THE USE OF COMPUTERS IN EMERGENCY RESPONSE PLANNING©

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The contribution of computer aids in preparing emergency procedures is described. The various stages of a project from conception through to operation are considered and techniques such as ICI's hazard studies are outlined. In particular the requirements of emergency planning and training are reviewed and the application of ICI's gas dispersion visualisation DISCOVER described.

DISCOVER's features are outlined. Initial experience from the first ten CIMAH sites is also discussed.

INTRODUCTION

Safety, Health and Loss Prevention (SHLP) have become major themes and key business levers driven by incidents such as Flixborough, Seveso, Mexico City, and more recently Piper Alpha. A recent viewpoint by Pasman, Duxbury and Bjordal presented at ACHEMA'91 (1) provides an excellent overview of hazards, risks, safety and loss prevention in the process industries, past, present and future. The incorporation of health and environment issues as part of the same framework is now happening as a logical consequence of an integrated treatment of acute and chronic effects, both aqueous and gaseous and the common underlying physics, chemistry, mathematical modelling and technology.

Incidents involving hazardous gas emission necessitate a fast and competent response. This can be improved by better planning and training, supporting carefully considered and well practised emergency procedures. ICI has been using computers to assist in preparing these procedures since the early 1970's and the pioneering work of Dicken and Illidge (2) on chlorine releases has provided the foundation for much of ICI's activities in this important area.

HAZARD STUDIES

For new projects ICI uses a six stage hazard study procedure eg see Turney (3). These procedures are also used, appropriately adapted, for reviewing existing plants and modifications.

Hazard Study 1 is usually done shortly after project conception. It identifies the hazards associated with the process chemicals and intermediates, environmental impact and hence suitability of siting, both in terms of nearby plant and population. The application of

DISCOVER at this stage offers improved visualisation and hence better decision making.

Hazard study 2 is done at the process and project specification stage as soon as the process flowsheets are available. The principle objective is to identify significant hazards and causes and to eliminate or reduce them by better design. Quantification and consequence assessment may be required which can provide information needed for emergency planning purposes and regulatory safety reports such as those required under the Seveso directive in the EC. Such toxic/hazard gas studies have been performed in ICI since the early 1970's using such programs as MFE53A, TOXIDISP, and currently DISP2, the principle gas dispersion module in DISCOVER. Where a full Quantified Risk Assessment (QRA) is required DNV Technica's SAFETI package could be used. Emergency scenarios can then be assembled and visualised using DISCOVER, and stored as training sets for later use on the real plant.

Hazard study 3 is done at the detail design stage when the engineering line diagrams are essentially firm, and is effectively a final audit on the design and operability of the plant directed to avoiding incidents using a guideword ('No', 'More', 'Less', etc) approach to generate deviations including transient and emergency conditions.

As a team based exercise it provides an excellent opportunity to transfer technology, design and operating philosophy from the design to operating/commissioning personnel. As a large consumer of time at an important stage of the project (on the critical path between sanction and beneficial production) when design changes are difficult to make, tending to lead to the bolting-on of extrinsic safety features, ICI are currently benchmarking Hazard Study 3 with a view to critically reviewing potential improvements to Hazard Study 3.

Hazard studies 4, 5 and 6 are performed at the construction, commissioning and operation stages to ensure all the actions identified have been done and the actual plant is consistent with the design basis.

EMERGENCY PLANNING

Emergency planning by site personnel is focussed on minimising the consequences of any incident If done properly it starts as stated previously at the earliest stages of design, before siting and plant layout has been decided (Hazard Study 1). In the UK guidance on emergency planning has been published by the Health and Safety Executive (4) and the Chemical Industries Association (5).

In all cases, especially CIMAH designated sites, the preparation of a comprehensive emergency plan requires consideration of a range of scenarios to represent the potential consequences of all significant incidents involving toxic gas, fire/explosion and the environment.

A fully effective plan will require the systematic training and retraining of operational personnel and well practised links with external emergency services and authorities. The use of a computer aids such as DISCOVER can greatly enhance the realism and effectiveness of such training.

DISCOVER

BACKGROUND

DISCOVER (Dispersion and Computer-Aided Visualisation of Emergency Releases), has been developed by ICI for use in the training for and preparation of emergency response procedures for hazard chemical releases on ICI's CIMAH regulated sites. It has been installed on ten such sites in the UK, and Eire. Three of these sites are now owned and operated by Zeneca. Plans to install it on appropriate ICI sites worldwide, including North America, Asia Pacific and Australia are now being developed.

The need for such a package was recognised in the late 1980's by ICI's *safety community in the knowledge that alternative commercially* available packages were either technically unsuitable and hence did not satisfy ICI's longer term requirements, or too expensive or both. A prototype was developed in 1990 displaying ICI's core competencies of gas dispersion modelling an advanced process systems engineering. This DISCOVER prototype confirmed the need for user friendliness, clear displays with advanced graphics.

The current production version of DISCOVER, has been structured to take account of the need to continually expand and adopt to meet the evolving needs of ICI's safety community. This includes the incorporation of new models for gas dispersion. This flexibility has been achieved by using state-of-the-art object oriented programming (OOP) techniques together with a fully functional graphical user *interface (GUI). It currently runs on a SUN IPX Sparcstation under* UNIX. The technical architecture of DISCOVER is described fully elsewhere(6).

DISCOVER

OVERVIEW

DISCOVER was specified by representatives from the ten CIMAH sites, all actively involved in the planning, training and execution of emergency response procedures.

The main functional features of DISCOVER Version 1 are:

1. *The ability to visualise both burst releases and steady state* continuous emissions of gas. Animation of burst releases uses a simple video style user interaction (stop, start, forward, rewind).

2. The ability to plot and colour isopleths (contours of constant concentration) with transparent overlays on plants and widescale (5-10km) Ordnance Survey maps.

3. The ability to investigate in an interactive graphical form the consequences of changing gas dispersion model parameters.

4. The ability to model changes in wind and weather conditions.

5. The need for DISCOVER to be simple to learn and highly user friendly in terms of both novice and experienced users

In addition the ability to display toxic chemical data and emergency procedure actions has been incorporated by means of a simple display. It is expected that these features will be enhanced as a result of user feedback in future releases of DISCOVER.

DISCOVER operates in two main modes: Planning and Training.

DISCOVER

PLANNING MODE

In planning mode the planner/trainer can edit all the model parameters and visualise all the effects by actually running the gas dispersion model and displaying the results. All sites are provided with a pre-prepared computerised map usually derived from site drawing office maps and, for the environs, Ordnance (National) Survey. Thereafter the trainer initially defines and locates plants on the map, together with a list of associated chemicals. Constructing a training scenario is a straightforward matter of inputting test data through the GUI, running the gas dispersion model and then visualising the results on the map. By selecting and carefully grouping these training scenarios into training sets, the planner/trainer can construct emergency procedure training sessions built around DISCOVER for a range of plants and chemicals and types of emission.

Figure 1 shows a typical scenario for a steady state 'plume' release and various cross-section analyses. Figure 2 shows a time-stepped burst release.

DISCOVER

TRAINING MODE

In training mode the trainee selects wind and weather conditions and an appropriate incident or set of incidents from the training sets constructed by the planner/trainer. These can be visualised at three levels: plant, site and environs, interrogated for data, labelled and stored as Case Studies for reference. Also plots of concentration in space and time are available for analyses.

DISCOVER

PRESENT STATUS

DISCOVER was installed at the ten CIMAH sites between September 1992 and April 1993. These sites vary greatly in size and nature, ranging from large single business, single toxic installations eg. ammonia, chlorine, to smaller multibusiness units handling several mixed toxics eg phosgene, hydrogen fluoride, hydrogen cyanide etc, but usually with minimised inventories.

In both kinds of situation DISCOVER has been installed in the emergency control centre to enable its contribution to planning and training exercises. Version 1 has been scoped to run off-line specifically for planning and training and not initially as a core part of real time emergency response. Some sites have indicated a willingness to test the validity of preselected scenarios alongside real incidents with a view to gaining confidence in eventual real time emergency response.

Initial feedback has been encouraging. Several sites have familiarised their planner by inputting all their CIMAH Safety Core scenarios. The resulting visualisations have been very instructive to plant personnel and favourably viewed by the HSE when seen.

Other sites have already benefited from having a computerised database of plants, their hazard chemicals and properties. To date (now 12 months) only one live incident has needed to be reconstructed using DISCOVER. This proved to be essentially benign and the DISCOVER graphical output greatly added to the incident enquiry.

CONCLUSIONS

The use of computers in emergency planning and training begins at the earliest stages of design in assisting siting, layout and minimising inventories. Use continues alongside the Hazard study process to better understand the consequences of incidents through a toxic/flammable hazard study and, where appropriate, a Quantified Risk Assessment (QRA). ICI's gas dispersion visualisation package DISCOVER can assist in these design stages, but its primary use is as an emergency planning and training tool on sites handling hazardous chemicals. As well as continuous improvement in the emergency area planning and training, DISCOVER is likely to find applications in other site-based visualisation studies eg inventories and environmental impact assessment.

ACKNOWLEDGEMENTS

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REFERENCES

1. Pasman, H.J., Duxbury, H.A., and Bjordal, B.N. 'Major Hazards in the Process Industries', Journal of Hazardous Materials, 1992, 30, 1-38.

2. Dicken, A.N.A. 'The Quantitative Assessment of Chlorine Emission Hazards' Presented at Electrochemical Society Meeting, San Franciso, May 1974.

3. Turney, R.D. 'Techniques for Analysis and Assessment of Accident Hazards', Presented at Industrial major Hazards Control, Kuala Lumpur, March 1987.

4. UK HSE. 'Control of Industrial Major Accident Hazard Regulations. Health and Safety Series Booklet HS(G)25, 1985.

5. CIA. 'Recommended Procedures for handling major Emergencies', Chemical Industries Association, London, 1976.

6. Struthers, A. and Preston M.L. 'An Object Oriented Model Management Tool for Emergency Response Planning', IChemE Symposium Series No. 133

FIGURE 1

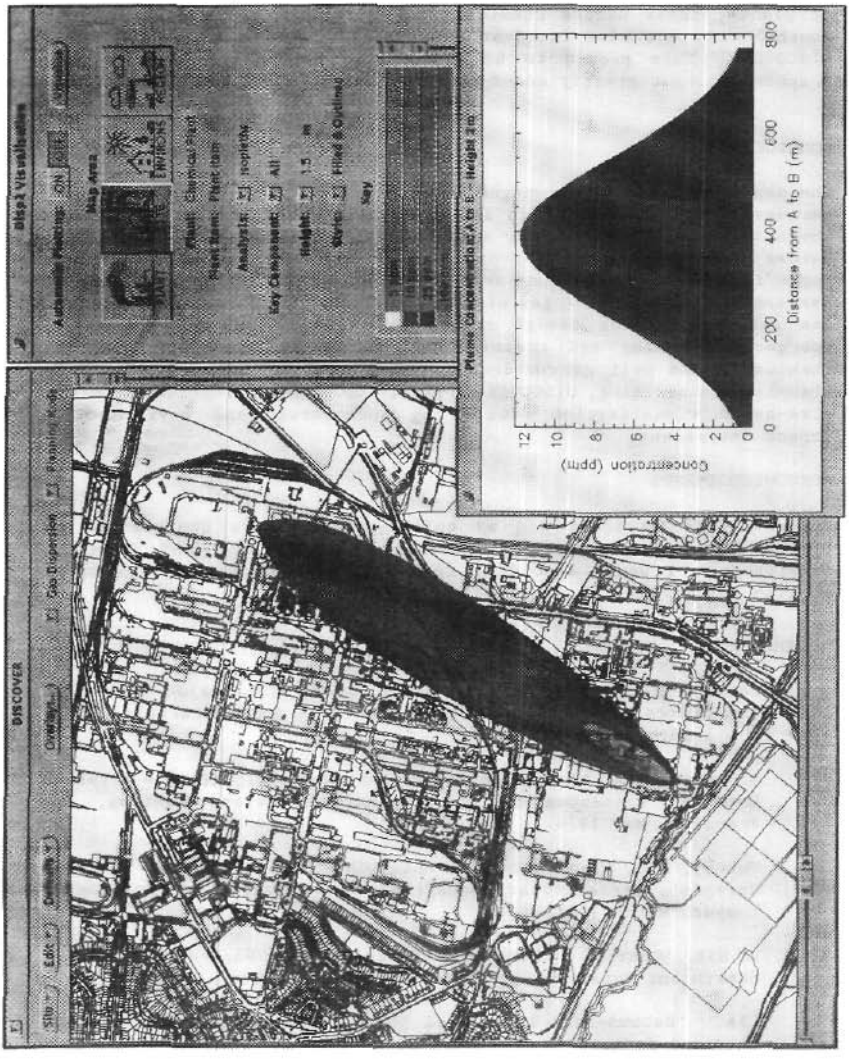
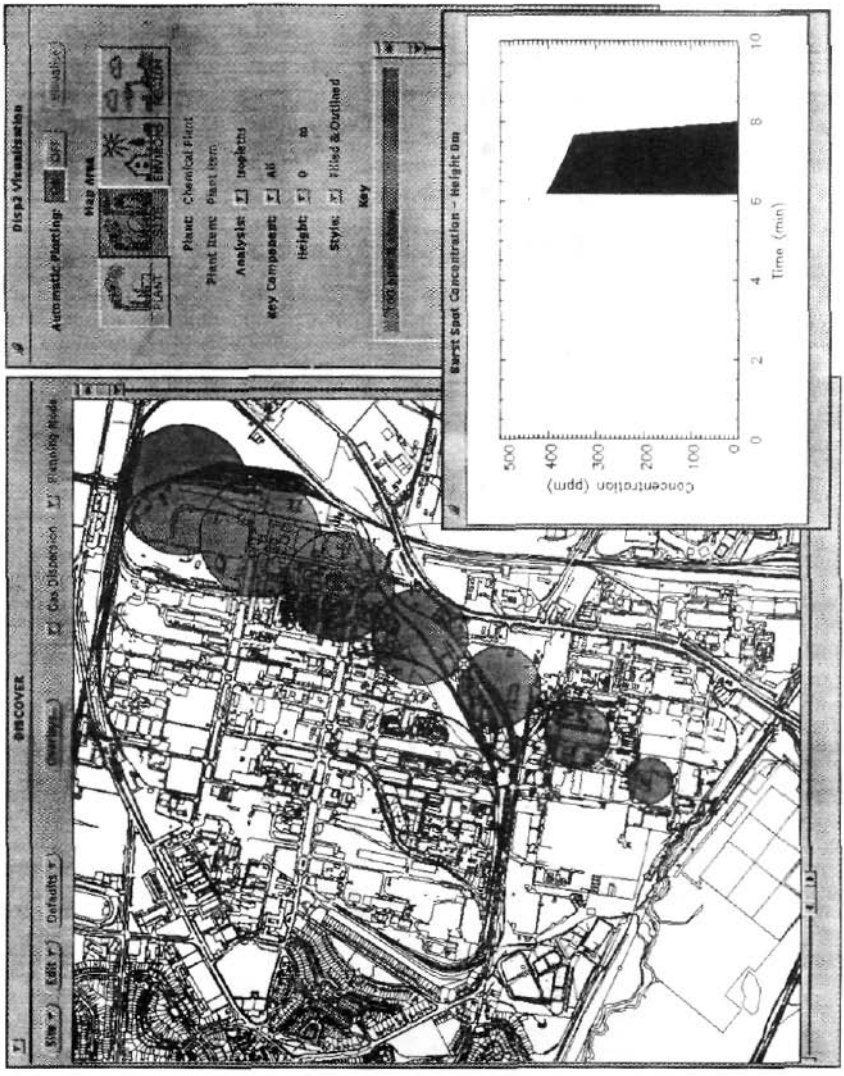

DISCOVER
Gas Dispersion
Plume Concentration at Axis B Height 2 m
Concentration (ppm)
Distance from A to B (m)
0
200
400
600
800
2
4
6
8
10
12

FIGURE 2


DISCOVER
Site
Edit
Defaults
Overlays
Gas Dispersion
Planning Mode
Disp3 Visualisation
Automatic Plantlogic
Map Area
Plant: Chemical Plant
Plant Item: Plant Item
Analysis: Isopleths
Key Component: All
Height: 0 m
Style: Filled & Outlined
Key
Burst Spot Concentration - Height 0m
Concentration (ppm)
Time (min)
0
100
200
300
400
500
2
4
6
8
10