

# WHY WE SHOULD “GO IN. STAY IN. TUNE IN.”

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It underpins advice given in the video launched by Home Office Minister Mike O'Brien at the Annual Conference of the Emergency Planning Society in July 2000. A similar article was published in 1994 in The Safety and Health Practitioner.

## Introduction

In the event of a major incident involving chemicals, technical assessments in the UK, the USA, Canada and New Zealand show that it is generally more beneficial for the population at risk to shelter than to be evacuated. It is also apparent that there are many responders to incidents who are not aware of these assessments and who feel obliged to 'play it safe' by initiating an evacuation.

Recognising this situation and the absence of advice on interpreting the phrase 'Consider Evacuation' when the Emergency Action Code letter 'E' was used on a HAZCHEM label, the CIA CHEMSAFE Liaison Group set up a working group to develop appropriate guidance. The working group had representatives from the Police and Fire Services, the Home Office, the National Chemical Emergency Centre and industry.

The working group proposed some minor amendments to the various, then existing HAZCHEM cards and prepared simple guide-lines which could be made available for use in Police and Fire Service Control Rooms. These proposals and guidelines were based on an extended version of this paper which was endorsed by the CHEMSAFE Liaison Group and several others including the relevant sub-committees of ACPO and CACFOA.

These guidelines became widely available when they were published in 1993 by the Home Office in HAZCHEM List 8 that gave overall guidance relating to HAZCHEM. They were repeated in 1997 & 1999 in HAZCHEM Lists 9 & 10.

## Sheltering and Evacuation

Where a community is being exposed to harm as a result of a major incident, appropriate mitigating measures must be implemented without delay. In the case of a top tier CIMAH sites, the local communities are likely to have been told to shelter until given further advice by the police. It is also probable that, although the off-site plan will include an evacuation plan, it will recognise that sheltering rather than evacuation is the preferred strategy for the majority of serious incidents arising on chemical production sites.

This strategy recognises that evacuations cannot be completed quickly and that few chemical plant incidents are likely to be both long lasting and to have serious acute off-site consequences. The reasons for this strategy may be less widely understood in areas that do not have top-tier CIMAH sites.

Based on various incidents in the UK and elsewhere, a decision to evacuate is unlikely to be taken in the first half-hour of an emergency. Thereafter, the actual time to evacuate a community of a thousand or more is likely to take several hours. This is demonstrated in figure 1 which shows a log/log plot of the numbers evacuated per hour against the total numbers evacuated for several major incidents<sup>1</sup>. More recent experience from Nantes, Poole and the military town of Jonava in Lithuania confirms the validity of these earlier data that relate to evacuations in Ipswich, Wealdstone, Flixborough, Barking, Chernobyl and Three Mile Island.

It should also be noted that people do not always evacuate when told to do so. For example, it has been reported that, in two transport incidents in the USA, 81% and 59% of those warned initially chose to disregard the warnings given<sup>2</sup>.

People may also suffer more harm from a short exposure during an evacuation than they would experience while sheltering. Actual experience to support this view is hard to find. However, although not statistically significant, it is interesting to note that, of nine interviewees who chose not to evacuate, only one may have been affected, compared with 20% of the 1275 interviewees who evacuated themselves from Nanticoke in 1987<sup>3</sup>.

## Toxic Gases

Supporting evidence can be deduced by considering the harm caused by a toxic gas which is usually considered to be equal to a constant (k) times the exposure time (t) times the gas concentration (C) raised to a positive power (n) which is usually greater than 1 (i.e. Harm =  $kC^n t$ ). In assessing dangerous toxic load values for two of the most commonly transported toxic gases, chlorine and ammonia, the HSE has concluded that n equals 2 in both cases<sup>4&5</sup>.

For the same two gases, the IChemE Toxicity Working Parties have shown that lethal effects ( $LC_{50}$ ) are best represented with n equal to 2.75 and 2 respectively<sup>6&7</sup>. Another study suggests that, for sulphur dioxide, n equals 3.5<sup>8</sup>.

It follows that proportionately more benefit is likely to be gained by minimising exposure concentration rather than by reducing exposure time. For example, with two air changes per hour, the concentration within a house would rise to almost half the outside concentration after about 20 minutes (assumed to be a typical time to control an on-site major release).

Assuming a constant chlorine concentration outside the house, the harm experienced by someone inside would be about 4% to 7% of someone outside during this period. The importance of going outside as soon as possible after the gas cloud has passed should be noted. Staying indoors for a further 30 minutes would give additional harm equivalent to about 7% to 15% of the original outside effect (Figure 2A).

There are three reasons for believing that the case for sheltering rather than evacuating may be even stronger than is shown above:

1. Gas infiltration rates for typical UK houses with doors and windows closed are likely to be lower than the gas infiltration rate which has been assumed. Data quoted from four American sources show infiltration rates in the range 0.2 to 2.0 air changes per hour<sup>9</sup> and, under low wind speed conditions, a test in southern Sweden (farther south than Edinburgh), gave an indoor concentration of 58 ppm ammonia after two hours during which the outside concentration was maintained in the range 20,000 to 25,000 ppm<sup>10</sup>.

2. No allowance has been made for the indoor attenuation of concentration peaks within the average experienced outdoors (Figures 2B & 4). (Outdoors, due to the power rule determining the harmful effect, the adverse effect of momentary increases in concentration will not be offset by equivalent decreases.)

3. No benefit is assumed from the closing of internal doors and optimal positioning within a building. It will always be safer to be in a room that faces away from an incident. It will also be safer to be upstairs when the wind speed is low, the atmosphere is stable and the toxic gas behaves like a dense gas. (Figure 3).

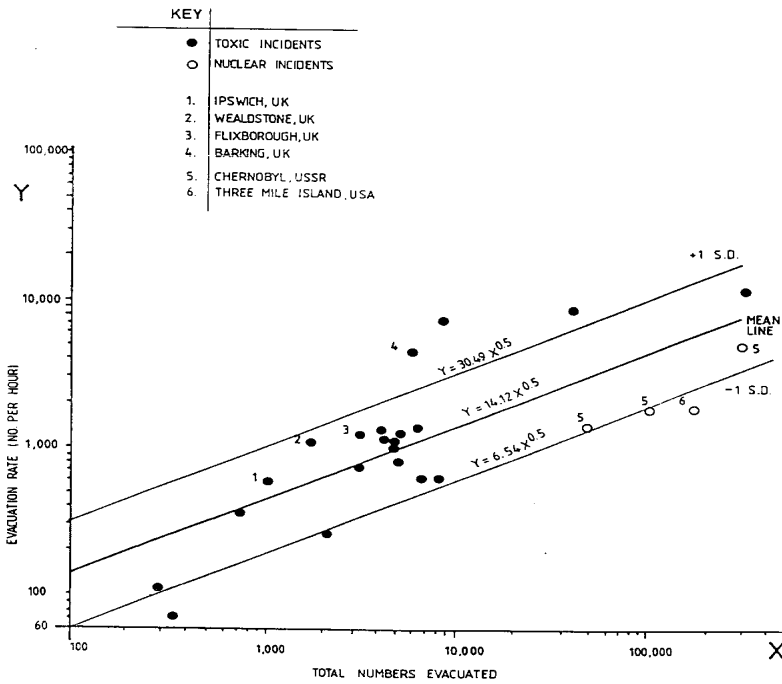
## Fires and Explosions

Assessments of the consequences of exposure to thermal radiation and over-pressure arising from various types of incidents involving flammables are made in risk assessment studies sometimes using tools such as SAFETI, a risk assessment software package marketed by Det Norske Veritas [DNV]<sup>11</sup>. This section is based on DNV practice in 2000 and is included with their agreement. The survival probabilities quoted below are based on the knowledge of experts from both DNV and industry.

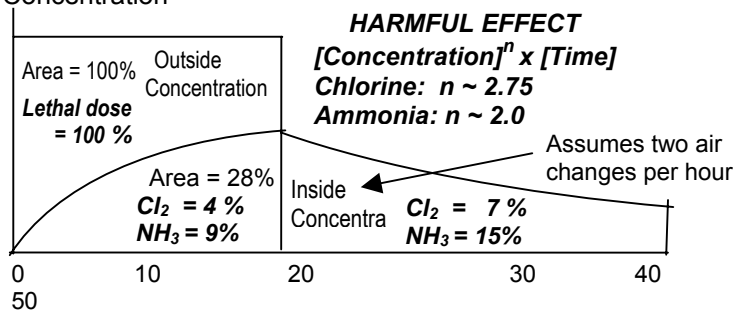
Flash Fires - It is considered that a person outdoors who is engulfed in a flash fire will have virtually no chance of survival due to

**FIGURE 1**

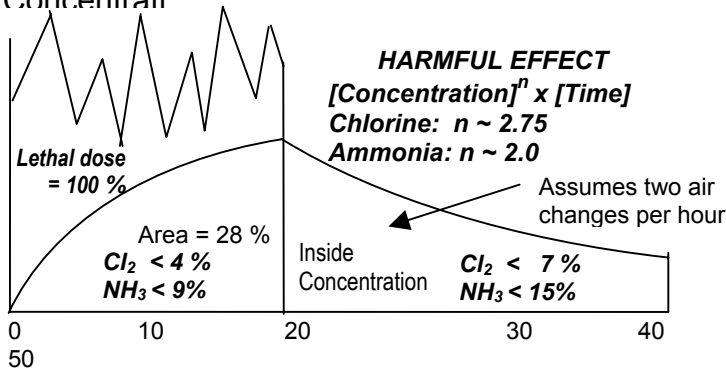
**LINE OF BEST FIT THROUGH EVACUATION DATA POINTS (REFERENCE 11)**



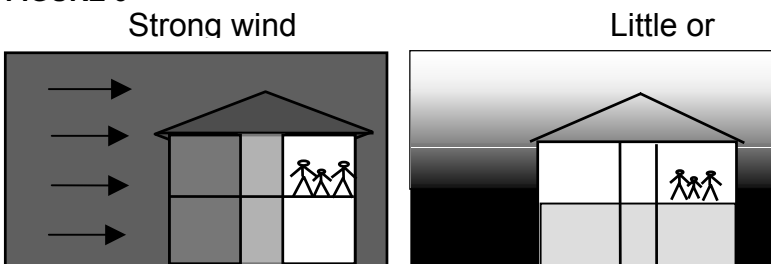
**FIGURE 2A**  
Concentration



**FIGURE 2B**  
Concentration



**FIGURE 3**



**Go in. Stay in** upstairs room that faces away from incident. **Tune in** to local radio

the inhalation of hot combustion gases. A person indoors will have a 90% chance of survival, depending on his being able to escape if the building catches fire.

**BLEVEs** - A person in the open will receive a radiation dose of 250 KJ/M<sup>2</sup> or more. Those outdoors are judged to have a 30% chance of survival. Those indoors will have some protection from radiation, but they could be exposed to the effects of subsequent fires and possible over-pressure and are judged to have an overall 90% chance of survival.

**Jet Flames and Pool Fires** - The radiation level at the outer edge of the affected area will be about 12.5 KW/M<sup>2</sup>. This level of radiation would cause 1% fatalities in 30 seconds and 99% fatalities in 200 seconds. As escape would be difficult, those outdoors are assessed to have a 30% chance of survival. Those indoors are better protected, but could suffer the effects of subsequent fires and are judged to have a 90% chance of survival.

**Explosions (Over-pressures of 1.5 to 5psi)** - A person in the open may be knocked over but is judged to have a 90% chance of survival. Indoors some building damage would occur reducing the chance of survival to an estimated 70%.

**Explosions (Over-pressures over 5 psi)** - A person in the open will almost certainly be knocked over by a 5 psi or greater over-pressure, but is estimated to have a 70% chance of survival. Indoors it is assumed that there would be no chance of survival due to major structural damage causing the collapse of buildings on to their occupants.

These assessments of survival probabilities can be summarised as follows:

	Indoors	Outdoors
Flash fires engulfment	0.9	Nil
BLEVEs 250 KJ/M <sup>2</sup> or more	0.7	0.3
Jet flames 12.5 KW/M <sup>2</sup>	0.9	0.3
Pool fires- 12.5 KW/M <sup>2</sup>	0.9	0.3
Explosions 1.5 to 5 psi	0.7	0.9
Explosions Over 5 psi	Nil	0.7

Inevitably, there is some uncertainty in these survival probabilities and some people have been known to survive conditions expected to prove fatal. Nonetheless, it is believed that, in each of the categories, the comparative chances of survival will not differ greatly from those shown.

**Conclusion**

Other than for the relatively rare case of an imminent major explosion, sheltering is the preferred initial strategy for all types of incidents involving chemicals. This initial strategy is equally valid for all outdoor major emergencies because of the potential need to give further advice over local radio to those who might be at risk.

Although this strategy is generally applicable and warrants wide dissemination, subsequent evacuation may still be appropriate on some occasions. The advice given on the next page is that now included in the 1999 Home Office HAZCHEM List 10 as an aid to Police and Fire Service Officers who may have to consider the action to be taken to protect the public when they attend an incident involving chemicals. Apart from some minor updating and word order changes, it is identical to that recommended by the working group in 1991/1992.

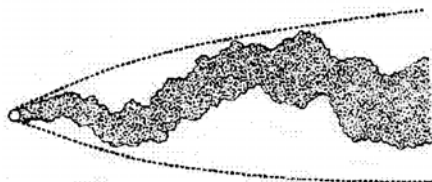


Figure 4.

An aerial view of smoke from a bonfire shows why outdoor gas concentrations will sometimes fluctuate

## REFERENCES

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3. Duclos, Binder and Riester: Journal of Hazardous Materials 22 (1989).
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6. Institution of Chemical Engineers: Chlorine Toxicity Monograph.
7. Institution of Chemical Engineers: Ammonia Toxicity Monograph.
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10. B-O Andersson, Private Communication.
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## Home Office HAZCHEM List 10 advice for transport incident responders

### 'E' "Public Safety Hazard"

3.2.5 An 'E' following the first two characters of an EAC indicates that there may be a public safety hazard and that the following actions should be taken:

- i. People should be warned to stay indoors with all doors and windows closed, preferably in rooms upstairs which face away from the incident. Ignition sources should be eliminated and any ventilation stopped.
- ii Effects may spread beyond the incident vicinity. All non-essential personnel outdoors should be instructed to move at least 250 metres from the incident.
- iii Police and Fire Service incident commanders should consult with each other and with a product expert, or with a source of product expertise.
- iv THE POSSIBLE NEED FOR SUBSEQUENT EVACUATION SHOULD BE CONSIDERED, BUT IT SHOULD BE REMEMBERED THAT IN MOST CASES IT WILL BE SAFER TO REMAIN IN A BUILDING THAN TO EVACUATE.

### SITUATIONS WHERE EVACUATION MAY BE NECESSARY INCLUDE:

EXAMPLES	ASSESSMENT
<ol style="list-style-type: none"> <li>1. i Smoke from bulk or packaged product fire that is allowed to burn out. (Often the safest and least environmentally damaging option).</li> <li>ii A small long lasting toxic emission.</li> <li>2. A larger long-lasting toxic gas emission which will be carried towards an inhabited area after a predicted wind change not due for at least two hours.</li> <li>3. Evacuation of people from an isolated house in the country may be feasible, possibly using additional BA sets.</li> <li>4. i. Righting a loaded tanker, especially a liquefied gas tanker.</li> <li>ii. Recovering or clearing petrol from drains.</li> </ol>	<ol style="list-style-type: none"> <li>1. Nuisance effects will last several hours. Smoke or gas concentrations in the open air are unpleasant but short-term exposure is not likely to be dangerous.</li> <li>2. Area considered for evacuation will not be exposed to significant danger for at least an hour, preferably longer.</li> <li>3. Downwind area is very sparsely populated and resources are available to protect people during their evacuation.</li> <li>4. Area considered for evacuation could be exposed to danger as a result of action necessary to restore normality at a time determined by the recovery team.</li> </ol>