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AN ANALYSIS OF THE RISKS ARISING FROM THE TRANSPORT OF LIQUEFIED GASES IN GREAT BRITAIN

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SUMMARY

In the Great Britain, the Goverment-appointed Health and Safety Commission has set up a Committee to review the transport of large quantities of hazardous substances by rail road or water and to suggest any appropriate further controls. To enable that Committee to understand the level and nature of the risks, the Officers of the Health and Safety Executive have developed methods to analyse the risks. The models have been designed to take account of human behaviour in the event of an incident. This paper describes the models produced to analyse the level of Societal Risk arising out of the transport by rail of chlorine and LPG. The models will allow the effect of additional controls to be estimated.

BACKGROUND

Great Britain's Health and Safety Commission has set up an Advisory Committee to consider aspects of the transport by rail, road and water of large quantities of dangerous substances which have the potential to present major accident hazards to the public; and to advise on the need for additional voluntary or mandatory controls. This Committee follows on from the work of the Advisory Committee on Major Hazards (ACMH) whose work, published in three Reports, (Ref. 1,2,3) contributed to the current controls on major hazards at static sites. The Committee comprises representatives from industry, trades unions, a university, the emergency services and local government as well as from the Health and Safety Executive (HSE).

The Committee started their work by reviewing the current controls governing the transport of dangerous substances but were unable to measure how effective existing safeguards were in controlling the risk of a major hazard accident or to estimate the potential benefits from any proposed additional control measures. So the Committee asked HSE to develop and carry out an analysis of the risks arising from the transport of dangerous substances in major hazard quantities. This paper describes the basic models developed and their application to this study. The objective has been to provide results that can be used by decision makers to understand the level and nature of the risk, its components and the effect of any proposed controls.

The models have been developed on a "Best Estimate" approach. Whilst the models are believed to be reasonably realistic, the clarity of the calculations and the need for easy quick recalculation have been paramount considerations.

The models were initially developed to analyse the risks arising from transportation by rail; they are to be developed further for the corresponding studies for road and water. For ease of use a "spread sheet" package has been used. This allows the sensitivity of the overall risk levels to assumptions, failure rates and human response models to be easily checked. It will also allow any control measures proposed by the Committee to be analysed in terms of their effect on the existing levels of risk.

OVERALL APPROACH

The committee identified 3 aspects of transportation that required examination:

(i) Incidents that could occur on-route along the transport way;

(ii) Stopovers at parking places, marshalling yards and moorings;

(iii) Loading/unloading at the origin/destination.

All 3 aspects will be considered in this study for all 3 modes of transport.

The initial study involved the analysis of risks arising out of the transport of hazardous chemicals by rail. So far only the on-route aspect has been considered. Four representative substances were chosen (see table 1), these represent 51% of the tonnage of bulk hazardous cargo carried on British Rail.

For each class of substance a different risk model was built. Models used in other studies appear to have either ignored or dealt very simplistically with the mitigation afforded to an exposed population by being or going indoors. As part of our study would be to test the effectiveness of additional controls it was felt that full credit should be given for existing or implicit safeguards in calculating existing levels of risk.

TABLE 1

Representative Chemicals and tank capacities

Class	Substance	Tank Capacities (te)	
		2 axle	bogies
Liquefied Flammable Gases	LPG (Propane & Butane)	20	40
Liquefied Toxic Gases	Chlorine	29	-
	Ammonia	-	53
Highly Flammable Liquids	Motor Spirit	32	75

In general:

$$P(N,E) = \sum_{J=1}^{n} P(E,J).P(J) \qquad (1)$$

Where P(N,E) is the probability of N deaths from release E, and P(J) is the probability of the J'th weather condition. We found it convenient to relate aspects of mitigation: percentage of the population found out-of-doors, gas ingress rates etc; to the weather condition. Generally stable weather is only found at night when there are few people out-of-doors, windows are largely closed etc. The number of fatalities is:

$$N = \sum_{J=1}^{n} D(q).A^{1}(E,J) \qquad (2)$$

where D is population density type q, A^1 the area affected by release E.

Overall assumptions

To simplify the calculations some overall assumptions have been made.

A. Events involving the loss of hazardous chemical from 2 or more tankers simultaneously, or 2 different substances from the same or different trains do not occur.

B. For sequential events, we have assumed that the tanker on which the incident occurs may cause a neighbour to rupture but the quantity of material released will not exceed a single tanker inventory.

C. Incidents occur in relatively flat, open terrain.

D. For weather dependant factors, the releases will either occur in Pasquill Category D, windspeed $5ms^{-1}$ (80% of time) or Category F, windspeed $2ms^{-1}$ (20% of time).

E. The general population is out of doors 10% of the time in D/5 weather and 1% of the time in F/2 weather.

Population Densities

The intention was to represent the population distribution along a length of railway line as falling within four categories with corresponding densities:

TABLE 2

Population Type	Density (km^{-2})
Urban	4210
Sub-urban	1310
Built up rural	210
Rural	20

It was assumed that the population is uniformly distributed throughout the area affected by an incident. The length of track corresponding to each population type was obtained by analysis of 1:25000 Ordnance Survey maps and from the 1981 census data for UK.

This approach has been refined in 2 ways.

(i) One sided population In suburban and built up rural areas it is found that the population is often located on only one side of the track. For directional events, eg, torch flame or toxic plume, the frequency of the basic event was halved for these areas. For events that affect both side of the track the final number of fatalities was halved.

(ii) Track areas The uniform population assumption suggests that population is on the track and immediately next to it. In fact there are very few locations in the UK where population comes within 25m of a rail track. For directional releases, 2 release directions have been considered; perpendicular to and in the direction of the track (fig 1). The 25m strip was omitted from the calculation. For symmetrical releases a 50m wide strip was omitted.

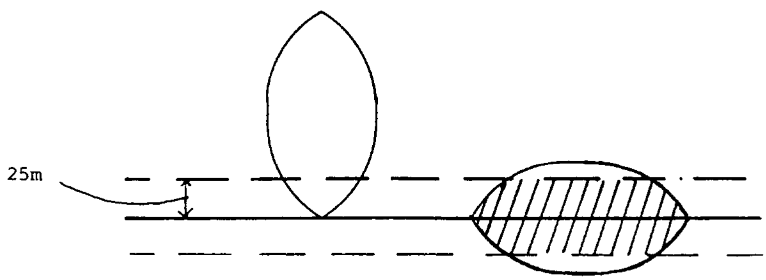
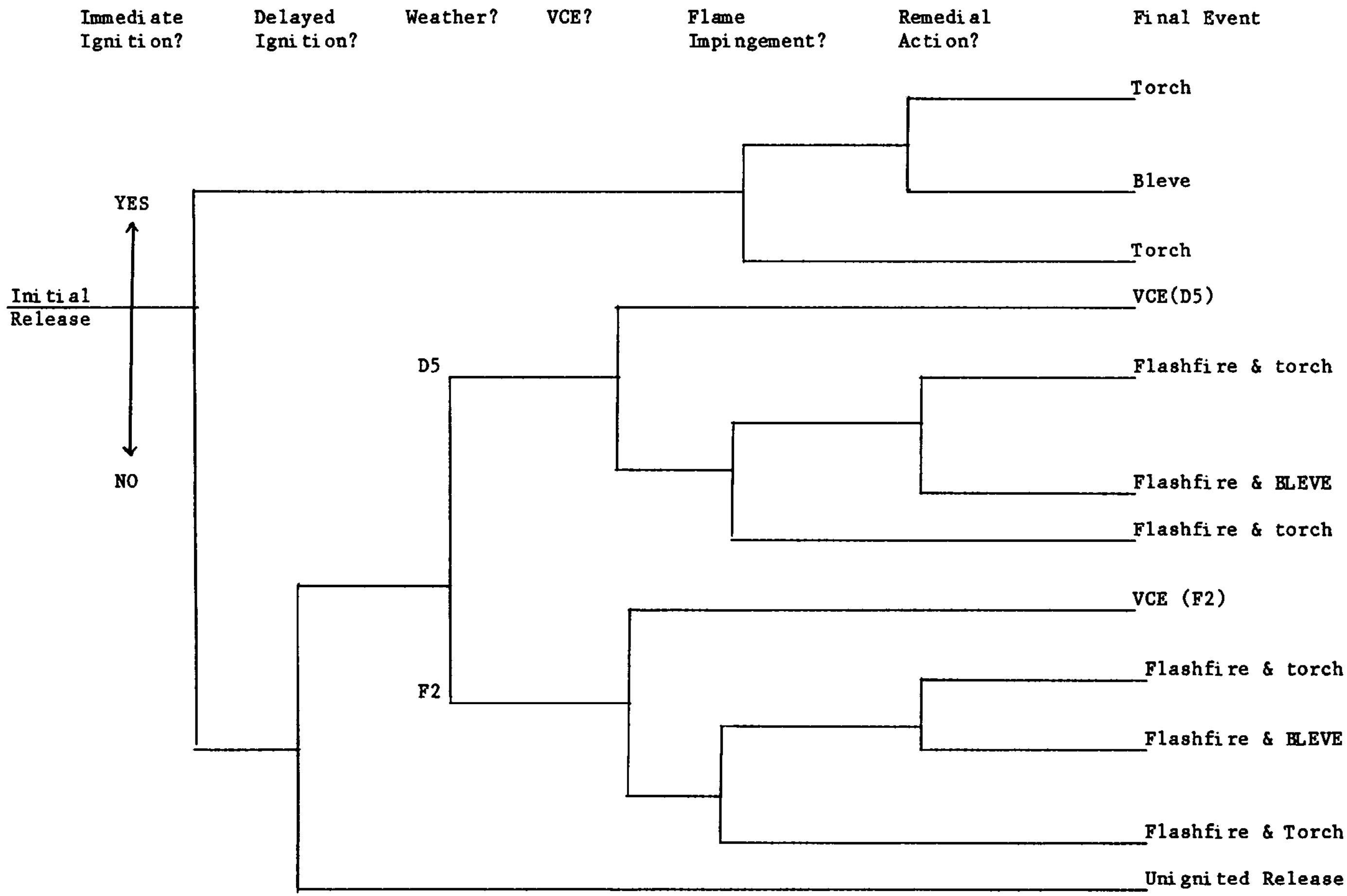


FIG. 1 - Removal of Track Width

Release cases and failure rates

The Safety and Reliability Directorate of UKAEA analysed the accident history and movement data for the representative substances. Two main potential causes of a release of a dangerous substance from a liquefied gas tank wagon were identified; puncture of the tank due to a high energy derailment or collision and failure or maloperation of the tank equipment, primarily that used for liquid loading/unloading. The former is related to the railway system and the distance travelled, the latter to the loading operation and the time taken on the journey. There have been no recorded incidents of either type involving liquefied gas tank waggons in UK, (small releases not involving loss from the body of the tank wagon have been ignored). It was considered inappropriate to

Figure 2 Event tree for LPG Continuous Release



use data from countries other than UK as the railway operations and tank wagon designs are significantly different.

Nine derailment and collision incidents were analysed in which other types of tank wagon (ie not liquefied gas tank wagons) were punctured. Engineering judgement was then used to predict the probability that a liquefied gas tank wagon would have been punctured in similar circumstances. This probability was combined with movements data to give a puncture frequency per laden wagon km. The result was in good agreement with the frequency derived using a Poisson distribution technique at the 50% confidence level based on the incident free experience and movements data over a $22^1/_4$ year period.

For those collisions/derailments in which the tanker is breached, it was assumed that 90% lead to a 50mm equivalent diameter hole and the remaining 10% result in catastrophic failure and total loss. The size and frequency of a release via the tanker equipment was estimated using fault tree analysis and the operating experience of the main consignors of liquefied gas tankers. The release rate for these and the 50mm hole event were estimated taking into account frictional losses, heads of liquid and the geometry at the point of release.

This approach, relating spill frequency to the initiating mechanism allows the benefit of remedial measures to be assessed.

LPG EVENTS

Event Modelling

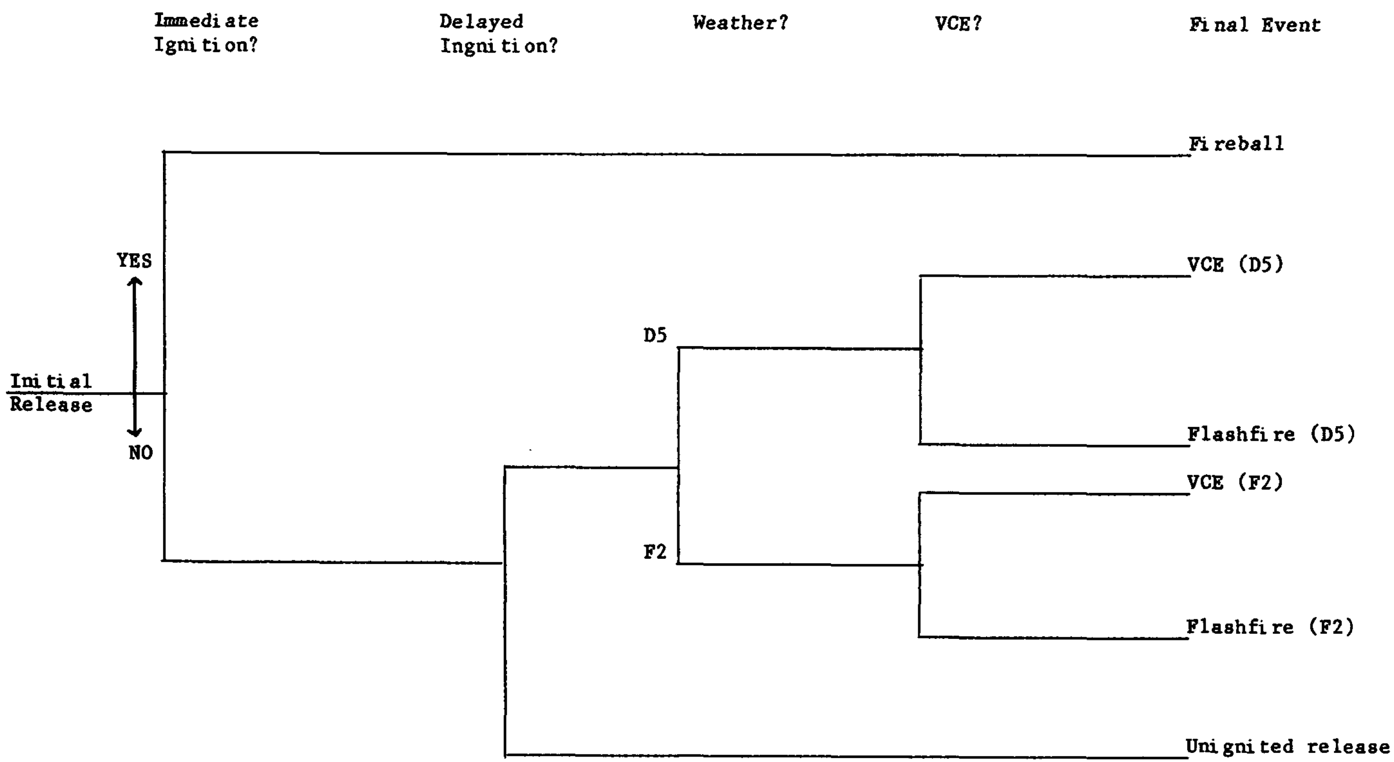
The consequences following a release of LPG depends on whether or when ignition occurs and whether the release is continuous or instantaneous.

Event trees (figure 2 and 3) were drawn to examine these consequences and conditioned probabilities assigned to enable the frequency of the final event to be estimated.

Basic Events

(i) Torch Flame. The model of Considine & Grint (Ref. 4) was modified to give torch length and width. Assuming the flame to be a solid cone, the thermal radiation at given distances was calculated assuming atmospheric attenuation after Simpson (Ref. 5) and the ranges to 50% and 1% lethality, based on the Eisenberg probit (Ref. 6), were calculated.

Figure 3 Event tree for Instantaneous LPG Release



$$Y = 2.56 \ln(\text{dose}) - 14.9 \quad (3)$$

Where dose is in $s(kWm^{-2})^{4/3}$. At the 50% level ($26.6kWm^{-2}$ for 30 seconds) wood and furniture in buildings can spontaneously ignite imperilling the inhabitants.

TABLE 3: Torch Flame Consequences

Release rate kg/s	Side on (m)[range from release point]			End on (m)[range from flame axis]		
	Length	Range to 50% lethality and to spontaneous ignition	Range to 1% lethality	Diameter	Range to 50% lethality and to spontaneous ignition	Range to 1% lethality
2	12.9	8.5	12.3	4.3	6.7	9.4
36	54.6	33	48	18.2	26.3	36.5

(ii) BLEVE. Roberts model (Ref. 7) was used to give fireball size and duration, assessing the tank to be 90% full. For a relative humidity of 60%.

TABLE 4: BLEVE Consequences

Rail tanker size (te)	Fireball radius (m)	Fireball duration(s)	Range to 50% lethality	Range to 1% lethality
20	76	12	110	175
40	96	15	160	245

Work is taking place in HSE (Ref. 8) on the size and turbulence of fireballs produced by BLEVE compared with ambient temperature releases.

(iii) Vapour Cloud Explosions (VCE)

A simple model for UCE has been used so far in which twice the flash fraction of the release has been assumed to enter the cloud with no explosions below 10te. This model is currently under review (Ref.8).

With continuous releases,the dense gas code CRUNCH (Ref. 9) and the paramaterisation of Considine & Grint (Ref. 4) were used to give the loss of gas between limits and the cloud dimensions. Assuming a circular cloud, the distance to give overpressures were calculated following Kingery & Pannill (Ref 10). At present the probit:

$$Y = 2.47 + 1.43 \log_{10}P \qquad (4)$$

has been used. Applying this relationship to continuous releases shows that outside the cloud, the chance of fatality is low and can be ignored.

(iv) Flash Fires It has been assumed that the flash fires will propagate through parts of the cloud above the lower flammable limit. For continuous releases, thermal radiation levels outside the cloud will be low. For instantaneous releases the flame speed will be lower and the emissivity higher. The flash fire model used (Ref. 4) has the flame front travelling radially out from the point of release. It has been assumed that people indoors are likely to survive.

TABLE 5: Areas of flash fires for continuous releases

Release rate (kg/s)	Area (m^2)	
	D5	F2
2	310	7,880
36	7,800	185,000

TABLE 6: Hazard Ranges for Flash Fires for Instantaneous Releases

Vessel capacity	Range to (m) 50% lethality		Range to (m) 1% lethality	
	D5	F2	D5	F2
20te	70	60	90	75
40te	80	70	110	95

LPG Events - Consequences for an Exposed Population

The estimation of the number of fatalities for an event is derived from the product of the population density and the area of hazard, given certain assumptions about human behaviour, protection measures etc. In general:

(i) People outdoors and in contact with flame are likely to die;
(ii) Of those people indoors, a fraction of those within the cloud (P(FI)) will be killed.
(iii) Between X% & Y% lethality ranges, (X+Y)/2% fatalities will occur;
(iv) No deaths are assumed to occur below 1% fatality;
(v) For non-continous events, people outside the burning cloud and in shelter, survive;
(vi) People are out of doors P(J) fraction of the time in J weather, in particular P(D5) during the day & P(F2) at night.

TABLE 7 : Coefficients for LPG fatalities equation

	a	b	c	d
$2kgs^{-1}$ Torch Flame	332	3.3	0	0
$36kgs^{-1}$ Torch Flame	5353	53.4	0	0
20te BLEVE	47596	182	0	0
40te BLEVE	87013	290	0	0
$2kgs^{-1}$ Flash Fire F/2 Weather	7800	78	0	0
$36kgs^{-1}$ Flash Fire D/5 Weather	7880	78.8	0	0
$36kgs^{-1}$ Flash Fire F/2 Weather	185000	1850	0	0
Flash Fire/Torch Flame/BLEVE(20te)D/5	48416	214.8	0	0
Flash Fire/Torch Flame/BLEVE(40te)D/5	87225	298	0	0
Flash Fire/Torch Flame/BLEVE(20te)F/2	213587	1951	0	0
Flash Fire/Torch Flame/BLEVE(40te)F/2	238145	2016	0	0
20te Flash Fire D/5	64808	211	0	0
20te Flash Fire F/2	57969	222	0	0
40te Flash Fire D/5	97644	340	0	0
40te Flash Fire F/2	88180	346	0	0
$36kgs^{-1}$ VCE	185000	1850	925	0
20te VCE	22167	222	111	25874
40te VCE	34636	346	173	52916

Using geometric considerations the number of people killed for each event can be estimated. It can be shown that:

N(E,J)=D(q). a.P(J)+b. 1-P(J) .P(FI)+c.{1-P(J) . 100-P(FI) +d} (5)

Table 7 gives the values of the coefficients a,b,c & d for each event. These events are given in figures 2 & 3 but exclude those where the numbers of fatalities will be very small.

CHLORINE EVENTS

Event Selection

As with LPG, 2 main causes of release were considered: punctures due to derailment or collision leading to either a 50mm hole or catastrophic failure, and equipment failure. UK chlorine rail cars do not have external pipe-work and valving is protected by a substantial cowl. The only forseable leak from equipment would be from valves either improperly closed after filling or coming open during a journey. The operating experience of UK manufacturers was used to calculate base event frequencies. These were input to fault trees to calculate the frequency of the top event.

Release Cases

Three representative cases were used:

(i) 1.3 kgs^{-1}, 2 phase release from a valve;

(ii) 45.1 kgs^{-1}, single phase release for a puncture, and

(iii) 20te instantaneous release from total catastrophic vessel failure.

For the continuous releases a delay of 30 minutes was assumed to occur before the incident could be controlled by emergency services. This may be optimistic for incidents occuring in rural areas, away from roads but as the population density in these areas will be low, this assumption may not have a significant effect on the overall risk figure.

Human Effect Modelling

Two important aspects of human behaviour and response to toxic gases were incorporated in the model.

Individual Sensitivity In early work, isopleths (hazard envelopes) corresponding to LCT_{50} (LD_{50}) toxic loads were used to estimate the number of fatalities. Poblete Lees & Simpson (Ref.11) have suggested that, given a uniform population density, those who survive within a LCT_{50} isopleth are balanced by those who will perish outside. However, this approach does not allow for the subtraction of the areas on and alongside the rail line from the calculation.

It is normally assumed that human response follows a log-normal relationship and that a probit expression can be used to describe the dose-response. For chlorine we have used:

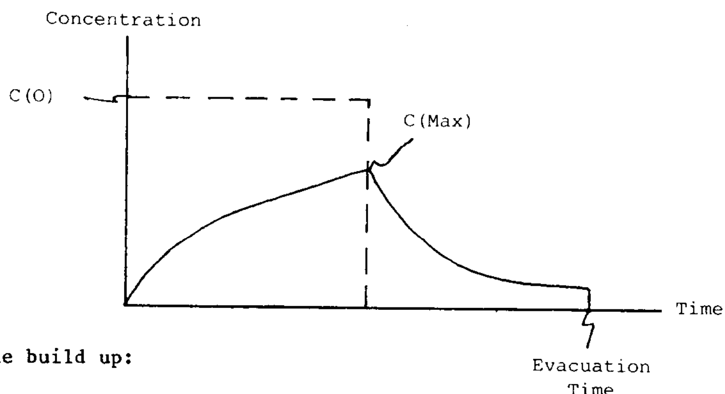
$$PR = 0.52 \ln C^{2.75} t - 4.4 \qquad (6)$$

to obtain corresponding values of C & t for LCT_{10}, LCT_{50} & LCT_{90}. The model uses these isopleths and assumes that a person between LCT_X and LCT_Y will have (X+Y)/2% probability of fatality.

The HSE risk assessment tool RISKAT (Ref.12) uses the dense gas dispersion codes DENZ & CRUNCH to calculate the dimensions and areas of isopleths for a specific dose level for a given release under a given weather condition. It will calculate these for open air exposures and for people inside buildings.

Mitigation RISKAT uses a simple gas infiltration model to calculate the dose a person will receive inside a building. This assumes exponential build up and decay phases. Figure 4 shows the general scheme.

FIG. 4 Simple gas Infiltration model.



For the build up:

$$C(I) = C(O).\ (1 - \exp(-\lambda.t)) \qquad (7)$$

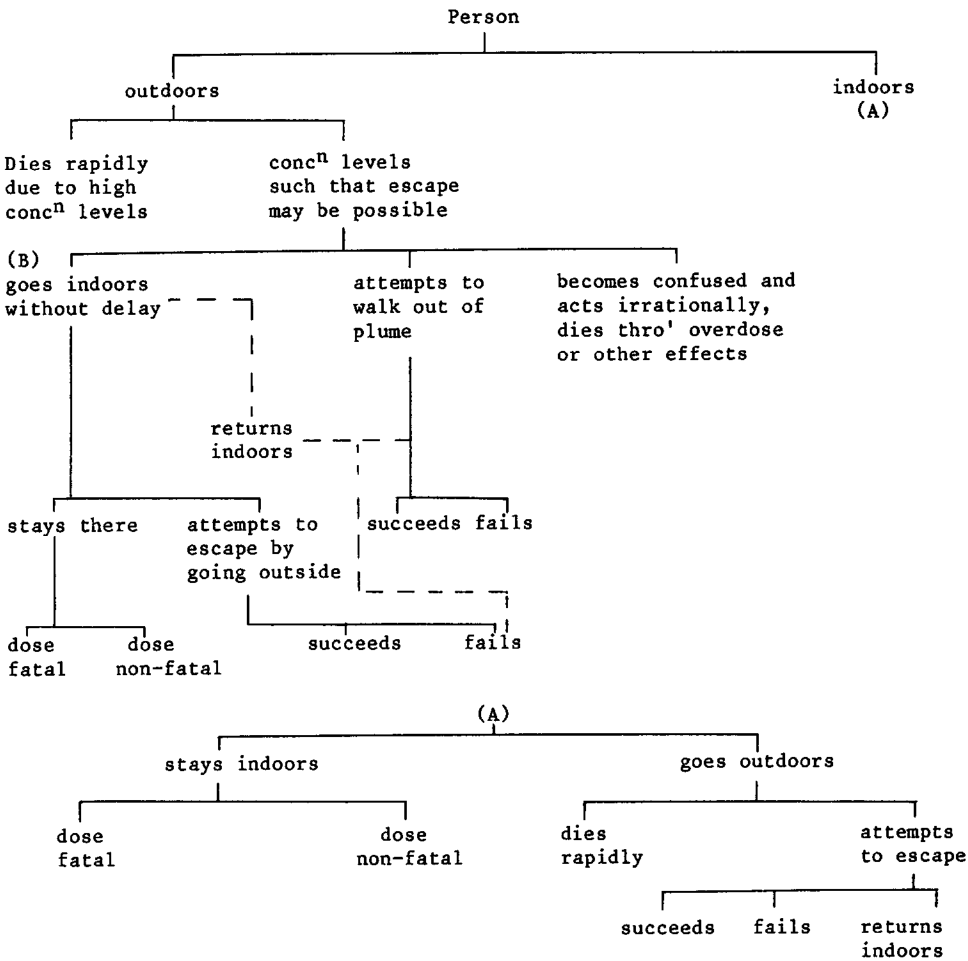
where C(O) is the ouside, "top hat" concentration and λ the ventilation rate.

For the decay phase:

$$C(I) = C(Max)\ (-\lambda . t) \tag{8}$$

where C(Max) is the maximum C(I). For this study ventilation rates of 2 & 3 air changes per hour were used in F/2 & D/5 weather respectively (Ref.13).

FIG 5. Possible Actions of Individuals Affected by Toxic Gas



It has been shown (Ref.14) that going indoors provides considerable mitigation against the effects of toxic gases and can be an important element in the strategy of emergency planning. Evacuation is of limited usefulness until the cloud has dispersed and escape from the cloud is a doubtful option; at concentrations significantly below fatal levels the escapee is likely to experience a great deal of discomfort and disability, he will be disorientated and unlikely to take a rational escape route. This approach conflicts with other studies (Ref. 15,16) which have assumed that people can escape or be evacuated through a gas cloud.

Figure 5 demonstrates some of the potential actions of a person affected by toxic gas. Figure 6 is the basis of the model for evaluating the number of fatalities arising from people out of doors.

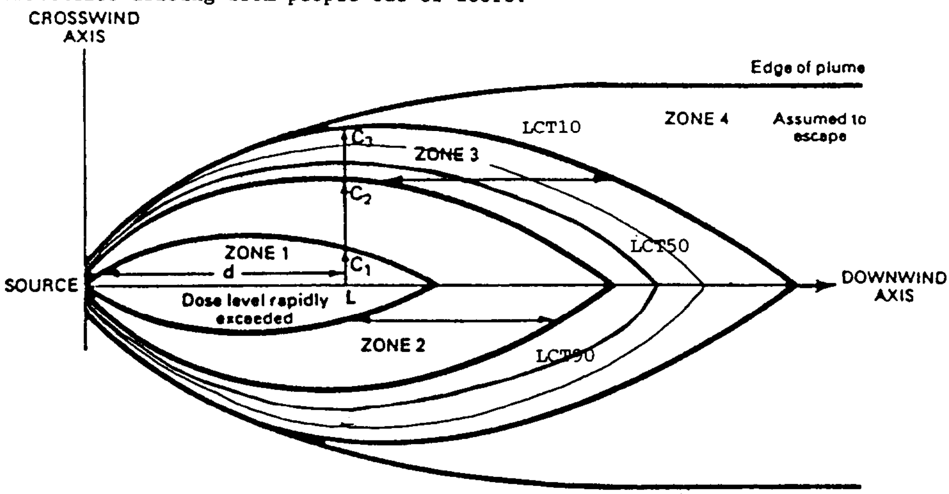


FIG 6. Basis of model for calculating "out-door" fatalities

Within zone 1 people will be exposed to a concentration in excess of C1; this is the level at which a few short breaths will prove fatal. Within zone 2 people will be exposed to a concentration C2 or greater. At this level there is a probability of escape indoors (say 0.2).

C3 is calculated using the probit expression (equation 6) for the 3 fatality levels, within C3 people will have a greater probability of escape indoors (say

FIG 7. Sample out-put for chlorine model.

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CHLORTRAM2                    CHLORINE RAIL RISK ASSESSMENT
*************************************************************************

29 TONNE RAIL TANKER

TWO SIDED TRACK

25M SWATHE REMOVED

-------------------------------------------------------------------------
POPULATION TYPE :                         Sub-urban
POPULATION DENSITY (KM^-2) :                   1310          LENGTH :          19
LENGTH OF ROUTE (KM) :                          101
NO. OF WAGGONS (YR-1):                         1216
-------------------------------------------------------------------------
EVENT                          RATE (KGS^-1)      FREQUENCY (*1E-6/WAG/KM/YR)

SMALL SPILL                          1.3               .005(PER JOURNEY)
MEDIUM PUNCTURE                     45.1             .00225
CATASTROPHIC FAILURE                 29TONNES        .00025
-------------------------------------------------------------------------
WEATHER PROB                   D/5 :             .8          F/2 :             .2
PROB. OUTSIDE                                    .1                           .01
-------------------------------------------------------------------------
ESCAPE INDOORS
                                          C1 / PPM           C2 / PPM
CRITICAL CONCENTRATIONS :      -             500                300
PROB. OF ESCAPE :                             .2                 .8
-------------------------------------------------------------------------
SOCIETAL RISK ASSESSMENT

EVENT                                     FREQUENCY         NO. FATALITIES
                                                                 OUT        IN
SMALL SPILL :       D/5                    .0000009         .6077824 4.531949
                    F/2                    .0000002         .6031332 68.81458

PUNCTURE :          D/5                    .0000416         23.64441 109.9914
                    F/2                    .0000104         26.07768 1008.612

CAT. FAILURE :      D/5                    .0000046         170.0118 183.5887
                    F/2                    .0000012         41.46983 1042.925

-------------------------------------------------------------------------
SOCIETAL RISK                  FREQUENCY OF N OR MORE (*10-6 YR-1)

                               NUMBERS OF FATALITIES (N)
                          >=1       >=10      >=30      >=100     >=300     >=1000

SMALL SPILLS         1.143762 .2287525 .2287525          0         0          0

PUNCTURES              51.984    51.984    51.984    51.984   10.3968    10.3968

CAT. FAILURE            5.776     5.776     5.776     5.776     5.776          0

CAT F WEATHER        11.78075 11.78075 11.78075    11.552    11.552    10.3968

-------------------------------------------------------------------------
** TOTAL **          58.90376 57.98875 57.98875     57.76   16.1728    10.3968
-------------------------------------------------------------------------
```

0.8). Therefore for hazardous event E in weather J, the number of people killed out of doors is

$$N(O,E,J) = D(q).\ P(O,J).\ \{\ A(C1) + A1^{1}.\ [1-P(e1)]\ + [1-P(e2)].\ [.95\ A2^{1} + .7A3^{1} + .3\ A4^{1}\ ]\ \} \quad (9)$$

where P(O,J) is the probability of being out doors in J weather

P (e1) is the probability of escape within C2

P (e2) is the probability of escape within C3

and area $A1^{1}$ is A(C2) - A(C1)

$A2^{1}$ is A(C3,90) - A(C2)

A3 is A(C3,50) - A (C3,90)

& $A4^{1}$ is A(C3,10) - A (C3,50)

In reality expression (9) is more complex as for some releases A(C3,90) = A (C2) or even A (C3,90) = A (C1) and AC3,50 = A(C2).

Once people escape indoors any dose they may have received out-of-doors is ignored. The number of people killed indoors by event E in weather J will consist of those who were already indoors and perish and those who escaped indoors and yet still perish.

$$N(I,E,J) = \{\ D(q).[1-P(O,J)\ ] + D(q^{1})\ \}.\{.95A(D,90)+.7A5^{1} + .3A6^{1}\ \} \quad (10)$$

where A(D,90) is the area of the indoor/90% isopleths

& $A5^{1}$ is A(D,50) - A(D,90)

$A6^{1}$ is A(D,10) - A(D,50)

The proportion of those people who escape indoors but who subsequently die will depend on whether they escape from C2 concentrations, ie, P(e1) go indoors, or C3 concentrations, ie, P(e2) go indoors. $D(q^{1})$ represents the average population density of escapees.

MODEL RESULTS AND FUTURE WORK

The LPG and Chlorine models have been implemented on a spreadsheet program. This allows the greatest transparency to the risk calculation process. The

FIG 8. Sample out-put for LPG model

PROTRAM2 LPG RAIL RISK ASSESSMENT

40 TE RAIL TANKER

ONE SIDED TRACK

POPULATION DENSITY :	1310/SQ KM	ONE SIDE ONLY
LENGTH OF POPULATION DENSITY:	24.5KM	
No. OF WAGONS:	1323	
LENGTH OF TRACK:	85KM	

SIZE	RATE,KG/S	FREQUENCY,*1E-6/WAG/KM/YR
SMALL	2	.029(PER JOURNEY)
MEDIUM	36	.00225
Q-INSTANTANEOUS	40TONNES	.00025

HAZARDOUS EVENTS (SEE EVENT TREE)

A) SMALL RELEASE

EVENT	FREQUENCY	No. FATALITIES
TORCH	.3041149	0
BLEVE	.4976426	10.5
VCE(D5)	0	NONE
FLASH FIRE(D5)+TORCH	0	0
FLASH FIRE(D5)+BLEVE	0	10.5
VCE(F2)	0	NONE
FLASH FIRE(F2)+TORCH(L)	0	3
FLASH FIRE(F2)+TORCH(P)	0	5
FLASH FIRE(F2)+BLEVE	0	10.5

B)MEDIUM RELEASES

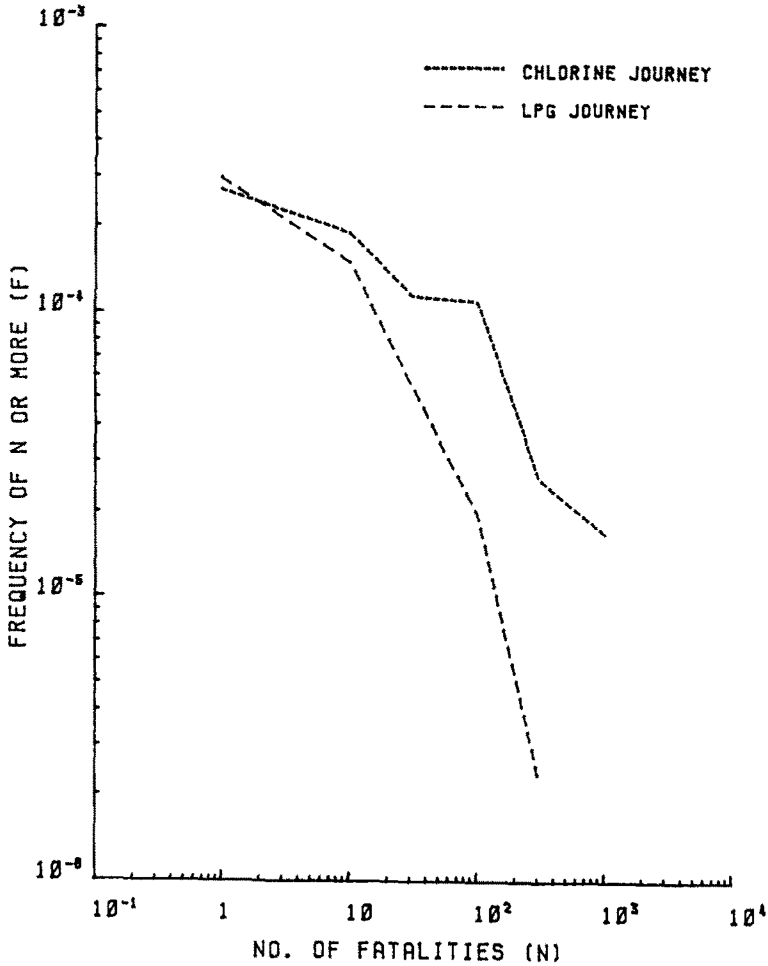
EVENT	FREQUENCY	No. FATALITIES
TORCH(L)	2.096748	.5
TORCH(P)	1.048374	3
BLEVE	10.39258	10.5
VCE(D5)	0	NONE
FLASH FIRE(D5)+TORCH(L)	3.354797	1.5
FLASH FIRE(D5)+TORCH(P)	1.677399	5
FLASH FIRE(D5)+BLEVE(L)	8.314063	10.5
FLASH FIRE(D5)+BLEVE(P)	4.157031	21
VCE(F2)(L)	.2917215	85
VCE(F2)(P)	.1458608	185
FLASH FIRE(F2)+TORCH(L)	.7548294	60.5
FLASH FIRE(F2)+TORCH(P)	.3774147	131
FLASH FIRE(F2)+BLEVE(L)	1.870664	67.5
FLASH FIRE(F2)+BLEVE(P)	.9353321	148

C)QUASI-INSTANTANEOUS RELEASES

EVENT	FREQUENCY	No. FATALITIES
FIREBALL	1.620675	21
VCE(D5)	.259308	84
FLASHFIRE(D5)	2.333772	33
VCE(F2)	.064827	84
FLASHFIRE(F2)	.583443	32

SOCIETAL RISK	NUMBER OF FATALITIES >=1	>=10	>=50	>=100	>=300
FREQUENCY(*1E-6/YR)	38.67973	32.59916	4.699958	1.458608	0

Fig 9. Sample results for route societal risks for Chlorine route & LPG route.



consequences of changes in the basic assumptions, failure rates, population densities can be easily observed and because of the relative simplicity of the models, sensitivity testing is easy and the results understandable. This approach is ideal for providing a full understanding of the level of risk and its contributory factors to decision makers. The models have been used to calculate the overall societal risk for particular routes on which these substances travel. Sample results are given in figure 7 and 8 and the F/N curves for two routes plotted as figure 9. These results are "average" societal risks for the whole route; it has been assumed that events have the same probability of occurring at any point along the track. In fact, along the route the level of societal risk will vary depending on local factors such as the potential frequency of incidents, topography, population density and so on.

The results of the analysis will allow the Advisory Committee to assess the levels of risk arising from the transport of dangerous substances. Following on from this the major factors contributing to the risk will be able to be identified and scrutinized. Any proposed control measures aimed at reduction of the potential frequency of major accidents or mitigation of their consequences will be able to be assessed in terms of the reduction in risk which might accrue. The Committee will thus be able to make recommendations about the desirability of introducing such measures.

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