Bhopal disaster: Lessons learnt and ignored

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The biggest ever process industry accident

Occurred at five past midnight, on December 3, 1984

Over 40 tones of the deadly MIC (methyl isocyanate) leaked from the Union Carbide Corporation (UCC) Plant

Killing ~ 5000
Toxifying ~ 50,000
Why Bhopal is relevant even today

• Yes, the Bhopal incident sent shock waves across the world

• It brought about major improvements in R&D, legislation, and implementation of safety
  - But has enough been done?
  - Has the chemical process industry learnt its lesson well?

• Those who forget history are condemned to repeat it

• Lest we forget...
Date with disaster

1969
Union Carbide India Limited (UCIL) established as a people-friendly industry

1980
Starts manufacturing methyl isocyanate (MIC) based pesticides
Date with disaster

- Profits drop as the sale of carbaryl based pesticides drops
- Production of carbaryl pesticides drops
- Safety neglected as the unit stopped making profits
Date to disaster contd.

23 December 1981:
A worker is accidentally exposed to phosgene, dies

• The UCC Management had violated a safety regulation which prohibited storage of phosgene when the unit was not in production
• Management was also guilty of not warning the worker that a significant quantity of phosgene had been left in the tank
• Workers at UCC aware for the first time that the chemicals they were handling were not merely unsafe, they were deadly poisons

A month later, another leak of phosgene takes place leading to the hospitalization of 25 workers

• None of the victims had been forewarned by the UCC management to wear protective masks while moving about in the area prone to phosgene leaks
Date to disaster contd.

• February 1982
  25 workers hospitalized following leaks in pipes carrying chlorine, MIC and hydrochloric acid

• December 3, 1982
  A massive leak of chlorine affects 16 workers, neighboring shanties affected
Faced with mounting public criticism the Employment Minister comes out declaring ‘there is no cause for concern about the presence of UCC because the phosgene it uses is not a toxic gas’!
Date to disaster contd.

- May 1984
  Relief valve vent header and the process vent header of the MIC storage tank connected

- October 1984
  Refrigeration system of the MIC tank shut down to save costs
  Vent gas scrubber to neutralize MIC vapours put in passive mode

- November 1984
  Operators attempt to transfer MIC from tank 610 to the processing facility, but the tank fails to pressurize, indicating a leak

- December 2, 1984
  Another failed attempt made to transfer the MIC from tank 610; plant supervisor orders washing the lines to clear the blockage
  Slip blind required for isolation not inserted
Valve reseated between 02.00 and 02.30 HRS.
By then, 40-45 tonnes of MIC had leaked.
So the MIC leaked

And the after-effects are being felt till today

And will be felt for generations to come
Failures in the line of defense

- Refrigeration unit of the MIC storage tank shut down
- Vent gas scrubber system turned down
- Flare tower taken out of service
- High temperature alarm was faulty, as was the pressure controller and level indicator
- Siren which was to warn the public delinked from the in-plant siren
There were warning signs galore but the UCC management steadfastly ignored them.

To hide from the public the extent of lethality of MIC, HCN, and Phosgene, UCC never made public knowledge about medical treatment required by people exposed to these poisons.

The smugness was such that...
Even the UCC management got carried away by their own misrepresentation of facts:

• A few days before the Bhopal tragedy, on the prompting of UCC, the Minister had declared that the Carbide plant is totally safe because the phosgene they use isn’t poisonous!

• On being woken up from sleep to be informed of the MIC leak, a top UCC executive had blurted out, “The leak can’t be from our plant because our plant is totally safe!”
“Mr J. Mukund, Union Carbide’s works manager exhibited a rather chilling overconfidence. He is believed to have expressed that the gas could not have leaked from his plant as the plant was shut down. Once the leak was confirmed, the Company’s Medical Officer opined that the gas was not fatal but was just a minor irritant. And yet people choked to death on the streets of Bhopal!”

R.K. Bisarya, then mayor of Bhopal
Swaraj Puri, then Director General (Police), Bhopal
“...I heard of this tragedy...I contacted Dr Loya, the head of medical department of Union Carbide. He did not know any antidote. He said that the gas was a minor irritant”

R.K. Bisarya, then mayor of Bhopal
Impact of Bhopal on process safety legislation
The Bhopal incident sent shock waves across the world and brought about major improvements in R&D, legislation, and implementation of safety.
India, too, has enacted elaborate legislation

- Identified hazardous chemicals and fixed their threshold handling quantities
- Made risk assessment, safety audit, accident post-mortem, public education, onsite-offsite emergency preparedness etc. mandatory
- The stipulations have a broad sweep which covers the gamut of accident prevention and safety promotion

But has it prevented major catastrophic accidents from occurring?
Incidents in India over the decades

- 1940s: 1
- 1950s: 1
- 1960s: 1
- 1970s: 1
- 1980s: 40
- 1990s: 60
- 2000s: 67
The world’s worst industrial accident of the 1990s

14 September 1997, Vishakhapatnam, India

Hindustan Petroleum Corporation Limited petroleum refinery

- 60 dead
- $15 million worth damage to property
Jaipur fire, 2009

29 October 2009, Jaipur, India

Indian Oil Corporation’s oil depot

• 12 killed
• 200 injured
• $32 million worth of damage caused
There are legislations galore

But the devil is in the detail...
• Industries continue to downplay hazards

• Regulatory agencies often believe that lay people ‘cry wolf’ too often

• There are no detailed guidelines on how to conduct HAZOP, MCAA etc. Often the agency conducting the RA and the one evaluating it are both not fully conversant with the subtleties of RA
Examples of misconceptions

• Chlorine is non-flammable. It’s pressure-liquefied storage can’t cause a BLEVE

• The fireball accompanying an explosion can be so destructive that blast effects pale in comparison, hence can be neglected

• There are no guidelines available to study domino effect, so one may avoid doing it

• A safety measure is in place, so there is no chance that an accident can occur
Then there are cultural, socio-economic, demographic, political and infrastructural factors which are special to India

- Low wages and excessive job security combine to make a lax supervisor

- Technical and infrastructural modernity is embedded in outdated procedures and attitudes. Islands of excellence lie side by side with sprawls of inaptitude

- As the political priorities and economic policies change, so do the extent of rigor expected from regulatory agencies
Special challenges for disaster management in developing countries: as magnified in the Bhopal tragedy

- Densely populated areas around the plant
- Absence of a proper road network. Rescue workers had to move on foot through densely populated areas
- Poor communications
- Lack of effective emergency medical facilities
- Inadequate transport for emergency evacuation
- People sleeping on pavements/railway platforms
- Unidentified dead bodies, creating difficulties in identification of religion (Hindu/Muslim) and also creating medico-legal problems
- Along with humans a large number of animals, mostly cattle, perish in disaster. Their disposal became a serious health problem
- Relief operations became difficult as the disaster caused enervation
R&D in process safety in India

- Research in process safety has also been very slow in coming up, with only a few developing countries except China and India presently contributing to the global output.

- Of these Indian research acquired some intensity only from 1994 onwards when a process safety group led by this author with F.I. Khan as the prime mover began developing new methodologies and do-how packages.

- In recent years further momentum has been generated at some other institutions as well, notably the
  - Indian Institute of Chemical Technology, Hyderabad
  - Indian Institutes of Technology at Madras, Kanpur, Roorkee and Gandhinagar
What is true of India appears to be true for most of the ‘developing’ world, as well

What about the safety capabilities of the ‘developed’ world?
In the words of Carolyn W. Merritt, Chairman, Chemical Safety & Hazard Investigation Board

"It is eerie how many investigations we do where we find the same conditions that led to the accident at Bhopal“

....the U.S. has dodged a chemical tragedy mostly through "luck and good fortune."

"There are companies that are leading the charge with chemical safety, process safety, and integrated chemical management programs, but we still find the same situations that occurred at Bhopal.“

She stresses that these accidents are not "engineering mysteries." The hazards are well known, as are the measures to prevent or control them. She argues that many companies put more resources into accountants than safety engineers.
In the words of Mark Hertsgaard

*The Nation*, June 8, 2010

commenting on the similarities of the BP oil disaster with Bhopal

“The parallels between the Bhopal chemical explosion of 1984 and the BP underwater oil gusher of today are downright eerie. In the lead-up to each catastrophe, warnings of impending disaster were repeatedly given--and repeatedly ignored, by corporate officials as well as their supposed government regulators.

In the case of BP, Abrahm Lustgarten and Ryan Knutson of ProPublica report, "a series of internal investigations over the past decade warned senior BP managers that the company repeatedly disregarded safety and environmental rules and risked a serious accident if it did not change its ways."
The common thread

The common thread that binds together the follies of industries

• The easy but illogical nonchalance *Don’t worry, nothing is going to happen*

• The ignoring of early warning signals

• The cost-cutting in implementing process safety

• The general attitude that process safety scientists like to make mountains of out of molehills
Lessons for Managing Hazardous Facilities
Technological aspects

- Setting up of condition monitoring equipment/emergency handling equipment
- Installing reliable control systems using microprocessors/distributed data processing systems, etc.
- Installing safety interlocks for preventing operation of systems if certain vital subsystems are inoperative
- Automation of facilities to reduce the need to have human operators
- Hazardous facilities with zero venting or completely closed loops; and
- Non-destructive testing systems for regular inspection
Human aspects

- Skill development for systems safety procedures
- Imparting hazard analysis skills
- Developing emergency handling capability
- Strengthening EIA capabilities
- Improving capability for inspecting hazardous facilities
- Training people in hazard and operability studies
Technological advancements

• Technological advancements do strengthen human capabilities of process safety

• But it is the human failure, rather than machine failure, that is behind most process industry accidents
To minimize human errors

- Safety audit to be made statutory involving external persons and a manual to be prepared
- Preparing hazard assessment manuals
- Institutionalizing emergency procedures
- Early warning procedures to be made specific: minor accidents to be given much more attention as it can foretell and forestall bigger disasters
- Safety regulations manual
The most important prerequisite for accident prevention is the top management’s commitment towards safety.
Thank you