

## International Dimensions of Ethics Education in Science and Engineering Case Study Series

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### Bhopal Plant Disaster – Situation Summary

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During the night of 2-3 December 1984, a leak of some 40 tons of methyl isocyanate (MIC) gas mixed with unknown other gasses from a chemical plant owned and operated by Union Carbide (India) Limited, a partly-owned subsidiary of the US-based Union Carbide Corporation, caused one of the highest-casualty industrial accidents of the 20th century. At least 2000 people died immediately and another 200,000 to 300,000 suffered respiratory and other injuries of varying severity. Property damage consisted mainly of contamination to nearby areas by various chemical residues. The defoliation of trees immediately afterward is clearly attributable to the gas leak; contamination in the nearby settlements may have multiple sources, the contamination of the plant site resulted from many years of general production activity.

#### India's Economic Ambitions

When India attained independence from Great Britain in 1947, its new political leaders wanted to make the country wealthier by encouraging development of modern industry. It had strong support from the citizens, who generally agreed that India's current lack of industrialization and economic development were the result of these colonial-era policies. Thus, the new government could expect widespread support for any policy that appeared to set the country on the path to industrialization. The new political elite brought to this task a set of beliefs about economic policy that sought a middle way between the heavy reliance on private enterprise that had characterized British industrialization in the 18<sup>th</sup> and 19<sup>th</sup> centuries and the reliance on central planning of the whole economy characteristic of the Soviet Union's industrialization effort since 1917. The combination of welfare state and mixed economy developed by Indian leaders was very similar to Western European ideas of the period.

Indian political leaders, like their Western European counterparts, believed that private enterprises were too focused on profitability of the firm to undertake the economic reorganization needed for assuring broad-based prosperity and, in primarily agricultural countries like India, the transformations needed to introduce

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modern industry. Both believed that only a mixed economy, in which state-owned enterprises operated the major sectors of the economy and private enterprise guided by considerable government regulation to protect workers and the general public, would successfully meet the economic challenges facing the country. In India, steel making, railways, shipping, aviation, and electrical power generation were the most prominent industries dominated by state-owned firms; the nascent Indian chemical industry was a mix of state-owned and private firms.

In its Resolution on Industrial Policy in 1948, the Indian government expressed a strong preference for Indian enterprise, but indicated willingness to allow some collaboration with foreign firms:

... while it should be recognized that participation of foreign capital and enterprise, particularly as regards industrial technique and knowledge, will be of value to the rapid industrialization of the country, it is necessary that the conditions under which they may participate in Indian industry should be carefully regulated in the national interest. Suitable legislation will be introduced for this purpose.

The follow-up legislation included limits on foreign shareholding in Indian firms, so that multinationals could not own 100% of their Indian subsidiaries but had to share ownership with Indian nationals. It also preferred collaboration only when the foreigners owned technology not available in India. The government hoped to determine the terms on which Indians could acquire technology by law, but its early preference for importing "at the lowest cost" and not paying license fees on imported technology for more than 5 years (typical patent protection lasts 20) had to be modified in the face of foreign companies' unwillingness to make deals with Indian firms (state-owned or private) on those terms. Thus, the Indian government fell back on a system of requiring that subsidiaries of foreign firms be part-owned by Indian nationals, that the Indians be trained in all aspects of firm operations and technologies, that any business operation using foreign technology be licensed by the state, and that the government specifically approve the type and duration of employment of foreigners hired as managers, technical specialists, or workers.

### **The Company and the City**

Union Carbide (India) Limited (UCIL) operated in India even before independence, primarily as a maker and seller of dry cell batteries under the "Eveready" trademark also used in the USA by Union Carbide. UCIL expanded into making fertilizers and pesticides in the 1960s as the government encouraged local production to supply farmers with the chemicals needed to raise the new hybrid types of rice, wheat, and cotton. India had suffered serious food shortages in the early-mid 1960s because of drought, and the greater drought-resistance of the new hybrids made them very attractive to a government concerned with feeding a growing population and increasing the supply of locally grown cotton for the growing textile industry.

When UCIL established its Agricultural Products Division in the mid-1960s, the largest concentration of Indian chemical plants was located in Chembur near Bombay [Mumbai], an area called "gas chamber" by residents because of the extensive air pollution. There was relatively little industry in Bhopal, but both the

central government and the state government of Madhya Pradesh, of which Bhopal is the capital, were anxious to bring industry to the area. Thus, UCIL's plans for a chemical plant and an agricultural products R&D center met with a favorable reception, and the state government even supplied the land for the proposed chemical plant on a favorable 99-year lease. The UCIL plant brought with it good paying jobs, not only for members of the growing technical stratum but for lower-level workers as well. UCIL executives maintained good relations with local political leaders as well.

In the 1960s and 70s, the rural population of Madhya Pradesh was increasing at a rate of 2% a year. Bhopal was one of the fastest-growing cities in India during the 1960s and 1970s as unemployed people from the surrounding countryside came looking for better opportunities, and the state government was anxious to have an industrial base. As in other Indian cities, growth was haphazard, and planning frequently followed after people had settled on an unoccupied area of land and built themselves improvised shelters. The resulting "hutments," as they are called in India, were usually narrow strips of ramshackle shelters with mud walls and wood or sheet metal roofs separated by narrow alleys located along already-constructed roads. They typically lacked basic infrastructure such as piped water, sewage, electricity (except where inhabitants could tap illegally into existing power lines), and access to public transportation. Even in the more established areas of town, infrastructure was weak. There were approximately 10,000 phones in the city, most in government offices, and they often failed to work. Electricity was unreliable and usually not supplied all day. In 1984 there were 1800 hospital beds and 300 doctors in the whole city.

When UCIL constructed the first elements of its plant in 1968-69, the population of Bhopal was approximately 300,000 and large portions of the area next to the plant were still uninhabited though it was about 2 miles from the center of the Old City and nearer to some established neighborhoods with hospitals and a railway station. As other industrial concerns located nearby, electricity was brought in to the plants, and supplied more reliably than in many parts of the city. These developments made the area more attractive to newcomers seeking employment, and the fact the state government owned much of the vacant land made the area particularly attractive to squatters and to people posing as landowners and "renting" huts to others because it was less likely than private owners to try displacing them.

City plans were developed in 1958-59 and 1962-63, but never implemented. In 1975, the Madhya Pradesh government adopted a new Master Plan for Bhopal designating areas for residential and other developments and establishing a "hazardous industry" district in an area about 15 miles from the center of town. UCIL had been formulating pesticides (taking concentrates and diluting them to the strength needed for use on farms) at its plant since 1969 and in October 1975 secured a license from the central government to produce up to 5,000 tons of "SEVIN," a carbaryl pesticide, using a methyl isocyanate-based process. This would require adding new facilities in the existing compound and undertaking more complicated production processes. Even so, the state planning board classified the plant as "general industry" rather than "hazardous industry" in a 1976 review. This decision allowed both current activity and the new construction to go ahead at the existing location.

Population growth continued, and the 1981 Indian census put the population of Bhopal at about 896,000. In April 1984, with the city population estimated at 900,000, the state government gave in to the

accomplished fact of settlements near the UCIL plant by distributing certificates confirming squatters' ownership of approximately 50 square meters (500 square feet) of land where their hut stood. This decision had several motives: the party in power's desire to secure electoral support in future elections, a realization that the settlers could not be moved, and a desire to reduce the amount of extortion they suffered from persons posing as landowners. Though many in the area had already tapped into the electric grid illegally, neither the state nor the city government made any plans to extend piped water or sewers into the area, or to address the significant industrial and residential pollution of the nearby lakes.

### **The Economic Situation of the Chemical Plant**

The UCIL plant succeeded as a chemical formulary, a simple operation in which high-concentrate versions of fertilizers and pesticides are diluted and packaged for customer use. Company efforts to realize its, and the Indian government's, ambitions to have the plant move on to full production of chemicals were dogged by problems. UCIL's initial plans called for making local versions of Union Carbide's carbaryl pesticides using an alpha-naphthol process its own chemists had worked out in 1969. However, it proved much harder than UCIL expected to scale up to the volumes that would be needed to produce a pesticide on-site. The first version of the alpha-naphthol unit failed soon after construction was completed in 1978, and an additional US\$2 million was spent on rebuilding it. The reconstructed unit also failed soon after its completion in 1981. The plant had to import alpha-naphthol from Union Carbide.

After reviewing production costs in 1981, Union Carbide suggested that UCIL should import the methyl isocyanate as well, but the Indian government, which had approved the project in the expectation of getting local production, rejected the application to import MIC and established a January 1985 cutoff date for alpha-naphthol imports as well. This effectively established a tight deadline for getting the process to work. By 1982 as construction of the methyl isocyanate unit was moving to completion, UCIL and Union Carbide both realized that the plant was not economically viable because of changes in the market. Local demand for UCIL's pesticides had dropped significantly after 1977 as Indian farmers shifted to cheaper local products. New generation carbofuran pesticides under development in the USA and Western Europe appeared likely to render "SEVIN" obsolete at the upper end of the market. Though the Bhopal plant returned a modest profit in 1981, it operated below capacity and at a loss afterward. Discussion of various alternatives between UCIL and Union Carbide in 1982-84 led UCIL to accept Union Carbide suggestions for selling all or most of the plant. By fall 1984 it was operating at about 1/5 of capacity.

### **The Gas Leak**

As UCIL and Union Carbide considered the fate of the Bhopal plant and losses continued, the quality of its operation deteriorated. The initial Indian managing and supervisory staff for the Bhopal methyl isocyanate production unit were trained in Union Carbide's West Virginia plant in 1981-82. As the Bhopal plant's prospects declined, they began leaving for more attractive jobs and were replaced by less-skilled employees. Low production volumes seemed to justify reductions in the workforce though the local labor unions insisted that they were going too far. In the methyl isocyanate unit, the workforce was reduced from the Union Carbide-recommended 3 supervisors and 12 workers on each shift to 1 supervisor and 6

workers. Other areas of the plant were also affected by reductions. Labor-management relations had been rocky since a fatal gas leak in December 1981, and the workforce reductions did not improve matters.

In the late fall of 1984, plant operations were focused on using up existing stocks of chemicals to prepare for sale of the plant. In October, the remaining stocks of phosgene and methylamine were combined to make about 62 tons of methyl isocyanate, which was then stored. About 22 tons were put into Tank 611 and the rest in tank 610. Plans to draw off the MIC one ton at a time and make the last batches of SEVIN were soon disrupted. On October 31<sup>st</sup> rioting broke out in several parts of Bhopal after news that Prime Minister Indira Gandhi had been assassinated by some of her Sikh bodyguards reached the city. City authorities imposed a curfew for several weeks. The resulting difficulties in getting the second and third shift of workers into and out of the plant limited activity for much of November. Production was also hampered briefly by inability to pressurize Tank 610, but resumed when operations shifted to drawing from Tank 611.

In the evening of 2 December, the second shift supervisor ordered workers to perform a periodic washing of pipes in the MIC storage area to control corrosion. As this operation began about 9:30 pm, most of the safety systems in the plant were not in good operating order. The vent scrubber, designed to neutralize any gas leak through the vent with caustic soda, was on standby and appeared ready for operation. The flare, which would handle larger leaks via flame neutralization, lacked sufficient capacity to deal with a major leak. It had been shut down a few weeks earlier for replacement of a corroded pipe, and all relief pipes in the plant were directly connected to the gas vent scrubber. The refrigeration system designed to keep MIC storage tanks cool, had been turned off several months before and the freon drawn off for use elsewhere in the plant. The firewater spraying systems designed to deal with fires, cool down overheated equipment, or provide supplementary water neutralization of gasses was operational but the spray could not reach the top of the flare stack. The high-pressure escape valve, which would release if pressure in the tank exceeded 40 psi, and shunt gas to the vent or the flare was operational.

In the generally accepted account of events, the washing operations proceeded despite a.) failure to insert a slip blind into the pipes to make sure that water did not back up into storage tanks and b.) the fact one or two of bleeder valves at the bottom of the pipes where wash water should have come out were blocked. The worker doing the washing noticed this, and suspended washing to report the problem. His immediate superior, an operations supervisor rather than a maintenance supervisor, told him to continue. The blockage caused water to back up. This was not detected, and washing continued after the third shift comes on at 10:30-10:45 pm. Water then began entering Tank 610 by passing through a normally-open pressurization valve and then through a partly-open isolation valve that should have been closed after the last draw of MIC but was not because of either human error or mechanical failure. By 11 pm, the control room pressure indicator for Tank 610 read 25 psi, up from 2 psi earlier in the evening. However, this was within normal fluctuations so did not cause alarm. Worker concern was first inspired by the smell of gas about 11:30. A small leak was found and a water spray set up to neutralize it. Workers discussed the situation and what to do during their regular 11:30 pm tea break. Pressure continued to build relatively slowly, with the control room indicator reading somewhere between 25 and 30 psi at 12:15 am. By 12:30 am, however, it read 55 psi – well above operational limits and gauge error.

At this point the control room operator went out to the tanks to double-check the gauges there. He heard a relief valve pop, heard rumblings from the underground tanks, and felt heat through the concrete covering the tanks. He returned to the control room to engage the stack scrubber, but the caustic soda failed to flow. A large cloud of gas escaped from the vent stack. At about 12:40 am the plant supervisor was informed of the problem and the alarm sirens sounded. However, the sirens audible outside the plant were shut off after a few minutes. Efforts to reduce the danger by transferring liquid MIC to another tank failed because the alternate tank was not empty as supervisors initially believed. Efforts to neutralize the escaping gas with water also failed because the spray could not reach the top of the vent stack. Thus, gas leaked out for about 2 hours. The amount of gas escaping is usually put at 40 tons.

Residents of nearby areas begin smelling the gas about 1 am. Lack of information about what to do induced panic and people began to flee. The Bhopal police were poorly organized and did little to help immediately after the leak. An army engineer unit mobilized after a personal request to its commander by a retired officer now running an industrial plant near the UCIL plant, evacuated that plant's workers at about 3 am and then began transporting local residents to hospitals and clinics. Medical staff converged on their hospitals and clinics as they heard about the situation, but their initial efforts to treat patients were hampered by lack of information about the gas or antidotes. Inquiries to UCIL medical officers yielded little specific information and downplayed MIC hazards.

## Impacts

Though there was defoliation of trees and some additional contamination of soil and lakes, the main impact of the accident was death and injury to humans and animals. Estimates of the number of immediate human deaths caused by the Bhopal gas cloud vary from the official Indian government figure of approximately 2000 to the 10,000 favored by local activists. The number treated for gas exposure and continuing to suffer ill-health over the next several years has been estimated at 200,000 to 300,000, and by 1990 when the government of Madhya Pradesh provided the Supreme Court of India with a list of victims eligible for compensation, 3,818 persons were listed as dead from the effects of gas exposure. Additional thousands were made sufficiently ill to be unable to work. Medical treatment of survivors was complicated by lack of knowledge about what gasses escaped the plant, the paucity of information provided by Union Carbide and UCIL, the general lack of information about the long term (as distinct from immediate) effects of high exposure to MIC or related gasses, and uncertainty about what toxic chemicals other than MIC had poisoned the victims. The deaths also led to considerable disruption of family lives as widows and orphans joined households of relatives. Since most of these households were very poor, the strain of extra mouths to feed was considerable, particularly for families taking in survivors who needed continuing medical care.

Locally and globally, blame for the accident was quickly assigned to Union Carbide. Consistent with widespread beliefs that multinationals control their subsidiaries' operations very closely, it rather than UCIL was deemed ultimately responsible for the condition of that plant and the level and training of staff. In Bhopal itself this sentiment was assisted by an influx of US lawyers seeking to sign up clients for lawsuits against Union Carbide in the USA; in other parts of the world Union Carbide's weak safety record made it a target for general frustration about the lack of transparency about chemical company operations and a focal

point for environmentalist mobilization. This was intensified in 1985 as a string of smaller gas leaks at the West Virginia plant made the news and the US government investigated conditions at the plant.

Though it was clear immediately that Union Carbide and/or its executives would face criminal and tort charges in India, investors imposed penalties far more quickly. Standard and Poors dropped the company's credit rating to the lowest investment grade while institutional investors (universities, pension funds, mutual funds) dumped enough shares for their stake in the firm to decline from 65 to 35%. By December 1985, some 30% of Union Carbide stock was owned by rival companies or speculators poised for a hostile takeover. The company spent the next several years fending off takeover bids, most often by selling its more profitable divisions to raise the money needed, while also required to set aside funds for payment of legal settlements. It sold its 50.1% stake in UCIL to an Indian firm in 1994, with the proceeds going to build and endow a hospital for gas victims in Bhopal. The last remnants of Union Carbide were absorbed by Dow Chemical Company in 2001.

Victims filed lawsuits against both the company and the Indian government (citing its failure to regulate effectively) in India and the USA during early 1985. To deal with the proliferation of claims the Indian Parliament adopted special legislation in March giving the government sole authority to sue on behalf of victims, and the government filed its own lawsuit in US courts. The US courts consolidated the several thousand private claims and the Indian government suit into a single case, which was heard in the Federal District Court for the Southern District of New York. Efforts to negotiate a settlement floundered on Indian government objections to the amounts offered by Union Carbide, and the suit went to trial. The initial US hearing focused on admissibility of the lawsuit since the events had occurred in India and international legal norms usually favor trial in the place where events occurred. The Indian government and the lawyers for individual claimants argued strenuously for a US hearing while Union Carbide argued equally strenuously for dismissing the case in favor of hearings in Indian courts for the same reason: US courts allowed greater opportunities for class action suits and were likely to award higher compensation to the victims. Yet, in a decision interpretable either as deference to the Indian legal system or a victory for Union Carbide, the US District court ruled that the lawsuits should be heard in India.

Efforts to negotiate a settlement continued, with the Indian Supreme Court pressing the sides to come to a global settlement of all cases. They agreed on compensation of \$470 million, a settlement panel of the Indian Supreme Court approved and ordered the parties to carry out. The settlement aroused considerable opposition as it fell far short of the \$3 billion that victims' advocates were seeking, and appeal was made to the full Supreme Court. It affirmed the decision in 1991, adding a provision requiring Union Carbide to fund building of a hospital in Bhopal to treat surviving victims. Only in 2003 did the Government of India complete paying compensation to victims, at which time a new dispute arose over what to do with the approximately \$390 million remaining after compensation was paid (the money having earned interest between 1989 and the payout). The Indian Supreme Court ordered the government to release this to programs for victims.

This settlement did not cover the related question of liability to clean up or pay for cleaning up the plant site. Union Carbide and UCIL performed some cleanup work under Madhya Pradesh supervision in 1986-98.

UCIL's successor turned the land back to Madhya Pradesh in 1998, and all work put under state authority. Efforts to file class action suits in the USA to compensate victims of later exposure to contamination and to secure money for cleanup of the plant site were initiated in 1999 and 2007. The 1999 suit was rejected in 2004 and 2005, and the 2007 suit suspended pending the outcome of appeals against those rulings. UCC's and UCIL's successor companies, Dow Chemical in the USA and Eveready Industries in India (mainly the former), are now the targets of transnational campaigns on behalf of the victims.

For anti-corporate and anti-capitalism activists, "Bhopal" has become shorthand for corporate greed and callousness. For the victims and their supporters, the word conjures up continuing inaction by their own government as well. The accident also inspired considerable discussion of need for better regulations addressing chemical plant safety, information about toxic chemicals, and contingency planning for mitigating the impact of gas leaks inside and outside plants. In Western Europe, this process was well-advanced in reaction to the 1976 Seveso gas leak in Italy. Policy initiatives were more numerous in the USA, particularly after a significant leak from Union Carbide's MIC plant in West Virginia in early 1985 sent local residents to the hospital. Reaction was less strong in India, where environmental law was less developed and citizen environmental movements weaker.

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