DEVELOPMENTS IN THE CONTROL OF MAJOR HAZARDS

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Greater media attention and increasing public awareness of major accident hazards in Britain and elsewhere has produced demands for tighter safety controls and more public information. There are now both voluntary and statutory controls on town and country planning in and around major hazard sites in Britain. The plants themselves are to be subject to more detailed regulatory requirements. The development of this legislation has proceeded in parallel with, and has been influenced by, a major programme of theoretical and experimental research designed to assess and reduce the risks. This paper describes the controls and main areas of research and suggests the directions in which future work might most profitably proceed.

1 HISTORICAL BACKGROUND

The potential hazard to the public from large chemical plants was first highlighted, in the UK at least, in the Annual Report for 1967 of HM Chief Inspector of Factories. The inventories of hazardous materials in process plants had grown after the second World War, and the increase in the size of plants in order to benefit from economies of scale, coupled with the close proximity of many such plants to areas of population, had resulted in a measurable risk to many members of the public.

At about the same time, the easing of the post-war economic situation resulted in a growing concern and expectation for the 'quality' of life, along with a more directly expressed wish of the public to be involved in matters which affected them. The issue was again addressed by the Report of the Robens Committee in 1972(1), in which it was also suggested that there was a need for a Specialist Unit to investigate the risks of what were becoming known as 'major hazards'. Someone once translated 'Ex Africa semper aliquid novi'(2) as 'strange things happen in other places', and in fact most of the events which had given rise to the growing concern about the risks posed by modern industry had occurred abroad. But then in 1974, it was the UK's turn, at Flixborough.(3) It was this event, I think, more than any other, which concentrated the minds of those closely involved in the issue; and, more importantly, caused a quantum leap in the public perception of the hazard potential of large scale industrial operations. It was an event which focussed, probably for the first time, the attention of the media; and it produced a 'political' will for control.

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Since then, such events have come thick and fast, (remember - they are events of extremely low probability!). Many of them, such as Manfredonia, Beek, and Quatar, will already be known to you. Some, like Seveso, have acquired an extra dimension of meaning, indeed a notoriety, which has caused the location of the incident to pass into the general vocabulary. This paper is being prepared in the first week of December 1984 - by the time the paper is presented it is likely that Mexico City, and, particularly Bhopal, will have achieved similar overtones of dread in the perceptions of the public.

Part of this paper deals with progress in the UK since 1967; a further part deals with suggestions for the future, for it is clear that recognition of the risks is only the first step to adequate control.

I believe that the contribution of the UK to this international issue, has been, and remains substantial. We have come a long way since 1967. The 3 reports of the Advisory Committee on Major Hazards (ACMH)(4)(5)(6) are milestones in the consideration of the issues involved on both theoretical and practical levels; they have helped to form the basis and thrust of the wider European approach, culminating in the eponymous EC Directive on the Control of Major Accident Hazards.(7) The two Canvey reports(8)(9) are fundamental, indeed seminal, to the methodology of risk evaluation of major hazards and their public impact. The 'Canvey Approach' is now seen by many as an appropriate framework - the Mossmorran hazard surveys(10)(11)(12) (carried out, as a condition of planning permission, by a firm of international consultants, and overseen by HSE) are a developed example - for addressing the problem. Within HSE, the Major Hazards Assessment Unit has developed and refined both its expertise and its approach - the latter, particularly as a result of the reaction of industry and the public (a point to which I shall return later), since 1979, when it was first formed. The approach of the Unit remains technically based - members of the Unit have a background of a variety of disciplines - but the problems with which it is faced are essentially a microcosm of the 'major hazard' issue. The technical aspects are themselves inter-disciplinary, but there are many sides of the problem which are not 'technical' at all: the wider considerations call for an approach which is both eclectic and flexible. We think we are now structured to deal with the demands of the present situation in the UK, and to influence, significantly, future development and progress.

2 THE PRESENT AND IMMEDIATE FUTURE

In the first part of this paper I have briefly described the background and development of 'major hazard' thinking in the UK from 1967 to the present day. I now propose to outline the current position as regards control, and relate that position to one aspect of HSE involvement - the development of our siting advice to planning authorities; this is, of course, one way of approaching the risk problem - the probability of an occurrence and its potential consequences.

The Third Report of the Advisory Committee on Major Hazards listed the four basic elements of control.

1. identification
2. recognition
3. elimination (or reduction of probability)

4. assessment (and mitigation) of consequences

These elements form the cornerstones of a package of legislation, put together by the Hazardous Installations Policy Branch of HSE, which is designed to put into effect many of the recommendations of ACMH, and to implement the 'Seveso' Directive. The first block is already in place. Since 1983 the Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS)(13) has required the operators of many hazardous installations (currently about 1750 in number) to notify HSE of their location, and of certain details of their operations. This has allowed HSE to notify, in turn, local authorities and emergency services of the sites.(14) Concurrent changes in planning law(15) have put on to a statutory basis the previously less formal consultative arrangements about developments on or in the vicinity of hazardous sites.

The Control of Major Industrial Accident Hazard Regulations 1984 (CIMAH)(16) are about to become law. These Regulations (which embody the requirements of the EC Directive) will require the identification and general demonstration of adequate control of risks, by the operator, on all sites to which the regulations apply; and all major accidents (including damage to the environment) will have to be notified to HSE (as will premises subject to CIMAH not already subject to NIHHS). But for the 250 sites which might be considered to present the greatest hazard, the 'large-inventory top-tier sites' (LITTS) (and for about 1000 sites with smaller amounts of very toxic, inflammable, or explosive materials - the 'small inventory top-tier sites' - SITTS) the Regulations will impose important new duties. These include:

1. the preparation of on-site emergency plans by the operator
2. the preparation of off-site emergency plans by the authority responsible for civil emergency planning
3. the duty on the operator to give, to those members of the public who might be affected by his activities, appropriate information about the risks to which they are exposed, and
4. most importantly, the preparation and presentation to the HSE of a written report (the 'SAFETY CASE') which shows that the potential for major accidents has been identified and demonstrates that the necessary degree of protection and control is being exercised. This is not a once-and-for-all exercise: it needs to be updated every three years, or more frequently if changed circumstances warrant it.

For new sites, these requirements will have to be complied with at least 3 months before the sites become operational; for existing sites, implementation will be staged. At the time of writing the relevant dates are

on-site emergency plan	:	1 April 1985
off-site emergency plan	:	1 October 1985
information to the public	:	1 January 1986
safety case	:	1 January 1989

We are, of course, already discussing with industry the implications of these changes, and the necessary content of their safety cases. Preliminary guidance has already been published.(17) We intend to publish further advice on the preparation of safety cases in the near future.

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Side by side with the above, changes have been proposed in planning law which would have the effect of requiring 'consent' from planning authorities for hazardous installations.

Taken together, all these measures represent a comprehensive system in the UK for the control of hazardous installations. But for all their breadth and detail, they do not remove the risk of a major industrial accident, they simply diminish the probability of its occurrence and the degree of any subsequent harm to people working and living nearby.

Later in this paper I shall invite you to consider not only the resource implications of the present controls, but also whether they go far enough. But first, to point up the issues I wish to address, I propose to outline the development, over time, of the HSE advice to planning authorities about the siting of, and developments in the vicinity of, hazardous installations. The choice of this example is intended to show not only how HSE has endeavoured to respond to public criticism and expectations, but also how, in embryo at least, a cost-benefit approach has been built into our responses.

3 THE DEVELOPMENT OF THE RISK APPROACH

Since 1976 when planning authorities first started to consult us in significant numbers in accordance with advice from the Department of Environment(18), HSE (and MHAU since 1979) have been on a very public learning curve. The advice which we have given has placed some local (planning) authorities in considerable 'social' difficulty. We have appeared to tarnish the desired public image of good neighbourliness of operators of certain hazardous installations. We have been accused of damaging the morale of the public living near potentially hazardous plants. We are told by some that we are a major, if not the major current cause of land blight in the UK.

Much of the resultant debate has been very open and public. This is, of course, partly due to the consultative process built into the law-making procedures in the UK. It is partly because, at the planning stage, we are dealing with elected representatives of the public rather than spokesmen for individual concerns. But it is fair to say that just as Canvey, Mossmorran, and (latterly) the Upper Forth Studies(19) exposed the methodology of HSE to the scrutiny of the public, so the development of our approach to land use has been tested and validated at intervals, and in public, in forums ranging from local meetings in a church hall to public inquiries. We have moved from a totally advisory, discretionary consultee position, to that of a statutory consultee. And our overall response has changed as our approach developed in the face of comment, criticism, and, on more than one occasion, outcry. We started with a 'blanket' approach to land use (the 'cordon sanitaire') with a very conservative consultation distance. We refined consultation distances, and based the 'cordon' concept on hazard ranges. We refined those hazard ranges, and then built in some risk element; and we are continuing to move towards risk appraisal as the basis of our advice. While we continue to deal with individual cases, we now encourage submission of local and regional structure plans, so that we can advise on, and influence where necessary, strategic development.

There are, of course, implications for the contents of 'safety cases' here, and these will need to be more fully explored. It is, furthermore, unlikely that our advice could ever exclude some element of 'hazard', particularly in sensitive cases. I think you might agree, after all, that no one would wish a hospital or a school to be located within the fireball radius of an LPG vessel, however remote the residual risk of BLEVE might be. Furthermore, Mexico City and Bhopal have re-emphasised the need for adequate separation of incompatible land uses.

It will be clear that our move towards a risk basis for our advice has concomitant implications for both the 'image' of operators, and for the ongoing surveillance by HSE of the control exercised by operators and of the competence of their managers. There are also wider implications for the way in which not only HSE, but industry also, must structure and direct its future work in this field. I have some suggestions to make about this later.

The changes which have occurred, and which will continue to occur, have not taken place in a vacuum. They have taken place against a background of action and reaction from employers, employees, local authorities, individuals and pressure groups of varied identity and commitment, which inevitably places the debate in the political area, with the added dimension of the need to insure against over-reaction, and to ensure, by positive planning, an adequate supply of appropriate sites. There are all the associated problems of information disclosure, and, most importantly, the public perception of risk. This perception depends on many factors, and relates to potential, presentation, perceived benefits, personal suspicions and attitudes whether justified or unjustified, amongst others. What degree of entitlement to extra protection should there be for those who do not receive any direct benefit? How far should it be the role of HSE (or employers) to be educative here, or innovative? The problem becomes even more complex when the question of the acceptability of risk is considered. I do not propose to do more than refer to that issue here - it has already been addressed by many, ranging from Lord Rothschild(20) through ACMH,to a study Group of the Royal Society(21) - and the debate still rages. There can, however, be no single target of acceptability, because it is so judgemental.

Flexibility is needed to cope with a wide variety of situations. There can be no doubt, however, that HSE, manufacturers, professional and commercial associations, etc cannot avoid the debate. We must all be involved, on either an initiative or a responsive basis. The argument about the acceptability of risk inevitably centres on cost-benefit considerations, whether these are judgemental or quantified, subjective or objective. The debate includes many aspects which are not susceptible to quantification; for those which are (and these are in the risk assessment field) it behoves us to get the risk figures right and to remove the uncertainties, so far as we can, to enable those who will take the wider decisions to make judgements which are as informed as is practicable.

In my view, Industry and HSE should have nothing to fear from such a debate. Putting it at its very least, adequate assessment permits the critical areas of risk to be identified, addressed, and, if necessary, improvements made.

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And if the figures demonstrate an 'unacceptable' level of residual risk, this is surely something about which those most likely to be affected are entitled to have a voice? In the final analysis, there may be some land uses which are incompatible, and as recent examples in the North East of England, and in Northern Ireland demonstrate, appropriate solutions of last resort may be possible. Where they are not, it may become incumbent on HSE to exercise its powers of prohibition, or, for planning authorities, their powers of refusal.

4. HAVE WE GOT IT RIGHT?

All of the foregoing, and the proposals for the direction of further work that I will shortly make, have considerable resource implications. The existing requirements place onerous duties upon HSE, LPAS, Emergency Services, Employers, Employees, in other words, on the UK national resource. That such resources be deployed in this way is one aspect of the wider cost/benefit equation. Inevitably the available resources are limited. What we must ensure is that the resources are used efficiently and effectively, and that they address the areas of greatest risk, either actual or perceived. In this respect I pose two questions.

The first one is

'Has CIMAH got it right?'

In other words, does the UK version of the EC Directive meet its objectives, and are those objectives appropriate? If we wish to use our limited resources to best effect, should we be trying to change the Directive? Do we accept the explicit distinction between process and storage risks? Can we justify the use of scarce resources on the production of 1000 Safety cases for SITT sites? Should some substances be deleted from the Directive? - and are there any significant omissions? A very good case could be made for the inclusion of Sulphur Trioxide. Is it appropriate to include environmental issues in the Directive when such issues will be the subject of a separate Directive?(22) If so, what are the implications of this? Are the thresholds for certain substances set at the correct level - even accepting that we are not suggesting equivalence of hazard or risk?

The mention of thresholds leads me to my next question

'What do we do about 'sub-notifiables'?

which is, of course, another way of asking if we have set the thresholds at the right level. I think we would all accept there would be little difference in hazard or risk between 24 te and 26 te of butane stored in the same way on the same site. There will always be the problem of arbitrary cut-off levels, aside from the effects of inevitable resource constraints. We must identify and concentrate on priority areas, and apply the lessons we learn in those areas to the safe design and operation of subnotifiables, at whatever level they may be.

5 WHAT OF THE FUTURE?

I have already said that the need for the efficient and effective use of resources makes it important that we get our figures right in those areas we can quantify. A measurable amount of national resources is devoted to this field, and HSE is a major contributor. It is pleasing to see a lessening of suspicion and distrust between industry and HSE, and a growth in co-operation of effort in the investigation of such problems. The Maplin Sands and Thorney Island trials are good examples of this. The CIMAH dialogue should accelerate this growth in co-operation and mutual understanding. If we structure our future work on the basis of our mutual needs it will achieve an efficient use of our joint resources. Some of the work will, inevitably, be basically pure science, some will relate to the development of methodologies. Some will involve very pragmatic and practical issues. An outline of the potential fields for such work can be found in Ch 8 of the Third Report of the Advisory Committee.

HSE as a whole has heavy in-house research commitments, and extensive extra-mural involvement. MHAU work closely, not only with the HSE Research Division, but also by contractual arrangement with the Safety and Reliability Directorate of the UK Atomic Energy Authority, whereby they carry out special project work for us using the equivalent of 17 man/years of effort, and involving a current expenditure of ca £730K per annum.

The work which is carried out is very much the mix of the theoretical and practical to which I refer above.

For the future, our investigative work will need to concentrate on the remaining areas of uncertainty in risk assessment. These will include:

i Consequence

Of all aspects of risk assessment, this is probably the most thoroughly researched to date. The degree of refinement likely from further research is unlikely in my view to warrant the degree of commitment which has latterly been deployed, and the time may well be approaching for resources to be moved on to other problems. Of those problems which remain, in this field, I suggest that further work should concentrate on the following topics:-

a) release mechanisms and intermittency in gas cloud dispersion
b) the effects of topography, ground roughness, and the presence of obstacles
c) the development of wind and/or water tunnel modelling techniques to complement expensive large scale tests.
d) the effect of flashing flow, frictional losses, and padding pressure on release rates.
e) an approach to a consensus on the heat intensity of pool fires and fireballs.
f) (U)VCE's - the modelling of the effects of blast loading on structures, flame acceleration, and the behaviour of non-spherical explosions.

ii Probability

Although great advances have been made in the past 10 years in the collection of relevant data, failure rate information is still scarce and unreliable. The existing data bases remain inadequate in terms of hardware reliability; human data bases are, at best, embryonic and unproven. I would strongly encourage industry to co-operate with such bodies as the Systems Reliability Service and the National Centre for Systems Reliability in providing and making available data, so as to extend and refine the information already available. Such incremental data will reduce the inherent difficulties of time relevance and specificity in such data banks, and will reduce the problems of inappropriate application of generic data to specific situations. Indeed, the validity of the latter approach, and its confidence limits, could in itself be a subject for research.

iii Vulnerability

The human response to toxic, heat and pressure exposures is currently an area of great uncertainty, as is the question of the integration of such exposure with time to derive 'toxic' or similar loads. One aspect of this issue is the subject of a paper to be presented to another Conference by members of MHAU(23). It is a topic in which working groups of the Institution are deeply involved.

iv Mitigation

Many aspects of this problem remain to be investigated in depth. Some are based on technical issues, eg. the integrity of secondary containment in the *areas of bund overtopping, dynamic loading, thermal shock, etc. Others lie in* the 'human response' field to which I have referred earlier. Experience and earlier work has shown that the capacity for escape has an important bearing on the final outcome of any incident, but we are so far unable to model this with any degree of precision. Equally, the uncertainties associated with organised evacuation procedures need to be addressed as a matter of urgency - many people accept that Mississauga went over the top, but are less definite when asked to outline an appropriate 'bottom line' response. Indeed the desirability, let alone the structuring of an evacuation, in all circumstances, is at best unproven. Most housing in the UK would provide greater protection than that at Bhopal, but all agree that for a continuous release, an immediate refuge can develop into a place of increasing relative danger. Should we, as a consequence, deploy resources to limit release times? Is it possible to reconcile the capabilities, and the capacities of emergency *services with the predictions of risk assessments?*

v Avoidance/Prevention

These approaches are, of course, not necessarily the same. It is unlikely that the chemical industry will ever be able to operate with processes and inventories which present no offsite risk, although there are a number of advocates of changes to existing processes (and of the development of new

processes) to achieve greater intrinsic safety. There are both hardware and software elements here, of course. My own experience tells me that industry is at present happier justifying the hardware element of their prevention and avoidance techniques. I would suggest, however, that the potential for progress is by far greater in the 'software' field. I turn to this issue now.

6 HUMAN INFLUENCES

This is, of course, a subject which has already been extensively researched and debated, nationally and internationally, and there is general agreement on the importance of the issue. There is however, as yet no consensus of approach or of conclusion. The emerging methodology is producing models varying from the simplistic, to a degree of oversophistication which renders them useless as a practical tool. What we need is a practical model which can address the very complex issues involved in such a way as to enable us to build in human influences to the overall risk equation. Considerable effort has already gone in to producing human failure rates. But a failure rate approach(and there is already a human element in historical failure data) only looks at one aspect of the issue. The potential for hazard control by positive intervention and corrective action is enormous and should not be underestimated. But it brings with it both the need for a commitment to provide better training and deeper understanding for all those who might be enabled thus to intervene, and also concomitant implications for the identification of critical roles, and, for individuals at all levels, of competency. The Institution of Chemical Engineers is seeking to identify those of its members who are experienced in the risk assessment field. The Flixborough report highlighted the critical nature of the wider management role. How far should we seek to influence the development of these initiatives, and extend the recommendation of para 128 of ACMH 3 even as far as operator level?

> 'Engineers, other than chemical engineers, and scientists including chemists, physicists and biologists, may be the key responsible persons for some processes and plants, in which case they will require a similar understanding of safety. It is recommended that other professional institutions, where appropriate, should follow the example set by the Institution of Chemical Engineers'

7 THE RISKS FROM TRANSPORT

In this paper I have referred to a number of incidents involving varying degrees of catastrophe. Such a list could be extended almost indefinitely. It would include names such as Bantry Bay, Good Hope Louisiana, San Luis Potosi, and San Carlos. To date by far the largest part of the investigative effort on major hazards has been related thus far to the risk from static installations. Yet it is fair to say that some of the most catastrophic events in the historical record (and a great proportion of those involving whole tank failure) have occurred during the transport of hazardous materials by sea, road and rail. Of course, risk figures for individuals in a transport context may be very small, but the societal risk in many cases exceeds that from a fixed hazard. It is also an area in which the human element is particularly important. It is not an area where the 'segregation' approach is readily applicable.

The transport of major hazard quantities of substances is an area of risk for which further investigation has been recommended by ACMH. I would support that recommendation and commend it to you. We must address the risks from the whole of the transport operation, and this will include the risks from transit depots and loading/unloading sites of all types including major ports. We need to look at the implications of routeing and the adequacy of our current arrangements for emergency response.

To the above list of transport examples I could have added incidents involving pipelines such as Austin in Texas, Meridian in Missouri, and Ruff Creek in Pennsylvania. Most major pipelines in the UK are notifiable under NIHHS. There can be little doubt that a well designed, constructed, and operated pipeline can provide a very safe means of transport of large amounts of hazardous materials. A pipeline is not inviolable, however; and it is particularly vulnerable to third party damage. It presents a permanent risk (albeit usually very small) to the public along the whole of its length and the range of its potential consequences (because of large inventories and throughput and lengthy shut off times) considerable. The methodology for the assessment of risk from pipelines already exists, but we need to consider more deeply the implications for planning control, particularly for existing pipelines, and for emergency response.

8. RESOURCE IMPLICATIONS

In this paper I have outlined the growth of the awareness of major hazards risks and of the measures which have been developed to assess and control them. I have referred to important new Regulations about to be implemented. And I have made some suggestions for the future.

The 'reasonably practicable' criterion is only one aspect of the whole cost/benefit equation. Our resources and those of industry, in both professional expertise and financial terms, are strictly limited. I appreciate that the suggestions I have made, taken with the burden of CIMAH, will stretch those resources even further. I am well aware of the enormous economic pressures on industry, pressures which may well be intensified in the next year or two, particularly for the chemical industry. We must try to ensure, therefore, that our limited resources are deployed to best effect. But we must also meet the legitimate expectations of the public who are exposed to the risks we wish to control. The public are inevitably involved in the acceptability debate, whether it is in qualitative terms or quantified. HSE, industry and commerce have a major information role to play. It is encouraging that the Confederation of British Industry in its evidence to Royal Commission of Environmental Pollution(24) committed itself to openness subject to certain safeguards.

We must identify the information the public needs (HSE have already published draft guidelines on this) and present it in such a way that it can be placed in context with other risks. We all have a role to play in seeking an informed consensus on the industrial risks to which both employees and the public are exposed HSC and HSE are looking to the removal of certain obstacles to disclosure of information (for example, by the possible revision of Section

28 of the Health and Safety at Work etc Act 1974), and may ultimately wish to propose criteria for acceptable risk. Acceptability is a concept all businessmen and professionals are familiar with, although many of our assumptions are covert and implicit. Such assumptions will be an inevitable part of the safety cases which CIMAH will require. I suggest that CIMAH thus provides the opportunity for industry to become positively and overtly involved in the risk debate. The underpinning message of Robens was that the responsibility for the control of risks rested with those who created them. I suggest that the open commitment and involvement of industry and the professions in the matters I have outlined (and here I commend the initiatives already taken by the Institution, amongst others) is clearly a way in which that responsibility can be efficiently and effectively met.

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