AFTERMATH OF BHOPAL

International Conference on ‘Bhopal Gas Tragedy and its Effects on Process Safety’

The chemical process safety summit held recently in Kanpur covered several key issues covering inherent safety design, legal and regulatory frameworks and allied aspects related to safety in process industries. In this, the second of a two-part report (see Chemical Weekly, January 21, 2004 for the first part), the highlights of key issues deliberated in several parallel sessions are presented.

Country frameworks

Bhopal and its Effects on the Canadian Regulatory Framework

Jean-Paul Lacoursiere, P.E.
University of Sherbrooke, Quebec, Canada

Instead of legislating after the Bhopal accident, Canada chose to innovate by adopting a consultative approach. In 1987, Environment Canada set up the Major Industrial Accident Council of Canada (MIACC), a non-profit organisation financed by the federal and provincial governments and industry. MIACC was based on the Canadian Chemical Producers Association (CCPA) ‘Responsible Care’ initiative. Its strength was its process to build strong consensus.

Until 2001, Canada was unusual among the world’s industrial countries in having very little in the way of legislation and regulation controlling major accident hazards in the process industries. There was of course basic regulation of pressure vessels, flammables, etc., and a fairly comprehensive system of regulations governing traditional workplace health and safety, environmental control and so forth, but nowhere near the same degree of attention to controls instituted by other countries in the wake of high-profile incidents such as Flixborough, Seveso, Bhopal and Pasadena.

The legislative process started in 2001 with the Province of Quebec adopting a new Civil Protection Act for the protection of persons and property against disasters. 2003 saw major developments in the regulation of emergencies - changes that are likely to have significant influences on how companies operate in Canada. Surprisingly, however, these changes have received little attention in the media, and many companies may not be aware of their implications.

An Experience in Japan Process Industry before, after 1984, and then
Koji Nishikawa
International Committee of Japan Society for Safety Engineering, Chiba city, Japan

The paper discussed the regulations and the measures of process safety in Japanese process industries, and explained how Japanese process industries had introduced and modified the predecessor’s methods or technology on their traditional corporate culture. For example, Japan introduced the product quality control system or standards from USA after the Second World War, but modified them to the ‘Total Quality Control (TQC)’ as a characteristic bottom-up movement among the workers.

The Bhopal Tragedy: Influence on Process and Community Safety as Practiced in the US
Ronald J. Willey
Northeastern University, Boston, MA, USA.

Chemical accident in Bhopal had a profound effect on the practice of chemical process safety in the US. Fearing the possibility of similar events occurring in the US, Congress convened several hearings and investigations into the causes of the disaster. The inquiries focused both on the state of process safety within the US chemical industry and on the readiness of communities located near chemical operations to respond to sudden and dangerous toxic discharges.

The paper also reviewed major legislative, academic, and industrial changes initiated in the area of process safety after the event, their influence on saving lives, and on improving living conditions surrounding chemical complexes in the US.

Process Safety in the European Chemical Industry, Particularly the Insurance Angle
Karl Strässle
Zurich Insurance Company, Zurich, Switzerland

There have been significant changes in the European chemical industry in the past few years. The main drivers are transfer of production closer to the markets in Asia; industry consolidation with the creation of new industrial parks; cost pressure along with a trend of chemical products to be more and more commodities; increasing governmental regulations; pharmaceutical and agrochemical products are under an increasing observation by public organisations.

From an insurance point of view, it is important to know the consequences to the risk exposures associated with these trends and to create risk awareness. Using the value chain of the chemical industry, he explained that the key risk exposures are very different, going from property, transportation & environmental risks more towards product liability risks. These need to be addressed.

The Post-Bhopal and Post-9/11 Transformations in Chemical Emergency Prevention and Response Policy in the United States
James C. Belke
United States Environmental Protection Agency, Washington, D.C., USA

The United States’ approach to inci-
dent prevention and response at hazardous chemical facilities has undergone two major transformations in the last 20 years. The first was triggered by the Bhopal tragedy in 1984, which, along with other less severe incidents in the United States that occurred around the same time, led to major changes within the US chemical industry, and to a series of Federal laws and regulations intended to prevent major chemical accidents, and to mitigate and respond to any that do occur.

These laws and regulations included the Emergency Planning and Community Right-to-Know Act of 1986, and the Clean Air Act Amendments of 1990, which authorised both EPA’s Risk Management Program, and OSHA’s Process Safety Management standard.

A more recent transformation is currently underway in the wake of the 9/11 attacks on New York and Washington. It involves the advent of various security-related requirements affecting many of the same facilities covered under the existing accident prevention rules, as well as a complete re-evaluation and restructuring of the US system for responding to national emergencies.

Status of process safety management in India
B. Karthikeyan
Director, Prism Consultants, India

Post-Bhopal a number of changes were made in the Indian Factories Act and environmental legislation. Over the last decade, the Indian chemical industry has been striving to improve its safety and environmental performance.

A lot remains to be done in the realm of process safety to ensure that another Bhopal does not occur in India. He proposed specific steps in the areas of legislation and initiatives by the industry.

Reactive chemicals

Risk reduction & elimination of polymer chunk hazards formed during process upsets
G. Francis Arulanandam et al
Saudi European Petrochemical Company (Ibn Zahr), Saudi Arabia

Polymer manufacturing teams are facing this problem for quite some time, which not only induces potential hazards like hydrocarbon getting entrapped inside chunks, but also reduces their reaction & production rates. These process variations yield negative consequences like loss of production, injuries & fire, while removing polymer chunks using normal maintenance practices.

As the formation and growth of chunks inside process vessels are inevitable under continued reaction and extreme process upset conditions, the chances of hydrocarbon getting entrapped inside chunks become more. Reducing the risk levels and elimination of hydrocarbon from the polymer lumps has become a challenge for the plant maintenance crew to overcome fire hazards while carrying out their tasks.

Mr. Arulanandam discussed the solutions to these issues with examples, unique process hazards associated with the formation of polymer lumps, the causative factors, proactive actions to eliminate risks of hydrocarbon, safe maintenance methods & techniques including the plant safety administrative controls that assist in reducing the higher levels of risk.

Case studies of some reactive chemistry incidents and how they could have been prevented
Dennis C. Hendershot
Rohm and Haas Company, USA,

Good process safety management systems, including consideration of reactive chemistry issues and the handling and storage of individual reactive chemicals, are important to operating a safe chemical process. In many cases, reactive chemistry hazards are not thoroughly considered in a process safety management programme because the process does not involve any intentional chemical reaction – it may consist only of blending or physical processing operations such as dryng or distillation.

Reactivity hazard awareness and recognition is often a major contributor to reactive chemistry incidents, and education of process development and operating personnel on these hazards can reduce their occur-

CHEMICAL INCIDENTS IN INDIA AFTER BHOPAL

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Origin of incident</th>
<th>Chemical(s) involved</th>
<th>Number of:</th>
<th>Deaths</th>
<th>Injured</th>
<th>Evacuated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kochi</td>
<td>1985</td>
<td>Release</td>
<td>Hexacyclopadiene</td>
<td>—</td>
<td>200</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>New Delhi</td>
<td>1985</td>
<td>Release</td>
<td>Sulphuric acid</td>
<td>1</td>
<td>340</td>
<td>&gt;10</td>
<td>—</td>
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<tr>
<td>Bombay</td>
<td>1988</td>
<td>Fire in refinery</td>
<td>Oil</td>
<td>35</td>
<td>16</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Bhatinda</td>
<td>1989</td>
<td>Leakage</td>
<td>Ammonia</td>
<td>—</td>
<td>500</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Nagothane</td>
<td>1990</td>
<td>Leakage</td>
<td>Ethane and propane</td>
<td>32</td>
<td>22</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kolkata</td>
<td>1991</td>
<td>Leakage from a pipeline</td>
<td>Chlorine</td>
<td>—</td>
<td>200</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Vishakhapatnam</td>
<td>1997</td>
<td>Refinery fire</td>
<td>LPG</td>
<td>60</td>
<td>31</td>
<td>1,50,000</td>
<td>—</td>
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<tr>
<td>Vellore</td>
<td>2003</td>
<td>Explosion</td>
<td>Explosives</td>
<td>25</td>
<td>3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Mohali</td>
<td>2003</td>
<td>Fire</td>
<td>Not known</td>
<td>4</td>
<td>25</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kochi</td>
<td>2004</td>
<td>Fire</td>
<td>Toluene</td>
<td>—</td>
<td>Not known</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

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The absence of management control over process changes has resulted in several catastrophic failures. Almost every major incident can be linked to a change that was not subjected to a proper safety review as required by MOC.

MOC is required to maintain the safety integrity of the chemical process facility and administration of a cost-effective MOC program requires careful planning. A simple MOC procedural workflow and a document management system are practical necessities.

Various screening techniques have been used to optimise scarce technical resources, particularly by allowing small hazard / low risk changes to be analysed and authorised without the need for unnecessary red tape.

Risk assessment study carried out for the pipeline system

Dr. G. Madhu
Cochin University of Science and Technology, India

As part of the study, the probable failure modes associated with different operational areas for the proposed facility were identified.

The predominant causes of hydrocarbon release from the pipeline have been identified as failure due to external factors, corrosion, construction defects and human error. Consequence analysis was carried out for the identified failure scenarios using empirical models.

Cross-country pipeline safety assessment

H. N. Mathurkar and Dr. A. Gupta
National Environmental Engineering Research Institute (NEERI)

The study quantitatively evaluates the risk involved based on the actual population data along the pipeline route for the entire stretch of the pipeline.

Pipeline safety assessment studies were carried out at the design stage of cross-country natural gas pipeline for implementation of various safety measures. The risk level for the pipeline is computed through the use of Event tree analysis, Consequence analysis, Vulnerability analysis and Individual risk computation.

Pipeline design parameters like pipeline thickness, its depth cover, routing, locations of sectionaising valve and site specific surrounding population density, terrain etc. was considered for arriving at the risk level for the pipeline.

Evaluating Safety Information Management Performance – A Key to Preventing Disaster

Tzu-Lien Tzou, Geoff Hankinson, David Edwards, Paul Chung
Loughborough University, Loughborough, UK

The relationship between mismanagement of information and its adverse effect on plant safety in the process industries is now widely recognised. Ignorance of essential facts and messages will lead inexorably to a catastrophic outcome. Evaluating SIM performance can provide interventions to prevent disasters and improve plant safety. Petrochemical plants were surveyed to evaluate the current state of SIM in the Taiwanese process industry.

Fire safety and law

Thermal shielding by water spray curtains

Jean-Marie Buchlin and Karin Hald
Von Karman Institute (VKI), Belgium

The water spray curtain is today recognised as a useful technique to mitigate major industrial hazards. It combines attractive features such as simplicity, efficacy and adaptability to different types of risk.

Revised fire consequence models for offshore quantitative risk assessment

Ravichandra Pula, et al
Memorial University of Newfoundland, Canada

Offshore oil and gas platforms are well-known for their compact geometry, high degree of congestion, limited ventilation and difficult escape routes. A small mishap under such conditions can quickly escalate into a catastrophe. Among all the accidental process-related events occurring offshore, fire is the most frequently reported.

It is critical to study the behaviour of
fires and quantity the hazards posed by them in order to complete a detailed quantitative risk assessment. While there are many consequence models available to predict fire hazards, only a few have been validated for the unique conditions found offshore.

**Dispersion analysis**

**Dilution method to minimise consequences of toxic/flammable gas releases**

Prof. J. P. Gupta  
Indian Institute of Technology-Kanpur

Dilution has long been considered a solution to many problems of toxic/flammable material releases. It implies diluting to a concentration that is below physiologically dangerous levels for a toxic substance, or to a level below LFL for a flammable material release, ensuring that the process adopted for dilution does not itself enhance the risks.

**Accident investigation and databases**

**Explosion and Fire in Gas-Oil Fixed Roof Storage Tank**  
Yigal Riezel  
Ashdod, Israel

The paper described an explosion and fire in gas-oil fixed roof storage tank located in the tank farm of Ashdod Oil Refinery, Israel, which occurred on November 2, 1997 and caused loss of life and fire in two adjacent tanks located in the same dike. The investigation pointed out that the source of explosive mixture in the tank was hydrogen that penetrated with the gas-oil to the tank as a result of non-complete gas-oil stripping with hydrogen at the exit of gas-oil hydrotreating unit.

**Present status of industrial accident database**  
M. Surianarayanan et al  
Cell for Industrial Safety and Risk Analysis (CISRA), Chennai

It is imperative to collate and categorise information on all accidents, so that the analysis results of these accidents could help in preventing its recurrence. The ‘Blaze Accident Database’ developed by CISRA, is specially designed to key-in the Indian industries’ accident histories. It covers accidents ranging from near-miss cases to major disasters.

**Company and community frameworks**

**Role of local communities in chemical accident prevention and preparedness**  
Timothy R. Gablehouse  
Colorado Emergency Planning Commission, USA

There is a strong recognition in the US that local communities working very closely with chemical handling facilities in their areas can directly and meaningfully reduce the threat of a chemical release incident, regardless of cause. Likewise, through similar means they can better prepare themselves to respond should an incident occur.