Gas Dispersion Modelling for COMAH Safety Reports.

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1 WHAT IS COMAH?

The Control of Major Accident Hazards Regulations 1999 (COMAH) are the implementation in the UK of the Seveso II Directive. This directive follows on from the Seveso I Directive which was intended to address incidents of the type which occurred at Seveso in Italy. The second directive for the first time includes major accidents caused by the loss of control of a chemical process; something not covered in the first directive.

COMAH provides for both new measures not included in the previous regime and strengthens existing provisions. For example, the regulations establish a joint competent authority (CA) responsible for regulating sites which are subject. The members of the CA are the Health and Safety Executive (HSE) and the Environment Agency (EA) and they are intended to act together with HSE leading on people safety and the EA leading on risks to the environment.

All sites which manufacture, store or use in excess of certain threshold quantities of the substances specified in the regulations have to notify the CA that they are doing so. There is a parallel set of planning regulations which require a separate notification or application to the local hazardous substance authority (usually the local authority) for hazardous substance consent at the same sites covered by COMAH. In the case of sites which become notified for loss of control of a chemical process, the sites become notified for the ingredients which enter the process for which the loss of control is a possibility.

COMAH requires that companies make a series of demonstrations to the CA. These are normally made as part of the submission of safety reports and the drawing up of emergency plans.

The Seveso II Directive also places a duty on member states to plan the land uses around major hazardous chemical sites. COMAH places this duty on the CA to provide land use planning advice to local authorities so that they can make planning decisions informed by calculations of hazards and risks from such sites. This is nothing new; HSE have been providing this service for over 20 years.

2 SOME COMAH DUTIES

Some of the duties placed on operators of sites which are subject to COMAH (those which impact on the use of gas dispersion modelling) include:

Regulation 4

Operators need to take …. all necessary measures to prevent major accidents and to limit their consequences…

Regulation 7

Operators need to provide a safety report, the purposes of which are given in Schedule 4 Part 1.

Regulation 8

The safety report should be reviewed and revised in the light of chages which take place on the site and also when there is any change to the technical basis including gas dispersion calculations provided in the safety report.

Regulations 9 – 12

Emergency plans should be in place; based on the hazard and risk calculations in the safety report. These plans should be rehearsed regularly.

3 PURPOSE OF SAFETY REPORTS

The purposes of the safety report as given in Schedule 4, provide most of the rationale for gas dispersion calculations by major hazard establishment operators. There are a series of demonstrations which need to be satisfied before a safety report can be said to be satisfactory.

All Major Accident Hazards should be identified in the safety report. At first sight this seems to be an open ended task. It is unlikely that every major accident can be identified but gas dispersion modelling is essential both to screen out those accidents which are genuinely not a cause for concern and to scope those accidents which are. In practical terms there must be interfaces between the calculation of a source term ahead of the dispersion calculation and the harm criterion which is used to calculate the numbers of casualties and fatalities which might be involved in each case.

The safety report should demonstrate that all necessary measures have been taken to prevent and limit the consequernces of major accidents. The CA have agreed that the phrase …all necessary measures … should be interpreted as that risks have been reduced …as low as reasonably practicable (ALARP). Then the normal tests which apply to the same phrase under the Health and Safety

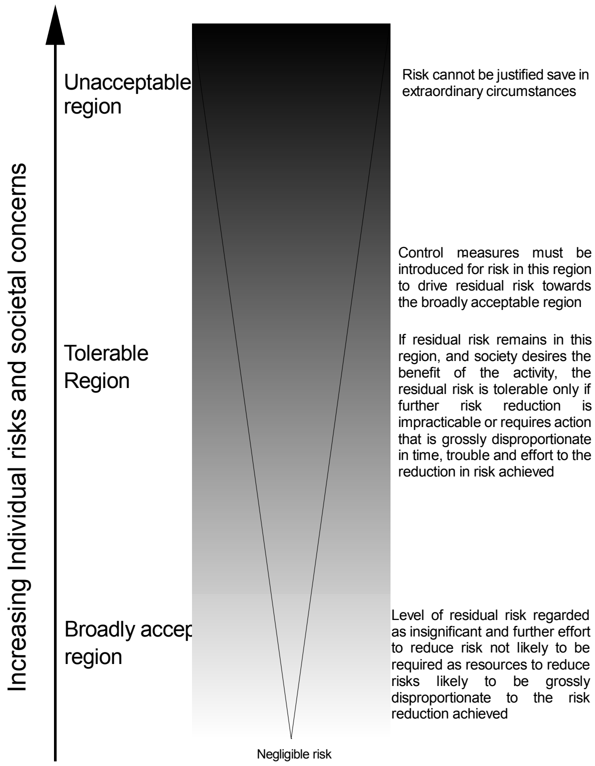

Figure 1. HSE criteria for the tolerability of risk

at Work etc Act 1974 can be used. Note that it is for companies to make this demonstration, not for the CA. Therefore companies need to have an understanding of what the CA believes ALARP to mean. For the chemical industry this involves an estimation of the hazards and risks posed by their operation, comparing this estimate with benchmarks published by the CA and providing information on whether the measures in place to prevent and mitigate reduce the risks ALARP.

HSE has published its understanding of ALARP in a few places including the ToR (HSE 1988) document and R2P2 (HSE 1999). These provide benchmarks based on both individual risk and societal risk. For both, gas dispersion modelling provides a means of calculating whether an individual or a group of people are at risk from the range of major accidents which can occur on a site. Figure 1 is the familiar "risk carrot" used to illustrate that there are regions at high levels of individual risk which are intolerableand regions at low risk which are deemed broadly acceptable. In the middle is an area where risks are considered to be tolerable if they are controlled ALARP.

Figure 2 is an equivalent diagram for Societal Risk. Now there are areas for risks which are broadly acceptable, tolerable if ALARP and intolerable. When companies are in the middle region they still need to examine whether there are any measures which could be put in place to control risks. Only where the cost of the measure is grossly disproportionate to the risk reduction obtained should it be dismissed.

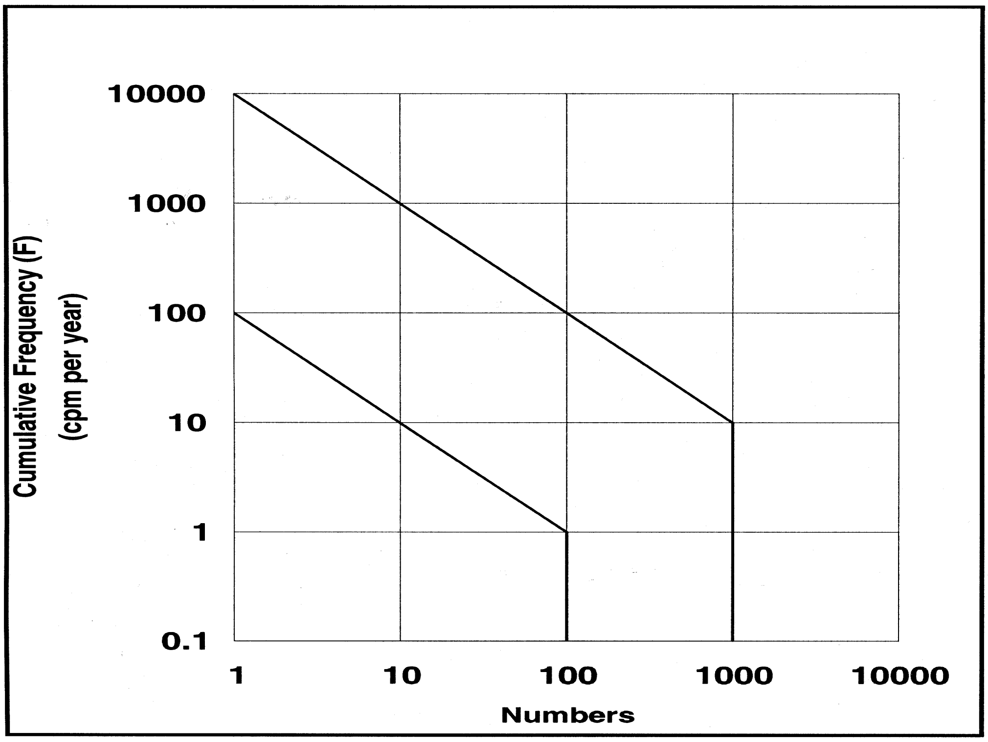

Figure 2. Societal Risk F-N Curve

4 IMPLICATIONS FOR GAS DISPERSION MODELS

Major accidents cover the whole range of possibilities on site, including fires, explosions, catastrophic failures resulting in instantaneous releases; pipework and process failures which might result in continuous releases of both toxic and flammable materials. A primary requirement therefore is for operators to recognise what type of hazard results from the many different accident types which they might be responsible for. Then to select a gas dispersion model appropriate to that situation.

Dispersion models should be capable of providing the information required to calculate casualties and fatalities but the harm criteria which operators choose to determine this is not prescribed. For example for toxic major hazards, operators could choose between a fatal concentration, dose or probit to determine the likelihood of becoming a fatality and the model should be able to provide the relevant output.

It is important when a dense gas release is identified that the appropriate model is used. For example, use of a passive model in place of dense one will result in an underestimate of the casualties and fatalities which might occur. Figure 3 demonstrates that a passive model always underestimates the width of a cloud, especially near the source. In this case the same size of continuous release of Chlorine (5 kg/s) modelled using a passive and dense model results in a severe underestimate of the cloud width and possibly therefore of the number of casualties and fatalities.

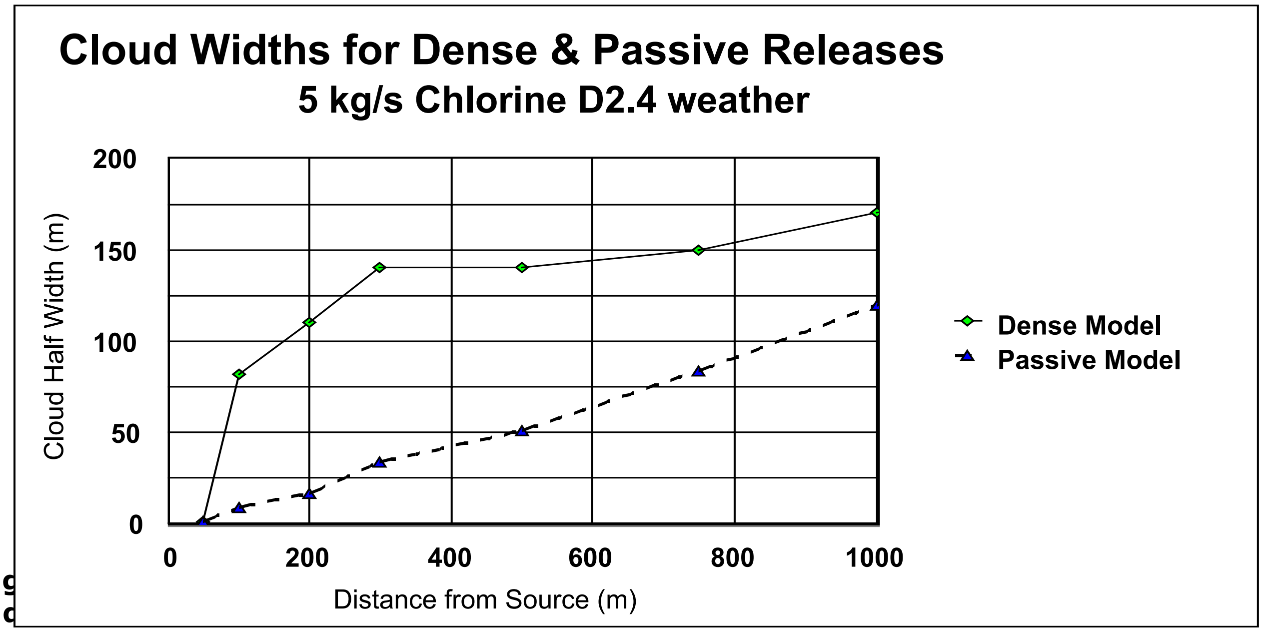

Figure 3. Underestimating cloud widths when using passive model instead of a dense one.

The need to be able to model instantaneous releases, for example when a catastrophic vessel failure occurs, also poses a problem of underestimation. It is well known from field trials that dense gas releases have significant upwind spread during the slumping phase of the release. Models should be able to predict that the extent of this so that populations upwind of this event can be taken into account in the fatality and casualty count. The extent of this problem is shown in Figure 4. This shows the positions of the leading and trailing edges of an instantaneous dense puff release as it moves downwind. It can be seen that the trailing edge extends approximately 300m upwind before beginning to move with the wind. It does not clear the release point until the leading edge has travelled 1500m downwind.

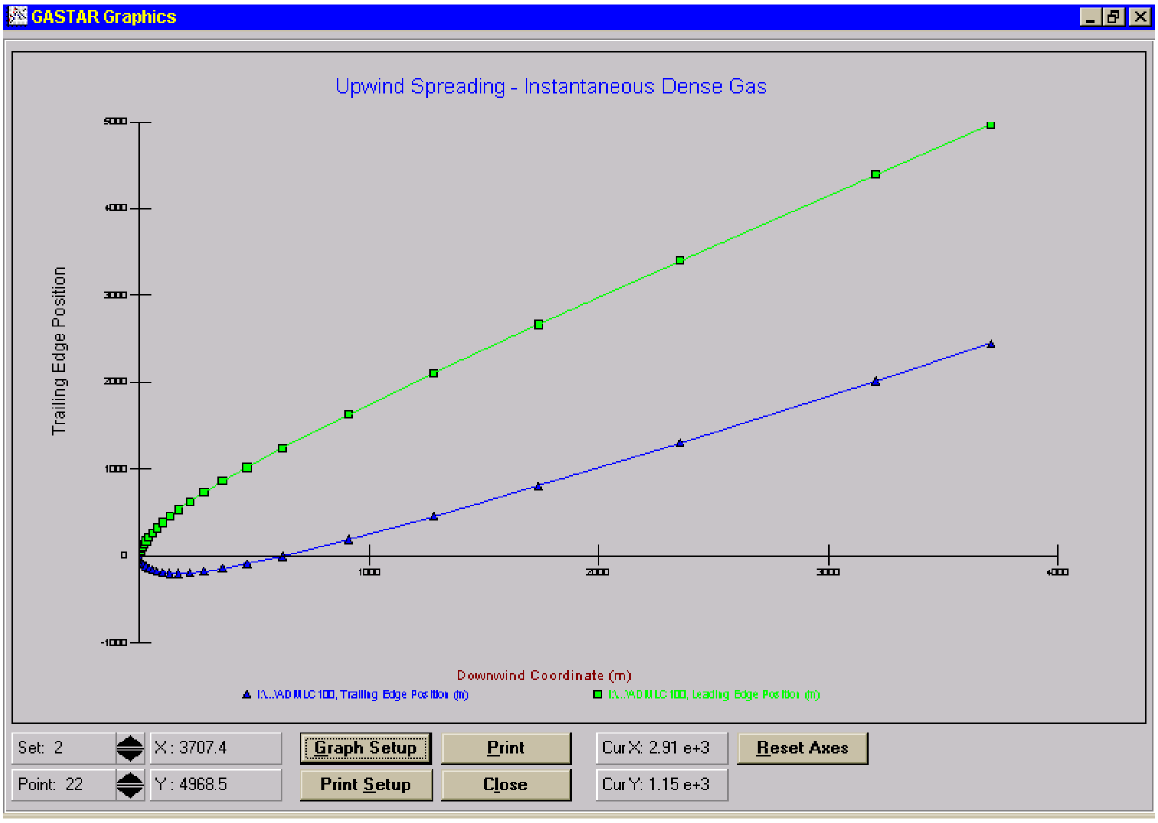

Figure 4. Demonstrating the extent of upwind spreading in an instantaneous release.

5 MODEL QUALITY

The extent to which an operator needs to select and use the dispersion model is also open to the ALARP test; and bearing in mind that safety reports are available on a public register, there is some impetus to ensure that sites which pose a large risk, with the potential to kill large numbers in a single accident use models which are quality assured, verified and evaluated to a high standard so that the local population and the CA has some confidence in the outcomes of the calculations.

Sites are either high proportionality or low proportionality depending on the relative risks, so the CA expects that low proportionality sites might use workbook or empirical models. In reality, most operators use integral models, because of their speed and reliability. High proportionality sites would be expected not to use workbooks but either integral models or perhaps CFD models in certain circumstances.

Models which have been through a model evaluation process such as the one developed under the EU SMEDIS project (SMEDIS 1999) or the earlier Hanna tests (Hanna et al 1993) are preferred for high proportionality sites. Previous experience also shows that an experienced user is required to consistently obtain reliable results for safety reports.

6 REFERENCES

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