

Guest Editorial

**Chemical Process Safety at a Crossroads**

December 2004 will mark the 20th anniversary of the worst industrial accident in history, the chemical plant disaster in Bhopal, India, that killed thousands of people and injured tens of thousands more. Along with other safety professionals from around the world, I will be traveling to India this fall to reflect on what has changed and what we still must do to better protect the lives of workers and the public from chemical accidents.

Chi ( $\chi$ ), the 22nd letter of the Greek alphabet, is an ancient symbol of a crossroads. At its center, the intersection point, or chiasm, marks a single event that separates past from future. Bhopal is a chiasm, an event that forever changed the path of the chemical industry and that continues to be felt around the world.

Thousands of Bhopal victims suffered permanent, disabling injuries, which they must live with every day. The tragedy has also changed public attitudes toward the chemical industry in lasting ways. The U.S. Congress passed the Emergency Planning and Community Right-to-Know Act (1986), followed by the Clean Air Act Amendments (1990). These laws have established a federal role in overseeing how companies manage the safety of chemical processes on a daily basis.

As directed by Congress, the U.S. Occupational Safety and Health Administration (OSHA 1992) and the U.S. Environmental Protection Agency (U.S. EPA 1996) issued regulations requiring companies to analyze the hazards of their processes, preserve safety during process changes, perform preventative maintenance, train workers and contractors, investigate safety incidents, and plan for emergencies. The rules do not require specific safety equipment or define an acceptable level of risk to workers or the public, but they do require companies to establish broad safety management systems before processing various hazardous chemicals. As radical as the rules were in some ways, in one important respect they were decidedly conventional: to be covered under the standards, a facility needs to use at least a threshold quantity of one of approximately 100 enumerated chemical substances or classes. Thus most chemical processes today are not covered under the safety rules.

Beyond mandating new regulations, the Clean Air Act Amendments (1990) authorized creation of a new independent federal agency, the U.S. Chemical Safety and Hazard Investigation Board (CSB), which investigates the root causes of serious chemical accidents that harm workers or the public. Governed by a board of five safety experts appointed by the president and confirmed by the Senate, the CSB has the authority to recommend needed safety improvements to the U.S. EPA, OSHA, industry, and other organizations, based on its investigations of accidents and hazards. Although the CSB was not funded until 1997, it is currently a fully operational body that investigates up to a dozen major chemical accidents each year and reports its findings to the public and Congress.

One ongoing purpose of the CSB is to evaluate just how effective OSHA and U.S. EPA process safety regulations are. Virtually since the CSB opened its doors, members began to realize that these rules had potentially serious gaps. The rules address hazards of individual chemicals, such as flammability, toxicity, and instability, but not the hazards of chemical reactions. Controlled chemical reactions are essential to manufacturing, but uncontrolled reactions have led to numerous accidents. For example, a chemical reaction can “run away” if excess heat is generated and not removed quickly enough. Uncontrolled reactions can generate gases that cause explosions or



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toxic releases. Other serious accidents are caused by inadvertent mixing of incompatible substances.

About one-third of the major accidents the CSB has investigated since 1998 are these “reactive” accidents—where a sudden, uncontrolled chemical reaction causes deaths, injuries, or serious damage. The following are among the more notorious examples:

- On 8 April 1998, an explosion and fire occurred during the production of a dye at a chemical plant in Paterson, New Jersey (CSB 2000). The blast resulted from a runaway chemical reaction that began when reactants were overheated. The explosion injured nine employees and showered a residential neighborhood with hazardous chemicals.
- On 19 February 1999, a process vessel containing several hundred pounds of highly reactive hydroxylamine exploded at a start-up chemical firm near Allentown, Pennsylvania, destroying the facility and killing four plant workers plus the manager of a nearby business (CSB 2002a).
- On 13 March 2001, three workers were killed as they opened a process waste vessel full of hot plastic at a polymer manufacturing plant in Augusta, Georgia (CSB 2002b). Unbeknownst to the workers, the waste plastic had been decomposing over a period of hours, generating gas and building up dangerous pressure inside the vessel.
- On 16 January 2002, two workers were killed and eight others injured when deadly hydrogen sulfide gas was released from a process sewer at a rural Alabama paper mill (CSB 2002c). The gas had formed due to a reaction of spilled sodium hydrosulfide solution with acidic wastewater in the sewer.

As diverse as these events are, they share many common features (CSB 2000, 2002a, 2002b, 2002c). First, all these accidents involved known chemistry, which had already been described in the literature. In several cases, similar incidents that occurred previously at the same facilities should have been more thoroughly investigated. In three of the cases (CSB 2000, 2002b, 2002c), the chemical processes were exempt from both OSHA and U.S. EPA process safety rules, and in the other instance it was ambiguous whether the process was legally covered (CSB 2002a).

In some ways reactive hazards are as broad as chemistry itself, but preventing most reactive accidents is not an insurmountable challenge. In many cases, we have found that companies have not invested the time necessary to thoroughly understand the hazards of their processes. Plant managers need to review the chemical literature, analyze different accident scenarios, take near-miss incidents seriously, and implement safety changes. In other words, they should follow good safe-operating practices for industrial-scale chemistry.

Faced with a growing list of accidents, the CSB conducted a nationwide study of reactive accidents going back to 1980. The results were striking: 167 serious accidents in the United States alone, together responsible for more than a hundred deaths as well as numerous injuries and huge property losses (CSB 2002d). Most of these accidents involved chemicals not currently covered under the process safety rules. Because of deficiencies in national accident data, many other serious accidents may not have been included in this study.

In September 2002, the CSB voted unanimously to call on OSHA and the U.S. EPA to broaden their process safety rules to better regulate reactive hazards. The majority of the CSB members voting for the new rules were former industry safety managers. Both industry and the regulatory agencies are taking this problem seriously and have committed to a variety of initiatives, including increased guidance and outreach.

Although worthwhile, these voluntary programs do not benefit companies that only do the minimum that is legally required. It is time for us to raise the standards for all businesses that have reactive hazards. For companies that already have strong safety programs, our recommended changes will add little burden. For companies that do not, new rules may well save workers' lives and protect the owners from financial ruin.

The Bhopal catastrophe was itself a reactive accident involving inadvertent mixing of incompatible chemicals, a runaway decomposition reaction, and finally a devastating toxic gas release. As we approach the 20th anniversary of this disaster, we are once more nearing a crossroads; this time, we should be enlightened enough to close remaining safety loopholes without waiting for more accidents.

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