



SHELTER

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Protective Action Guide
for Local Government and Industry
during Outdoor Hazardous Atmospheres





Shelter-in-Place Report
Issued by the Metropolitan Fire and Emergency Services Board
May 2011

Authorised by MFB, CFA, DH, OESC, ChemCentre

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Guide Definitions

ACH	Air Changes per Hour
AEGL	Acute Exposure Guideline Level
AIHA	American Industrial Hygiene Association
ALOHA	Areal Locations of Hazardous Atmospheres
CALD	Cultural and Linguistically Diverse Groups
CFA	Country Fire Authority
CSEPP	Chemical Stockpile Emergency Preparedness Program
Concentration	Concentration is the amount measured in parts per million (ppm) or milligram per cubic metre (mg/m ³), of a substance present in the atmosphere resulting from a release.
DH	Department of Health
ERPG(s)	Emergency Response Planning Guideline(s). Values intended to provide estimates of concentration ranges above which one could reasonably anticipate observing adverse health effects.
USEPA	United States Environmental Protection Agency
Evacuation	Evacuation is the timely and effective relocation of exposed persons or persons having the potential of being exposed to a toxic or chemical agent, to an alternate location having no potential for exposure to the same toxic or chemical agent.
Incident Controller	An incident controller is the person in charge of the overall incident management at site.
NEWS	National Emergency Warning System
NOHSC	National Occupational Health and Safety Commission
Protective Action Zones	This is the area downwind from the release point within which the airborne concentration of the vapour is high enough to necessitate a protective action.
SEWS	Standard Emergency Warning Signal
SIP	Shelter-in-place, is a protective action to provide public safety by going indoors and following the recommended shelter, shut and listen actions as instructed by the first responders.
STEL	Short Term Exposure Limit, 15 minute occupational exposure limit
Toxic	A substance that is poisonous and/or hazardous to life or health
TWA	Time-weighted average, 8 hour Occupational Exposure Limit

Summary

The guide is designed to be used as a tool for local government and industry. It provides information on best practice principles about planning for and implementing community protective actions during potential airborne chemical hazards caused by industrial or transport accidents, chemical/biological/radiological (CBR) events, or structure fires. We recommend the use of the terminology and templates incorporated in the guide to provide consistent public messages with that of emergency services.

The key points covered in this guide are:

1. Shelter-in-place (SIP) is an effective public protective action when prompt response and actions are implemented before a hazardous plume arrives.
2. When to terminate SIP is important for reducing community exposure.
3. Evacuation would be issued only for a predicted long term release (e.g. duration >4 hrs) or if a flammable atmosphere is expected/detected. Evacuation of residents may take up to 2 hrs. It is critical that the community is evacuated before the plume arrives, and in most cases a delay in ordering an evacuation will provide greater risks to the community.
4. Examples of public education programs and materials on the benefits of temporary SIP and the importance of prompt compliance with sheltering instructions.
5. The importance of delivering a uniform message for SIP with consistent terminology from local government, industry and emergency services.

1. Introduction

1.1 Purpose

To provide industry, local government and emergency services with a standard approach to community protective actions during a chemical incident or fire, being accidental or deliberate.

1.2 Shelter-in-Place

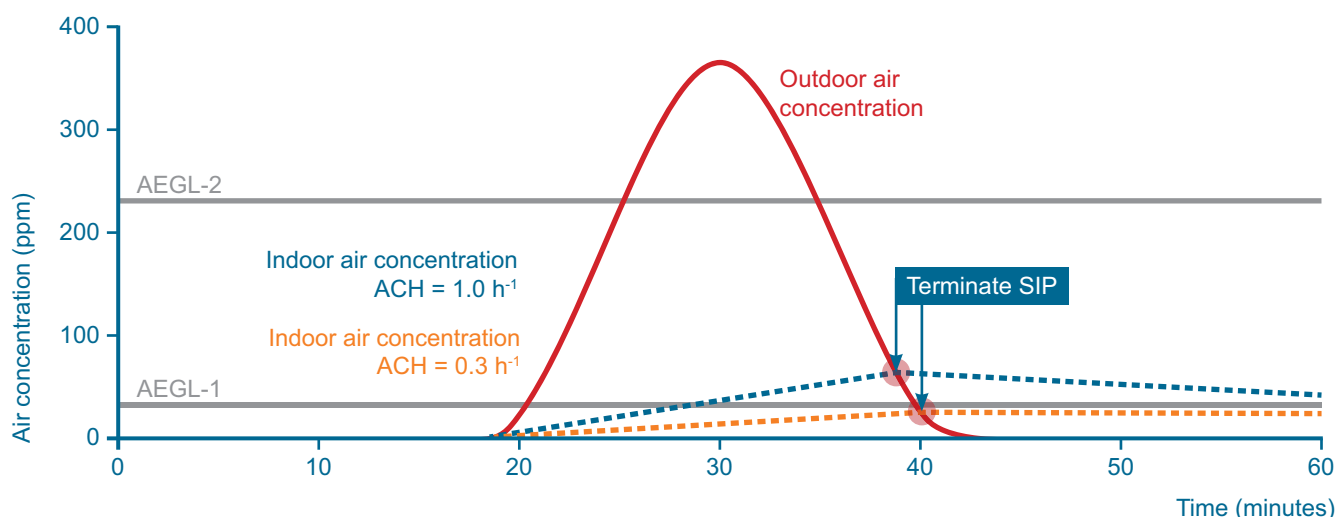
SIP has shown worldwide to be an effective emergency response action during short-term chemical release situations when the outdoor atmosphere is too toxic for evacuation. The SIP action requires the public to take shelter indoors and seal the building. The air inside a building provides temporary protection until the vapour cloud has passed. The level of protection provided by residential buildings varies with the rate at which outdoor air enters the building (e.g. how leaky the structure is). Recent research has validated the effectiveness of Australian residential houses for short term sheltering during toxic chemical releases, including smoke from fires.

The benefits of temporarily sheltering can be seen in Figure 1. This graph shows estimated indoor air concentrations for two houses with different air exchange rates (0.3 and 1.0 h^{-1}),

compared to an outdoor concentration of ammonia over one hour during a hypothetical release. Both houses have significantly lower contaminant air concentrations than outdoors as the plume passes over (i.e. at the peak of the outdoor curve), with the less leaky house ($\text{ACH} = 0.3 \text{ h}^{-1}$) providing the greatest level of protection. After the plume has passed, the outdoor concentration quickly drops, and a point is reached where the indoor air concentration equals the outdoor concentration. This time point, where the solid (outdoor air) and dotted (indoor air) lines intersect, is the best time for a person to end SIP. Continuing to SIP past this point would lead to greater exposure because the concentration continues to rise after the peak of the plume has passed, and it also takes a considerable amount of time for the indoor concentration to decrease and re-equilibrate with the outdoor atmosphere.

Educating the public on the importance of prompt action when advised to take shelter, and then when to leave the shelter, is vital for successful public protection.

Figure 1. Computer modelling of airborne concentration of ammonia, outdoors and indoors at a point 2 km downwind for two building air exchange rates



1.2.1 Variations in Protection for Shelter-in-Place

The level of protection provided by a shelter varies from building to building depending on the number of cracks and openings that allow outside air into the building. This rate of airflow is known as the air exchange rate, and is a measure of the number of times fresh air replaces the indoor air in one hour. In a recent study of air exchange rate on a variety of house types, a clear trend appears that older homes are significantly more leaky (Figure 2). This can be explained by changes in construction materials and techniques that were required by new building regulations introduced in the early 1980s, to reduce energy consumption. As a consequence newer buildings provide greater protection from outside contaminated air. Renovated houses and weatherisation techniques, such as door and window seals, have been found to dramatically increase the level of protection of buildings.

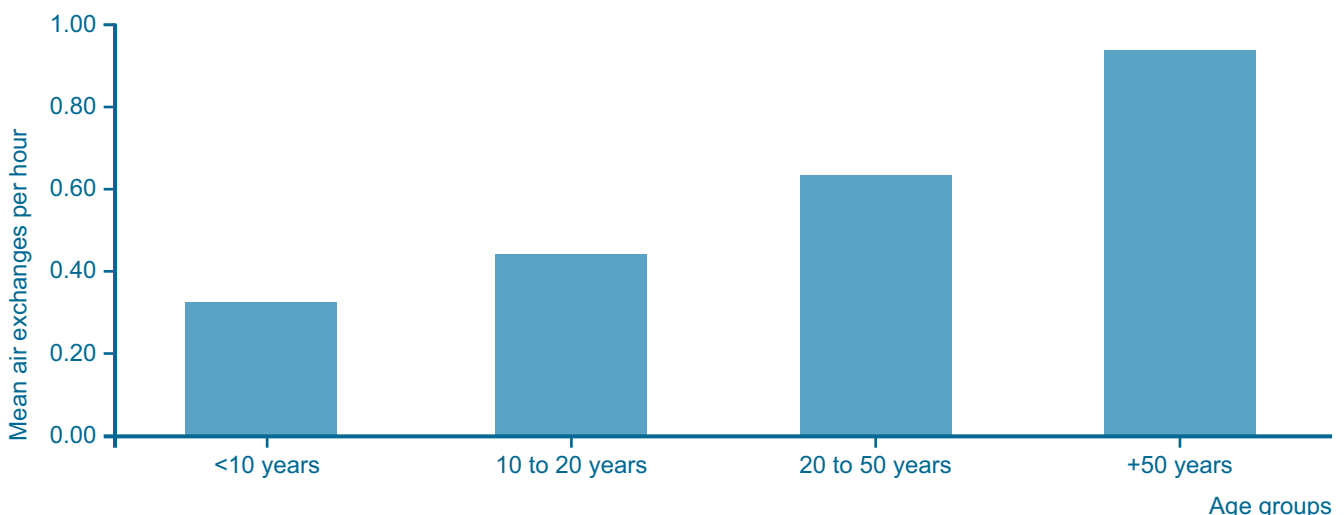
1.2.2 Improving Building Protection

Scientific studies have reported simple short term solutions to reduce the air change rate of buildings. Selecting an interior room for shelter on the downwind side of the house, preferably with no external doors or windows can be effective. Taping gaps under doors and around windows and vents with duct tape further reduces air infiltration into the shelter, this is known as expedient sheltering. In reality many people will not have the materials or capability to implement expedient sheltering.

1.2.3 Limitations of Shelter-in-Place

- SIP provides only a temporary protection for short term chemical releases (up to 4 hours). Sheltering time depends on a number of factors, most importantly, release duration and building air exchange rate.
- Evacuation is the safest option if there is time to do so before the arrival of the hazardous plume.
- Evacuation is preferred if the release duration is predicted to be long (> 4 hrs).
- Time delays for issuing a warning to SIP can reduce the effectiveness of building protection.
- Public awareness and education campaigns are essential for successful compliance with SIP.
- Findings from post chemical incidents studies have reported that there will always be a percentage of the population that will not follow emergency instructions or will act contrary to the direction (i.e. evacuation when instructed to shelter). Emergency pre-planning needs to consider these people.

Figure 2. Mean Air Exchange Rate (h^{-1}) versus Building Age (years)



1.3 Evacuation

Evacuating a population away from a toxic plume is a very effective protective action as it removes the people from hazard. However, due to the unexpected nature of chemical accidents and the limited time to carry out this process, it may lead to higher exposures, unless completed before the arrival of the toxic plume.

There are two types of evacuation: precautionary or responsive.

Precautionary evacuation may be instigated by an incident controller if informed of a potential hazardous material release that has not yet occurred. This type of evacuation may also be issued for a residential area during a chemical release that is not directly affected by the hazardous plume, but there is a possibility of a change in the direction of the plume which may lead to high levels of exposure in this area.

Responsive evacuation involves removing residents away from the area where outdoor air concentrations are expected to exceed community exposure levels. This type of evacuation is very difficult to do as people may be exposed to high outdoor air concentrations during this process. Fire Services may deem this to be a rescue depending on the level of personal protective equipment and respiratory protection required. It is generally safer to advise people to stay in their homes in this situation, to reduce the level of exposure to the public and to the emergency responders.

Both types of evacuation are very resource intensive and require extensive planning, including:

- Estimating the number of potential evacuees, with particular emphasis on populations with special needs,
- Identifying the most appropriate evacuation routes and safe destinations,
- Estimating the time needed for evacuation,
- Establishing Traffic Control Points; and
- Anticipating potential problems.


Consideration needs to be made of the estimated evacuation time as compared to the plume duration time. In most cases the plume duration will be far less than the time it takes to initiate and implement an evacuation, whereby most evacuations take 2 to 4 hours to accomplish successfully.

1.4 Community Exposure Standards

The level of risk to the community varies with the outdoor air chemical concentration and its related health effects. The level of public safety has previously been measured in terms of Occupational Exposure Standards, developed to protect the worker for an 8 hour day, over a working lifetime. These limits, however, do not provide protection for the general public, particularly the sensitive population, including infants, the elderly and people with respiratory diseases.

A hierarchy-based method for selecting air quality reference values that are appropriate for protecting the public from short-term exposure(s) to chemicals in air has been adopted. These values follow three exposure levels: the Acute Exposure Guideline Levels (AEGL's), the Emergency Response Planning Guidelines (ERPG), and the Australian Occupational Exposure Standards (Table 1).

Table 1. Order of selection for short-term community exposure standards

Hierarchy	Air Quality Exposure Standards	Selection Guide
	Acute exposure guideline levels (AEGL's)	Use AEGL's first. Values for 227 chemicals currently available
	Emergency response planning guidelines (ERPG's)	Use ERPG if no AEGL. Values for 136 chemicals available
	Australian occupational exposure standards	Use 8 hr TWA or 15 min. STEL if no AEGL or ERPG available

2. Protective Action Process

2.1 Initial Actions of Emergency Services

Most large chemical incidents require a multiagency response, through coordination between the Fire Services, Police, DHS, EPA, and Worksafe. It is the legislated responsibility of the Incident Controller from the fire brigade to assess and control the situation, as well as provide protective action information to nearby affected communities. In most cases there will be a time delay from the onset of the incident to when an initial community warning can be made. The length of time to issue a public message varies across incidents and depends on factors such as incident response time, hazard identification, control times and assessment of potential public health effects.

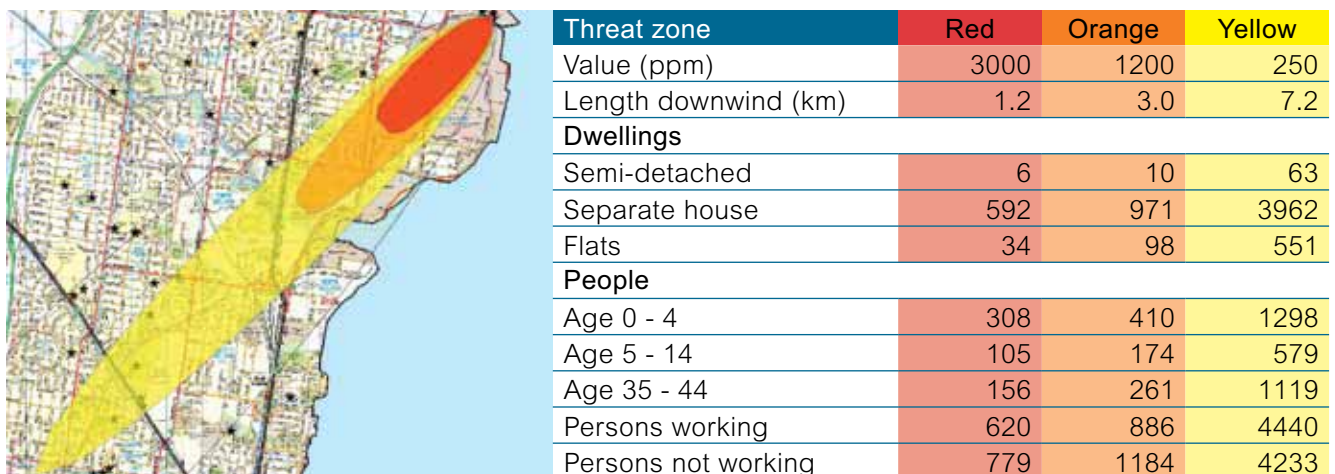
The Fire Services will most likely be first onscene to make an initial assessment with what information they have. In most cases, the preferred protective action will be to SIP until further information is gathered for the decision-making process (e.g. chemical, weather, population characteristics). Specialist advice may be provided to assist with the decision-making process. Plume modelling software and realtime air sampling with monitoring equipment can provide information to further assess risks to the community.

2.2 Atmospheric Modelling Software

An integrated modelling platform has been developed to assist incident controllers with the decision making process by:

- Identifying affected areas with predicted plume areas and concentrations displayed on mapping systems (refer to Figure 3).
- Identifying the number and type of buildings affected, including features of interest (such as hospitals, schools, day care centres) within the downwind plume.
- Identifying the number of residents affected, including an age breakdown, as well as the number of these working and not working (refer to Figure 3).
- Introducing a new default air exchange rate value into modelling software to better represent the majority of Australian house types and provide a more accurate estimate of indoor air concentrations.
- Identifying the termination time for SIP, as the time where the outdoor air concentration drops to or below the indoor air concentration.

Figure 3. Predicted plume dispersion in three different atmospheric concentrations for a simulated chemical release, and the associated features of interest



2.3 Public Warning

Warnings to the community can be given in emergency situations where public action is required for protection from hazardous atmospheres. The incident controller, in collaboration with the police, is responsible for issuing warnings to affected communities and other agencies. Issuing of warnings follows currently established protocols for public emergency communications. The types of warning systems used include:

- Emergency Alert (National Emergency Warning System (NEWS)) – uses telephone infrastructure to broadcast a short pre-recorded message to landlines and mobile phones, informing people of the incident and where to seek further information on what to do.
- Media broadcasters: ABC and commercial radio stations or SKY News TV, where regular programming will be interrupted to broadcast general advice and specific information to the public. Other electronic media will also carry information during special bulletins for major events.
- Standard Emergency Warning Signal (SEWS) is a 5-15 second tone alert for radio and television, to alert the resident of a proceeding emergency message.
- Door knocking by police and other emergency services can be used to notify residents to evacuate if time permits before a chemical plume arrives.

2.4 Terminating Shelter-in-Place

Terminating SIP at the right time is important to reduce the level of exposure to the hazardous material that slowly infiltrates the building during the passage of the plume. Delays in terminating SIP can have a significant effect on the level of protection provided by sheltering. The best time to terminate SIP is the point where outdoor concentration drops to and below indoor air concentration. Plume modelling can help officials identify this time (refer to Figure 1). Instructions must be given to the public once the time has been determined to end SIP, including:

- Areas where SIP should be ended.
- The importance of prompt compliance.
- Instructions on how to end SIP.
- Reference to previously distributed public education materials.

2.5 Public Education to Support a Shelter-in-Place Strategy

Evacuation is an instinctive and common response to an emergency situation, however, research has shown that SIP is a proven protective action that is easily understood and accomplished if explained properly and planned for. SIP community education programs that allow for an understanding and awareness of this protective action are essential for public compliance when official instructions by emergency services are made. SIP protective action messages and terminology used by emergency services must be consistent with the education programs to avoid confusion. There are various community emergency response information leaflets and fridge magnets currently distributed from major hazard facilities and local government. We recommend adopting and promoting the Shelter-Shut-Listen catch phrase so consistent terminology and awareness can be provided across emergency services, industry, local government and the community. This guide provides a generic set of templates for councils, industry and emergency response agencies to adopt and incorporate, including:

- Shelter-in-Place Community Education Fact Sheet (Appendix 1),
- Community Emergency Response Information Brochure (Appendix 2); and
- Shelter-in-Place Fridge Magnet (Appendix 3).

This combined approach using common phrasing reinforces the SIP message, providing an emergency preparedness plan for households during an outdoor hazardous atmosphere.

Appendix 1

Shelter-in-Place Community Education Fact Sheet

What is a hazardous atmosphere?

At a chemical fire or spill, chemicals and/or smoke can be released into the air at concentrations which may cause serious health effects by inhalation or skin contact. A hazardous chemical can be a solid, liquid or gas. You might not be able to see or smell anything because many gases are colourless and odourless.

How and where can this occur?

A hazardous atmosphere may occur in residential areas close to industry as the result of a fire, explosion or a chemical spill, or from a road or train transport accident.

How does this affect me?

A chemical, or smoke, can be carried downwind as a plume that expands and is diluted by clean air as it travels. The concern with the plume is that the airborne concentration can initially be very high and the contaminants in the plume may cause injury if they are inhaled.

How will I know if I will be in an affected area?

The first indication may be from a strong chemical odour, or you may see a dense smoke cloud in your area.

Large industry may activate warning sirens; residences close to some large industries will have previously received information on sirens. The Police, other emergency services or council will try to contact people who may be affected by the released chemical using:

- a telephone message or SMS
- information provided through the media

What to do in a chemical emergency?

The best way to protect yourself and others from harmful chemicals or smoke in the air is to go indoors immediately. This is called shelter-in-place. Emergency officials may tell you to shelter-in-place during a chemical release instead of evacuating. This will avoid

exposure to the high outdoor concentration of a chemical. Sheltering indoors works because the outdoor air does not mix quickly with the indoor air when the building is closed. The fresh air inside a building provides protection for several hours while the hazardous plume is carried downwind and is diluted by clean air. To maintain the fresh air inside the building before the plume arrives it is important to implement shelter-in-place immediately (see how to shelter-in-place below) when instructed. This will minimise exposure to toxic vapours and smoke.

It is necessary to consider that all buildings have small gaps and cracks, and some have air vents and chimneys. Some of the harmful vapours in the outside air will gradually infiltrate through these openings into the shelter. Eventually, sometime after the highest concentration of the hazardous plume has passed the shelter, outside air will be cleaner than the air inside the shelter. Sophisticated software allows emergency responders to calculate this time point. They will then issue instructions to ventilate the shelter and building and go outside or leave the area. For this reason it is very important to promptly leave the shelter when advised to do so, to avoid continued exposure. Hazardous vapours that might have infiltrated the building will eventually dissipate.

How to shelter-in-place

- Shelter-in-place means to go inside your home or the nearest accessible building without delay. Bring pets indoors if you can find them quickly.
- Close all windows and doors to increase the seal to outside air.
- Turn off heating, air-conditioning and fans (any ventilation system).
- Shut or cover air vents (including fireplace or wood-stove dampers).
- Quickly shut yourself in a room with as few exterior windows or other openings

as possible and close blinds or curtains. Gaps from windows that do not seal, or spaces under doors can be sealed with towels, blankets, duct tape or plastic.

- Tune your radio into local ABC or any commercial radio station, or watch SKY News TV for emergency broadcasting.
- Continue to listen to this station for additional information about protective actions you should take, and for when and how to end shelter-in-place.
- Do not call triple zero unless there is a life threatening situation.

What if my children are at school?

Do not collect your children at school. The schools will protect your children by evacuating or sheltering them in place.

What to do if external windows can't be closed?

- Go to an internal room and seal the room as well as possible, or shelter inside a room on the opposite side of the house to the wind direction.
- Use towels, blankets or duct tape to block any gaps under doors or around windows and wall vents.

What if I can smell a chemical odour inside the house before I shelter-in-place?

Most chemicals can be identified by smell well before the concentration is at high enough levels to cause any harm. If the chemical can be detected inside the house before closing the external doors and windows it is generally still safer to shelter-in-place rather than attempt to evacuate outside into the toxic plume.

Where can I get information during an emergency?

In the event of an emergency you should tune into your emergency broadcasters: local ABC and commercial radio stations or SKY News TV, where regular programming will be interrupted to provide detailed area specific emergency instructions and more up to date information at regular time intervals. The Fire Services work in close conjunction with local government, other emergency services and radio stations in the delivery of emergency instructions and up to date information.

Television stations will likely provide special bulletins.

Log on to the fire service or your local Council website:

www.mfb.vic.gov.au

www.cfa.vic.gov.au

PROTECTIVE ACTION GUIDE

SHELTER IN PLACE

WHAT TO DO

Shelter-in-place

- ➡ 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.

Display this information in your home or place of work. Discuss emergency procedures with family, neighbours and colleagues.

Three steps to take in a chemical emergency or large fire:

1. SHELTER

Go inside immediately.



Take family and pets with you.

2. SHUT

Close the doors and windows.



Close all external doors and windows. Seal gaps with blankets, towels or duct tape.



Avoid phone use. Emergency Services may need to contact you.



Turn off heaters, air conditioners and exhaust fans. Close fireplace dampers.

3. 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 www.mfb.vic.gov.au or www.cfa.vic.gov.au



Wait for "all clear" message, then open doors and windows to ventilate building. Go outside.

Appendix 3

Shelter-in-Place Fridge Magnet





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