high concentrations of CO in susceptible groups may cause flu-like symptoms such as headache and tiredness, progressing to dizziness, confusion, nausea or fainting. Very high amounts of CO in the body may result in oxygen deprivation, leading to loss of consciousness or death.

Neurological problems may be seen following an episode of unconsciousness due to CO poisoning. Symptoms may include cognitive and behavioural changes. People with symptoms from CO who have not lost consciousness are at very low risk of developing neurological problems.

Primary recovery from a severe CO poisoning may be followed by a subsequent neurobehavioral relapse days or even weeks after poisoning. The degree of brain damage after CO poisoning is determined by the intensity and duration of exposure.

Repeated exposure

CO is not stored in the body. It is completely excreted after each exposure if sufficient time in fresh air is allowed. CO takes between 10 and 30 hours to clear from the body in fresh air depending on the amount absorbed and other individual factors. However, it is possible that repeated

19 Adapted from S Bull; HPA Compendium of Chemical Hazards: Carbon monoxide (UK Health Protection Agency 2011); and the Agency for Toxic Substances and Disease Registry; Toxicological Profile for carbon monoxide (US Department of Health and Human Services, June 2012)

20 S Bull; HPA Compendium of Chemical Hazards: Carbon monoxide (UK Health Protection Agency 2011)

21 Ibid
mild/moderate poisonings can lead to permanent nervous system damage (headaches, dizziness, impaired memory, personality changes and weakness in limbs).\textsuperscript{22}

Exposure to CO can result in hearing loss. Hearing loss is more likely to occur if a worker is exposed to both noise and CO than if exposure is just to noise or CO alone. The \textit{Code of Practice Managing Noise and Preventing Hearing Loss at Work} recommends hearing is monitored with regular audiometric testing in situations where workers are exposed to:

- ototoxic substances where the airborne exposure (without regard to respiratory protection worn) is greater than 50 per cent of the workplace exposure standard for the substance, regardless of the noise level
- ototoxic substances at any level and noise with LAeq,8h greater than 80 dB(A) or LC, peak greater than 135 dB(C).\textsuperscript{23}

\textsuperscript{22} ibid

\textsuperscript{23} Safe Work Australia Guidance on the Interpretation of Workplace Exposure Standards for Airborne Contaminants (April 2013)
Frequently Asked Questions

**What is carbon monoxide?**
Carbon monoxide (CO) is an odourless, colourless gas that can cause sudden illness and death at high concentrations.

**Where is CO found?**
CO is found in smoke and is formed from incomplete combustion of coal, wood, peat, natural gas, petrol, kerosene, oil, or propane. It is also found in exhaust fumes from cars, petrol and gas engines, gas ovens and cooktops, generators, lanterns, BBQs and gas and wood heaters. Cigarette smoke contains CO. Regular smokers are expected to have higher levels of carbon monoxide in their body than non-smokers.

**What are the symptoms of CO poisoning?**
The most common symptoms of CO poisoning are headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion. High levels of CO inhalation can cause loss of consciousness and death. Seek medical advice if you are experiencing any of these symptoms.

**How does CO poisoning work?**
When breathed in, CO replaces oxygen in the blood and deprives the heart, brain and other vital organs of oxygen.

**Who is most at risk?**
Whether someone develops health effects from exposure to CO depends on a number of factors including:

- the levels of CO in the air
- how long a person is exposed
- individual factors, such as an existing heart or lung condition; having anaemia; being pregnant (the unborn child)
- the level of exercise or physical activity, which increases the amount of air breathed into the lungs
- other lifestyle factors such as being a smoker.

**Individuals who should avoid CO exposure include:**

- Pregnant women – because of potential harm to the unborn child from reduced levels of oxygen
- People with anaemia (low blood count or haemoglobin concentration) because of lowered oxygen carrying capacity of the blood

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24 S Bull; HPA Compendium of Chemical Hazards: Carbon monoxide (UK Health Protection Agency 2011)
- People who have heart conditions, especially angina
- People who have breathing disorders and lung disease
- Smokers with elevated levels of CO in their blood before they are exposed to contaminated air.

Why am I being tested?

At the incident site, personnel are required to undergo pre and post deployment health checks, conduct personal monitoring for CO and adhere to control agency SOPs.

Testing for raised levels of CO is part of the health monitoring process. There are no symptoms from low levels of CO in the blood. However, if levels are increased, further health checks may be required to rule out any possible health concerns. Work processes may also have to be reviewed to ensure that further exposure to CO is minimised.

The test is painless and involves a probe which very gently clamps onto a finger to take a reading. During breaks personnel should avoid other sources of CO exposure such as those listed above.

How does this standard apply to Bushfires?

This Standard has been developed based on the experience of a High CO exposure event such as the Hazelwood Mine Fire, and community and firefighter safety risks need to be assessed for other sources of smoke. For example CO in smoke from bushfires varies significantly in time and space, and while past research by CSIRO scientist has found that these standards can be exceeded, this occurs infrequently and in certain circumstances. This science will be used to inform response to future bushfires.
Attachment 3 – Crew Leader Instruction for Carbon Monoxide Management

Briefings – Pre Entry, Pre Tasking and Pre Release

On shift change, strike teams are to be given a specific briefing on health and CO exposure issues (Attachment 2 – Carbon Monoxide Information Sheet for Personnel).

All crew members must be checked by Health Monitoring personnel prior to entering the hot zone, at breaks and post shift when established.

All crew leaders are to collect personal atmospheric CO carbon monoxide detectors and ensure there is at least one detector per crew while working at the site. They are not required to be worn in clean areas (e.g. Staging Areas).

Readings should be noted as follows:

- Log the detector CO reading every 15 minutes on the attached sheet
- Provide average and peak readings and map grid/location reference of location to the Operations Point every hour via radio.

Crews can only work for 2 hours and then must have a 2 hour break.

If in any 1 hour period there are 2 measurements greater than 60 ppm workers must relocate/withdraw immediately or don BA to remain working in the location. This must be reported immediately to the Operations Point.

At any time a CO reading of greater than 100 ppm is recorded, BA must be donned or workers must withdraw immediately. This must be reported immediately to the Operations Point.

All crew must be rechecked by Health Monitoring personnel at the conclusion of their shift prior to leaving the site. Personnel will not be permitted to leave the site without appropriate clearance provided by the Health Monitoring personnel.

Crews are to be advised that if, after release from the site, they develop symptoms of potential CO poisoning such as headache, dizziness, weakness, nausea, vomiting chest pain and confusion, they should seek medical advice. On return home personnel are advised to rest for 24 hours, avoid further exposure to sources of CO, avoid alcohol and ensure good hydration.
Attachment 4 – Standard Approach for CO Health Monitoring Process

The following process is to be undertaken to monitor and manage the health of all personnel. The health monitoring process will be established for large and complex incidents producing CO when health monitoring resources are available. The health monitoring team may include Advanced First Aiders and qualified Health Professionals. The health monitoring process will be overseen by a qualified Health Professional to ensure the protocol is followed.

Health Monitoring Team

Advanced First Aiders have the following qualifications:

- HLTFA403C Manage first aid in the workplace
- HLTAID003 Provide first aid
- HLTFA402C Apply advanced first aid
- HLTFA404C Apply advanced resuscitation techniques,

Or equivalent Senior First Aid qualifications from the Public Safety ITAB.

Qualified Health Professionals include:

- Registered Medical Health Practitioners
- Registered Nurses
- Paramedics

On Arrival, Break and Exit

All personnel will enter through the staging area and be directed to the Health Monitoring area for biological COHb monitoring.

Hand washing and use of a nail brush will be required as measurement of COHb requires clean hands.

The Health Monitoring team will obtain COHb readings on all personnel.

A Health Monitoring team member records:

- COHb reading
- Time
- Name
- Organisation and appliance/location point
- Smoker or non – smoker status
- Previous activity associated with fire in the last 24 hours
- Pre-existing medical conditions/pregnancy or possibility of pregnancy
- Symptoms reported.
### Table 5: COHb Action Levels

<table>
<thead>
<tr>
<th>COHb Readings by CO-Oximetry</th>
<th>Actions</th>
</tr>
</thead>
</table>
| **Reading is less than 5%** | Person is released from Health Monitoring assessment area via designated exit and instructed to:  
• enter the incident control centre for tasking, or  
• return to staging area for deployment and/or  
• rest,  
All personnel that have a reading under 5% COHb are approved to enter the staging area for tasking. |
| **Initial reading is equal to or greater than 5%** | Person is wrist tagged and is unable to start work until all of the following is completed:  
• Wait in Health Monitoring area for 20 minutes and rest  
• Rewash hands  
• Must be retested. |
| **Repeat reading is equal to or greater than 5% and less than 8%** |  
• All personnel who have a second reading equal to or over 5% and less than 8% COHb will be wrist tagged (indicating excessive COHb reading).  
• If they have no symptoms they should be released from duty for at least 24 hours.  
• Any person reporting any symptoms such as headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion should be referred to a health professional for assessment.  
• At any time during monitoring of COHb during a shift if the 5% level is exceeded after retesting, the worker will not be allowed back to work in areas of atmospheric CO contamination. |
| **Equal to or Greater than 8%** |  
• Immediate referral to a health professional for assessment and either sent home or to hospital for further assessment and monitoring.  
• Must remain off active duty for at least 48 hours.  
• Exposures over 8% COHb are to be logged as an OHS Issue. |
Pre Deployment Medical Monitoring

Prior to being deployed, personnel should be in good general health and not:

- be pregnant due to potential harm to the foetus from low levels of oxygen
- suffer from anaemia (low blood count or Hb concentration) - because of lowered oxygen carrying capacity of the blood
- suffer from cardiovascular or heart conditions, especially angina
- have breathing disorders and lung disease.

Post Deployment Medical Monitoring

Crews are to be advised that if, after release from the site, they develop symptoms of potential CO poisoning such as headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion they should present to hospital. On return home, personnel are advised to rest for 24 hours, avoid other sources of CO, alcohol and ensure good hydration. If symptoms persist after 24 hours, personnel should seek medical advice.
Attachment 5 – Shelter Indoors

What to do?
When the plume or smoke is passing over it is safer to stay indoors. After the plume or smoke has passed, it is safer to move outdoors.

Sheltering inside your home or a building in an emergency provides immediate protection from contaminated air outside. The fresh indoor air provides short term protection.

Over time some of the contaminated outdoor air will enter the building through small cracks, and eventually, after the plume or smoke has passed, the outdoor air may be cleaner than the indoor air. At this time it is safer to go outside.

Shelter, Shut, Listen

Shelter
- Go inside immediately.
- Take family and pets with you.
- Avoid phone use. Emergency Services may need to contact you.

Shut
- Close the doors and windows.
- Close all external doors and windows. Seal gaps with blankets, towels or duct tape.
- Turn off heaters, air conditioners and exhaust fans. Close fireplace dampers.

Listen
- Listen to the radio for further information and additional instructions.
- Listen to local ABC or any commercial radio station, turn on the television for media messages, or visit the Vic Emergency website www.emergency.vic.gov.au
- Wait for “all clear” message, then open doors and windows to ventilate building.
- Go outside.

Display this information in your home or place of work. Discuss emergency procedures with family, neighbours and colleagues.
How will I be warned of an emergency due to carbon monoxide?

- Warning systems:
- The fire services may contact you via a telephone message or the media with information on the incident and safety advice.
- Some councils provide community information via their customer service and website.
- A warning will be issued on Vic Emergency website [www.emergency.vic.gov.au](http://www.emergency.vic.gov.au)

For an emergency phone 000 for Fire Brigade, Police, and Ambulance.