MITIGATION AND PREVENTION OF CHEMICAL DISASTERS

Gopal Dutt Pandey
Assistant Director of Factories, Ghaziabad
Directorate of Factories U.P
Labour Department, Uttar Pradesh

The challenge is to address areas whether India is still weak in enforcing provisions laid out in the Environment (Protection) Act 1986 and Disaster Management Act 2005 for effective on-site as well as off-site emergency management planning for both industry and Central/State/District/Local governments.The subject is very critical but sensitive.

Handling large quantities of HAZCHEM in installations, isolated storages, and during transportation, poses the grave risk of a sudden release of copious quantities of toxicants in the environment. There are approximately 1,949 Major Accident Hazard (MAH) units in 286 districts in the country, as well as a large numbers of small and medium enterprises having inventory of hazardous chemicals and handling a large number of chemicals as raw materials, in processes, products, and wastes, with flammable, explosive, corrosive, toxic and noxious properties. Any accident involving these may have an adverse impact on both the community and the environment.

Large quantities of chemicals are also stored/ processed in industries that are located in densely populated areas. Inappropriate and haphazard construction and the lack of awareness and preparedness on the part of the community further enhance their vulnerability. The potential of heavy losses and adverse consequences on the environment due to a chemical accident calls for further improvement of safety measures in all processes/procedures and the adoption of appropriate methods for handling HAZCHEMs.

As per data availiable in State of Uttar Pradesh there ar appox. 15739 industrial units covered under the Factories Act,1948. Out of which 2472 units are covered under section 2 (cb) (HAZARDOUS FACTORIES) and 121 MAH (Major Accident Hazard) units in state of Uttar Pradesh. The data shows that in State of Uttar Pradesh most of all MAH units have prepared their On- Site emergency Plan as per statutory requirements and all the District have been developed their Off –Site emergency plan in coordination with District Authority and Director of Factories.

Although as per statutory provisions **regarding constitution of Crisis Groups** under The Manufacture Storage and Import of Hazardous Chemicals rules,1989 (Ammended 2000) and The Chemical Emergency (Planning Preparedness and Response) Rules 1996 under E.P. Act 1986 all MAH industries have to prepare and implement **on-site emergency plans** and **participate in off-site emergency plans** prepared by district administrations in line with regulatory provisions. They also have to participate in mock drills to test the operation for the worst case scenario, which also provides data for improving existing plans.

All districts have constituted their DCG and LCG, but still lack of coordination in between Governmental Service Organisation is in existence with. (Status MAH UNITS-All India). There is a need of co-ordination in between the SCG, DCG and LCG

In the state of UTTAR PRADESH, district and local crisis groups have the following cumulative responsibilities as per the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules 1996:

- reviewing all district off-site emergency plans,
- assisting the state government in planning and preparing for chemical accident and their mitigation and management,
- continuously monitoring the post-accident situation, and
- conducting full-scale mock drill of a chemical accident at a site.

The Bhopal Gas Disaster in December 1984 brought into sharp focus the unprecedented potential of HAZCHEM like Methyl Isocyanate in terms of loss of life, health, injury and the long term effects on the population and environment. It created compelling evidence to approach Disaster Management and chemical safety holistically. The era of restructuring with the induction of new HAZCHEM control systems and procedures all over the world in the wake of the Bhopal disaster also resulted in the strengthening of institutional mechanisms at local, district, state and central levels for the management of chemical disasters in India. The consolidation of these institutional mechanisms and the mobilisation of corporate support for the preparation and implementation of emergency plans is an integral part.

Sources of Chemical Disasters

Chemical accidents may originate in:

i) Manufacturing and formulation installations including during commissioning and process operations; maintenance and disposal.
ii) Material handling and storage in manufacturing facilities, and isolated storages; warehouses and godowns including tank farms in ports and docksand fuel depots.
iii) Transportation (road, rail, air, water, and pipelines).

Causative Factors Leading to Chemical Disasters Chemical disasters, in general, may result from:

i) Fire.
ii) Explosion.
iii) Toxic release.
iv) Poisoning.
v) Combinations of the above.

What is a Chemical incident?

`There are many definitions of a chemical incident. Definitions vary according to each organisation and agencies roles and capabilities.

DIFINITION OF A CHEMICAL ACCIDNT :-

An occurrence of public health or environmental concern caused by a release of a toxic or potentially toxic agent or agents. The chemical incident life cycle describes the stages through which emergency personnel prepare for emergencies and chemical incidents It summarises the methods used to plan for prevention, preparedness, responce and recovery from such incidents. These provide a framework in which medical professionals, emergency responders, those concerned with environmental containment and other aspects of chemical incident management can mitigate and reduce the risk of effects to health, the environment and property.

STAGES OF THE CHEMICAL INCIDENT LIFE CYCLE

Prevention phase

Prevention is the actions taken to avoid or eliminate the occurrence of a chemical incident and therefore to prevent any harmful effects.

An example

The preventive measures taken by the industrial installation during process through In-built safety measures, operational safety measures, standard operating procedures, safe

operating procedures, rigorous operational safety training and retraining of the employees and public at large.

The another example is preventive measure might include a prohibition on the road or rail transportation of chemicals over a certain tonnage through a city during rush hour. Through the application of prevention practices, our society can ensure that fewer peoples and their communities become victims of chemical incidents.

Preparation phase

Whether you're a responder or a health professional or a member of a volunteer group or a government agency, preparedness means identifying the actions that you and members of your organisation will need to take in the event of a chemical incident. For example preparedness ensures that when a chemical incident occurs, emergency responders provide effective response safely.

The actions taken during the prevention phase improve resource and skill capabilities by structuring and establishing a mechanism for effecting a timely and appropriate response. Other activities in this phase may include activities undetaken by a range of government organisations and professional groups leading to legislation, resource inventories, hazard and vulnerability analysis, risk estimation, development of emergency response plans, aquiring necessary equipment to respond to a chemical incident and the training of emergency response teams.

Emergency plans and training, for example, to determine actions required if essential services break down are very valuable. Most importantly, practising the plan within your own organisation and with all the other agencies and professional groups likely to be involved in the response phase will help to identify any weaknesses preferably before an incident occurs.

Warning phase

Preceeding a chemical incident, occasionally a period can be identified when it becomes obvious that something hazardous will occur. This is known as the warning or alert phase and prediction of, for example, severe weather phenomena, volcanic eruption, large scale fires or earthquakes allows a period of time when an appropriate response can be geared up. However most chemical incidents are unforeseen, therefore a level of preparedness will need to be maintained at all times.

Response phase

Response begins as soon as a chemical incident is detected or threatened. Once the chemical incident is declared a number of actions must be taken to save lives and reduce suffering requiring co-operation and co-ordinated actions of all responders. Depending on the type of incident these actions may include

- identifying the hazard
- assessing exposure from the hazard to the population and environment at risk
- mobilising and positioning emergency equipment and responders; who may also undertake search and rescue actions
- providing appropriate first aid and medical assistance
- taking action to limit harm to the population either by in place sheltering or evacuation; provision of uncontaminated food and water
- identifying environmental contamination
- recovering damaged services and systems

Local responders and emergency services, government agencies and private organizations take action. Sometimes the destruction goes beyond local and state

capabilities. That's when specified external help may be required and sought from international support agencies

Recovery or rehabilitation phase:

A chemical incident can damage vital services of a population (water, light and gas supply) Rehabilitaion is providing in the short-term essential services such as water and electricity to the affected community until the reconstruction can take place.

In this phase of recovery, actions are taken to determine on going hazards such as environmental contamination and to help the community to return to normal Support to manage psychological distress leading to emotional recovery should be provided for those families and individuals at risk as they put their lives back in order.

Reconstruction

This phase involves the physical recovery of the community. Before starting this phase, study the damage produced by the chemical incident and rebuild damaged property. The task of rebuilding after a chemical incident can take months, even years. Not only services and infrastructure, not only the facilities and operations, but the lives and livelihoods of many thousands of people may be affected. External loans and grants can help. Funds are used to rebuild homes, businesses and public facilities, to clear debris and repair roads and bridges, and to restore the normal water, sewer and other essential services supply.

TYPES OF CHEMICAL EMERGNCIES

The chemicals products are indispensable part of our daily lives. Inside homes you may find corrosives, flammables and toxic products. In the workplace the chemicals are used to manufacture many a wide range of things from a simple chair to a complex machine. How these products are used determine the potential for an incident. For instance, the manufacture, transport, use and disposal of these products may cause an accident. For this reason, all the parties involved in the response of chemical incidents should be prepared to face them in a safe manner.

Fire involving hazardous chemicals

Chemicals are involved in almost all fires. There may be multiple products of combustion that may be more dangerous than the burning chemical. People exposed to a fire can inhale toxic or corrosive gas, or develop skin irritation and burns. Once in contact with fire, some chemicals may cause greater thermal radiation or produce flying projectiles. Oxidizers may facilitate further combustion making fire containment more difficult. In the process of extinguishing the fire, runoff of contaminated water and foams may pollute the environment and later might affect living organisms.

Explosion of storage containers

Many chemicals used in the industry are often stored in tanks or drums. Flammable gas or liquids, toxic gas, corrosives liquids and similar others may be found in large quantities at the industry sites. Examples of flammable products are fuel, solvents, etc. If the tank is heated in a fire it may explode causing flying projectiles of burning parts to a radius of hundreds of meters. Burning parts of the tank might also cause a fire in another location. Furthermore, toxic gases may be released, causing severe burns to many people as well as exposure to combustion products. Traumatic injuries can be inflicted due to the explosion wave or the impact of objects.

Chemical leaks

Chlorine, used for water treatment, is stored in pressurized tanks and if there is valve failure, toxic chlorine gas can escape into the environment. Chlorine gas has great expansion factor, meaning that an increase in volume covering a large area can occur rapidly. This “toxic cloud” may move according the weather conditions and may travel over

medical facilities, schools, sports club, or cover a town just in minutes. Acute toxic manifestations such as eye and skin irritation and respiratory difficulties can develop following exposure.

Transport - related

During transportation of chemicals, spillage can occur following accidents in the roads or sea hence contaminating the environment (land, sea, air) and affecting communities, wildlife (fishes, birds etc) or the food chain. If fires develop, explosion may occur.

Chemical Contamination of products

Contamination of products like food, water, medicine or goods (shampoo, etc.) is a potential threat. Contamination may be accidental due a missuse of chemical (ie. Inappropriate spraying of persistent pesticides), manufacturing error (ie. use of ethylene glycol instead of propylene glycol in vaccine production), uncontrolled release of chemicals, or intentional (i.e. malicious contamination of cyanide in medicines). Following ingestion or use of these contaminated products, poisoning may occur and these harmful health effects may be immediate or may appear much later (days, months or years). It must be emphasized that poisoning in living organisms may appear far away from the site of the chemical incident (for instance, chemical release in food production area and later transported to consumer area).

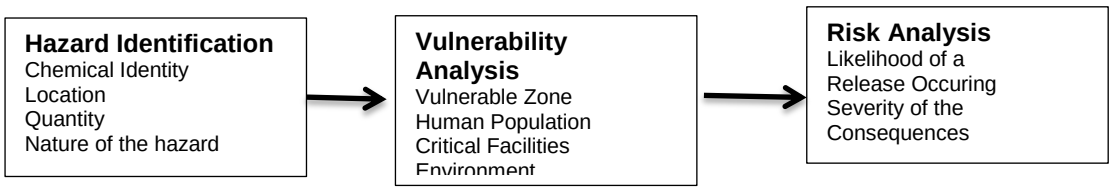
Improper disposal of chemical waste

This occurs when there is inappropriate process for landfill, unexpected discharge of industrial effluents or untreated chemicals into the waterways or sewerage causing chemical contamination in vegetation and bodies of water, which in turn affect the ecology. The situations presented here illustrate the complexity of the chemical incidents and the necessity of multi-sectoral response to ensure the safety of the population exposed or the environment contaminated. There are many other types of incidents with various degrees of complexity. They are detailed in the the specialized courses for firefighters, rescue teams, physicians, etc.

RISK ASSESMENT

Risk assessment is one of the most important step in preparing for chemical emergencies. Basically the risk assessment is a three step decision making process to identify potential hazards facing a community with respect to accidental release of hazardous substances.

The following graphic explains the risk assessment process:



A. *Hazard Identification*

Hazard identification provides the information on the characteristics of situations that have the potential for causing injury to life or damage to property ant the environment. The information needed for this step must include:

- identitying of the chemical hazard
- the location, quantity, conditions of storage, uses or process with the chemical product.
- the type and design of container or vessel
- the nature of the hazard most likely to accompany hazardous materials spills or releases. (e.g. toxic vapor, flammable gases, etc.)
- previous accidents occured in the location

B. *Vulnerability analysis:*

This step identifies the areas in a community that may be affected due to a chemical release. This analysis includes studies on the adverse effects that a chemical may cause on people, environment or property. It is necessary to consider the following information:

- The extent of vulnerable zones. Usually this is done by applying air dispersion models for chemicals. For running this models information on weather conditions, topography, building constructions, etc. are necesary.
- The population that can be affected. Number of people,activities, density, type of individuals (employees, residents, etc.)
- Property. Buildings such as schools, hospitals, shopping centers, transportation corridors, water or power supply sites, etc. that can be affected are considered as “critical buildings” due to people concentration or vital services that they provide.
- The environment. rivers, lakes, agricultural sites, etc.

C. *Risk Analysis:*

Risk analysis Is a study that determines the probability of an accidental release of a hazardous chemical and the consequences that might occur. Risk assessment is a judgement of probability and severity of consequences based on the history of previous incidents, local experience and current technological information.

It provides information on:

- The probability of occurrence of an accident based on the history of current conditions and controls at the facility, consideration of unusual environmental conditions (floods, earthquakes, etc.) or simultaneous emergency incidents.
- Severity of consequences on life. Estimated number of people or animals dead, injured or poisoned, short and long term effects on life.
- Severity of consequences on “critical buildings” and property.
- Severity of consequences on the environment

PROTECTIVE ACTIONS FOR PUBLIC

An accidental release of hazardous chemical sometimes necessitates evacuation of people from certain areas to prevent injury or death. These areas can include those directly affected by toxic fumes and gases or fire and those areas that may be potentially affected during the course of the incident (e.g., through wind shift, a change in site conditions). Evacuation is a complex undertaking.

Decisions about whether or not to evacuate as well as about evacuation distances are incident-specific and must be made at the time of an actual release. When considering the safety of the population at risk, the authority in command must decide about ordering

- in-place sheltering: remaining indoors and sheltering
- evacuation with the removal of the population from the at risk area
- other actions

A. IN-PLACE SHELTERING PROTECTION

Evacuation decisions are of necessity very incident-specific and skilled judgment will be necessary. If the release occurs over an extended period of time, or if there is a fire that cannot be controlled within a short time, then evacuation may be the sensible option. Evacuation during incidents involving the airborne release of a hazardous chemical is sometimes, but by no means always, necessary. Airborne toxicants can be released and move downwind so rapidly that there would be no time to evacuate residents. For short-term releases, often the most prudent course of action for the protection of the nearby residents would be to remain inside with the doors and windows closed and the heating and air conditioning systems shut off. A good message for the general population at risk required to shelter is:

- go in
- stay in
- tune in (to the radio or television)

An airborne cloud will frequently move past quickly vulnerable populations, such as the elderly and sick, may sustain more injury during evacuation, than they would by staying inside and putting simple counter measures into effect.

There are other disadvantages associated with evacuation during incidents involving airborne releases of a hazardous chemical. Changes in wind velocity and direction are difficult to predict and could be very important if evacuation were undertaken during a release.

Differences in temperature between air layers could also cause the toxic cloud to disperse in ways that would be hard to predict. These factors and others make it difficult to estimate how long the community would be exposed to a toxic cloud.

In-place sheltering guidelines:

- Close all doors to the outside and close and lock all windows. (Windows seal better when locked). Seal gaps under door-ways and windows with wet towels and those around doorways and windows with duct tape or similar thick tape.
- Turn off all heating systems and air conditioners.

- Seal any gaps around window type air conditioners, bathroom exhaust fan grilles, range vents. dryer vents, etc. with tape and plastic sheeting, wax paper, or aluminum wrap.
- Turn off and cover all exhaust fans in kitchens. bathrooms. and other spaces.
- block fireplaces or close fireplace dampers.
- Close as many internal doors as possible in homes or other buildings.
- If an outdoor explosion is possible, close drapes, curtains, and shades over windows. Stay away from windows to prevent potential injury from flying glass.
- If you suspect that the gas or vapor has entered the structure you are in, hold a wet cloth over your nose and mouth.
- Building superintendents should set all ventilation systems to 100 percent recirculation so that no outside air is drawn into the structure. Where this is not possible, ventilation systems should be turned off.

B. EVACUATION

Making a decision on evacuation

The first evacuation considerations determining whether an evacuation is necessary, involves a comprehensive effort to identify and consider both the nature of and circumstances surrounding the released hazardous material and its effect on people.

Hazardous Conditions Affecting Evacuation Decisions

Numerous factors affect the spread of hazardous substances into the area surrounding a leaking / burning container or containment vessel. Evacuation decision-makers must carefully consider each of these factors in order to determine the conditions created by the release, the areas that have been or will be affected, and the health effects on people.

The factors that affect an evacuation are:

- amount of released material(s)
- physical and chemical properties of the released material(s)
- health hazards dispersion pattern
- atmospheric conditions
- dispersion medium
- rate of release
- potential duration of release

Factors to consider in Planning a Evacuation

Populations in a hazardous Area

Local authorities should decide about evacuation or “in shelter protection” actions to be taken in the area. It is possible that a part of the affected area must be evacuated and other one remain indoors.

Populations in a threatened area

The criteria to follow for this areas is similar than the one for hazardous area, but the proximity and movement of the hazards should be considered to establish evacuation times, routes, etc.

Identifying people to be evacuated

A number of factor should be considered to ensure a safe and effective evacuation of buildings. Characteristics of people located in it, their degree of mobility, communication barriers, etc. Considering this factor the local authorities can decide about priority of evacuation from buildings such as: schools, hospitals, offices, residences, commercial establishments, government buildings, sporting stadiums, prison, etc.

Resources needed

To accomplish an effective and safe evacuation, the local authorities must consider transportation media for handicapped persons, prisoners, elderly, children, person lacking private transportation. Other items to consider are: provision in some cases, of protective equipment (masks, cloth, etc.) , identification tags for evacuees, communication equipment, health care of evacuees, etc.

Evacuation tasks

For an orderly evacuation, assistance personnel should cover the following tasks

- Identify and specific area to evacuate
- Protective gear to be worn
- Instructions to be given to evacuees
- Transportation of evacuees
- Assistance to special populations
- Shelter locations
- Security of evacuated areas
- Traffic and pedestrian control
- Communication procedures

C. OTHER ACTIONS

Depending on the circumstances of the incident, other actions may be required. These include:

- Provision of clean water during water containation incidents by providing bottled water or water from mobile bowsers may be essential to minimise contamination. Restrictions on use of contaminated water may aslo be required.
- Removal or recall of contaminated food, products or medicines may be required to minimise continuing exposure to the population at risk

RISK COMMINICATION

The term ‘risk communication’ has been used differently in different contexts. In some cases, it is used to mean only access to information or a one-way communication. In a more comprehensive context, it involves a two-way transfer of information and in some cases includes direct involvement in the risk assessment and decision-making processes. It was recognized that in the context of chemical accidents, all stakeholders have something to offer and something to gain and, therefore, the objective of risk communication should be a twoway process based on openness and trust.

Important elements in any risk communications process include, for example:

- the identification of key stakeholders (this may include plant employees, representatives of the local news media, community leaders, members of the health community, academics, schoolchildren, representatives of religious groups, persons with special interests, and others);
- ways to take account of the needs and interests of the various stakeholders from multi-faceted communities concerned with economic as well health and environmental consequences);
- the identification of the objectives of the process and the needs of the various stakeholders;
- fostering an interactive flow of information among stakeholders;
- approaches to facilitate the development of trust and credibility; and
- the use of techniques to help people reach a common understanding of risk, recognising that the public often perceives risk differently than do experts. It is essential that approrpiate and timely information is provided in a clear logical manner by expert communicators. In some countries experts in communication include public health professionals. Informing the public and media liason should be planned for and managed effectively.