MODELLING OF ESCAPE FROM A CHLORINE CLOUD

Modelling of Escape

The basic parameters used in the modelling of escape from the chlorine cloud are as shown in *Table F1* below.

Table F1 *Parameters for Escape from Chlorine Cloud*

Parameter	Value
Speed of escape	0.67 m/s (half walking speed)*
Escape distance	
- escape directly out of cloud	Cloud 'half-width'
- escape to nearest building (to which a person could gain access)	200 m
Concentration above which escape considered not possible (due to incapacitation)	Concentration corresponding to 90% fatality level
% of outdoors population attempting escape (outside 90% fatality level contour)	80%
Destination for those successfully escaping from cloud	50% (directly out of cloud) 50% (nearest building)

* considered appropriate given debilitating effect of chlorine gas and noting that escape path assumes shortest distance across the cloud, ie half-width

From the wind tunnel test results for 1 tonne instantaneous releases (covering both Group A WTWs), the distance to the 90% fatality contour and the cloud half-width beyond this point are shown in *Table F2* below.

Table F2 *Wind Tunnel Results for Group A WTWs - Cloud Half-Width*

Release scenario	Distance to 90% fatality (metres)	Cloud half-width (metres)	Escape time (minutes)
1 tonne instantaneous	100 - 350	100 - 200	2.5 - 5

From *Table F2* above, the time to escape directly out of the cloud at distances beyond the 90% fatality contour is between 2.5 min and 5 minutes. Noting however that the Hazard Assessment also considers larger releases than 1 tonne, e.g. event RU1TMRU (3 tonne release, scaling factor 1.7 - see *Annex D*) then the range of escape times extends up to 1.7x200/0.67 = 8.5 min. The maximum exposure duration for large clouds is set by the time to reach the nearest building (to which a person can gain access), which is approximately 5 minutes (*Table F1*).

On the basis of the above, the time of escape is set as 5 minutes, as this is representative of the majority of release scenarios of interest.

Effective Outdoors Probability of Fatality

Based on a time of escape of 5 min the probability of fatality during escape may be calculated as shown in *Table F3* below.

Table F3 *Probability of Fatality During Escape*

Contour	Relevant chlorine concentration* (ppm)	Probability of fatality during escape
LD03	247	negligible
LD50	560	0.245
LD90	975	N/A (90% fatality assumed)

* chlorine concentration corresponding to the specified level of fatality for a person outdoors exposed for a period of 10 minutes.

From the above information, an effective outdoor fatality probability may be calculated, taking into account those remaining within the cloud, those escaping directly out of the cloud and those escaping indoors. These figures are shown in *Table F4* below.

Table F4 *Effective Outdoor Probability of Fatality*

Contour	Effective Outdoor Probability of Fatality (see Example calculation below)	Geometric Mean
LD03	0.007	0.047
LD50	0.31	0.53
LD90	0.9	0.95

Example: At the 50% fatality level, the effective outdoors fatality probability is calculated as follows:

Fraction of population unable to escape = 0.2
Relevant fatality rate = 50%

Fraction of population attempting escape = 0.8
Relevant fatality rate = 24.5% (during escape)

Fraction of population escaping indoors = 0.8 * (1 - 0.245) * 0.5 = 0.302
Relevant fatality rate = 5% (1/10th of outdoors fatality percentage)

Fraction of population escaping out of cloud = 0.8 * (1 - 0.245) * 0.5 = 0.302
Relevant fatality rate = 0%

Therefore, effective outdoors fatality probability = 0.2 * 50% + 0.8 * 24.5% + 0.302 * 5% + 0.302 * 0% = 31.1%

The approach outlined is similar to that used by the Health and Safety Executive in the UK in their RISKAT software.