The Bhopal Accident

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Presentation Layout

- **Background Information**
- The Bhopal Disaster
  - Technical Details / Factors for Failure / Aftermath
- **The Stakeholders**
- **Consequences of the disaster**
- **Who were primarily responsible?**
- **The Ethical Issues**
- **Implications for Software Engineering**
- **Q & A**

Background Information

- Sunday, December 2nd, 1984.
- One of Union Carbide's Pesticide factories was located in Bhopal, India.
- Union Carbide of India Limited (UCIL) was a subsidiary of The Union Carbide Corporation (UCC).
- A rapidly growing community of roughly 900,000 people.
- The Factory produced carbamate pesticides. One component was Methyl Isocyanate (MIC).

(a)(b)

The Bhopal Disaster

- The MIC production unit had been shut down for 2 months for routine maintenance.
- 9:30pm - Several pipelines linked to 3 MIC storage tanks were being washed.
- 11:00pm - Many workers became aware of an MIC leak, but weren't able to find the source.
- 12:30am - The stinging sensation of MIC got stronger.

(a)(b)

- MIC tank 610 was checked out. The ground around the tank was unstable.
- 40 tons of deadly gases suddenly burst out into the atmosphere. Workers fled in panic.
- Neighbouring communities fled in panic shortly after.

(a)(b)

The Bhopal Disaster – Technical Details

- Many pipelines were interconnected with each other.
- A jumper line was installed several months prior to the disaster to ease routine maintenance.
- The jumper line allowed water to flow through. Along with another leaky pipe, water was able to pass into tank 610.

(a)(b)

- Production of MIC:

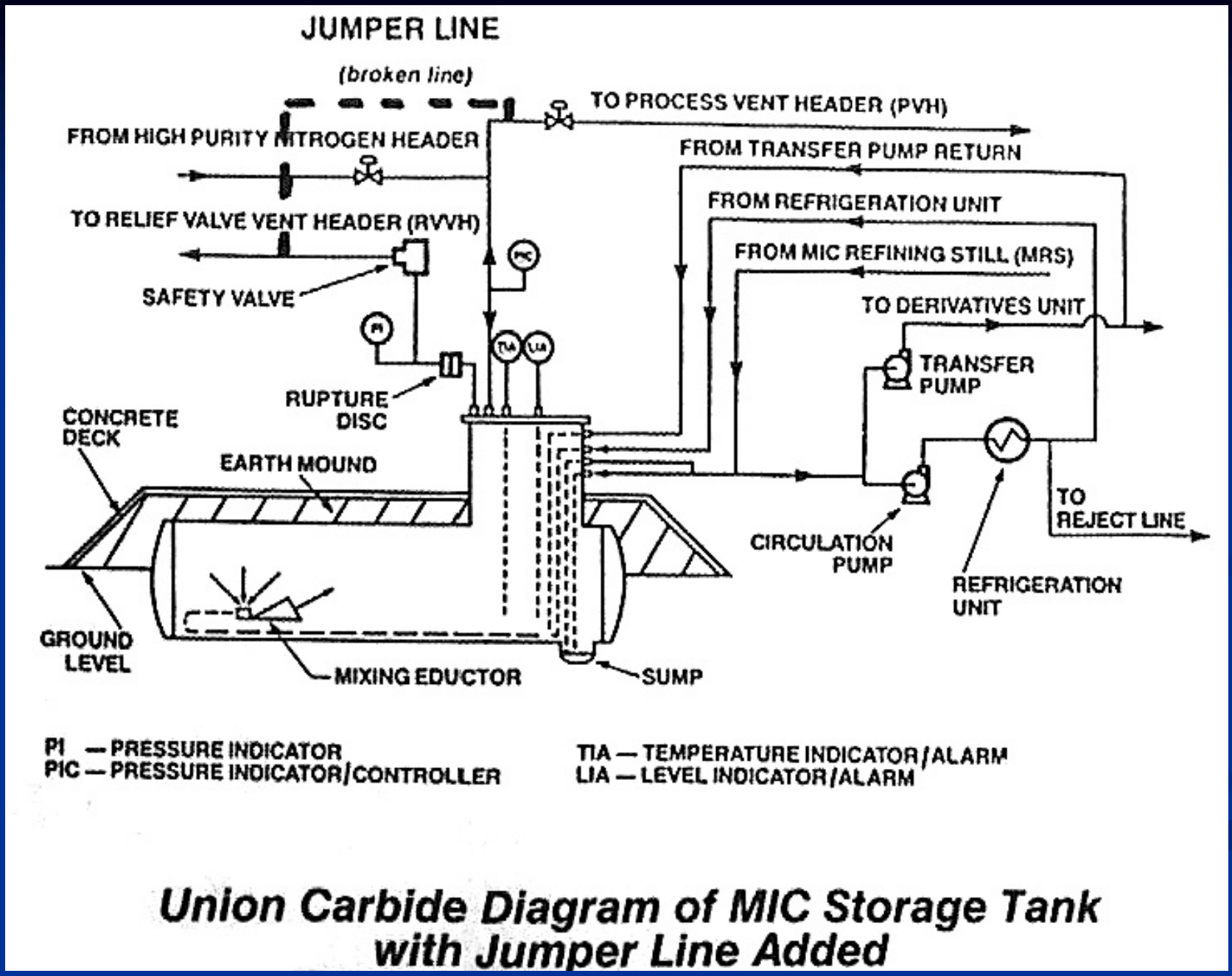
  Carbon Monoxide + Chlorine = Phosgene

  Phosgene + Monomethylamine = Methyl Isocyanate

  Methyl Isocyanate + Alpha Napthol = SEVIN.

- MIC went through a ‘runaway’ reactions because it was contaminated with water.

(a)(b)



Union Carbide Diagram of MIC Storage Tank with Jumper Line Added

(bi)

The Bhopal Disaster – Factors for Failure

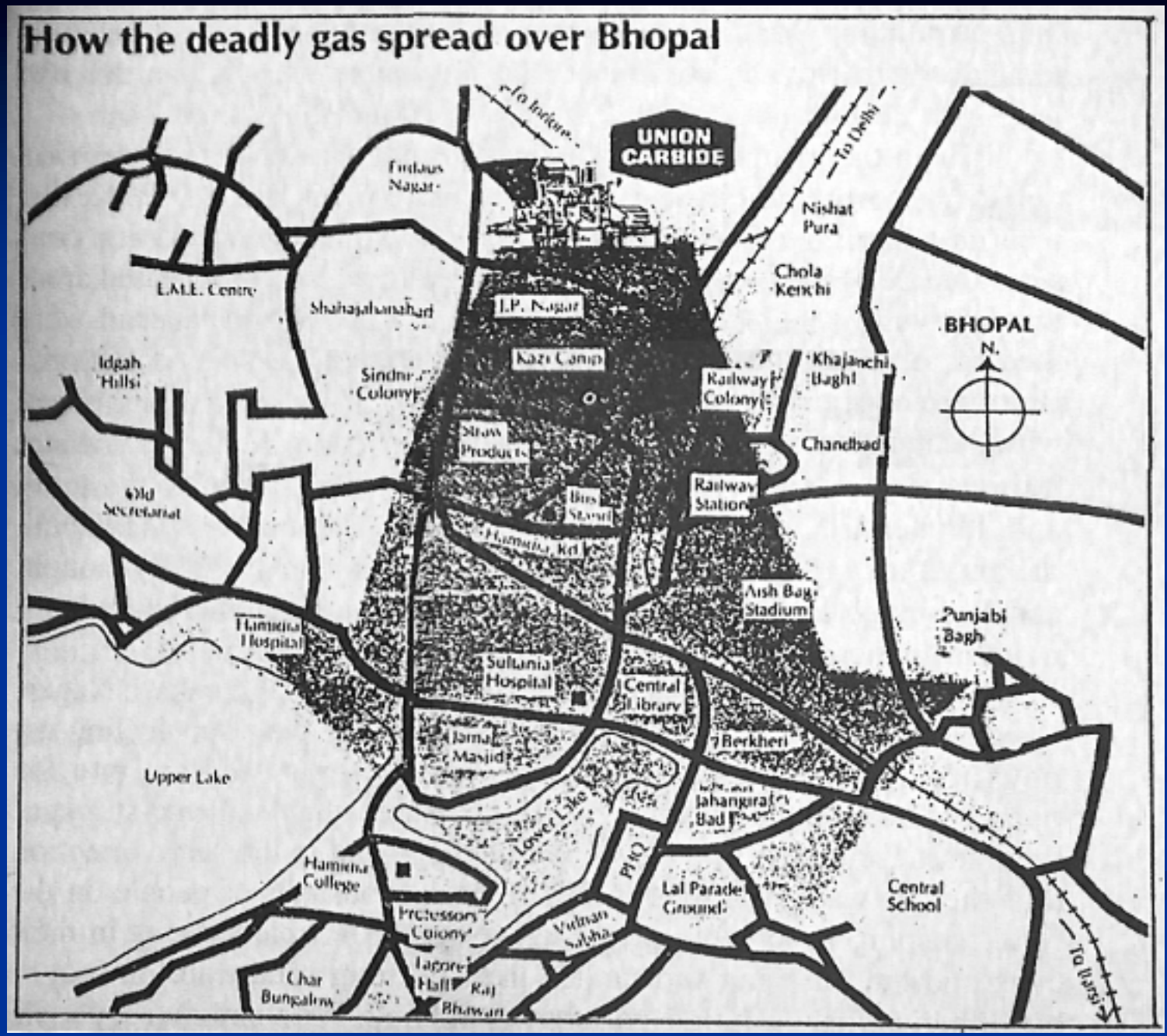
- Instrumentation and control devices were inadequate and weren't extensive enough.
- Plant safety systems were not designed to meet extreme cases.
- The plant design was severely affected by economic issues.

(a)(b)

The Bhopal Disaster – Aftermath

- The largest industrial disaster in history.
- Approximately 2500 deaths at the time of the disaster.
- July of 1985, it was estimated that about 50-60,000 people were severely debilitated.
- Other estimates say the total number of deaths up to 1997 totaled to more than 16,000.

(a)(b)


How the deadly gas spread over Bhopal
UNION CARBIDE
To Indore
To Delhi
Firdaus Nagar
E.M.E. Centre
Shahjahanabad
I.P. Nagar
Kazi Camp
Nishat Pura
Chola Kenchi
BHOPAL
N.
Idgah Hills
Sindhi Colony
Railway Colony
Khajanchi Baghl
Chandbad
Old Secretariat
Bus Stand
Railway Station
Hamidia Rd
Ash Bag Stadium
Punjabi Bagh
Hamidia Hospital
Sultania Hospital
Central Library
Jama Masjid
Berkheri
Upper Lake
Lower Lake
Jahangirabad
PHQ
Hamidia College
Lal Parade Ground
Central School
Professors Colony
Vulcan Shala
Tagore Hall
Raj Bhawan
Char Bungalow
To Itarsi

(bii)

The Stakeholders

- Union Carbide Corporation.
  - Interested in making more money in foreign countries.
- Warren Anderson.
  - Same interests as above.
- Union Carbide of India Limited.
  - Interested in making super profits.
  - Also interested in expanding the economy.

(e)

- The West Virginia Engineering Firm.
  - Primary concern was for the design of the plant.
- The Government Of India.
  - Interested in the expansion of the economy.
  - Interested in more jobs and money.
- The Bhopal community.
  - Interested in the expansion of the community and economy as well as available jobs at the plant.

(e)

Consequences Of The Disaster

- 1985 – Bhopal Gas Leak Disaster Act
  - Allowed Government of India to represent all affected individuals.
- $2.2 Million grant to Arizona State University for new vocational-technical training facility for the citizens of Bhopal.
- Meanwhile, the Institute Plant in West Virginia had a chemical leak due to several faults and unsatisfactory software performance.

(e)(f)(g)(h)

- Emergency Planning and Community Right To Know Act.
  - Provides information to local communities and individuals about hazardous materials in their local areas.
- Responsible Care ® under the Chemical Manufacturers Association.
- Creation of the Chemical Safety and Hazard Investigation Board.

(e)(f)(g)(h)

Who Were Primarily Responsible?

- Union Carbide Corporation (UCC).
- Union Carbide Of India Limited (UCIL).
- Warren Anderson (CEO of UCC).
- Eight Indian Officials (Some were part of UCIL).

(d)

The Ethical Issues

- **“Hold paramount the safety, health and welfare of the public.”**
  - Poor quality and lack of many instruments, safety equipment and reduced operation of critical systems
    - Flare Tower, VGS, Water Sprays, MIC refrigerator, Tank 610.
  - The local community was never given any information about MIC and other chemicals.

(a)(b)(i)

- Gross negligence by the Government of India and UC.
  - 3 separate safety audits. No actions made.
  - Cared more about saving money.
  - Coffee breaks were more important.
  - First official meeting took place 40 hours after the disaster.
- Workers were never informed of the dangers of MIC as well as other chemicals.
  - Gained information the hard way.

(a)(b)(i)

(c)

- **“Perform services only in areas of their competence”**
  - Jobs were continually cut to reduce costs.
  - Some shifts only had 8 workers.
  - Many workers never had the expertise required for their positions.
  - Training went down from 6 months to 15 days.

(a)(b)(i)

- **“Issue public statements only in an objective and truthful manner.”**
- **“Avoid deceptive acts.”**
  - Workers sometimes went for random medical examinations. Were never told the truth.
  - Chief Medical Officer of UCIL told doctors that MIC was a non toxic irritant.
  - Police officials were told lies.
  - Many false claims and accusations in the trial.

(a)(b)(i)

- **Why were these Ethical codes broken?**
- **How can we prevent future disasters of this type?**

Applications & Implications to Software Engineering

- Problems found in the Bhopal disaster that may be found in software systems:
  - Extreme Case handling.
  - Measurement readings and calculations.
- The above examples can pave the way for the Software Engineering profession.
- Code of Ethics for Classical Engineering apply directly to Software Engineering.

Bibliography

(a) Everest, Larry. Behind The Poison Cloud, Banner Press; U.S.A. 1986.

(b) Morehouse, Ward & Subramaniam, M. Arun. The Bhopal Tragedy, Council on International and Public Affairs; U.S.A. 1986.

(bi) "Union Carbide Diagram of MIC Storage Tank with Jumper Line Added" was taken from pg. #18.

(bii) "How the deadly gas spread over Bhopal" picture was taken from pg. #22.

(c) Bhopal Plant picture source from http://www.chemsafety.gov/images/bhopal01.jpg

(d) Bhopal, http://www.ucaqld.com/au/community/bhopal

(e) Bryce, Amy. Bhopal Disaster Spurs U.S. Industry, Legislative Action, http://www.chemsafety.gov/_lib/bhopal01 July 29, 1999.

(f) Union Carbide Corporation. Chronology, http://www.bhopal.com/chrono.htm 2001-2002.

(g) Union Carbide Corporation. The Settlement, http://www.bhopal.com/sna.htm 2001-2002.

(h) Union Carbide Corporation. Incident Review, http://www.bhopal.com/review.htm 2001-2002.

(i) Online Ethics Center for Engineering and Science. National Society of Professional Engineers (NSPE) Code of Ethics for Engineers, http://www.onlineethics.org/codes/NSPEcode.html 2003.