THE DEVELOPMENT OF AN EFFECTIVE EMERGENCY PROCEDURE FOR A TOXIC HAZARD SITE

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A procedure to cover emergency actions following a toxic release and the equipment requirements are described. The conversion of such a procedure on paper to an effective working piece of factory organisation and the practical problems which have to be overcome are discussed.

The paper covers liaison with the off site emergency services, the unfamiliar strains placed on those services and the extent to which external inputs can divert the emergency control staff.

INTRODUCTION

The development of plans to cope with unintended deviations from normal operation has always been a feature of good management. In the case of major hazard establishments, it has become a requirement. This paper reviews the development of emergency plans for such an establishment and discusses the lessons learnt.

BASIS OF THE PROCEDURE

The major potential hazard on the particular site considered arose from the storage of a significant weight of liquid chlorine. Hazards of much smaller significance could arise from escapes of acidic fume from various sources. The site itself is relatively remote from domestic habitation but has other factories as neighbours. One side of the site abuts an estuary shore. About 1000 people could be on the site in normal daywork hours with a much smaller shift complement continuously present.

Step one in the development of an emergency procedure is to recognise and quantify the possible consequences of feasible hazards. In this case the consequences posed an obvious risk to people on the site should there be a significant loss of containment. Clearly the emergency plans had to include measures to ensure the safety of personnel on the site.

Early draft plans relied heavily on observing wind direction and moving people to open air assembly areas which were safe by reason of being either upwind or well across wind. It was never felt to be very satisfactory to ask each person to make his or her own decision on choice of refuge and various schemes to direct people were discussed.

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In the end these schemes were dismissed because of the proximity of the estuary. The toxic cloud could feasibly produce a barrier trapping groups of people between the cloud and the shore. The source of the release was close to the river wall and made moving in that direction unattractive. Moving parallel to, and in the same direction as, the cloud, because of the possible length of it, involved the risk that a change in wind direction could envelop the refugees. The decision would have been different had free escape in all directions been possible but the particular topography involved led to the rejection of this escape mode.

The alternative was to collect people in a limited number of refuge areas. These had to be well scattered about the site so as to be readily accessible and arranged so that whatever the wind direction a number would be positively clear of fume. They should be clearly marked, adequate in size and provided with some basic equipment. Ideally they would be gas tight but in practice this was not considered feasible. Schemes involving forced draught provision of uncontaminated air to keep buildings under positive pressure were considered and rejected as too fallible.

Industrial buildings tend to provide generous rates of air change and steps were taken to modify the areas chosen to limit air changes. It was recognised *that a refuge downwind of a serious escape would only provide limited protect*-ion until secondary evacuation to a clean area could be organised. The decision was taken therefore to provide sufficient emergency escape respirators of the halfmask or "grip in the mouth" variety to cover everybody. This provision gave confidence in the feasibility of secondary evacuation.

Each refuge was identified by an illuminated sign marked "Toxic Gas Refuge Area", lit during the hours of darkness except on two refuges used for daywork staff only and not required at other times because of the reduced numbers on shift. Each refuge had an appointed Marshal and Deputy Marshal, identified by an orange waistcoat. The Marshal's kit included brief refresher instructions, equipment for sealing ventilators and similar openings, roll call, sufficient respirators for the numbers anticipated in the area (generously allocated) and an emergency telephone.

All staff were instructed that in the event that they were affected by toxic gas or fume (on this site all possible escapes were immediately recognisable as dangerous by smell, irritation of the breathing passages and stinging eyes) or on hearing the gas warning they should, if outside, note wind direction from wind vanes, wind socks or chimney stacks and proceed to the nearest safe refuge. If inside they should proceed to their designated refuge.

EMERGENCY WARNING

The warning of emergency is an important feature of the system, the choice being debated between public address system and sirens. The chosen method was sirens, based upon better universal audibility. However subsequently minor emergency systems have been built up based on the greater versatility of the public address system, requiring extensions of that system to give total coverage. After installation, audibility tests were necessary to ensure that the sirens could be heard throughout the factory under all wind conditions and in fact one more siren than initially planned was required. There were areas - adjacent to crushers and in compressor houses - where an alternative was necessary and in these areas flashing lights were used.

Testing of the warning system is necessary and a regular weekly test at a fixed time was initiated, preceded by a statement of practice on the public address. Such testing has an educational function, familiarising all staff to the nature of the warning. Care is required that the test achieves its aim - it is easy to miss one failed siren unless an observer perambulates during the testing.

CONTROL STAFF

Overall control of the emergency was organised in the manner advocated in the CIA guidelines for Emergency Procedures[1]. An Incident Control group has responsibility for initiating the procedure and then concentrates on containing the incident. A Main Control Group takes overall responsibility for the site, especially for the safety of the persons gathered into Refuge Areas and calls out and liaises with the external emergency services.

Function holders in the procedure were chosen entirely from the shift workforce. A toxic emergency calls for very rapid response and there is no time to bring in off-duty staff other than for a second phase reinforcement of the procedure.

The fire service particularly emphasised the need for clear identification of responsible staff in the emergency. To this end function holders were provided with special labelled fluorescent waistcoats and in the case of the Main and Incident Controllers a uniquely coloured helmet.

A shortfall in the original plans was failure to provide pathfinder staff to act as guides for the fire service within the factory (trained in the location of hydrants and their supply capability).

DISPERSION ESTIMATION

The Works Main Control Group have to be in a position to direct the emergency services to the site by a safe route and to advise the police on the possible areas affected. This involves estimation of gas escape rate, atmospheric stability conditions and gas dispersion. The system has to be capable of giving very quick results and simple enough to be operable under the highly stressful conditions of a major emergency.

Wind speed and direction indication were provided in both the incident control and main control areas.

Gas emission rates were calculated for a variety of pipeline breaks in the plant system, using flashing flow calculations for liquid line failures.

Gas dispersion was originally calculated using the method advocated by Simmons, Erdmann and Naft[2]. The vertical dispersion was taken as 20% of the horizontal dispersion to simulate a dense gas effect. Recent comparison of the results obtained by the Gaussian dispersion model of Pasquill/Bryant (3,4) with the S.R.S. model "Crunch" indicates that for far field low concentration calculations, at the accuracy required for emergency planning, Gaussian distribution is an adequate model. (It would not be a suitable model for calculating higher concentrations at short ranges).

The limiting concentration used in the calculations was taken as 15 ppm, an arbitrary choice of significant concentration.

Initially the system was designed to produce a series of plastic isopleths, the appropriate lozenge shape being placed on an area map. This system was subsequently streamlined to that shown in Figs. 1 and 2.

Figure 1 is a simple decision tree to deduce weather stability from wind speed, cloud cover and time of day and year. Having decided on the stability the operator turns to the appropriate following chart of which Fig. 2 is a "D" stability chart. This enables emission rate and wind speed to be converted to range to the 15 ppm limit. As the direction indicators oscillate, the recorders define an arc of wind rather than a precise direction and give an indication of lateral dispersion usually greater than calculated isopleth widths.

The right hand margin of Fig. 2 has the release rates appropriate to a series of events on the particular installation marked up to aid in the early assessment of release rate by comparison with similar events.

NEED FOR PRACTICE

At this stage of development of the procedure there was superficially an effective system. Well labelled and equipped Refuge Areas, stocks of respirators, an effective warning system and communication equipment represented a substantial investment in the system. The procedure was fully documented and circulated to all function holders. Notices around the site and a hand out to all staff ensured that the evacuation procedure was fully circulated. Looking back at that stage there was a great sense of achievement. However at that stage the procedure was rather analagous to a learner driver who knows all the correct actions but has yet to develop reflexes.

When preparing a procedure, for example for a plant operation or maintenance procedure there is a built in evolutionary process. The procedure is thought out, written down and issued. It is then put into effect and the results are observed. Where the results compare with the objectives favourably the procedure is left in force. But where the objectives are not met then either the standards of performance or the methods are changed until the objectives are achieved.

In the case of the emergency procedure, fortunately the emergency is likely not to happen, but that means that the procedure is untested and the evolutionary phase is lost. Somehow that omission must be replaced, by some form of simulation. Additionally, an operator will not readily rely, in emergency, on a procedure that he has not practised and become thoroughly familiar in so that he trusts it. Just reading the procedure, no matter how beautifully presented, is no substitute for practice.

EVACUATION TRAINING

For the full works complement required to understand and follow the evacuation procedure, regular training was assisted by a tape/slide presentation. This helped with regular refresher training (once each six months) and was invaluable in giving induction training to new staff and contractors.

Practice evacuations were organised for separate departments, using a single refuge, telling people in a section to treat the weekly trial of the sirens as a real emergency, leaving sufficient staff out of the practice to keep plants operating. Such practices lack the element of surprise but if personnel revise the procedure and then go through the motions in practice, the training aims are met. And the ability of the refuge to cope with the anticipated numbers is demonstrated.

As dedication to adequate training grew the whole works was evacuated in a preannounced practice by the expedient of holding a shift on overtime for 2 hours while the incoming shift evacuates. At this stage such aspects as the full magnitude of the roll call procedure are tested and the system is demonstrated as effective to the participants.

ROLL CALL

Mention of the Roll Call raises one of the most difficult aspects of the procedure to perfect. Society expects that in an emergency the company can account for all persons on site to identify anyone missing. In practice this is a target difficult to achieve. In a toxic release the missing need to be identified very quickly if any rescue attempt has a chance of success.

Problems arise with people changing shifts, having time off, with visitors, contractors and with keeping abreast of staff changes. The basic system used was based on a computerised roll divided into the Refuge Areas expected to be used, the roll being taken by Refuge Marshals as an early task. Each refuge is contacted by central control staff for their missing and extra persons, to build up a total site roll. Early practices gave rolls completed in impressively short times. Only when the accuracy of the returns was checked was the failure of the system apparent. Regular practice transmissions of prewritten rolls, involving just the marshals and communications staff were needed to sharpen the receipt of information. Communications and recording skills should not be taken for granted. There are other common skills which can cause unexpected problems. The first procedure had the shift nurses driving the ambulance loaded with resuscitation equipment to the alternative upwind casualty centre if the normal first aid centre was downwind of a release. One nurse does not drive!

CONTROLLER TRAINING

So far nothing has been said of the main function holders in the procedure, the Incident Control and Works Main Control groups. Although the more experienced staff were concentrated in these groups a minor and relatively unimportant escape of fume demonstrated that practice was no less necessary.

For these groups training has been by "table top" simulations. For these exercises an office area was provided with sufficient telephones and simulated radio links to provide copies of the main control and incident control areas and with sufficient additional telephones to receive management call out, 999 calls, communication with simulated fire and police services and to initiate incoming calls from worried relatives, press and local radio. A number of individuals are deputed to act the parts of 999 call operator, fire station and police operators, all the management staff on the call out list, local radio station etc. The emergency scenario is preselected and presented to the Incident Control group as a series of observed phenomena. Umpires provide reactions to any actions taken and provide information which would be available from panel instruments or by observation.

The exercises start with the Incident Group in position. When they decide that they would, in a real situation, sound the emergency sirens, a public address announcement requests emergency staff to take station, which they do in the simulated area or in the case of Refuge Area Marshals, in their Refuge Areas. In each Refuge Area there is a prepared roll of persons present and a list of observed effects at that position against real time. A Marshal may thus telephone Main Control at some stage to announce worsening conditions and a need for medical help or evacuation.

The weather condition, wind speed and direction are prechosen and relayed to participants at the start of the exercise.

These exercises create a very high level of individual involvement and commitment on the part of the participants who take the simulated situations very seriously. For instance the decision to sound a major emergency may be debated at length whereas one might have supposed that the very existence of the practice would make this a self evident step. Similarly, Controllers come under considerable emotional stress as they handle the situations thrown at them.

The practices reveal a number of weaknesses in the performance of the procedures, in understanding of the intended actions or of aspects of the procedures themselves. The final phase of each simulation is a "post mortem" discussion on how the practice was handled, where mistakes were made and how the performance can be improved. The procedure thus develops into a joint effort.

The fire service officers from the local station and the police have been quick to volunteer to take part in simulations, playing their real role. This has been very rewarding, revealing differences in the perception of actions as seen by the different bodies.

Typical misconceptions were that all the crew of a fire tender driving to an incident could don B.A. and drive through a toxic cloud; that the first crews on site would set up water curtains (if roll calls are incomplete their first priority in fact is search and rescue); that wind speed and direction in kph and degrees should be in the initial request for fire service turnout (the preferred information is for positive statements of the safe route into the site). The police on the other hand do welcome precise wind information and possible range of effects.

Table top exercises are economical, very effective and well worthwhile. Personal involvement is of a high order and there is a very noticeable improvement in the way people carry out their duties.

DEALING WITH THE MEDIA

One area of emergency planning which was grossly underestimated was the role of the media. The P.R. member of staff was originally well down the call-out list, in anticipation of liaison with the media after a substantial time interval. A minor incident and discussions with other organisations who had experienced real emergencies showed that in fact the media have a most impressive fast response - a reporter is likely to turn up with the first wave of fire engines. In these days of full information there is no way anybody can have an incident in anything other than the full glare of publicity.

It is unrealistic to think that a press statement can await a full managerial conference on what has happened, well into the event. The press will insist on getting an early story in and won't mind where they get it from. The media need to be controlled and this will be much easier if you are seen to co-operate. They need an early press statement and conference and at this stage there is no harm in there being phrases like "don't know", "trying to find out". Saying nothing does not stifle comment, they will go elsewhere. Trades Union officials, fire and police officers and so called "experts" will be ready to provide information.

There is a beneficial side to the media - they give instant communication with your employees at home, their families, your shareholders and industrial peers.

They can bring offers of assistance from outside experts and from organisations like the Salvation Army, who can be useful.

The procedure requires early call out of a senior person to handle PR, with authorisation to talk, facilities to get information and desirably some training in technique.

The media enquiries put a load on the emergency control staff at an early stage when they are least free to handle distractions. Also local radio coverage produces a flood of incoming telephone calls from anxious callers who have relatives at work or want to know what is happening.

The "table top" simulations have a heavy input of "media" and "anxious relative" calls built in so that the communications staff develop a skill in answering such calls effectively and learn to handle this as part of the work load. The simulations are tape recorded so that responses can be played back as part of the learning process.

OFF SITE REQUIREMENTS

The Fire Service are well equipped to provide assistance in a toxic emergency, being trained and equipped to operate in breathing apparatus and to set up water curtains. As part of their liaison with industry they visit sites, familiarise themselves with geography, position of hydrants, etc. There should be plans of buildings (for search and rescue), plans of hydrant positions and water availability, clear rendezvous points, lists of radioactive sources available at the rendezvous. There should be training in the nature of the hazardous materials they might meet, and how they should be handled, with summary information including first aid available.

The ambulance and hospital service need facilities to cope with the particular hazardous materials involved and need to be familiar with the medical regime. Cards should be available carrying details of the specific chemical involved and the basic treatment to accompany any casualties.

Police carry a difficult responsibility for protection of the public. Liaison with them can ensure there is a system whereby they will quickly set up road blocks to prevent movement into the risk areas. Incidentally all senior staff carry "Emergency Team" cards to get them through road blocks.

The public have to be kept indoors with doors and windows closed as their best immediate protection. There are real and unresolved problems in this area. The police are not provided with equipment or training to equip them to move into contaminated areas. A loud hailer car moving through an area telling people to stay indoors does tend to bring people outside to find out what is going on. People like to act on a specific warning rather than respond to the hazard which they can detect for themselves by smell. Nevertheless the most effective solution seems to lie with educating people how best to protect themselves.

Evacuation is only likely to be the correct reaction where toxic material containment is threatened, particularly by fire, where the evacuation is precautionary.

Neighbouring factories provide a more straightforward situation. Here it is possible to discuss one's possibly hazardous interactions and set up a warning communication system and a proper response.

Factories in an area can with advantage set up mutual aid schemes covering such items as assistance with nursing, sharing B.A. cylinders, responding to transport emergencies.

CONCLUSION

In summary, the preparation of an emergency procedure as a theoretical exercise although a necessary first step, does not provide an effective emergency system. Before one can have confidence in the system it must be tested by practices and simulations. The individuals who are expected to perform the duties outlined in the procedure cannot be precipitated into an emergency on the basis of a written exercise only. They must practise the procedure until they are proficient and have trust in it. Setting up the necessary practices requires a high level of commitment. It is a necessary part of the development of an effective emergency procedure.

REFERENCES

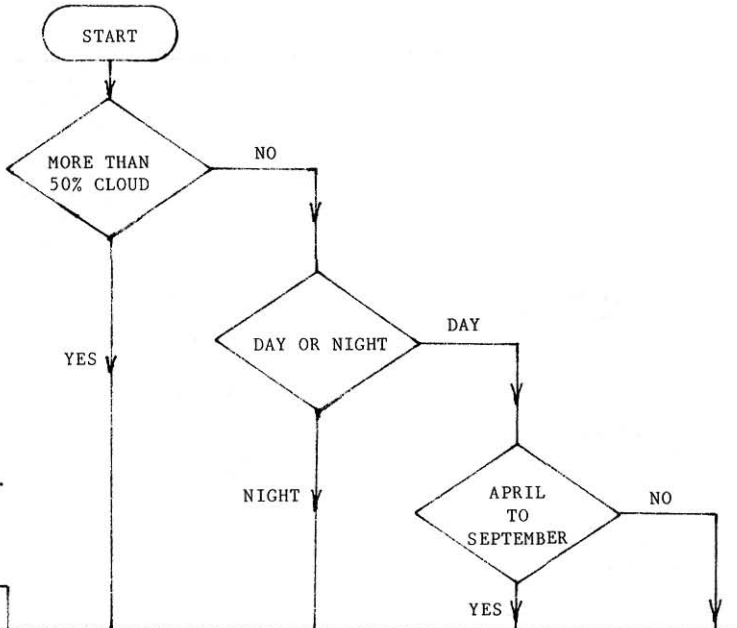
(1) "Recommended Procedures for handling Major Emergencies" 1976, Chemical Industries Association, London.

(2) Simmons J.A., Erdmann R.C., Naft B.N. 1974. UCLA-ENG-7425. U.S. Atomic Energy Commission Division of Research.

(3) Pasquill F., 1961. Met. Mag. London 90 No. 1063, 33-49.

(4) Bryant P.M., 1964 UKAEA Health and Safety Branch, AHSB(RP)R42. Harwell.

FLOW CHART 1 - SELECTION OF WEATHER CATEGORY



NOTES:

1. A summer haze, when cover is more than 50%, but is thin enough to allow sunlight through should be taken as less than 50%.
2. DAYTIME is from 1 hour after sunrise to 1 hour before sunset.
3. In fog, there is no dispersion. When the gas cloud begins to move use Category F.

WIND SPEED KM/h				
LESS THAN 12	D	F	B	C
12 - 18	D	E	C	C
MORE THAN 18	D	D	D	D

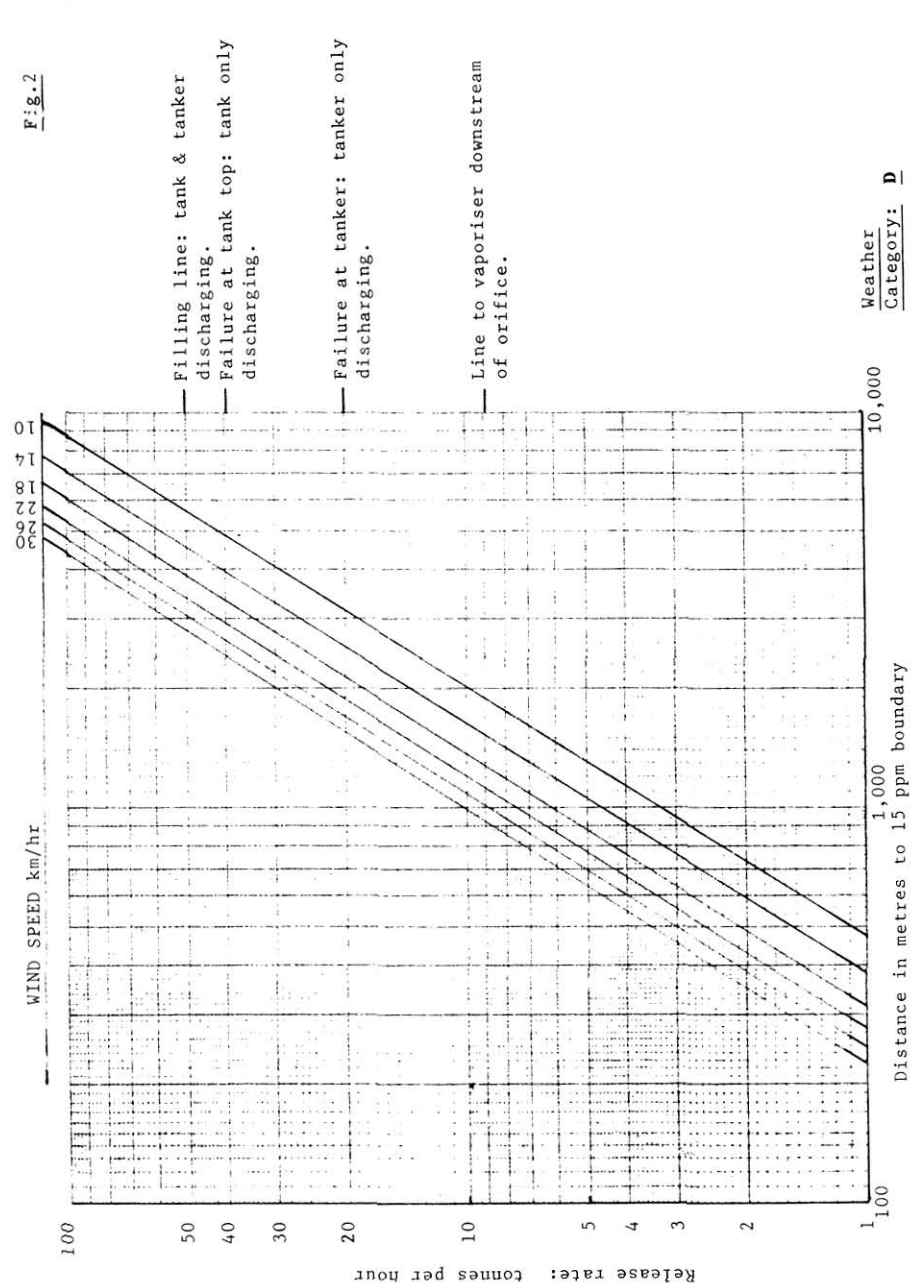


Fig.2
Filling line: tank & tanker discharging.
Failure at tank top: tank only discharging.
Failure at tanker: tanker only discharging.
Line to vaporiser downstream of orifice.
Weather Category: D
WIND SPEED km/hr
10
14
18
22
26
30
Release rate: tonnes per hour
100
50
40
30
20
10
5
4
3
2
1
100
1,000
10,000
Distance in metres to 15 ppm boundary