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EVALUATION OF PUBLIC HEALTH HAZARDS ASSOCIATED WITH CHEMICAL ACCIDENTS

V. SILANO

PANAMERICAN CENTER FOR HUMAN ECOLOGY AND HEALTH
PAN AMERICAN HEALTH ORGANIZATION
WORLD HEALTH ORGANIZATION

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VITTORIO SILANO

Department of Comparative Toxicology
Istituto Superiore di Sanitá Viale Regina
Elena 299 00136 - Rome
ITALY

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I. INTRODUCTION

The ever-increasing volume and diversity of chemicals being extracted, manufactured, marketed, stored, used or dispersed as waste, create a growing likelihood for significant accidents involving the release of potentially toxic chemicals. It is not surprising, therefore, that an exponential increase in the number of chemical accidents has been documented (1).

Chemical accidents may affect human health causing mortality and morbidity in exposed people. Illnesses caused by chemical accidents may be immediate or delayed. Delayed illnesses are more difficult to be associated with the accident than the immediate ones. Such an association for delayed illnesses would require clinical surveys and epidemiological monitorings lasting for many years after the accident. Chemical accidents may also affect human activities and/or living organisms and ecosystems.

Considering the potential damage which exposure to potentially toxic chemicals under accidental situations can cause to human health and environment, it is essential that every country develop mechanisms for effectively coping with such accidents. Most countries have some sort of emergency response system for natural accidents, but most of these systems are not prepared for the additional requirements for information and expertise associated with an accidental release of toxic chemicals. In fact, in such a case, it is also necessary to know the toxic, physical, and chemical properties of the chemicals released, the levels of risk involved in exposure of human beings, and possible ways to deal with them.

This situation demands for a more adequate chemical emergency preparedness particularly in countries characterized by a rapid growth of the agro-industry, of mining and metal production and the chemical and energy transformation industries, where situations prone to chemical acciddents are more likely to occur.

Chemical emergency preparedness (FIG. 1) refers to all documents, activities, formal and informal agreements, and social arrangements intended to reduce the probability of accidents involving the release of chemicals and the severity of the disruption caused by their occurrence (2). After a chemical accident has occurred there are three main phases of activity that follow (FIG. 1): (i) the *emergency phase*, which may be concluded in a relatively short time; (ii) the *follow-up phase*, which is the real substance of emergency response activities and may continue for days; and (iii) the *rehabilitation phase*, which may take weeks, months and even years to accomplish.

To be successfully and timely performed all these activities require accurate planning before the accident takes place to develop effective systems to respond to specific emergencies, and to carry out rehabilitation of affected people and areas following the accident. The first key step for all the activities aiming at controlling chemical accidents is the evaluation of accident hazards imposed on the community by installations, developments and/or operations involving potentially toxic chemicals.

This evaluation consists of three conceptually distinct stages:

(i) *identification and analysis of hazard sources*, i.e. any situation that has the potential for causing damage to life, property and/or the environment;
(ii) *identification and analysis of vulnerable areas*, i.e. the susceptibility of life, property and/or the environment to damage if a hazard manifests its potential;
(iii) *assessment of risks*, i.e. the probability that a hazard manifests itself and that damage to life, property, and/or the environment occurs (3, 4).

The WHO/EURO, acting on behalf of the International Programme on Chemical Safety, has already produced guidelines to assist countries in developing strategies for preparing effective contingency planning systems to respond to specific emergencies, (Annex 1) and for developing adequate rehabilitation systems following chemical accidents (Annex 2). This paper is devoted to a discussion of prospective and retrospective approaches for the evaluation of hazards associated with chemical accidents.

II. TYPES OF CHEMICAL ACCIDENTS

Chemical accidents may arise in a number of ways, and no two accidents are exactly the same. Some of the more important types are as follows:

- disaster/explosion in a plant or in storage facility
- accident during the transportation of chemicals
- misuse of chemicals resulting in contamination of food stuffs or of the environment.
- improper waste management

There are distinct differences between those accidents such as explosions, trasportation accidents involving railway, highway and waterborne craft, which have easily identifiable point sources, and those accidents which derive from point sources which have not been identified, such as an unknown contaminant in a food supply. It should be obvious that an identified point source is usually going to be easier to evaluate, in terms of associated hazards, to contain, and to manage than an unknown point source. The same considerations hold for mon-point source accidents.

A general sketch of the possible combinations of known and unknown sources, known and unknown chemicals, related to point and non-point sources is shown in FIG. 2. The most difficult combination to evaluate, in terms of associated hazards, and to manage, is II-2-B, an unknown non-point source of an unknown chemical; the easiest I-1-A, a known point source of a known chemical. An example of the former might be an abandoned or hazardous dump site, where neither the extent of the contamination, nor the chemicals involved are known. An example of the latter might be the derailment of a placarded train carrying a particular chemical. Variants between these extremes encompass the range of possible accidents to be considered.

The main differences between transportation accidents and those in stationary facilities are as follows:

(a) Transportation accidents may occur at any location, and hence it is difficult to prepare any site -specific hazard evaluation or contingency plan.

(b) They may occur in locations remote from emergency services, resulting in a delay in obtaining any expert help or advice.

(c) Transportation routes are inextricably mixed with population concentrations (specially in large urban centres), and thus many people may be exposed to toxic hazards.

(d) The result of an accident occuring at any location may create a disposal (after containment) problem, requiring further transportation to an off-site location.

III. EVALUATION OF HAZARDS

To assess the potential hazard in a specific situation, two different conceptual approaches can be used: the predictive (prospective), and the historical (retrospective) one. Actually, these two approaches are always used in a complementary way. In fact, the techniques of prediction allow to reach a better understanding of historical records and enable to foresee situations, for which historical evidence is lacking or insufficient. On the other hand, for predictive techniques to be valid they must lead to results which are in agreement with the generality of historical experiences of chemical accidents (7).

It is sometimes possible to make direct use of information relating to previous accidents in assessing possible consequences of an accident, but it is often necessary to adjust historical experience to consider different circumstances, wather conditions, population distribution and so on, as relevant for the specific situation examined. Theoretical approaches, designed to indicate the possible consequences of various types of accidents, must take into account all the relevant factors and, in the meantime, pay due regard to assumptions that are reasonable and founded on reliable and realistic data. These problems require a theoretical approach which embodies imagination of high quality to foresee situations that are without direct historical precedent but are, nevertheless, not beyond the bonds of credibility (7).

According to the type of situation being considered there are 4 different levels of responsibility for carrying out evaluation of hazards. The are:

a) *Level I (Operator)*
An operator is any activity within a single facility, factory or organization having a potential for a chemical accident (e.g. individual manufacturing plants, stores and wholesalers of chemicals, vehicles transporting chemicals and units responsible for waste management). Every operator has to conduct an evaluation of hazards associated with chemical accidents and identify possible remedial measures. The results of this activity have to be transmitted to public Authorities for supervision.

b) *Level II (Local/Community)*
The responsible Officers of each community should supervise the hazard evaluation carried out by all the operators within the jurisdiction of competence and consider possible hazards deriving from interaction of the activities carried out all the operators within the community.

c) *Level III (Regional/National) and Level IV (International)*
These levels are needed for inter-jurisdictional or more serious accidents which exceed the boundaries and/or resources of one community or country.

In view of the difficulties possibly associated with the process of hazard evaluation, some countries have found it useful to establish one or more scientific institutions to help the relevant level involved in the exercise. Establishing a country-wide programme for evaluating public health hazards associated with chemical accidents requires time and considerable efforts. If such a system does not exists and resources are limited, it could be appropriate to identify within a country priority areas for hazard evaluation.

As it has already been mentioned in the introductory section, the evaluation of hazards conceptually consists of three stages: (i) identification and analysis of hazard sources; (ii) identification and analysis of vulnerable areas; and (iii) assessment of risks.

III.1. *Identification and analysis of hazard sources.*

Possible sources of release of hazardous materials include raw material extraction and refining, farm and related industry, secondary manufacturing and/or processing, generation of electricity, services, transportation, storage facilities and management of wastes. For a detailed discussion of this subject see Annex 4, paragraph 1, of this paper. This phase should aim at (5):

(a) *Identifying vulnerable (weak) points, process and/or activities.*

This analysis should provide information on the following questions:

— Where, within the plant or system of operation, is the potential for a major accident, e.g. as a result of a malfunction of normal operating procedures, fire, explosion, intervention from outside, or accidental, large-scale release of toxic chemicals?

— Is any "weak" point sufficiently far away from neighboring industrial installations to prevent a "domino effect", where a failure at one point leads to more serious failures elsewhere?

— Does the design and layout of the plant, or system of operation of an enterprise, permit the effects of minor accidents to be localized without serious risk of spreading to the rest of the plant or to the surrounding area?

— How adequate are existing resources and arrangements to handle the most serious foreseeable emergency?

(b) *Estimating nature and amount of possible chemical emissions*

The key information that is needed is the nature and the toxic, physical properties of the chemicals involved. An estimation should be made of what chemicals might he released, in what forms, and quantities. Their classification may include flammable liquids and solids, combustible liquids, oxidizing materials, explosives, toxic chemicals, corrosive materials, ect. Attention should be paid not only to the original chemicals, but also to possible products of their reactions during an accident and/or during the process of dispersion in the environment.

(c) *Estimating pattern of possible chemical emissions*

The emissions, as well as the resulting ambient concentration of chemical releases, will depend not only on the processes and operations which may be involved, but also on the concrete course of the accident, as well as on local climatic conditions and prevailing winds. It would be appropriate to use, where suitable, existing simulation models, particularly dispersion models, including a prediction of the changes in toxicity, and concentration with time. There is a variety of gas dispersion models that have been devoloped to sketch trajectories under various climatic and wind conditions, which could assist in establishing the expected limits of the effect of the accidente (8, 9).

To gather all the information needed for the identification of hazard sources there are two possible approaches. The first one consists in contacting the managers in charge of the activities and interviewing them in person or through a written check list/questionnaire. Many examples of check list/questionnaire are available (10-15) and Annex 3 is one of those applicable to stationary facilities. Another approach used for hazard identification at the plant level is the safety audit (16) that consists of a detailed analysis of the industrial activity considered with the aim of minimizing losses and is usually carried out by a team of professionals who produce a formal report and action plan (3).

An example of how the gathered information can be used to determine the relative degree of source hazardousness is shown in Table 1.

III.2. *Identification and analysis of vulnerable areas*

The aim of this stage of the hazard evaluation process is to determine whether the effects of an accidental release could extend beyond the particular facility. This requires (i) the identification of the areas in the community that that could be affected by the chemical release and (ii) the examination of these areas to determine the population and facilities located there (16).

As far as the identification of susceptible areas is concerned, the impact range of a hazardous release depends on the amount of the chemical(s) spilled, the nature of the chemical(s) and the dynamics of release. For vapors released in a chemical spill, there are several Emergency Action Guides (17-19) that provide guidance on *evacuation distances* from varying-sized spills of a large number of chemicals from containers located outdoors. This approach can be applied to both stationary facilities and routes used to transport chemicals. The susceptible area for the transportation routes will be the area within the specified evacuation distance for the entire length of the route in view of the fact that the chemical spill can take place anywhere along the route. Moreover, the potential area that could be affected by runoff into a waterway or storm drain needs to be evaluated by means of an examination of the terrain and potential flow patterns at specific sites. It should be understood that, for a given accident, areas lying beyond the suggested evacuation distance are not meant to be completely safe from a chemical release (16).

Once the susceptible areas around each possible site of a chemical spill within the community have been identified, the characteristics of these areas should be reviewed. The residential population should be estimated as well as the number of persons who may be present at commercial, industrial and recreational facilities. Any special facilities with dependent populations or where population density is especially high (e.g. hospitals, schools, and playgrounds) should be also noted. Similarly, roadways with large volumes of traffic, water supply sources, dairy farms, wastewater treatment plants, and sensitivie environmental areas (e.g. coastal areas, wildlife habitats, historical and archaeological sites) should be considered. Fire and police departament generally are good sources for these types of information.

An example of how community characteristics of the susceptible areas can be used to determine the realtive degree of community vulnerability is shown in Table 2 (16).

III.3. *Assessment of risks*

The aim of this stage of the hazard evaluation process is to establish what is the likelihood that the hazard present in the source manifests itself and how the accident would affect the vulnerable areas. The methodologies used in risk assessment can be qualitative and quantitative (3). The first group includes methodologies based on expert judgement (10, 20, 21), whereas the second group includes methods such as Fault Tree Analysis (11, 22, 23), Event Analysis (11, 24), Human Error Prediction Studies (25) and Epidemiological Approach Studies (22, 26).

Trying to estimate the probability of a chemical accident is the most difficult part of the whole hazard evaluation process. Attempts to quantify the likelihood of a spill are time-consuming and, even if based on very sophisticated techniques, can lead to controversial results. The probability of an accident can more easily be estimated in qualitative terms by means of qualitative categories such as "low", "medium", and "high" or simply "likely"/ "unlikely. Additional inputs which may add confidence to an assessment of the probability of an accident are information on frequency of chemical handling or movement, records of previous chemical accidents, and truck and rail accident data.

In order to predict what would happen in the event of an accident, it is advisable to map sources of hazardous materials, important transportation routes and sensitive areas. All the complications of a large accident and the effects of natural disasters on the ability to cope with the accompanying accident should be considered as well as possible complicating factors such as traffic jams, business closure and reduced availability of manpower for emergency squad. Much can be learned also in this respect from retrospective studies of past accidents (see section V).

IV. SELECTION OF REMEDY

Once the likely causes of accidents have been identified, the next phase is the selection of a remedy from among the available possibilities. The guiding principle in the process is, if possible, to design the hazard out of the system or to minimize the probability of failture by modifying individual components, or to select more realiable alternatives, if available. A less satisfactory means of control is to add warning and protective devices to the basic design. The least desirable is to include hazard controls into training, operating, and maintenance procedures. Other possible outputs include a formalized set of emergency procedures, indicating what possible protective or remedial measures might be taken to help minimize the adverse impacts of expected chemical emissions on the public and the environment. In particular, the hazard evaluation provides guidance not only on the type of contingency plan required and types of response to emphasize, but it also helps in establishing contingency planning priorities. The hazardousness of the source of the spill can be combined with the degree of community vulnerability and with the probability of the accident to determine contingency planning pririties as shown in Table 3.

V. RETROSPECTIVE STUDY OF CHEMICAL ACCIDENTS

The study of past accidents, their courses and effects, and the circumstances in which they occurred, is basic for identifying accident-prone processes and situations as well as impacts of accidents on human health and the environment. This facilitates the definition and implementation of preventive and emergency response measures.

V.1. *Usefulness and Applications*

If adequate and sufficient data are available, retrospective studies may provide enlightening results. For instance, in 1979, an analysis of major incidents involving the chemical industry showed (1) that accidents were increasing exponentially in number, but not in severity, despite the increasing complexity of chemical plants. A general review of rail transportation accidents showed (27) that a considerable reduction in both knowledge and security of confinement occurs during storage and shipment to users far from the manufacturing plant. Retrospective studies indicate that the incidence of chemical spills is related to the volume produced and transported. A Canadian study (28) revealed that ten chemicals accounted for 37% of the number of spills, 50% of the supply volume, and 83% of the spill volume. The study also revealed that 150 chemicals encompass well over 90% of the number of spills and the spill volume X. These findings can assist response organizations to establish a priority for the allocation of resources, in order to develop the technology for responding to loss of containment, rehabilitating the site, and ensuring the health and safety of response personnel. Furthermore, an American study (29) examined primary causes of a large number of spills and determined the probable hazard potential. In descending importance these were: tank ruptures, 0.23; tank overflow and other leakage, 0.19; failure of hoses and transfer systems, 0.08; rupture or puncture of containers other than tanks, 0.03. As shown in Table 4, basically three pesticides (i.e. parathion, endrin and alkyl-mercury derivatives) have been responsible for the most severe accidents, involving ingestion of pesticides, in the period 1940-1975. Knowledge of the probable causes of equipment failure is extremely useful to several groups: to designers of emergency response equipment; and also occupational health and safety professionals, required to assess the consequences of approaching the spill and to select personnel and protective equipment appropriate to the circumstances. Moreover, accidents grouped according to causation, such as unsafe acts, reasons for unsafe acts, mechanical or physical hazards, and underlying causes (managerial or supervisory), provide insight into the deficiencies of procedure, equipment and personnel most likely to be experienced on the site.

An interesting approach to retrospective study of chemical accidents is that adopted by the advisory committee on major hazards set up by the Health and Safety Commission (UK), towards the end of 1974, to consider the safety problems associated with large-scale industrial premises conducting potentially hazardous operations (7). In order to assess the frequency, causes, and consequences of major accidents, the committee studied summaries and reports of recorded accidents that have occurred in the U K and overseas, in particular those which involved:

(i) toxic gases which, following release in tonnage quantities, were lethal or harmful for considerable distances from the point of release.

(ii) extremely toxic material which, following release and dispersion in kilogramme quantities, was lethal or harmful for considerable distances from the point of release.

(iii) flammable liquids or gases which, following release in tonnage quantities, formed a large flammable cloud, which in turn burnt or exploded.

(iv) unstable or highly reactive materials, which have exploded.

The committee restricted itself to studying the number of fatalities, because injuries were less quantified, and available information was frequently unreliable. In the course of this study, the committee calculated "mortality indices", i.e. the number of fatalities per tonne of material released, because this was considered as a possible way of comparing various categories of hazard.

The major proportion of the tonnage toxic releases recorded refer to chlorine (Table 5). Some of these releases resulted from hydrogen, generated by the same electrolytic process that produced the chlorine and finding its way into the chlorine storage, where it reacted explosively. The analysis of the data also showed (FIG. 3) that in recent years operational practices, engineering techniques, and mitigatory measures intended to reduce fatalities, have considerably improved. Most of the other recorded toxic releases of significance relate to ammonia, a gas which has also been produced and used in large quantities for over half a century. Data reported in Table 6 indicate a lower mean mortality index for ammonia, than for chlorine which is consistent with the lower toxicity of ammonia, as compared to chlorine (7).

In 1972 Strehlow drew attention to the increasing danger from the deflagration of unconfined vapour clouds. His data appear to show that the frequency of incidents was increasing at a significant rate; from about one per decade, to a rate of over 60 per decade. The analysis carried out by the UK Advisory Committee showed that there has been a greater number of releases of flammable, than of toxic materials (7). Table 7 gives examples of incidents that have occurred with flammable materials, and provides an indication of what can happen. However, the list reported in Table 7 is selective, and incidents where ignition did not occur have been excluded. Table 7 also shows that cross-country pipelines, carrying gas or liquified gases under high pressure, contain enough material to produce a significant vapour cloud in the case of a fracture.

Another potential source of an explosive release of energy is a range of substances (e. g. acetylene, ammonium, nitrate, sodium, chlorate, nitrocellulose compounds, peroxides, and ethylene oxide) which are highly reactive or unstable when subjected to pressure, temperature, mechanical force, or when mixed with other reactive materiales (Table 8). Of these substances, ammonium nitrate has been the cause of some disastrous explosions, although in more recent times, such events have become a rare occurrence. A book on uncontrolled chemical reactions with as many as 7,000 entries is available (30).

Another important source of accident hazards is dust explosion. Such dust explosions have usually, but not exclusively, taken place in premises proccessing grain into animal or human food-stuffs. Fatalities are usually the result of the collapse of buildings or structures, and to this extent the effects are localized. It is generally considered that the potential hazard exists in the circumstances of the production of sugar, starch and flour, where large quantities of flammable dust are processed in tall or multi-stored structures of heavy construction. In this respect, premises in which large quantities of aluminium or magnesium powder are processed are a matter of particular concern.

On the basis of the analysis carried out, the UK Committee concluded that tonne-per-tonne conventional explosives, ammonium nitrate, flammable gases and chlorine, seem about equally hazardous, with ammonia appearing to be less dangerous (7). However, the mortality indices calculated from this evidence should be used as no more than a framework of reference, due to the fact that variations in the circumstances of release give rise to a widely differing number of fatalities (Table 5). This is also shown for chlorine by a major train derailment which occurred just outside of Toronto, Canada, in 1979. One of the cars, containing tonnes of chlorine, was ruptured, and the gas escaped. A high number fatalities might have occured, but the adjacent car, which contained liquified propane, exploded and caught fire simultaneously, resulting in a convectional up-draught, which carried the chlorine high into the atmosphere, where it diluted and dispersed safely.

Another interesting type of retrospective study of chemical accidents, carried out by the UK Advisory Committe, has dealt with formation behaviour and explosion of vapour (7). The committee reviewed the available evidence and discussed the sources, characteristics and factors that affect the magnitude and destructiveness of vapour cloud explosions. This includes the quantity of material, the fraction likely to flash off to form a cloud, the composition of the cloud, the extent of drift and the pressure and duration of the blast. While it is not appropriate here to discuss in detail the approach used —the reader is referred to the original publication for this aspect— it is worth noting that guidance could be given on the likely strength, duration and range of blasts which will be useful in the consideration of the design of buildings on major hazard sites. Values can be calculated for these parameters, using knowledge of the behaviour of structures, subjected to known degrees of blasts from high explosives.

V. 2. *Limitations*

There are a number of factors that make it difficult to carry out satisfactory retrospective studies of chemical accidents, and may affect the quality of the results. The main problem is that available descriptions of chemical accidents, only seldom give a clear picture of relevant accident features (e.g. source, cause, reason, site, amount and properties of chemical(s) released, main routes of human exposure, consequences). Available information is often based on reports from people who could well have been in considerable danger, who may have been subject to shock, or who did not fully understand the technical implications of what they were witnessing. All are factors which are likely to add to the well-known fallibility of eye-witness accounts. Furthermore, it has been noted (7) that the data quoted in the original reporting by the news media have a great persistence and can override more authoritative data arrived at later by official inquiries by technically competent investigators. Another problem is the generally inadequate quantification of accident impact on human health, (except perhaps for the number of fatalities), and on the environment. Moreover, whereas major accidents are normally the subject of official inquiries by the authorities, minor accidents, especially where fatalities have not ocurred, are often not scrutinized in detail, or not even reported.

V.3. *Data acquisition*

Careful reporting and classification of data concerning chemical accidents, possibly according to an internationally-coordinated system, is the fact most likely to greatly improve the quality of retrospective studies of chemical accidents and, therefore, our capability of learning lessons from past accidents, and of coping with future ones. If some international agreement and co-operation can be achieved on these issues in the near future, we might be able, among other things, to considerably improve the possibilities of:

— detecting major trends, leading to the identification of situations prone to accidents and, therefore, to prevent more efficiently particular types of accidents which tend to recur;

— obtaining more easily useful information and guidance in planning and implementing rehabilitation of affected people and areas;

— obtaining data quickly to better respond to chemical accidents under emergency conditions.

Data on accidents, involving the release of potentially dangerous chemicals, can be reported and classified for many differente purposes, and according to a number of different criteria. Annex 4 deals with a global approach to identify, report and classify data which should be known and reported in relation to any accident. There are 12 main data categories to be taken into account, namely source, apparent cause, apparent reason, site of accident and area affected, amount of chemicals released and/or recovered, properties of chemical(s) released, dynamics of chemical release, main routes of human exposure, human health impacts, environmental, social and economic impact, environmental rehabilitation method(s), and level of resources management for emergency response or rehabilitation.

Each one of these categories consists of sub-categories, and some of the sub-categories are further sub-divided into groups. All these are detailed and defined in Annex 4 to provide at least one practicable option to those who will be responsible for reporting and coding chemical accidents. Some of the categories included are such that no coding may be possible at the time of initial reporting, although it could be possible at later stages. This implies that reporting chemical accidents according to the global approach, put forward in Annex 4, needs some periodical up-dating according to the development of knowledge on relevant features of accidents. However, it is advisable to adopt these criteria from the very beginning, as this will simplify further work and will help focus attention on more important information to be gathered. It is self-evident that a complet and adequate reporting of some accidents, according to all the above criteria, may prove to be impossible, due to a lack of sufficient information, or may have to wait many years, (e.g. some accidents cause delayed health and/or environmental effects). It cannot be emphasized enough that careful reporting and classification requiers well trained and knowledgeable personnel. The emergency and rehabilitation teams dealing with the accident can significantly contribute by ensuring a proper collection and classification of relevant data. Special attention to this issue should be given in the final reports of the emergency response and rehabilitation work.

VI. CONCLUSION

Although in many countries chemical industry, as compared to other types of industry, has good safety records, there is a strong need for an increases awareness of potential dangers associated with improper handling and disposal of chemicals. It is essential that the growth of chemical industry keeps pace with prevention of accidents and, when this fails, with mitigation of consequences. This is only possible with the development of an adequate chemical emergency preparedness; this is not costly and in a long run pays for itself. It is relevant to quote here the detailed recommendations to governments, scientists and industry of a WHO/IPCS working group, held in Bilthoven in 1981, and reported in Tables 9-11. These recomendations help to understand how an adequate chemical emergency preparedness can be developed and stress the importance of evaluating public health hazards associated with chemical accidents, that is the matter covered by this paper.

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TABLE 1

DEGREE OF SOURCE HAZARDOUSNESS BASED ON CHARACTERISTICS OF POSSIBLE SPILLS*

Characteristics of the possible spill	Low Source Hazardousness	Moderate Source Hazardousness	High Source Hazardousness
Flammability, explosivity, corrosivity, or toxicity of chemical(s) involved	Low	Medium	Medium/High
Number of chemicals released	One	One or more	One or more
Amount(s) released	Small/medium	Medium	High
Rate(s) of release	Slow/medium	Medium	Medium/Fast

* The ability of source personnel to cope with the spill is assumed to be in all cases adequate.

TABLE 2

DEGREE OF COMMUNITY VULNERABILITY BASED ON POPULATION AND FACILITIES LOCATED WITHIN SUSCEPTIBLE AREAS*

Community Receptors located whithin the Impact Range of the Hazardous Chemical	Low Vulnerability	Moderate Vulnerabiliy	High Vulnerability
Population	None/few	Small/medium	Large
Land use	Rural, agri-cultural	Residential, comercial, industrial	Schools hospitals high-density residential
Transportation	Access roads	Arterials, highways, railways	
Water supply	None	Surface water or wells	Municipal water treatment plant, water supply intakes

* Source: Powers, J.E., Pultz, S., Paxton, K and Hsu Hway-Ling, Guide to developing contingency plans for hazardous chemical emergencies. Center Planning and Research Inc., Palo Alto, Ca. U.S.A. 1981 and Chemical Industry Safety and Health Council. Recomended procedures for handing major emergency. Item 5, 2nd. ed. London, 1976.

TABLE 3

CONTINGENCY PLANNING PRIORITIES AS A FUNCTION OF COMMUNITY VULNERABILITY, ACCIDENT SOURCE HAZARDOUSNESS AND ACCIDENT LIKELYHOOD

Planning priority	Community Vulnerability	Source Hazardousness	Accident Likelyhood
1	High	High	High
2	High Moderate	High Moderate	High High
3	Moderate High	Moderate High	High Moderate
4	High Moderate	Moderate High	Moderate Moderate
5	Moderate	Moderate	Moderate

TABLE 4

THE TEN MOST IMPORTANT TOXIC ACCIDENTS CAUSED BY PESTICIDES, 1940-1975

Compound	Kind of pesticide	Cause	Total of poisoned people	Mortality	Place & Year
Methylmercury	Fungicide	Mixed with food	6530	459	Iraq, 1973
Endrin	Insecticide	" " "	691	24	Qatar, 1970
Parathion	"	" " "	600	88	Colombia, 1967
Parathion	"	Doubtful	559	16	Mexico, 1968
Parathion	"	"	360	102	India, 1958
Ethylmercury	Fungicide	Mixed with food	321	35	Iraq, 1961
Fluor	Insecticide	Consumption of insecticide	260	47	U.S.A. 1943
Parathion	"	Mixed with food	200	8	Egypt, 1958
Endrin	"	" " "	183	2	Saudi Arabia, 1967
Endrin	"	" " "	159	0	Wales, 1956

TABLE 5. RELEASES OF CHLORINE

	Location	Date	Area/ side	Source of leakage	Quantity released (tonnes)	Number of fatalities
1	Baton Rouge Louisiana USA	10 12 76	Factory	Storage tank	90	0
2	Rauma Finland	5 11 47	Factory	" "	30	19
3	Cornwall Ontario CANADA	30 12 62	Urban/Rural	Rail tanker	28	0
4	Griffith Indiana USA	13 3 35	—	Rail tanker	27	0
5	La Barre Louisiana USA	31 1 61	—	" "	27	0
6	St Auban France	13 12 26	Factory	Storage Tank	24	19
7	Syracuse New York USA	10 5 29	"	" "	24	1
8	Zarnesti Rumania USA	24 12 39	"	" "	26	60
9	Wyandotte Michigan USA	1917	Urban	" "	17	1
10	Chicago Illinois USA	4 2 47	Urban	Rail tanker	16	0
11	Niagara Falls New York USA	8 2 34	Factory	Rail tanker	15	1
12	Walsum West Germany	4 4 52	Factory	Storage tank	15	7
13	Brandtsville Pennsylvania USA	28 4 63	Rural	Rail tanker	8	0
14	Mjodolen Norway	24 1 40	Factory	Rail tanker	7	3
15	Freeport Texas USA	1 9 49	Factory	Pipeline	4	0
16	Lake Charles Lousiana USA	10 3 56	Factory	Connecting pipework	3	0
17	Johnsonburg Pennsylvania USA	12 11 36	Factory	Rail tanker	2	0
18	Mobile Alabama USA	12 7 64	Factory	Pipeline	Unknown	1

Mean mortality index $= \frac{\text{Total number fatalities}}{\text{Total amount lost}}$

based on incidents Nos. 1—17 in Table $= \frac{112}{361} = 0.3$

TABLE 6. RELEASES OF AMONIA

Location	Date	Area/ site	Source of leakage	Quantility released (tonnes)	Number of fatalities
Floral Arkansas USA	5 6 71	Rural	Pipeline	600	0
Enid Oklahoma USA	7 5 76	Urban	Pipeline	500	0
Conway Kansas USA	6 12 73	Rural	Pipeline	277	0
Landskrona Sweden	16 1 76	Port	Ship-storage connection	180	2
Blair Nebraska USA	16 11 70	Rural	Storage tank	160	0
Crete Nebraska USA	18 2 69	Urban	Rail tanker	90	9
Belle West Virginia USA	21 1 70	Urban	Rail tanker	75	0
Texas City Texas USA	3 9 75	Urban	Pipeline	50	0
Potchefstroom S. Africa	13 7 73	Urban	Storage tank	38	18+
Houston Texas USA	11 5 76	Urban	Road tanker	19	6
Lievin France	21 8 68	Urban	Road tanker	19	6

$$\text{Mean mortality index} = \frac{\text{Total number fatalities}}{\text{Total amount lost}} = \frac{41}{2008} = 0.02$$

TABLE 7. SUDDEN RELEASES OF FLAMMABLE GASES OF VAPOUR

	Location	Date	Area/site	Source of Leakage	Nature of Incident	Material Involved	Quantity of Material Lost (Tonnes) Total	Before Ign.	Time to Ignition	Number of Fatalities *
1	Austin Texas, USA	22 2 73	rural	pipeline	fire	NGL	530	80-100	10-12	6
2	Climax Texas, USA	29 6 74	rural	rail tanker	explosion	vinyl chloride	more than 100	100	short	0
3	Decatur Illinois USA	19 7 74	urban	rail tanker	explosion and fires	isobutane	not known	69	10	–
4	Port Hudson Missouri USA	9 12 70	rural	pipeline	explosion	propane	360	60	24	0
5	East St. Louis Illinois USA	22 1 71	urban	rail tanker	explosion	propylene/ propane	more than 56	56 max	1	0
6	Pernis Holland	20 1 68	factory	storage tank	explosion	mixed hy-drocarbons	more than 50	more than 50	8	2
7	Flixbor-ough UK	1 6 74	factory	chemical reactor	explosion	cyclo-hexane	more than 40	40	less than 1	28
8	Ludwig-shafen Germany	28 7 48	factory	rail tanker	explosion	demethyl ether	30	30	not known	207
9	Meldrim Georgia USA	28 6 59	rural	rail tanker	fire	LPG	36	18	short	23
10	New Berlin New York USA	25 7 62	urban	road tanker	fire	LPG	13	13	not known	10
11	Los Ange-les, Cal. USA	18 1 43	rural	road tanker	fire	butane	8	8	not known	5
12	Beek Holland	7 11 75	refinery	reactor	explosion	propylene fraction	5.5	5.5	2	14
13	Longview Texas, USA	25 2 71	factory	1/2" diame-ter pipeline	explosion	ethylene	'tonnes'	0.5	not known	4
14	Cleveland Ohio, USA	20 10 44	urban	bulk storage	fires and explosions	NGL	more than 2000	not known	short	128-136
15	Hearne Texas, USA	14 5 72	rural	pipeline	explosion and fire	crude oil	1000	not known	270	1
16	Devers Texas, USA	12 5 75	rural	pipeline	explosion	NGL	800	not known	7	4

Cont. Table 7

	Location	Date	Area/ Site	Source of Leakage	Nature of Incident	Material Involved	Quantity of Material Lost (Tonnes) Total	Before Ign.	Time to Ignition	Number of Fatalities
17	Lake Charles, Louisiana USA	8 8 67	refinery	storage sphere connection	explosion	isobutane	40	not known	not known	7
18	San Carlos Spain	11 7 78	holiday camp	road tanker	fire	propylene	22?	not known	short	more than 150
19	Natchito-ches Louisiana USA	4 3 65	urban	pipeline	explosion	natural gas (methane)	not known	not known	17	21
20	Amsterdam Holland	10 8 71	factory	–	explosion	butadine	not known	not known	more than 45	8
21	Antwerp Belgium	10 2 75	factory	compressor pipe	explosion	ethylene	not known	not known	4	6
22	Umm Said Qatar	3 4 77*	refinery	storage tank	explosion and fires	NGL	not known	not known	not known	6
23	Petal City Mississippi USA	25 8.74	storage-plant	underground storage cavern	explosions	butane (LGP)	several thousands	not known	not known	0
24	Plaque-mine Louisiana USA	3 5 63	factory	reactor	explosion	ethane-ethylene mixture	not known	not known	0.5	0

mean mortality index based on incidents when the amount released before ignition can be estimated ie Nos. 1-13 in table)

$$= \frac{\text{total number of fatalities}}{\text{total amount lost before ignition}} = \frac{306}{530} = 0.6$$

Mean mortality index (based on incidents when the total amount released can be estimated, ie Nos. 1-12 & 14-18)

$$= \frac{\text{total No. of fatalities}}{\text{total amount released}} = \frac{599}{5090} = 0.1$$

Confined and unconfined explosions have not been differentiated here because we had insufficient information to do so. This table is in two parts; items 1-13 are listed in order of magnitude of the quantity of material lost before ignition. This information is not given for items 14-24 which are therefore listed in order of magnitude of the total quantity of material lost.

* Because of conflicting official reports the exact number of fatalities is uncertain; we have identified their probable range.

** Based on unofficial press reports.

The table has a preponderance of incidents which involved road or rail tankers. This may reflect the fact that such incidents are probably subject to more rigorous and accurate reporting, particularly in the USA by the National Transportation Safety Board. They have been included to indicate the possible effects of the release of flamable materials although the circumstances of release are not of direct relevance to the work of the committee.

Source: Health and Safety Commision. Advisory Communitte on Major Hazards, Second Report. Health and Safety Executive, London (1979).

TABLE 8. SERIOUS INCIDENTS INVOLVING REACTIVE SUBSTANCE

Location	Date	Area/Site	Circumstances	Material Involved	Tonnes	Number of Fatalities
Oppau Germany	21 9.21		Store exploded	Ammonium Nitrate	4000	561
Texas City Texas, USA	16 18 4 47	Docks	Two ships blew up	Ammonium Nitrate	About 4000	550
Brest France	28 4 47	Docks	Ship blew up	Ammonium Nitrate	2500	21
Doc Run New York	17 5 62	Factory	Storage tank blew up, aerial explosions followed	Ethylene Oxide	35	1
Antwerp Belgium	4 6 64	Factory	Reflux vassel blew up, aerial explosion followed	Ethylene Oxide	1	4

Mean mortality index Ammonium Nitrate $= \frac{1132}{10500} = 0.1$

Source: Health and Safety Commission. Advisory Committee on Major Hazards, Second Report. Health and Safety Executive, London (1979).

TABLE 9

RESPONSIBILITIES OF INDUSTRY (OPERATOR) IN THE CONTROL OF CHEMICAL ACCIDENTS.*

Industry (operator)should:

(a) Develop a contingency plan and ensure that it is compatible with that of the local community;

(b) have its own emergency services, or have an arrangement with the local community to use theirs;

(c) cooperate and collaborate with the authorities, providing all necessary information for an effective, coordinated contingency plan;

(d) conduct a hazard survey, indicating all risks and possible remedial measures which may be required;

(e) share information with other plants in the same community or general area;

(f) provide mutual assistance by providing equipment and personnel, (particularly in the case of transportation accidents) and access to centres of expertise;

(g) follow international labelling and handling procedures;

(h) cooperate with public authorities in the operation and marking of pipelines;

(i) provide public authorities with all toxicological, medical and other relevant information.

* Source: Health Aspects of Chemical Safety-Emergency Response to Chemical Accidents-WHO/IPCS (1981).

TABLE 10

RESPONSIBILITIES OF LOCAL, REGIONAL AND NATIONAL GOVERNMENTS IN THE CONTROL OF CHEMICAL ACCIDENTS*

Governments should:

(a) require all chemical (using or producing) industries to undertake a "major hazard analysis" and submit it to government for approval;

(b) require all chemical industries to prepare and submit for approval a contingency plan; this requirement, as well as the former one, should apply to all premises where potentially toxic chemicals are produced, handled or stored;

(c) prepare its own plan for coordinating the many agencies and levels of government involved in responding to a chemical accident; it is particularly important that a national contingency plan be developed, adopted and tested before it needs to be exercised;

(d) mobilize, identify and maintain lists of experts advice at all levels, including the lower and even the highest levels;

(e) maintain information at the local level on all potentially toxic chemicals in, or transported through, that area; it is important that at least sufficient information be readily available to deal with any emergency that might arise;

(f) give careful consideration to prohibiting transportation of certain materials on certain routes through certain jurisdictions; this can restrict the area at risk and render emergency response to transportation accidents more manageable;

(g) engage in negotiations with neighbouring countries where chemical plants are close to national boundaries, so that any contingency plan involving a transboundary effect will be completed and approved a *priori:*

(h) consult with industry, labour unions, conservation groups and professional and learned societies in the development of laws and regulations concerning chemical products;

(i) require industries, which have been involved in an accident, to produce a report to improve its methodology;

(j) involve industrial experts in analyzing accident reports to improve safety for the future.

* Source: Health Aspects of Chemical Safety-Emergency Resoponse to Chemical Accidents-WHO/IPCS (1981).

TABLE 11

RESPONSIBILITIES OF SCIENTISTS IN THE CONTROL OF CHEMICAL ACCIDENTS.*

Scientists who are required to give expert assistance in a chemical emergency should:

(a) provide information for contingency planning in advance;

(b) in an amergency, be able to provide fast, reliable information under stress, so that it can be understood and acted upon by layman, such as firemen and police;

(c) know, and be known to, scientists and experts in other countries so that they can exchange information rapidly, in an inter-personal information network;

(d) be available at, or to, data banks and information centres in order to interpret the data on the accident; this availability should be on a 24 hour basis;

(e) include social and economic scientists, as well as national, environmental and medical representatives;

(f) maintain an "up-to-date" national roster of experts and have one of them identified as an international contact in case help is needed in another country;

(g) form an international committee of such "contact persons" to meet from time to time to exchange experiences, and to evaluate control actions taken in cases of major emergencies;

(h) be able to be effective under pressure, and wearing protective equipment; such equipment, in the possession of those scientists expected to play such a role, should be routinely tested and maintained;

(i) assist in proposing short-term emergency exposure tolerable limits for various risk populations to permit evacuation decisions to be taken as appropriate; premature evacuation decisions can have just as high social costs as late decisions;

(j) take part in the evaluation of accident records for the purpose of preventing or mitigating future accidents;

(k) help to plan pre-agreed detoxification and rehabilitation procedures.

* Source: Health Aspects of Chemical Safety-Emergency Response to Chemical Accidents-WHO/IPCS (1981).

FIG. 1— COMPONENTS OF CHEMICAL EMERGENCY PREPAREDNESS

	PHASE	ACTIVITY
BEFORE THE ACCIDENT	1) Hazards Evaluation	• Identification of hazards • Identification of vulnerabilities • Assessment of risk
	2) Prevention	• Removal of the hazard • Selection of alternatives • Hazards control
	3) Planning mitigation	• Contingency planning • Knowledge of rehabilitation methods • Instituting organizational frameworks
AFTHER THE ACCIDENT	4) Emergency	• Accurate response • Speed of action
	5) Follow—up	• Knowledge of chemical (s) • Fencing-in of the accident
	6) Rehabilitation	• Diagnosis of needs • Implementation • Monitoring • Feedback and Adjustment • Information transfer and storage

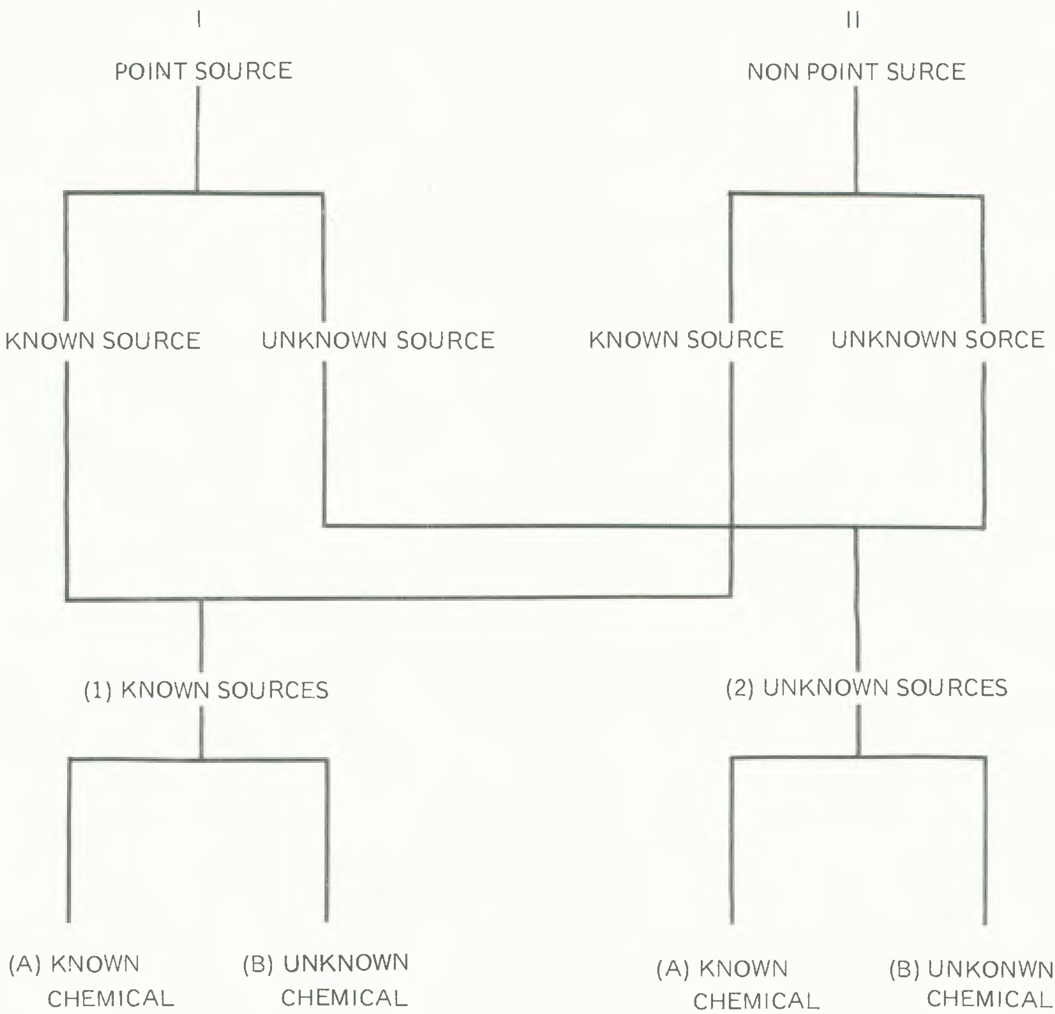
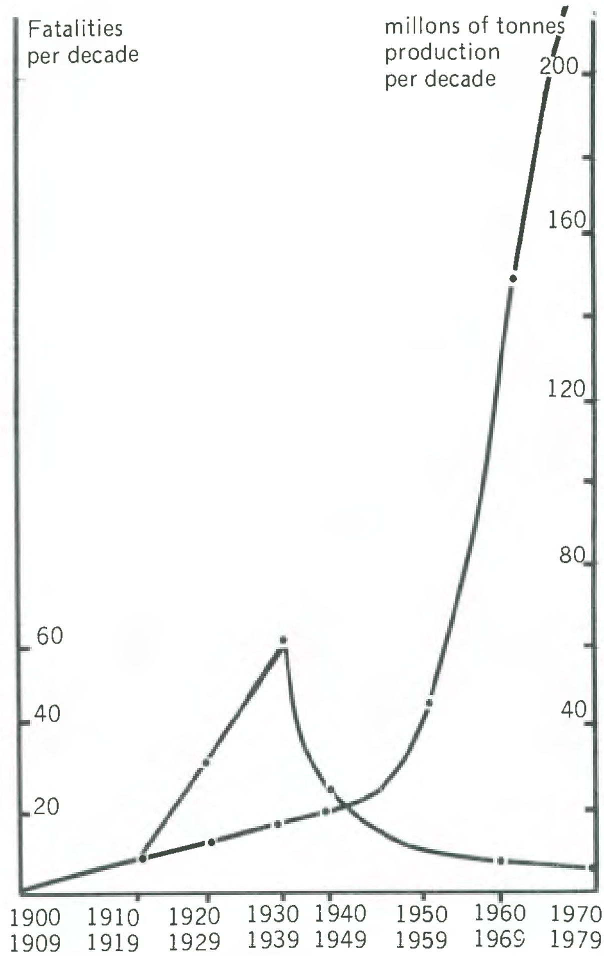


FIG. 2. COMBINATIONS OF IMFORMATION ON CHEMICAL ACCIDENTS*

* Source: Health Aspects of Chemical Safety-Rehabilitation following accidents involving toxic and potentially toxic and hazardous chemicals-WHO/IPCS (in preparation).



Decades

FIG. 3 WORLD PRODUCTION AND KNOWN FATALITIES FROM ACCIDENTS INVOLVING LIQUID CHLORINE.

* Source: Health and Safety Commission. Advisory Committee on Major Hazards. Second Report-Health and Safety Executive, London (1979).

ANNEX 1

A SUMMARY OF THE WHO/EURO INTERIM DOCUMENT ON "EMERGENCY RESPONSE TO CHEMICAL ACCIDENTS"*

* Source: Gilad, A. and Silano, V. (1983) Contingency Planning for Accidents and Emergencies Involving the Release of Potentially Toxic Chemicals. *J. Toxicol. Med.*, T. 3, No. 1, 67-77.

As a preliminary step towards "managing the unpredictable" an IPCS working group, held in 1981, has developed an organizational framework for a countrywide emergency response system for chemical accidents and emergencies which can serve as a model.

This conceptual model organizes the type of contingency planning needed according to four levels of accident containment. At level 1 or the operator level, the effects of the accident/emergency can be contained within one facility. At level 2 or the local/community level, the effects spread into the public sector but can be handled by the resources of the community. At level 3 or the regional/national level, the effects occur at the border between two regions or communities within one country and require the combined resources available at this jurisdictional level. At level 4 or the international level, the emergency may be a large-scale disaster or a small accident that occurs close to national borders. At level 4, the procedures for management may very well require the services of an international team.

Contingency planning

Contingency planning for chemical accidents should be carried out at the different levels (operator, local, regional and national). Operators responsible for preparing contingency plans include individual plants producing or using potentially toxic chemicals (PTCs) in their processes, wholesale or retail sellers of PTCs, vehicles transporting PTCs, enterprises using PTCs for improving the quality or increasing the quantity of their products (e.g. food industry, agriculture or forestry) and processes with units responsible for waste management. The following steps should be included in any procedure for contingency planning.

1. Designate responsibilities for contingency planning and implementation of an emergency response system. It is very important to define the roles of the supervisor of the activities at the site of the accident and that of the focal point in the emergency control centre.

2. Prepare plan of action. This step should de carried out as a standard operating procedure of handling specific accidents as well as for speedy response to any emergency.

3. Establish the liaison with external authorities (fire, police, ambulance, and health services, and occasionally units of the armed forces).

4. Identify and utilize resources for handling the emergency, including briefing and training of personnel and maintenance of equipment and material.

5. Prepare a system for collecting, processing, evaluating and disseminating information.

Emergency response system

A response system must be properly integrated into regional, national and, where appropriate international structure. Such planning is necessary because the scope and consequences of a chemical accident are often impossible to predict. In the event that large areas are affected, a well-coordinated response system can quickly and effectively mobilize the necessary help and initiate immediate protective action. The succes of this complex, integrated system is built upon the establishment of a "focal point" at each level of the countrywide structure. The individual designated as a focal point will coordinate emergency response action within the appropriate areas under his/her responsibility. The focal point will be responsible for processing, transmitting and receiving the necessary information to both the authorities and the public and to facilitate the help required from response units. The provision of complete information of the effects and counter measures to each succeding focal point is very important because he/she must decide whether or not escalation of action to a higher level is needed. Regardless of the level, the focal point will alert the emergency units and seek expert advice. The emergency units are then directed at the scene by their respective commanders, with the focal point managing and coordinating the overall activities. As an example, FIG. 1 illustrates the role of the focal-point at level 3.

To determine the extent of the effect, a measurement of the levels of the chemicals in the environment would immediately take place under the direction of the expert services (and/or laboratories). This information, together with the observed human and environmental health effects and the knowledge of the dynamics of release, will determine whether or not the management of the accident at a given level by the focal point was appropriate. Therefore, as more information, becomes available on the characteristics of the accident, the focal point may well move up in the hierarchy (e.g. from operator to community level, or from community to regional level). This shift would take place when additional help is necessary and/or when the human and ecological impacts of the accident spread from the individual site to a wider area pertaining to the community, regional or national responsibility.

Although the particulars will depend on the scope of the emergency, any response system should include a number of elements. An integral part of the response system should be the alert system. This component requires the establishment of suitable alarm systems, including a standard procedure for transmitting the information on the occurrence of an accident to the appropriate focal point. Also critical are the evaluation of the situation and classification of the accident. Basic information must be provided that enables preliminary classification of the accident to be made and that indicates probable consequences expected and actions required. This initial appraisal would normally be conducted by the person designated as the focal point. At the same time, detailed data and information related to the accident are collected, and internal, as well as external, expertise may be requested.

After the situation has been evaluated, an adequate flow of the necessary information must be assured to all relevant parties to ensure effective and fast response to the accident. In addition, external help may be needed. In many cases, chemical accidents cannot be effectively contained and adverse impacts minimized without some external help or advice. Examples of this help or advice include:

- access to relevant information;
- highly qualified assistance of experts with experience in coping with previous accidents;
- services of qualified, reliable and well equipped laboratories to perform the necessary analyses and tests;
- provision of skilled personnel to deal effectively with the emergency;
- provision of such material and equipment as may be necessary to provide adequate protection and remedial measures.

An important role in responding to chemical emergencies belongs to the health services. Pre-arrangements should be made with relevant health services regarding their respective participation in the handling of chemical emergencies. Included should be the provision of sufficient space in hospitals, together with the appropriate medical supplies. The planning of health services for emergencies must be based on detailed information supplied by the operator, industry or local government. This information should include the type of toxic chemicals which may be involved in any potential accidents, their properties and the possible consequences of an accident. In case of unusual or special substances, additional training of mediacal personnel may be required for the effective handling of an emergency. Most hospitals already have a contingency plan for emergencies. These plans should be examined to ensure that they have provisions for a chemical emergency.

A call for an ambulance is usually the first response to any accident. In case of unusual or special substances, additional training escalation, some injuries are expected. Calling an ambulance is usually a standard procedure regardless of the type of emergency. This procedure should be fully incorporated into the contingency plan. The emergency response system, however, should include a back-up provision for additional ambulances and for helicopter ambulances should they be needed.

Even at an early stage following the accident, the provision of effective protective measures is of high priority. Simultaneously, possible future remedial or rehabilitative activities should be considered. This approach may prove itself not only to be more economical, but it may also prevent a number of problems in the future. Monitoring and evaluating the human and environmental health impacts of the accident as well as the consequences of changes with time on the entire affected area, are essential for effective handling of the emergency. The measures adopted previously must be modified as circumstances change in the specific situation.

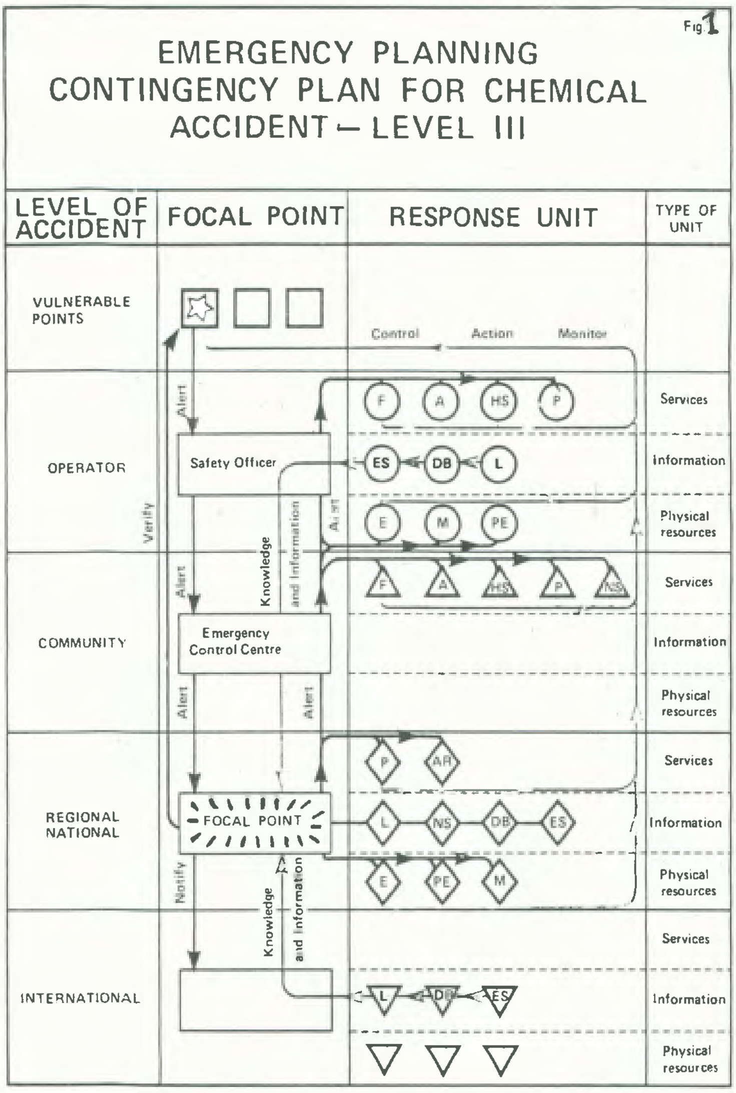
Parties to whom information on the development of the situation must be regularly provided include governmental authorities at the appropriate level, health services and the general public. To ensure internally consistent reporting, a single information officer to the mass media is preferred.

Finally, a terminal report on the accident should be prepared. The main objective of this report is to record all experience and knowledge gained from the recent event to provide the basis for the further improvement of both the contingency planning and the development and practical application of emergency response systems.

Verification of the emergency response model

To compare this idealized framework of emergency response systems with existing ones in Europe, a survey of 20 European countries was conducted. In particular, the survey provides information on the organizational frameworks, the systems of alert and response, centres of expertise, laws and regulations currently available in each of the 20 countries.

Although the true test of a model for emergency response to chemical accidents rests in an actual situation, case studies can be used to analyse the appropriateness and completeness of the model. Towards this end, two case studies have been prepared: the accidental release of TCDD at Seveso, Italy, and the train derailment involving liquid chlorine in Canada. In these two case studies, the emergency response model appears to be quite applicable.



○	Internal resources of operator	HS	Health services
△	Resources of the local community	L	Laboratories
◇	Regional and/or national resources	M	Material
▽	International resources	P	Police
AR	Military services	PE	Personnel
A	Ambulances	NS	Environmental services, water and waste management
DB	Data bank of information	Red	Alert
E	Equipment	Blue	Information
ES	Expert services (environmental)	Green	Physical resources and action
F	Fire brigades		

ANNEX 2

PROVISIONAL LIST OF CONTENTS OF THE WHO/EURO DOCUMENT ON "REHABILITATION FOLLOWING ACCIDENTS INVOLVING POTENTIALLY TOXIC AND HAZARDOUS CHEMICALS"*

* Source: Health Aspects of Chemical Safety-Rehabilitation following accidents involving toxic and potentially toxic and hazardous chemicals-WHO/IPCS (in preparation).

I. INTRODUCTION

I. Introduction

1.0 Goals and Alternatives
- 1.1 Restoration
- 1.2 Rehabilitation
- 1.3 Modification

2.0 Assessment of Post Emergency Situation

3.0 Planning and Implementation

4.0 Monitoring

5.0 Feedback and Adjustment

6.0 Information Transfer and Storage

7.0 International Cooperation

II. ASSESSMENT OF POST EMERGENCY SITUATION AND REHABILITATION NEEDS

1.0 Information sources

2.0 Description (attributes) of the accident
- 2.1 Classification according to source
- 2.2 Classification according to apparent cause
- 2.3 Classification according to apparent reason
- 2.4 Classification according to site of accident and areas affected
- 2.5 Classification according to amount of chemical(s) released and/or recovered
- 2.6 Classification according to properties of chemical(s) released
- 2.7 Classification according to dynamics of chemical(s) released
- 2.8 Classification according to toxicity of chemical(s) released
- 2.9 Classification according to main routes of exposure and health impact.
- 2.10 Classification according to environmental, social and economic impact
  - 2.10.1 Nature of effects
  - 2.10.2 Magnitude of effects
  - 2.10.3 Duration of effects
  - 2.10.4 Quality of effects
- 2.11 Classification according to level of resources required for rehabilitation
  - 2.11.1 Level I (operator level)
  - 2.11.2 Level II (local/community level)
  - 2.11.3 Level III (regional/national level)
  - 2.11.4 Level IV (international level)

3.0 Information on emergency action taken

- 3.1 Introduction
- 3.2 Information for post emergency action
  - 3.2.1 Estimation of possible chemical emission
  - 3.2.2 Properties of chemical
  - 3.2.3 Emergency organization
  - 3.2.4 Continuous monitoring of post-accident situation
  - 3.2.5 Assessment of risks

4.0 Observed effects

- 4.1 Introduction
- 4.2 Physical indicators
- 4.3 Humans
- 4.4 Plants
- 4.5 Animals
- 4.6 Water, air and soil
- 4.7 Social and economic effects

5.0 Results of initial testing and monitoring

- 5.1 Introduction
- 5.2 Environmental analytical methods
  - 5.2.1 Biological detection
  - 5.2.2 Physical chemical detection
- 5.3 Treatment of monitoring data

6.0 Properties of chemical(s) involved

- 6.1 Introduction
- 6.2 Physical and chemical properties
- 6.3 Biochemical properties
  - 6.3.1 Introduction
  - 6.3.2 Behaviour in higher organisms
  - 6.3.3 Behaviour in lower organisms
  - 6.3.4 Bioaccumulation
  - 6.3.5 Specific biochemical activities
- 6.4 Toxic effects (human)
- 6.5 Toxic effects (environmental)
- 6.6 Environmental transport
  - 6.6.1 Introduction
  - 6.6.2 Environmental fate analysis
  - 6.6.3 Computing, modelling and evaluating

7.0 Properties of area involved

- 7.1 Introduction

7.2 Natural systems (geography/ecology)
7.3 Managed or built systems (physical/technical)
7.4 Socio-economic systems

8.0 Assessment

8.1 Initial interpretation and diagnosis
8.2 Adequacy and consistency of available information
8.3 Further requirements and investigations
8.4 Need for rehabilitation

III. PLANNING AND IMPLEMENTATION

1.0 Management plan

1.1 Budget
1.2 Staff

2.0 Organizational aspects

2.1 Responsibilities
2.2 Relationships with other agencies
2.3 Management of rehabilitation action for ecosystem recovery

3.0 Definitions, assessment of needs and alternatives

3.1 Assessment of rehabilitation needs
3.2 Constraints of time and cost
3.3 Alternatives to rehabilitation

4.0 Action plan components

4.1 Post emergency health care

4.1.1 Surveillance
4.1.2 Initial census
4.2.3 Assessment of extent of exposure
4.1.4 Biological tests
4.1.5 Re-evaluation of initial diagnosis and treatment strategies
4.1.6 Re-assessment of health effects
4.1.7 Post emergency medical care
4.1.8 Intensive monitoring versus "routine" health information system surveillance
4.1.9 Health information system (cohort study)
4.1.10 Medical reports and records
4.1.11 Organization

        - 3.3.1 Introduction
        - 3.3.2 Soil
        - 3.3.3 Vegetation
    - 3.4 Human Health
    - 3.5 Animals
    - 3.6 Locally produced food/feed

4.0 Design of Monitoring System

V. ORGANIZATION

1.0 Assessment of effectiveness of rehabilitation

- 1.1 Introduction
- 1.2 Methodology
- 1.3 Coordination
- 1.4 Decision making
- 1.5 Team or staff modifications
- 1.6 Responsibility
- 1.7 Budget modifications
- 1.8 Interrelationships
    - 1.8.1 With local authorities
    - 1.8.2 With working groups
    - 1.8.3 With external groups
    - 1.8.4 With the public

2.0 Declaration of Completion or Re-examination of goals and objectives

- 2.1 Re-evaluation in relation to previous objectives
    - 2.1.1 Updating literature
    - 2.1.2 Updating new results
- 2.2 Emergence of new facts
- 2.3 Redefinition of priorities
- 2.4 Report on progress of works
    - Routine internal reports
    - Press releases
    - Scientific publications
    - Special reports

3.0 Adjustment of Rehabilitation Plan

- 3.1 Time schedule

3.1.1 Frequency of meetings
3.1.2 Frequency of sampling and observations
3.1.3 Monitoring

3.2 Evaluation of time factor

3.3 Readjustment of monitoring

3.3.1 Restoration of environmental balance
3.3.2 Redefinition of affected areas
3.3.3 Redefinition of indicators and parameters

3.4 Conclusion of rehabilitation

3.5 Psychological and social action plan

3.5.1 Population well being
3.52 Listening place
3.5.3 Psychological support

3.6 Economic rehabilitation

4.0 Continuous monitoring

4.1 Surveillance after rehabilitation
4.2 Final re-evaluation
4.3 Identification of forecasting indicators
4.4 Identification of minimal means of action

VI. INFORMATION AND EXPERIENCE TRANSFER

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1.1 Information for records
1.2 Experience available
1.3 Information for legislation and standard setting
1.4 Information for formal enquires
1.5 Information for public participation
1.6 Information for training
1.7 Education at higher levels for engineers and managers

2.0 Means

2.1 Permanent storage and retrieval systems

2.2 Publications
2.3 Special reports
2.4 Mass media information
2.5 Manuals and training aids
2.6 Provision of expertise

VII. INTERNATIONAL COOPERATION

1.0 Introduction

1.1 Major accidents
1.2 Accidents close to border
1.3 Complex and unique accidents
1.4 Multinational operations

2.0 Direct technical assistance

3.0 International publications

4.0 International working groups

5.0 Exchange of expertise and information

6.0 Symposia, workshops, conferences

7.0 Institutional framework for international cooperation

ANNEX 3

CHECK LIST/QUESTIONNAIRE FOR ACQUISITION OF DATA TO PERFORM A PROSPECTIVE HAZARD SURVEY OF STATIONARY FACILITIES*

*Sources: Document ISTISAN (Rome, Italy) 1978/22 and UNIDO/UNDRO/WHO/UNEP, Contingency Planning for the Industrial emergencies for the West and Central African Region. UNIDO/15.425 (1983). Modified.

ANNEX 3

1. NAME AND ADDRESS
2. SECTOR
3. CATEGORY
4. GOODS PRODUCED, MARKETED OR STORED
5. PERSONNEL
6. AREA SIZE AND LOCATION
7. AUTHORIZATIONS
8. STRUCTURES
9. PLANT LAYOUT
10. EQUIPMENT
11. CHEMICAL AGENTS
12. CHEMICAL PROCESSES
13. CHEMICAL AGENTS THAT CAN BE FORMED UNDER CONDITIONS ANOMALOUS TO THE ESTABLISHED PROCESSES
14. UNIT OPERATIONS
15. OPERATOR PRACTICES AND TRAINING
16. WASTES AND EFFLUENTS
17. HEALTH SERVICES
19. HEALTH AND SAFETY INDICATORS

1 NAME AND ADDRESS

Enterprise ....
Address ....
....
Municipality, ... State ....

2 SECTOR

— Industrial
— Handicraft workshop
— Commerce
— Agriculture
— Zootechnical
— Services

3 CATEGORY

— Agricultural or zootechnical	1
— Food and associated items	2
— Chemical and pharmaceutical	3
— Hides, leathers, and footware	4
— Cellulose, paper, editorial, photophono-cinematographic	5
— Electricity, gas and liquid fuels, water, refrigeration or heating	6
— Wood and associated items	7
— Metallurgy, automotive, electronic, electrotechnical	8
— Radiogenic devices and radioactive sources	9
— Extraction and manufacture of minerals	10
— Textiles and clothes	11
— Storage	12
— Others (to be specified)	13

4 GOODS PRODUCED, MARKETED OR USED FOR SERVICES

— Specify

5 PERSONNEL

5.1 PERSONNEL EMPLOYED IN THE ESTABLISHMENT

— Legal Representative:
— Address:

- Technical manager in charge, and academic degree
- Number of permanent workers
- Number of temporary workers:
- Number of shifts in 24 hours
- Number of technicians
- Number of administrative personnel
- Mean annual percentage of personnel absenteeism

5.2 SERVICES CONTRACTED

- Kinds of services and activities contracted and developed on the site of the establishment.

- Total number of persons present in the establishment to carry out contracted activities.

6. AREA SIZE AND LOCATION

6.1 AREA SIZE
- Area of the establishment in m^2
- Cadastral data
- Covered surface in m^2
- Outdoor paved surface within the area of the establishment in m^2
- Extension of the outdoor surfaces:
  - used for storage in m^2
  - intended for other uses in m^2
  - size of the protection zone in meters

Use foreseen, for the area of the establishment, in the zoning map of the municipality or another equivalent instrument (in effect or adopted):

- agricultural
- handicrafts
- industrial
- residential
- other (to be specified)

6.2 LOCATION (with regard to)

- topography and adequate drainage
- climate or natural disasters which can affect operations
- utilities (e.g. water, gas and electricity)
- major highways, routes, airports or congested areas near the plant site
- community fire fighting facilities

7. AUTHORIZATIONS

Date of beginning of activities in the establishment

Dates of important expansions or of eventual modifications

Possible classification in accordance with pertinent legal articles specifying the date of transaction.

Complete list and corresponding terms of the issued authorizations in possession of the interested party.

8. STRUCTURES

- Conformity of all buildings to national building code (if any)
- Adequacy of foundations and subsoil for all loadings
- Insulation of structural steel components and supports so as to be fire resistive
- Minimization of fire spread factors such as openings in floors, walls, elevator shafts, air conditioning and ventilation ducts
- Separation of hazardous process areas by fire walls
- Ventilation according to standards of buildings exposed to explosion hazards.
- Ventilation of all buildings to limit toxic and flammable substances
- Presence of sufficient and clearly marked exits in all buildings
- Conformity of electrical installations to the national electrical code
- Adequacy of drainage facilities in buildings.

9. PLANT LAYOUT

Specify whether:

- The plant area is enclosed by adquate fences and gates
- There is a safe distance from the boundary to the nearest plant unit
- Process areas are separated from utilities, storage, office and laboratory areas, and down wind from ignition sources
- Hazardous units are separated from all critical areas such as control rooms or process computer installations
- Spacing of equipment considers the nature of the material, the quantity, the operating conditions, equipment sensitivity, the need to combat fire, and the concentration of valuables
- Loading areas are on the periphery of the plant and away from sources of ignition
- Administrative buildings and warehouses are on the periphery of the plant
- Storage tanks are away from the periphery, not too closely spaced, and diked or buried
- Waste disposal systems are down wind from personnel concentration
- There are adequate roadways for vehicles for entrance and exit in the event of an emergency

10. EQUIPMENT

Specify whether:

- Each piece of equipment has its own detailed check list
- Recognized standards are used in the design of equipment
- Equipment is designed with adequate safety control to prevent overpressure and over-temperature
- Equipment has been properly constructed, installed, and throughly checked before operating
- Equipment is reliable and easy to operate
- Equipment is designed for easy inspection and maintenace;
- All instruments and controls are fail-safe
- The maintenance and inspection programme is adequate
- Spare parts and equipment repair crews are ready.

11. CHEMICAL AGENTS

- Provide a complete list of the substances and preparations employed in the manufacture, produced or stored in warehouse of the establishment.
- Indicate the chemicals by their respective chemical names and, in case of preparations, by their compositions. Provide commercial and/or common name.
- Specify amount maximum retained for every chemical as well as average utilized or produced daily.
- Indicate the type of possible hazards associated to every chemical (e.g. flammability, explosivity, corrosivity, toxicity) specifying the source of information as follows: A=label; B=*ad hoc* investigation; C=literature data; C=other
- All the above-mentioned information should be provided for the following types of chemicals:
  - Raw materials
  - Intermediate products
  - Solvents and adjuvants
  - Primary finished products
  - Secondary finished products

12. CHEMICAL PROCESSES

For each chemical process provide information on the following aspects:

- A schematic description of the main process lines
- An indication of the chemical reactions and/or biochemical reactions of the process specify whether combustion oxidation, nitration, halogenation, or any other unstable reaction is a carried out
- The length and frequency of the production cycle
- An indication of the foreseeable anomalies, especially in regard to the formation of hazardous substances
- Maintenance to avoid hazardous situations, specifying the kind and frequency. Annex

the maintenance program, if available. Specify provisions made to prerent:
- abnormal temperatures
- abnormal pressures
- abnormal rate of reaction
- improper addition of reactants
- material flow stoppage
- equipment leaks or spills

13. CHEMICAL AGENTS THAT CAN BE FORMED UNDER CONDITIONS ANOMALOUS TO THE ESTABLISHED PROCESSES

For each process provide information according to the scheme described under section 11 for any chemicals that can be formed in conditions of foreseeable anomalies.

14. UNIT OPERATIONS

- Precautionary measures taken to guard against accidental release of flammable or toxic liquids, gases or combustible dusts.
- Handling of unstable chemicals to minimize exposure to heat, preassure, shock or friction
- Design, instrumentation, and control of the unit operation facilities (e.g. distillation columns, adsorbers and stripper) to minimize losses
- Checks of all heat transfer operations and transport operations for operator safety
- Shipments of chemicals from the plant

15. OPERATOR PRACTICES AND TRAINING

- Standard Operating Procedure Manual. Is it reviewed periodically and when process changes are made?
- Employee training programmes instituted. Do they cover both supervisory and operating personnel?
- Start-up and shut-down programmes
- Permit system for hazardous jobs.
- Training of employees to recognize potential process malfunctions

16. WASTES AND EFFLUENTS

16.1 WASTES

Specify for solid, semi-solid and liquid wastes:
- nature
- whether they are produced under normal or anomalous conditions
- average daily amount
- methods of temporary storage and disposal
- Final destination

16.2 EFFLUENTS

Specify for liquid and aeriform effluents:
- composition
- whether they are released under normal or anomalous conditions
- average dailey volume
- methods of containement

17. SAFETY DEVICES AND MEASURES

17.1 ALARM SYSTEMS
- Specify types of devices available and modes of operation, types of installation or environment controlled, and whether a recording system is available.

17.2 SAFETY MEASURES

Description of the devices foreseen for the protection of the persons in charge and the personnel exposed to danger. Annex a report with reference to the following points:

17.2.1 Of an ordinary preventive nature:
a) Norms of behavior
b) Devices for personal protection
c) Devices for environmental protection
d) Training programme to recognize process malfunctions

17.2.2 In case of emergency
a) Contingency plan
b) Means of personal protection
c) Means of environmental protection
d) Training to handle emergency situation

18. HEALTH SERVICES

18.1 OCCUPATIONAL HEALTH SERVICES

18.1.1 FIRST AID
- Is there a first aid service?

18.1.1.1 *Dimensions of the First Aid facilities:*
- Number of places established for first aid service
- Number of beds

18.1.1.2 *Personnel in charge of First Aid:*

- Does the First Aid facility have a physician?
- Degree of the physician:
  - clinical
  - hygienist

— specialist in occupational medicine
— other

- Number of hours a week that the physician is on duty.
- Average number of consultations por week
- Number of auxiliary physicians

18.1.1.3. *Ambulances*

- Are means of transportation for first aid personnel available?
- Does the enterprise use an external first aid service?

18.1.2 PREVENTIVE MEDICINE

18.1.2.1. Personnel

- Number of physicians employed
- Total number of hours weekly spent by medical personnel in this service.
- Number of auxiliary physicians
- Total number of hours weekly spent by auxiliary physicians in this service

18.1.1.2. Activity

- Are systematic investigations being carried out?
- Are there any agreements with public or private institutions regarding consultations with specialists?
- environmental
- group
- individual
- Are there any on-going systems for the analysis of environmental data?
- Is there a register of environmental data?
- Is there a register of biostatistical data?
- Are there personal risk cards?

18.2 COMMUNITY HEALTH SERVICES

- hospitals
- ambulances

19. AND SAFETY INDICATORS

19.1 PROFESSIONAL DISEASES

A list of the professional diseases reported by the appropriate organizations in the last three years, and the corresponding number of cases.

19.2 FIRES, EXPLOSIONS, AND SPILLS

Number reported in the last three years.

19.3 ENVIRONMENTAL STUDIES

Indicate any environmental studies carried out in relation to the plant in the last five years, who did them and what were the results.

ANNEX 4

PROTOCOL FOR ACQUISITION OF DATA FOR RETROSPECTIVE STUDY OF CHEMICAL ACCIDENTS*

* Source: Health Aspects of Chemical Safety-Rehabilitation following accidents involving toxic and potencially toxic and hazardous chemicals-WHO/IPCS (in preparation). Modified.

ANNEX 4

TABLE OF CONTENTS

DATA CATEGORIES RELEVANT FOR REPORTING CHEMICAL ACCIDENTS

There are 12 data categories relevant for reporting chemical accidents. They are: (i) source; (ii) apparent cause; (iii) apparent reason; (iv) site of accident and area affected; (v) amount of chemical(s) released and/or recovered; (vi) properties of chemical(s) released; (vii) dynamics of chemical release; (viii) main routes of human exposure; (ix) human health impact; (x) environmental, social and economic impact; (xi) environmental rehabilitation method(s); and (xii) level of resources management for emergency response or rehabilitation. All these are detailed and defined in this Annex to provide at least one practicable option for those who will be responsible for data acquisition. Some of the categories included may not be identifiable at the time of initial coding, but might be available subsequently. This implies that classification of chemical accidents, according to a global approach proposed here, needs some periodic up-dating, as knowledge develops on relevant features of the accidents. However, it is advisable to adopt classification criteria at the very beginning, as this will simplify further work and will help focus attention on the more important information to be obtained.

1. SOURCE

Possible accident sources can be listed in seven subcategories:

1.1 Production process
1.2 Transportation
1.3 Service
1.4 Storage
1.5 Management of municipal, industrial and hazardous wastes
1.6 Unknown
1.7 Other

1.1 *Production Process*

When analyzing accidents according to production processes, the location, type of plant, chemicals involved, etc. should all be taken into account. A ruptured process stream, which released one of the products of the plant, or a "run-away" chemical reaction, (as in Seveso), resulting in other unexpected products, would indicate different responses. These types of classification may be useful in preventing future accidents. Industrial managers should have some detailed knowledge of the chemical processes, and the products which may result from run-away reactions. This information, properly documented and stored, could be used as an "early warning" of potential accidents, and also could be used as a planning tool in order to isolate particulary hazardous facilities. The industry as a whole, including all those chemical manufacturing plants which deal in these products, should have some records on the type and frequency of accidents which occur. This information would be particularly useful on a worldwide basis. There should also be some notion of the risk involved, both to the workers, and to the adjoining community.

This classification is also useful for land-use planners so that they can, together with other information on stream flows, wind directions and urban development plans, be able to minimize the potential hazard involved in siting facilities.

(a) *Raw material extraction and refining*

Includes any primary manufacturing activity concerning mining, oil and gas extraction, as well as mineral smelting, and oil and gas refining. Some examples are:

- coal
- asbestos

— haematite and magnetite (iron)
— lead
— zinc blende
— cadmium
— copper ores
— cinnabar/mercury
— sulphides and sulphur
— tin stone
— chromate
— calcium ores/cement
— uranium and other radioactive minerals
— petroleum (sea, ground)
— natural gases

(b) *Agriculture, forestry and fisheries*

Includes any activity concerning the production of plants and animals useful to man, involvinq soil cultivation, breeding and management of crops and livestok, and harvesting fish or other aquatic life. It also includes the management of forest land for wood, forages, waste, wildlife and recreation.

(c) *Secondary manufacturing and/or processing*

Includes any further conversion of material from one form to another. Some examples are:

— producing industrial chemicals (basic and intermediates);
— producing chemical substances for specific uses (e.g. agrochemicals, drugs, household products, paints, soaps and cleaners);
— producing asbestos fibres and man-made mineral fibres;
— producing components for automotive, aerospace, electrical and electronic industry;
— producing explosives and armaments;
— producing pulp, paper, and other wood products;
— producing polymers and elastomers;
— metal finishing;
— industrial cleaning;
— processing leathers;
— processing fertilizers;
— processing food for animals;
— processing animal feeds;
— purification of drinking water
— chlorination of drinking water

(d) *Generation of electricity*

Includes any transformation of energy into electricity. Examples of some materials used to generate electricity are:

— coal
— gas
— oil
— uranium

(e) *Others*

Includes all other production processes not covered by one of the foregoing specific groups.

1.2 *Transportation*

In this case, transportation of chemicals may involve transportation by water, road, railway and, in some unusual instances, air. The analysis of an accident, in terms of transportation, is usually more significant when considering the emergency response, than the rehabilitation programme. However, in the case of transportation accidents, it is particulary important to maintain adequate records, so that the posibilities of accidents under various circumstances may be predicted. Contingency plans for accidents controls under various, high-risk circumstances may then incorporate some measures for rehabilitation. It should be added that the frequency and probability of accidents in transportation situations are likely to be much higher than in the case of either production or storage facilities.

Various provincial and national data bank systems and methods have been developed for recording transportation accidents in terms of the time, chemical, surrounding and weather conditions.

Some relevant sub-categories in this category can be listed as follows:

(a) *Tanker*

Includes any ship, hydrofoil, or other watercraft carrying liquid or gaseous cargo in bulk.

(b) *Carrier*

Includes any ship, barge, hydrofoil, or other watercraft carrying solid cargo in bulk.

(c) *Tank truck*

Includes all vehicles (except aircraft, rail, and watercraft) carrying liquid or gaseous cargo in bulk.

(d) *Transport*

Includes all other non-passenger transportation vehicles, excluding aircraft, rail and watercraft.

(e) *Other motor vehicles*

(f) *Train*

Includes all vehicles that run on rails

(g) *Aircraft*

Includes all vehicles that fly; does not include aircushion vehicles operating over water or land at the time the event occurred.

(h) *Pipeline*

Includes bulk transportation lines, regardless of size; does not cover local "in-plant" piping.

(i) *Other*

Includes all other transportation systems not covered by one of the foregoing specific groups.

1.3 *Service*

This category includes any facility where chemicals are distributed (for sale) to the general public or where toxic chemicals are used to provide special servicing. Some major sub-categories can be identified as follows:

(a) *Service station*

Includes fuel outlets, e.g. airport and marine fixed fuel dispensing installations, "gas-bars", self-service petrol stations and garages that sell fuel and lubricating oil, including fleet shops.

(b) *Marine terminal*

Includes waterfront facilities, off-shore mono-buoys, and other such installations created expressely for transferring material on or off ships.

(c) *Dry cleaners*

Includes any facility for dry cleaning clothes.

(d) *Food services (catering, restaurants and food shops)*

Includes any provision of food and service to groups, and any place where foods are sold.

(e) *Drugstores and Pharmacies*

Includes any shop where drugs, medical supplies, and other chemicals are sold, and prescriptions are filled.

(f) *Other*

Includes all other services not covered by one of the foregoing specific groups.

1.4 *Storage*

This classification, includes warehouse storage of certain chemical in transit from the manufacturer to distributor or retailer; or, the storage of wastes such as landfill sites or remote storage vaults.

An accident could occur at a warehouse, where materials are stored prior to incorporation into some finished product, or where a range of many different chemicals are stored in the same facility in which, over a period of time, the kinds of products may change. This kind of storage calls for a very careful set of records, and requires very up-to-date information on the contents of the warehouse.

In the case of storing hazardous wastes, as in landfill sites or remote vaults, there may be some overlap between this classification and proper waste management classification.

In the case where materials are stored on a chemical manufacturing site, some duplication would occur in the classification of accidents in production processes and accidents in storage facilities. The key, however, the possible interactions between these chemicals, and the resulting effects on the human population and ecosystems in the immediate vicinity of the site.

(a) *Storage depot*

Includes all facilities used for bulk storage, from which materials are used for distribution.

(b) *Other storage facilities*

Includes private storage facilities such as those belonging to industrial plants, farms, and private homes.

1.5 *Management of municipal, industrial, and hazardous wastes*

This class of accident would probably involve the older abandoned dump sites, more than the current operating facilities in most industrial countries. There is still, however, considerable controversy over the safety of so-called, fully-secured landfill sites and buried secure vaults.

In some countries, industrial waste treatment facilities are being established to deal with mixtures of various complex industrial wastes hauled to a specific site, where a series of unit operations are blended to deal with specific types of waste. Under these conditions, it migth be possible to create an accident through incorrect blending, or incorrect labelling of certain wastes with the mixtures, producing a substance or mixture far more toxic than the original substances. Overflowing vessels, flooded treatment facilities, and other process failures, which result in the release of toxic and hazardous materials from these treatment units, may be described as improper waste management problems.

Probably the largest group of accidents in this class would involve the abandoned toxic and hazardous waste dumps, dealt with in greater detail in a technical appendix to the WHO/IPCS Interim Document series entitled "Reclamation and Rehabilitation of Abandoned Toxic Chemical Dumps" (WHO Document under preparation).

(a) *Physical treatment*

Includes all physical treatment methods, usually encountered in hazardous waste treatment, including phase or component separation and solidification encapsulation processes, whereby the hazardous material is fixed in an inert, impervious matrix.

(b) *Chemical treatment*

Includes all chemical treatment methods used to effect the complete breakdown of hazardous waste into nontoxic gases and, more usually, to modify the chemical properties of the waste; e.g. to reduce the water solubility, or to neutralize the acidity or alkalinity.

(c) *Biological treatment*

Includes treatments such as activated sludge, percolating filter, rotary biological contractor, aerated lagoon, fluidized bed, composting, anaerobic digestion, aerobic filter and stabilization pond. Many industrial wastes are subjected to biological treatment by methods analogous to those used for domestic sewage treatment.

(d) *Recycling treatment*

Includes methods of treatment of urban wastes for the recovery of valuable metalic wastes, and the production of animal feed, as well as more sophisticated methods used for the recovery of valuable chemical from process residues.

(e) *Disposal by landfill*

Includes all the methods for disposing municipal, industrial and hazardous wastes by burial.

(f) *Disposal by thermal processes*

Includes all the methods (e.g. incineration, gasification, calcination, pyrolysis) for the high temperature oxidation of gaseous, liquid, or solid wastes, which converts them into gaseous materials and an incombustible solid residue. It may take place on land or on board ship at sea.

(g) *Disposal by dumping*

Includes all unloadings in an open storage area.

(h) *Disposal by dumping at sea*

Includes all the disposal of land-generated waste by releasing it in sealed or unsealed containers, at sea.

(i) *Underground disposal*

Includes all the disposal processes in deep-mine facilities It is used for certain hazardous wastes that are excessively expensive to dispose of in an environmentally acceptable manner at landfill sites, or by chemical or thermal processes.

(j) *Deep-well disposal*

Includes all the disposal processes involving injection of wastes into underground aquifers at great depth.

(k) *Other*

Includes all other systems not covered by one of the foregoing specific groups.

1.6 *Unknown*

Includes all incidents where, following research, the source of the spill cannot be positively ascertained.

1.7 *Other*

Includes all other sources not covered by one of the foregoing specific groups.

2. APPARENT CAUSE

In this context *cause* means the physical event leading to some release of chemical(s) into the environment. They are 23 sub-categories in this category.

2.1 *Collision*

Only applies to those events wherein a ship or other vehicle collided with some other object.

2.2 *Grounding*

Only applies to watercraft that hit bottom in shallow water.

2.3 *Sinking*

Only applies to watercraft, and only to those cases where the cause of sinking is not known, or is not covered by a more specific cause such as "Collision" or "Grounding".

2.4 *Ship's tank bilge pumping*

Includes accidental or deliberate discharges overboard while pumping bilges, deballasting, washing tanks, or performing other similar operations.

2.5 *Derailment*

Only applies to railway accidents in which one or more cars and/or engines leave the rails.

2.6 *Crash*

Only applies to aircraft accidents.

2.7 *Overturn*

Only applies to motor vehicles (trucks, etc.) that accidentally roll, upset, overturn, etc.

2.8 *Overflow*

Overfilling of fixed or mobile tanks or containers.

2.9 *Pipe leak*

Includes leaks from the pipe itself, as well as leaks from some unidentified part(s) of a pipe system, and applies to any type or size of pipe, including flexible hoses.

2.10 *Valve of fitting*

Applies to valves, gauges, filters, pumps, joints, cover gaskets, or other similar accessory/ components of a pipe system, tank or other container.

2.11 *Tank leak*

Applies to tanks used for storage, both above and underground, and includes cargo tanks. Leaks occurring at the weld points between pipes and tanks are also considered tank leaks, and include fuel tanks of motor vehicles, if the vehicle was not involved in a collision or other accident.

2.12 *Container leak*

Covers cartons, boxes, bottles, barrels, bags, and any other type of container except tanks.

2.13 *Discharge*

For all other types of inadvertent or deliberate discharges, including pumping station bypasses, dumping of storage tank contents, etc.

2.14 *Well blowout*

Only applies to oil gas well events.

2.15 *Process upset*

An upset in a process facility, which results in an unusual discharge of a contaminant in the environment.

2.16 *Dike failure*

Storage ponds and lagoon wall failure.

2.17 *Elevator failure*

Includes all failures of lifting systems.

2.18 *Coolant leak*

Includes all failures of cooling systems, regardless of cooling media.

2.19 *Gasket or joint failure*

Refers to any form of connection (except weld) shaft seals or glands, cover gaskets, valve stem packing.

2.20 *Misuse of chemicals*

Includes any incorrect or improper use of a chemical substance or mixture of substances.

Accidents resulting from the misuse of chemicals involves probably the broadest of all considerations for accidents. The 1981 incident in Spain, concerning the adulterated cooking oil, is a clear example of this type of accident. The use of mercury contaminated seedcorn in Iraq in the 1960's for edible purposes (See technical Appendix to the WHO/IPCS Interim Documents series containing case studies — WHO under preparation) is yet another example of misuse of chemicals.

One of the biggest problems associated with this class of accidents is the serious difficulty involved in managing chemicals, once they get out of the hands of professionals and into the hands of the community. There are obvious examples of the possible misuse of pesticides and even some fertilizers which could have a role in this kind of accident. Fortunately, in these latter cases, the quantity of chemicals would be in these latter cases, the quantity of chemicals would be very much reduced, unless it involved significant farm operations, where large quantities of chemicals may be used incorrectly.

Another example of an accident in this category might be the use of either badly labelled, or incorrectly labelled products, which coud result in either ecological or public health problems.

Relevant groups of substances that can be misused are as follows:

a) *Food additives, including flavouring and colouring agents*

Include any chemical agent added deliberately to food to impart some desirable property, and intended to be consumed with food.

(b) *Technological adjuvants for foods*

Include any chemical agent used as a technological aid in food processing, and not expected to be present as such in finished food.

(c) *Food packaging materials*

Include any material used to wrap solid foods, or to contain liquid foods.

(d) *Cosmetics*

Include any article intended to be rubbed, poured, sprinkled, or sprayed on, or introduced into or applied to the human body for cleansing, beautifying, perfuming or altering the appearance. Also, any material intended for use as a component of any such articles.

(e) *Human drugs (Medication)*

Include any substance used internally or externally as a medicine for the treatment, cure, or prevention of a disease in human beings.

(f) *Disinfectants*

Include any chemical agent that destroys microorganisms, but not bacterial spores.

(g) *Disinfestants*

Include any chemical agent used to kill rodents or other small animals.

(h) *Household chemicals*

Include any chemical agent used as a component of household goods and to which some human exposure may take place.

(i) *Paints, adhesives and inks*

Include any pigment or vehicle that can be applied and dried on a surface to impart a color, and any substance used to bind two or more solids.

(j) *Agricultural chemicals*

Include fertilizers, soil conditioners, fungicides, insecticides, herbicides, and other chemicals used to improve farm crop productivity and quality.

(k) *Veterinary drugs*

Include any substance used internally or externally as a medicine for the treatment, cure, or prevention of a disease in animals for meat production.

(l) *Feed additives including integrators*

Include any chemical agent added deliberately to feed to impart some desirable property, and intended to be consumed with feed by animals for meat production.

(m) *Solvents*

Include any chemical agent, except water, used to dissolve another substance.

(n) *Industrial chemicals*

Include any chemical agent which is produced to be further transformed by industry. These chemicals are not produced because of their biological activity, if any, and are not intended to come into contact with human beings, although some human exposure may occur.

(o) *Adjuvants for polymers and elastomers*

Include any chemical agent used as a technological aid in producing and processiong of polymers and elastomers.

(p) *Other*

Includes all other chemical groups not covered by one of the foregoing specific groups.

2.21 *Unknown*

Where apparent cause of the accident cannot be determined.

2.22 *Other*

Includes those causes that are not properly classified under any of the groups in this section.

3. APPARENT REASON

In this context, *reason* means the human, natural, or mechanical factor causing the event leading to some release of chemical(s) into the environment. In this case, there are 19 sub-categories.

3.1 *Intent*

Intentional release by employer, employee, or some unknown person.

3.2 *Error*

Release due to a human mistake.

3.3. *Proven negligence*

Release due to proven carelessness on the part of the operator.

3.4 *Vandalism*

Intentional release usually constituting acts of sabotage and trespassing (ussually indicatable under the Criminal Code of the country).

3.5 *Ice or frost*

Covers a range of occurrences resulting from stresses due to low temperature (freezing).

3.6 *Road conditions*

Covers a range of occurrences resulting from bad road conditions.

3.7 *Power failure*

Applies to discharges directly resulting either from a loss of power or during the ensuing start-up.

3.8 *Fire or explosion*

Only applies to events that occurred because of a fire or explosion, not those that result in a fire or explosion.

3.9 *Storm or flood*

Events that occurred because of natural precipitation, storms and associated phenomena, i.e. lightning.

3.10 *Earthquake or slide*

Applies to earth movement resulting from natural causes, including mud slides, collapse, or eroded river banks, etc.

3.11 *Subsidence*

Applies to earth movement resulting from man's activity, e.g. sittling of backfill, of landfill areas, and of mining complexes or oil fields.

3.12 *Equipment failure*

Pertains to system components and includes:

(a) malfunction of an anti-overflow device;
(b) vehicle brake or steering system breakdown;
(c) other similar mechanical malfunction.

3.13 *Weld failure*

Encompasses welds in tanks, pipes, etc.

3.14 *Overstress and overpressure*

Includes any form of overloading wherein the intended strenght of the pipe, tank, container, gland, gasket, etc. was exceded.

3.15 *Corrosion*

Covers all forms of corrosion whether internal or external.

3.16 *Material failure*

Pertains to poor design or sub-standard material; material failure even though design stresses may not have been reached.

3.17 *Damage by equipment*

Applies to events such as:

(a) a bulldozer or backhoe breaking a pipe;
(b) a forklift vehicle damaging a container;
(c) an airport vehicle colliding with an aircraft wingtip tank.

3.18 *Unknown*

Where reason for discharge cannot be determined.

3.19 *Other*

Any reason that is not more accurately covered by one of the other reasons listed in this section.

4. SITE OF ACCIDENT AND AREA AFFECTED

This category applies to the site where the accident took place and to the whole area affected by the consequent release of chemical(s). More than one of the following 25 sub-categories are usually relevant for any accident.

4.1 *Air*

Applies to the mixture of a variety of individual gases forming the earth's atmosphere.

4.2 *On ground*

Applies to anywhere on the soil surface.

4.3 *Underground*

Applies to anywhere under the soil surface.

4.4. *Bridge*

Applies to any structure built over a river, etc. to provide a means of crossing.

4.5 *Road*

Applies to any way or highway made for tavelling by motorcars and similar devices.

4.6 *Railroad*

Applies to any track laid with steel rails along which cars are drawn by locomotives.

4.7 *River*

Applies to any large, natural freshwater surface stream having a permanent or seasonal flow.

4.8 *Stream*

Applies to any small, natural surface freshwater river having a permanent or seasonal flow.

4.9 *Lake*

Applies to any inland body of waster, small to moderately large, with its surface water exposed to the atmosphere.

4.10 *Gulf/Fjord*

Applies to any large extension of the sea partially enclosed by land.

4.11 *Bay*

Applies to any body of water, smaller than a gulf and larger than a cove in a recess in the shoreline.

4.12 *Sea*

Applies to any salty lake lacking an outlet to the ocean, and to any major subdivision of the ocean.

4.13 *Strait*

Applies to any narrow waterway connecting two large bodies of water.

4.14 *Ocean*

Applies to any primary subdivision of the intercommunicating body of salt water occupying a major depression of the earth's surface.

4.15 *Harbour*

Applies to any body of water of sufficient depth for ships to enter and find shelter from storms.

4.16 *Inlet*

Applies to any short, narrow waterway connecting a bay or a lagoon with the sea.

4.17 *Other water*

Applies to any water body not covered by one of the foregoing specific groups.

4.18 *Urban area*

Applies to any area characteristic of a city.

4.19 *Village or town area*

Applies to any concentration of houses smaller than a city.

4.20 *Industrial area*

Applies to any area devoted to industrial settlements.

4.21 *Agricultural area*

Applies to any area devoted to the production of plants and animals for commercial use.

4.22 *Forest area*

Applies to any ecosystem consisting of plants and animals and their environment, with trees as the dominant form of vegetation.

4.23 *Semi-desert area*

Applies to any almost uninhabited, arid region, which fails to support any significant plant growth.

4.24 *Undefined*

Where site and area affected cannot be defined with any confidence.

4.25 *Other areas*

Applies to any other area not covered by one of the foregoing specific groups.

5. AMOUNT OF CHEMICAL(S) RELEASED AND/OR RECOVERED

May be classified by mass (kg or metric tonnes) or volume (litres or cubic meters). Significance, however, will relate more to the properties of the substance(s) than the amount released.

6. PROPERTIES OF CHEMICAL(S) RELEASED

Properties of chemical(s) can be classified in a number of different ways. The approach adopted hereafter is similar to that used in many countries for labelling chemical substances being marketed. It is thought that this system is particularly useful here as, at least in some accidents, properties of released chemical(s) can be obtained from the label on container(s).

6.1 *Explosives*

Includes any substance, whether or not contained in device specially prepared or manufactured, intended to produce a practical explosive or pyrotechnic effect, or any other substance which by reason of its explosive properties, should be treated as such.

6.2 *Gases*

Includes any substance, which when contained in a vessel, occupies all the space in the containing vessel. This includes vapors and fumes.

6.3 *Radioactive substances*

Includes any unstable substance that undergoes a series of decay processes to reach a stable state.

6.4 *Oxidizing substances and organic peroxides*

Includes substances which easily yield oxygen and can cause or contribute to the ignition of combustible material on contact. Oxidizing substances, yielding oxygen, increase the risk and intensity or fire in other materials; organic peroxides are extremely unstable and present serious fire and explosion hazards.

6.5 *Highly flammable substances and preparations*

Include:

(a) substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any further application of energy, or

(b) solid substances and preparations which may readily catch fire after brief contact with a source of ignition, and which continue to burn or to be consumed after removal of the source of ignition, or

(c) liquid substances and preparations having a flash point below 21°C, or

(d) gaseous substances and preparations which are flammable in air at normal pressure, or

(e) substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.

6.6 *Flammable substances and preparations*

Includes any liquid substance and preparation having a flash point equal or greater than 21°C and less or equal to 55°C.

6.7 *Toxic substances*

Includes all substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may cause serious, acute or chronic health risks, and even death.

(a) *Acute toxicity*

The most commonly used acute toxicity test is aimed at determining the median lethal dose (LD_{50}) which has been defined as "a statistically derived expression of a single dose of a material that can be expected to kill 50% of the population." Data profiles for several potencially toxic chemicals will usually include lethal doses for several different life forms. This permits classification to be based on potential target organisms, representing a variety of trophic levels in the ecosystem.

(b) *Chronic toxicity*

The single most important and difficult criterion to evaluate when assessing the potentially detrimental health effects of a chemical is its chronic toxicity. Chronic toxicity may be tested for several specific effects including hepatotoxicity, nephrotoxicity, neurotoxicity, cardiovascular pathology, and immunosuppression.

6.8 *Corrosive substances*

Includes all substances and preparations which may, on contact with living tissues, destroy them; or damage or corrode other freight or the means of transport.

6.9 *Irritant substances*

Includes all non-corrosive substances and preparations which, through immediate, prolonged, or repeated contact with the skin or mucous membrane, can cause inflammation.

6.10 *Allergenic subtances*

Includes all substances capable of inducing immunological immediate adverse reactions.

6.11 *Mutagens*

Includes all chemical agents which, if inhaled, ingested or absorbed through the skin, may induce mutations.

6.12 *Carcinogens*

Includes all substances or preparations which, if inhaled, ingested, or absorbed through the ski may induce cancer.

6.13 *Teratogens*

Includes all chemical agents which, if inhaled, ingested, or absorbed through the skin, may induce congenital anomalies or monstrosities.

6.14 *Infectious substances*

Includes any substance that is reasonably suspected of being infectious to man and animals.

6.15 *Mobile substances*

A mobile chemical is one which is capable of passing through the environmental compartments and/or the food chain, eventually reaching an appropiate target organism and/or ecosystem. The water soluble chemicals are the most obviously mobile, but very good examples of very poorly water soluble (lipophilic) substances have been found distributed broadly (PCBx and DDT). This may be accounted for by the fact that have a high fugacity potential. Fugacity can be regarded as the "escaping tendency of a chemical substance from one place to another". It has units of pressure and can be related to concentration. For example, if the fugacity in fish for a specific compound is lower than the fugacity in the water, this indicates that the uptake is kinetically controlled or some pollutant-removal mechanism is operational in the fish.

6.16 *Non-mobile substances*

Mobile chemicals might ultimately become non-mobile in the ecosystem or somewhere in the food chain such as the accumulation of PCBs in certain organs of fish, or the fat of humans. Other more obvius, non-mobile materials may be inorganic metal salts with very low water solubility characteristics or ionic forms of toxic substances with high adsorption coefficients where they would adsorb readily and tenaciously to colloidal particles in the soil. Other less obvious materials might be high molecular weight organic complexes containing toxic substances which, through their large molecular size, are unable to permeate cell membranes and are therefore unable to reach a target site.

6.17 *Persistent substances*

Persistent substances are those substances which fail to break down (or break down very slowly) biologically or chemically in the natural environment. Examples of such materials are the heavy metals and some of the more complex organic compounds which do not have a counterpart in nature such as branched molecular structures or hydrocarbons with a large percentage of quaternary carbon atoms.

6.18 *Degradable substances*

Certain organic chemicals, particulary when they have a counterpart in nature, are degradable by normal microbiological and biological activites as well as chemical oxidatión processes. When an organic substance is degraded naturally through an aerobic process, it will normally proceed all the way to CO_2 and H_2O But when these same substances are degraded anaerobically, they produce a series of intermediates which may be more toxic than the original material.

6.19 *Substances dangerous for the environment*

Includes all substances and preparations, the use of which presents, or may present, immediate or delayed risks for the environment. Among other chemicals, all persistent chemicals with an apparent environmental half-life greater than one week and biocaccumulative chemicals with a bio-concentration factor greater than 50 could be classified in this group.

6.20 *Unknown*

Where properties of chemical(s) involved cannot be determined.

6.21 *Other*

Includes those substances that are not properly covered by the provisions of the other classes.

7. DYNAMICS OF CHEMICAL RELEASE

The two extremes would be the explosion and the slow leaching release (e.g. landfill sites). The fundamental difference between these, of course, has to do with the emergency response. The time available to deal with a contaminant released explosive force is much shorter than the time available to assess the slow spread of a contaminant through the ground. The range of rates between these two extrems is considerable. They include a spill into a slow moving river, or an accident involving a mixture of particularly volatile chemicals, which although not explosive, convert into vapour and disseminate in the air. Such concerns relate to the extent of contamination and have a special importance when mapping possible rehabilitation zones. Slow release can be much more insidiously dangerous: the experiencia of Love Canal in Niagara Falls, New York, is an example of a slow release wich caused little initial alarm because of its gradual onset.

Dynamics of chemical(s) release can be self-evident, non self-evident, only evident for trained personnel and unknown. Accidents where chemicals are released at a high speed are more likely to be self-evident, whereas accidents characterized by a low rate of chemical release are more likely not to be self-evident.

7.1 *Self-evident*

Applies to all cases where dynamics of release are such that any incidental observer could have an understanding that an accident involving some release of chemicals into the environment was taking place. A train derailment where some cars explode is an extreme example of accidents classified in this group.

7.2 *Non-self-evident*

Applies to all cases where dynamics of release are such that it is not possible to detect the accident until the effects on humans or other living organisms are evident. Environmental contaminations caused by a slow release of chemical from abandoned, forgotten or even active dump sites may well exemplify this type of accident.

7.3 *Other*

Applies to any accidents not covered by one of the two above groups including those for which there were signs of occurrence only understandable to knowledgeable and trained people.

7.4 *Unknown*

When dynamics of release of chemicals cannot be determined.

8. MAiN ROUTES OF HUMAN EXPOSURE

8.1 *Air, airborne particles and aerosols*

A chemical accident may be classified as air-routed because the main route of exposure of the gaseous or particulate contaminant is directly through the air to the target organism. A material so transported may be then integrated, inhaled, or simply create a problem through deposition on the surface of the organism. This ties in quite importantly with the toxicity of the material because materials have different toxicity depending on the route of exposure.

One important aspect of an airborne accident is that the broad extent of the damage is generally much greater, since it will often be related to either an explosive incident or a fairly rapid release of a volatile chemical.

This class of accident does depend greatly on velocity and direction of the winds to establish the extent of the affected area and the rate at which that area is affected.

The velocity of the air movement is critical in such an accident in that, if there is zero velocity, the affected are may be very small indeed, and if here is very high velocity, the dissipation of the material might be so great as to have no adverse effect measurable anywhere, except perhaps, right at the source.

8.2 *Water*

When considering water as the route of exposure in an analysis one must include groundwater and surface water, and the various modes of contact such as ingestion, contact, or contamination through the food chain. In the case water, the direction of flow is far more predictable than air, although the velocity might be variable. This variability, however, tends to be seasonal. The exent of damage resulting from accidents when the contaminants are transported by water is more predictable and somewhat easier to manage than those involving air as the transporting medium.

When water is the route of exposure, the solubility of the material is of great significance, as is the persistance of the substance. The nature of the chemicals released, of course, is also of differing importance when water is the route of exposure, because of the possible interactions between the chemical and the various, inorganic minerals, found in water. Furthermore, biologically descompensable materials may be stabilized and even mineralized in an acquatic system or a marine system, and thus reduce the extent of the damage by eliminating or modifying the chemicals which have been released.

8.3 *Soil*

Since soil doesn't normally move, except through erosion, the route of exposure through soil would involve interaction with water beneath the soil, direct contact with the soil, or the food grown upon the soil. As a route of exposure, it might therefore be of minor concern. However, highly-contaminated airborne particles, that can be inhaled or ingested, may originate from contaminated soil. Moreover, soil may be a major route of exposure through dermal contact or ingestion by children playing on the ground, or by workers exposed to high concentrations of soil particles in the air.

Furthermore, some chemical contamination may result from midnight dumping of unknown materials, or even approved and regulated dumping of unknown materials or materials whose effects is not fully understood. This may permit the transfer of contaminants, with soil acting as the route of exposure. The ecological consequences of this may be far more significant than the public health consequences. If soil is contaminated in such a manner, it may result in the destruction of some natural resource such as a forest, a grassland, or some economically viable activity such as agriculture.

Some other methods, involving some of the physical/chemical properties in the material, may be employed to partition the contaminant into some other phase, and thereby remove it from the soil, or, indeed, to precipitate it in some innocuous complex which is sufficiently stable to render the site, or any products of the site, safe.

8.4 *Food*

Food may be an important route of poisoning. Any time an epidemic of poisoning occurs, food is suspected as one of the possible causes.

The route of exposure involving plant food may result from direct contamination, following airborne contamination of the food, direct contamination through explosive release, or waterborne or soil contamination, where the crops pick up the contamination through either water or the soil. Plant food can also be contaminated through misuse of agrochemicals and pesticides, or through a lack of compliance with withdrawal times recommended for pesticides. For instance, the incorrect use of alkyl mercury would be described as a chemical accident whose route of exposure was food.

Animal food can be contaminated at production level through the use of contaminated feed. In such case, the route of exposure would first of all have to be the soil, air or water to reach the crop, where it would be concentrated for subsequent ingestion in animal feed. Moreover, feed may be contaminated through the addition of mercury or other chemically treated seed. Cases of feed chemical contamination are not rare, but not always dangerous to human beings, due to the fact that animals that become sick and die, as a consequence of acute poisoning, are usually destroyed.

Another major route of animal food contamination at production level is through improper or illegal use of animal drugs, feed additives and hormones. The biomagnification of various toxic contaminants can also occur through the aquatic system, resulting in bioaccumulation in fish, rendering them toxic for human consumption. A typical example is the epidemic poisoning which occurred in Minimata, Japan, through the use of methyl mercury contaminated fish as a food.

Contamination of animal and plant food can also take place during processing and/or distribution.

Poison Information Centres receive frequent reports of food poisonings at restaurants or at home with usually only a few people involved. This suggests that contamination of both animal and plant foods may occur frequently during preparation and cooking.

9. HUMAN HEALTH IMPACT

Chemical accidents may affect human health causing mortality and morbidity in exposed people. All the health effects should be classified in terms of their nature, duration, reversibility degree, and extent. Illnesses caused by chemical accidents may be immediate or delayed. Delayed illnesses are more difficult to be associated with the accident than the immediate ones. Such an association for delayed illnesses would require clinical surveys and epidemiological monitorings lasting for many years after the accident.

9.1 *Mortality*

Includes any death associated with the accident. A quantification of casualties should be attempted. Moreover, affected people should be classified by age, sex, primary cause of death and whether or not they were exposed to the accident for occupational reasons.

Besides the enumeration of casualties, the evaluation of mortality requires the computation of age, sex, and cause-specific death-rates, and their comparisons with suitable reference rates (e.g. national or regional figures).

(a) *Quantification of casualties*

- no casualties;
- less than 10 casualties;
- between 10 and 100 casualties;
- between 100 and 1,000 casualties;
- more than 1,000 casualties.

(b) *Age of affected people*

Number of people in each group should be indicated.

- elders;
- adults;
- children;
- babies;
- fetuses.

(c) *Reason for exposure to the accident*

Number of people in each group should be indicated.

- occupational (specify: production, use transport, etc.);
- non-occupational.

d) *Cause of death*

Number of people in each group should be indicated.

- Infectious and parasitic diseases;
- neoplasms
- endocrine, nutritional and metabolic diseases, and immunity disorders;
- diseases of the blood and blood-forming organs;
- mental disorders;
- diseases of the nervous system and sense organs;
- diseases of the circulatory system;
- diseases of the respiratory system;
- diseases of the digestive system;
- diseases of the genitourinary system;
- complications of pregnancy, childbirth, and the puerperium;
- diseases of the skin and subcutaneous tissue;
- diseases of the musculoskeletal system and connective tissue;
- congenital anomalies;
- certain conditions originating in the perinatal period;
- symptoms, signs and ill-defined conditions;
- injury and poisoning.

9.2 *Morbidity*

Includes any illness which may be associated with the accident. A quantification of acute and chronic illnesses should be attempted. Moreover, affected people can be classified by age, type of illness and if they were exposed to the accident for occupational reasons or not.

Besides the enumeration of cases, the evaluation of morbidity requires the computation of age, sex, and cause-specific disease incidence rates, and their comparison with suitable reference rate (e.g. morbidity among the non-exposed).

(a) *Duration and quantification of illnesses*

Acute illnesses

- No acute illness;
- less than 10 cases;
- between 10 and 100 cases;
- between 100 and 1,000 cases;
- between 1,000 and 10,000 cases;
- more than 10,000.

Chronic illnesses

- No chronic illness;
- less than 10 chronic illnesses;
- between 10 and 100 chronic illnesses;
- between 101 and 1,000 chronic illnesses;
- between 1,001 and 10,000 chronic illnesses;
- between 10,001 and 100,000 chronic illnesses;
- more than 100,000 chronic illnesses.

(b) *Age of affected people*

- Elders;
- adults;
- children;
- babies.

Number of people in each group should be indicated.

(c) *Reason for exposure to the accident*

- occupational (specify: production, use, transport, etc.);
- non-occupational.

(d) *Type of illness*

Number of people showing symptoms and signs attributable to a malfunction of the organs and systems indicated below, should be reported.

- Reproductive system
- muscular — skeletal system
- nervous system and sense organs
- cardiovascular system
- respiratory system

- genitourinary system
- blood and blood-forming organs
- immuno-system
- alimentary system
- skin and mucosa
- endocrine system

Psychiatric disorders (e.g. anxiety, depression, behavioural abnormalities) should be given attention in this context.

(c) *Disability and impairment of health*

Number of people showing disabilities or impairments as indicated below, should be reported.

- *temporary total* (complete, but temporary inability to work);
- *temporary partial* (ability to perform any lighter work than is usual in one's ordinary occupation for a limited time);
- *permanent partial* (limited use of the body, or a part of the body, after recovery has reached a permanent state);
- *permanent total* (entire loss of use of the body, or part of the body, permanently or immutably affected).

Impairment may be total or partial.

Permanent impairment is defined as an anatomic or functional abnormality or a permanent loss after maximum medical rehabilitation has been carried out and which the physician considers stable or nonprogressive.

10. ENVIRONMENTAL, SOCIAL, AND ECONOMIC IMPACT

Chemical accidents may affect human activities and/or living organisms and eco-systems. All these effects should be classified in terms of their nature, duration, reversibility, degree and extent.

10.1 *Nature of effects*

In view of the fact that effects of chemicals on environmental living organisms become significant when one (or more) population(s) in a given ecosystem is affected, all the effects listed below are meant to be produced at a population level (in a given ecosystem) and not at an individual level.

(a) Damage to soil microorganisms

- procaryotes
- eucaryotes
- nitrogen-cycle microorganisms
- carbon-cycle microorganisms
- other

Whenever possible, specify extent of damage

(b) Damage to terrestrial plants

- higher plants

- lower plants
- agricultural system
- natural systems
- other

Whenever possible, specify plants affected and types of effects observed (e.g. lethality, sublethal biochemical and structural effects, reduced growth and biomass).

(c) Damage to terrestrial animals

- mamals (wild/domestic)
- avians (wild/domestic)
- worms
- insects
- other

Whenever possible, specify animals affected and types of effects observed (e.g. lethality, sublethal biochemical and structural effects, behavioural effects, reduced growth, impaired reproduction, interactions among populations).

(d) Damage of acquatic organisms

- phytoplanktonic organism
- (adult) zooplanktonic organism
- (embryos, larvae and fry) meroplanktonic organisms
- benthic organisms
- open-water fishes
- aquatic mamals

Whenever possible, specify organisms affected and types of effects observed (e.g. lethality, sublethal, biochemical, and structural effects, behavioural effects, reduced growth, impaired reproduction, interactions among populations).

(e) Environmental contamination of

- air
- water (drinking/deep well/surface)
- soil and sediments
- terrestrial organisms
- acquatic organisms
- terrestrial food chains
- acquatic food chains
- specific ecosystems

(f) Degree of contamination

(a) *Low* contamination of all or part of the environment with minor annoying effects, but not requiring protective and/or extensive remedial measures.

(b) *Serious* contamination of all or part of the environment, creating difficulties for man's activities and requiring some protective and/or remedial measures.

(c) *Dangerous* contamination of all or part of the environment, limiting some of man's activities in the area.

(d) *Extremely dangerous* contamination of all or part of the environment preventing the continuation of man's activities.

(g) Social and economic disruption

— housing;
— schools;
— hospitals;
— factories;
— shops;
— offices;
— transportation;
— others.

Whenever possible, quantitative estimates should be provided for each group.

10.2 *Duration of effects of environmental contamination*

(a) *Short-term effects*, affecting the area from several hours to a few days.

(b) *Long-term effects*, having impact on the area for several weeks or months.

(c) *Almost permanent effects*, when the effect is expected to last for years.

10.3 *Total economic loss (U.S.$)*

— less than 5,000;
— between 5,000 and 50,000;
— between 50,001 and 500,000;
— between 500,001 and 5,000,000;
— between 5,000,001 and 50,000,000;
— more than 50,000,000.

11. ENVIROMENTAL REHABILITATION METHOD(S)

Rehabilitation methods dealt with in this section concern affected areas. There are 5 sub-categories to be considered: 1. Containment methods. 2. Removal methods. 3, Treatment methods. 4. Disposal methods. 5. None. Each one of the above sub-categories consists of several groups.

11.1 *Containment methods*

Includes any method used to constrain within certain limits the spreading of released chemical(s).

(a) *None*

Includes all accidents in which no containment was attempted.

(b) *Boom*

Includes any spar attached to a mast or kingpost of a ship carrying cargo-hoisting gear; or, a floating boom to contain flotable chemicals such as oil or flotable solids.

(c) *Ditch*

Includes any small, artificial channel cut through earth or rock to carry water for irrigation or drainage.

(d) *Dam*

Includes any barrier constructed to obstruct the flow of the watercourse.

(e) *Dike*

Includes any bank, usually of earth, constructed to control or confine a fluid.

(f) *Combination*

Includes any combination (to be specified) of the above containment methods.

(g) *Other*

Includes all other containment methods not covered by one of the foregoing groups.

(h) *Unkown*

Includes all accidents in which the containment method(s) used cannot be positively ascertained.

11.2 *Removal methods*

Includes any method used to remove the released chemical(s) from the affected area.

(a) *None*

Includes all accidents in which no attempt to remove the released chemical(s) was performed.

(b) *Skim*

Includes any operation concerning removal of floating matter from a liquid.

(c) *Sorbent*

Includes any material, compound, or system that can provide a sorption function, such as adsorption, absorption or desorption.

(d) *Excavate*

Includes any process of removing earth, stone or other materials.

(e) *Pump*

Includes any machine that draws a fluid into itself through an entrance port and forces the fluid out through an exhaust port.

(f) *Burn*

Includes any destruction by fire.

(g) *Combination*

Includes any combination (to be specified) of the above removal methods.

(h) *Other*

Includes all the other removal methods not covered by one of the foregoing groups.

(i) *Unknown*

Includes all accidents in which the removal method(s) used cannot be positively ascertained.

11.3 *Treatment methods*

Includes any method used to render harmless or less dangerous the released chemical(s) on the site of the accident.

(a) *None*

Includes all accidents in which no attempt to treat the released chemical(s) was performed at the site of the accident.

(b) *Physical treatments*

Includes all physical treatment methods. Some examples are:

a) phase and component separation as well as solidification and encapsulation processes whereby the hazardous chemical is fixed in inert, impervious matrix;

b) addition to solid-in-liquid, or liquid-in-liquid suspension of dispersing agents to separate the individual suspended particles;

c) addition of a solvent to decrease the concentration of the solute per unit volume;

d) use of light of any wavelength to inactivate the hazardous chemical(s) released;

e) washing off with a sudden flow of water or of any other fluid.

(c) *Chemical treatments*

Includes all chemical treatment methods used to effect the complete breakdown of hazardous chemical(s) into nontoxic gases and, more usually, to modify the chemical properties of the chemical(s), e.g. to reduce the water solubility, or to neutralize the acidity or alkalinity.

(d) *Biological treatments*

Includes all uses of living organisms (e.g. microorganisms, plants) to degrade, uptake and/or inactivate the chemical(s) released. Some examples are activated sludge, composting, anaerobic digestion and fluidized bed.

(e) *Combination*

Includes any combination (to be specified) of the above treatment methods.

(f) *Other*

Includes all other treatment methods not covered by one of the foregoing groups.

(g) *Unknown*

Includes all accidents in which the treatment method(s) used cannot be positively ascertained.

11.4 *Disposal methods*

Includes any method used to dispose of the released chemical(s) away from the site of the accident.

(a) *None*

Includes all accidents in which no attempt to dispose of the released chemical(s) was performed.

(b) *Recycling treatment*

Includes methods of treatment for the recovery of valuable metallic wastes, as well as more sophisticated methods used for the recovery of valuable chemicals from process residues.

(c) *Disposal by landfill*

Includes all the methods for disposing municipal industrial and hazardous wastes by landfill.

(d) *Disposal by thermal processes*

Includes all the methods (e.g. incineration, gasification, calcination, pyrolysis) for the high temperature oxidation of gaseous, liquid or solid wastes, which converts them into gaseous materials and an incombustible solid residue. It may take place on land and onboard ship at sea.

(e) *Disposal by dumping*

Includes all unloading in an open storage area.

(f) *Disposal by dumping at sea*

Includes all the sea disposals of waste which are generated on land.

(g) *Underground disposal*

Includes all the disposal processes in deepmine facilities. It is used for certain hazardous wastes that are excessively expensive to dispose of in an environmentally acceptable manner at landfill sites or chemical or thermal treatment plants.

(h) *Deep-well disposal*

Includes all the disposal processes performed at injection plants.

(i) *Combination*

Includes any combination (to be specified) of the above disposal methods.

(j) *Other*

Includes all the other disposal methods not covered by one of the foregoing groups.

(k) *Unknown*

Includes all accidents in which the disposal method(s) used cannot be positively ascertained.

11.5 *None*

Includes all the accidents in which no rehabilitation was carried out.

12. LEVEL OF RESOURCES MANAGEMENT FOR EMERGENCY RESPONSE OR REHABILITATION

12.1 *Level 1 (operator level)*

An accident in which the adverse effects are limited to confines of one facility (such as a plant, railway station, storage depot, farma, gas or oil pipeline, booster station and/or terminals, etc.), and where emergency response or rehabilitation was perfomed within that area by the operator on the site.

12.2 *Level II (local/community level)*

This involves an accident in which the effects are spread to the public sector (the community) but in which emergency response or rehabilitation was performed with the resources of that community, plus resources of the plant or industry involved.

12.3 *Level III (regional/national level)*

This may be a larger and/or more serious accident, or it may be simply that it occurred at the border between two jurisdictions (regions or communities) within one nation or country. This may be described as an inter-jurisdictional accident, and emergency response or rehabilitation was handled with the resources available at the regional or national level, employing also the resources of the communities and industries involved.

12.4 *Level IV (international level)*

This is more than a complex accident exceeding the boundaries or resources of one nation. This may be a very large-scale national disaster or it may be a unique event requiring for its handing special skills or facilities not available in that country and/or it may simply be a small accident which occurs close to the border of a neighbouring country. The last type of emergency response or rehabilitation is performed using national resources, but the management of the control might be undertaken by an international team (two or more affected nations) established for the purpose.

12.5 *Unknown*

Includes all accidents in which it is not known who supported emergency response or rehabilitation.

12.6 *Other*

Includes all accidents not covered by one of the foregoing specific groups.

Edition
Fernando Rulfo V.
ECO — Editor