Overview

Impressions of Bhopal

Fiona Macleod

Introduction

I had not realised how beautiful Bhopal is.

View of Upper Lake, Bhopal (FM)

When news broke of the Union Carbide accident in India, I had just started my first job as a chemical engineer in Scotland. Many years later, I found myself involved with a major investment program in India along with a team of well-educated, hard-working, ingenious and inventive Indian colleagues. Despite the common language (English), I was struck by the cultural differences and it awoke an intense curiosity to understand what had really happened in the early hours of 03 December 1984 in Bhopal. I read every book that I could get my hands on[1234] and finally visited the capital of Madhya Pradesh in June 2013.

Some Indian friends arranged for me to visit the Sambhavna Trust clinic in Bhopal. Set up in 1995 it provides free treatment to those who need it most. It is a beautiful, tranquil place full of green open spaces, a children's playground, a yoga hall, an open garden meeting room. Alongside conventional medicine, the plants from the large garden are used in complementary therapies. There are people who listen and offer practical support.

I made it clear that I worked for a multinational chemical company and that I did not support the campaign against Dow Chemicals. I was made very welcome, and given the full run of the library and the assistance of a very knowledgeable archivist, who helped me to find all the information that I was looking for.

Reading the eyewitness accounts of the accident and the aftermath so close to where it had happened was a harrowing experience.

Sambhavna Clinic Bhopal (FM)

Afterwards I went to the factory. It is still there.

What remains of the Union Carbide India Limited (UCIL) pesticide factory is invisible from the road, lost inside a jungle of greenery. It would be easy to miss it, along with the memorial on Kali Parade. The brutalist modern representation of a grieving mother with her dead infant was being used to dry jeans; the squat statue was artistically improved by the denim decoration.

On the wall behind is a colourful mural with a poem:

History says, don't hope
On this side of the grave.
But then, once in a lifetime
The longed-for tidal wave
Of justice can rise up,
And hope and history rhyme.

Factory complex from Kali Parade (FM)

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Bhopal tragedy memorial (FM)

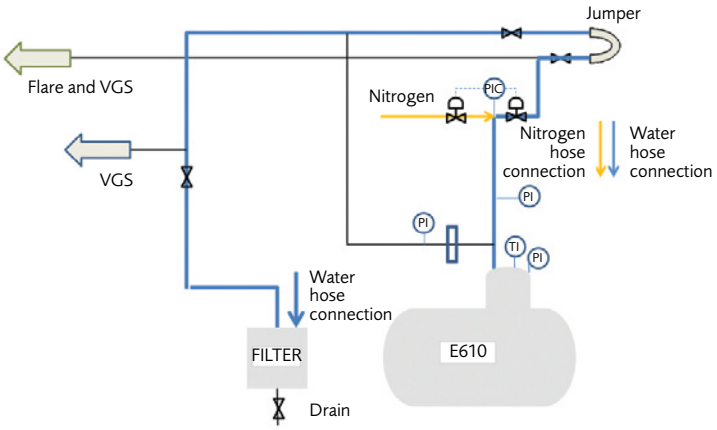

Figure 1– Water washing theory

It is strange to see only the work of Dutch sculptor Ruth Waterman and Irish poet Seamus Heaney here because Bhopalis know how to do public art. The 1982 Bharat Bhavan complex above the upper lake in Bhopal celebrates the verbal, visual and performing arts with style and panache. The new tribal museum that opened in June 2013 is simply gorgeous, overflowing with dramatic displays, not just the individual artefacts, but their combination. The concrete memorial on Kali Parade stands in particularly stark contrast to the exquisite stone sculptures in the Bhopal state museum, including a terrifying statue of Chamunda wreaking death and havoc, the perfect symbol for the carnage of the night of 02/03 December 1984.

What really happened to lead up to the world's worst industrial accident? Why is there no proper public memorial? Why has the site not been cleaned up? Why do the victims, relatives and neighbours still feel betrayed?

The accident

In the early morning of 03 December 1984, a gas cloud was released from the Union Carbide pesticide factory in Bhopal. Within a few hours, thousands of people were dead and hundreds of thousands were injured.

The cause

Most people agree that the release of toxic gases was caused by a runaway reaction in a tank E610 containing about 40 tonnes of methyl isocyanate after it came into contact with about one tonne of water. There are at least four competing theories as to how this happened.

The water washing theory

Accidental entry of water through a common vent line during a filter washing operation over a hundred metres away on 02 December.

The water washing theory is the accepted explanation in the official Council of Scientific and Industrial Research (CSIR) report.[5] During the routine cleaning of a filter, no physical barrier (spade) was inserted contrary to correct procedure and attributable to the cut backs in maintenance staff on shift. Water found its way back though a common header and travelled up 7m and along 150 metres to E610. This theory is contested on the grounds that there was insufficient pressure of water, there were closed valves in the way, and no water was found in the header when it was drilled at its lowest point two months later. Hydraulics are complex and we have no way of knowing what valves were opened and closed to aid the washing of the filter. In addition a high temperature, high pressure runaway in E610 could have cleared the header, or water could have escaped from leaking flanges (several were reported).

The sabotage theory

Deliberate entry of water by a disgruntled employee connecting a water hose directly to the tank E610 on 02 December.

The sabotage theory was proposed in the Arthur D. Little (ADL)[6] report commissioned by Union Carbide. The evidence is circumstantial (disgruntled employees, a missing pressure gauge, a water hose left running, evidence of altered log sheets and general commotion during a tea break) and is hotly contested by all those on shift at the time. It used to be common practice to blame individual workers for accidents but more sophisticated understanding of process safety, layers of protection and human factors has thankfully reduced this practice. In 1985 this was the company defence – that no safety system can ever be designed to protect against deliberate malicious acts.

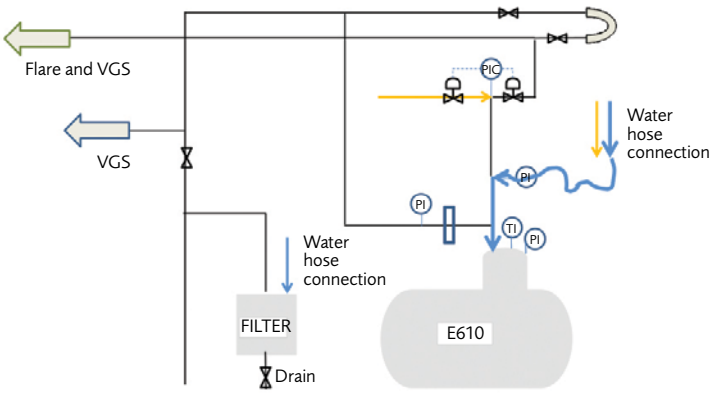

Figure 2 – Sabotage theory

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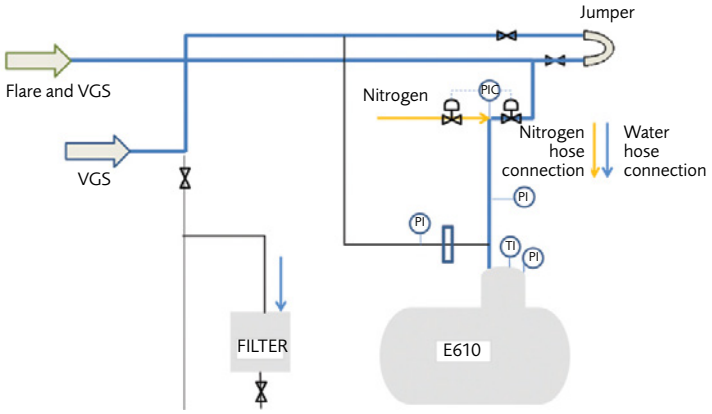

Figure 3 – Decomposition theory

The decomposition theory

Gradual entry of water and other contaminants over many weeks prior to 02 December.

Although extensive trial work was done (based on residues in E610), it is impossible to know the exact composition of the tank contents before the accident, or what happened to it between October (when the last MIC was added) and December (when the runaway reaction occurred). It is known that the composition in E610 was unusual; it contained high levels of chloroform due to distillation to a higher temperature when shutting down and emptying the MIC plant. If E610 was not pressurised with nitrogen it is possible that water or caustic from the scrubber, along with other contaminants, could have entered the tank over the six week period when it sat full and unused. While the chemists were able to replicate the residue found in E610 by adding a single slug of water to a sample of MIC and chloroform, it does not prove that there were no other possible ways to arrive at the same residue.

The nitrogen mix up theory

Mix up of hose connections leading to accidental entry of water instead of nitrogen on or prior to 02 December.

There is some evidence that repeated attempts to transfer tank E610 had failed because it was not holding pressure. There was chloroform found in the SEVIN feed tank suggesting that some material had been transferred from E610. Could a worker have tried to connect nitrogen directly to the tank and inadvertently connected water instead? This theory was discounted on the basis that "The water lines are blue, nitrogen lines grey and air lines white... They are also labelled. And the nitrogen and water lines have nozzles of different sizes."[7] It is worth noting, however, that despite clear labelling and colour coding and nozzle differences, the Automobile Association (AA) estimate that 150,000 drivers put the wrong fuel in their car every year in Britain alone.

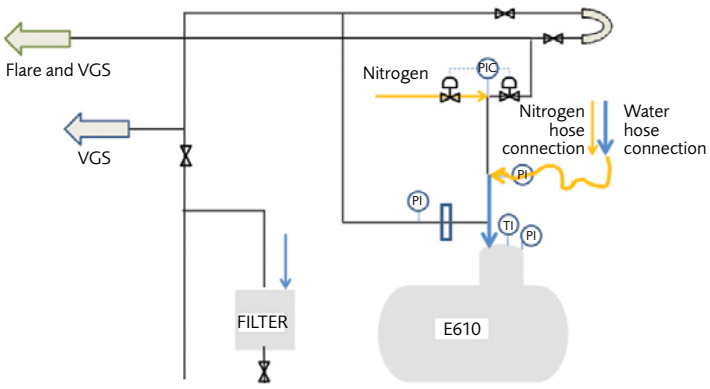

Figure 4 – Nitrogen mix up theory

It is now too late to be sure how the accident happened or to know the exact composition of the gases released.

What we do know is that, whatever the cause, had the multiple safety systems been working as designed, then the catastrophe could have been avoided altogether, or had much less severe consequences, i.e.:

- If the tank had been filled to less than 50% full (as designed) instead of over 80% there would have been less material to release.
- If the caustic scrubber had been connected and working continuously, it would have lessened the severity of the release.
- If the refrigeration system had been working along with reliable temperature gauges, there might have been time for operators to react and prevent the release altogether.
- If the flare had been connected and lit, it could have significantly reduced or possibly prevented the consequences of the event.

Also, an emergency water spray could not reach the height of the vent stack, having been designed to alleviate the effects of a ground level spill rather than a high level release.

It is generally accepted that the plant and safety systems were allowed to fall into disrepair while the plant was losing money and closing down. There were a series of cost saving initiatives culminating in the 1983 Operation Improvement Program, which imposed savage cuts in staffing, maintenance and training. The local factory management underestimated the risk of the stored chemicals after the MIC production unit closed down.

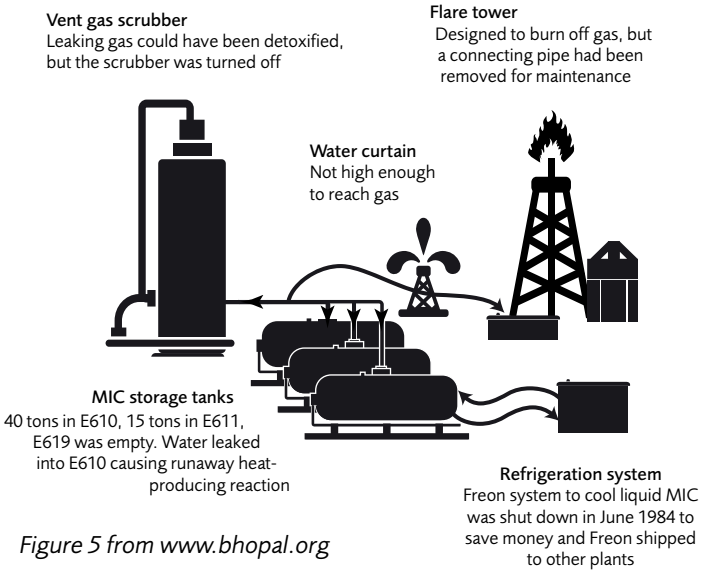

Figure 5 from www.bhopal.org

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Several warnings went unheeded:

- The union safety concerns were not addressed and the union leaders who raised them were fired.
- A local journalist, Raj Keswani, repeatedly drew attention to safety issues at the site but was ignored.
- UCC (the parent company) carried out a safety audit in 1982 but did not follow up on the recommendations.

The number of dead and injured increased because:

- There was no offsite alarm or emergency plan;
- The public and emergency services were not aware of the hazards or safest response;
- The factory was sited close to the old town and to bus and railway hubs;
- Slum dwellings had also grown up around the factory on land zoned as industrial.

It is particularly painful to realise that a wet cloth over mouth and nose might have been enough to save many lives if they had also known to stay indoors or to flee across instead of down-wind.

There are known facts and competing theories, but in the absence of a thorough independent investigation, with forensic preservation of evidence at the time and detailed interviews immediately afterwards, it is impossible to be sure what caused the accident.

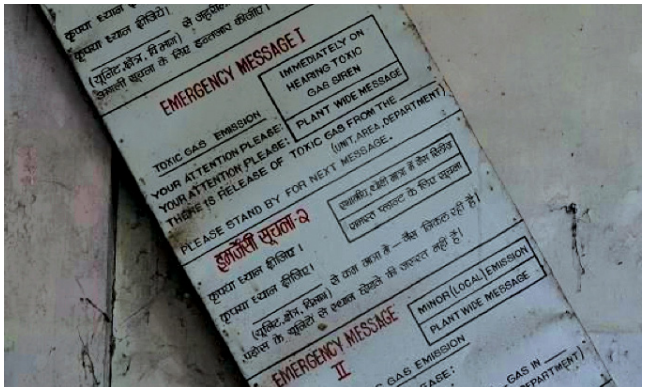
The aftermath

After the accident, the inadequate response in support of those affected was shocking. There were people in desperate need and there was a rich US corporation willing and able to finance some alleviation of their suffering, but it somehow seems to have all got tangled up in a mess of endless court proceedings.

Others have documented the years of legal wrangles but among them were two key events in 1989 and 2010.

In **1989**, almost five years after the accident, an out of court settlement of US$ 470 million was reached between the Government of India (acting on behalf of the victims) and Union Carbide Corporation (UCC). There are several problems with the settlement:

- It underestimated the number killed.
- It underestimated the number and severity of the injuries.
- It ignored the fact that chronic ill health prevented some from ever returning to work.
- It failed to value the contribution of "non-working" women, children and the elderly within a family unit.
- It ignored mental health injuries.
- It ignored the loss of livelihood for the former workers and the network of small businesses dependent on the factory.
- It ignored inflation.
- Compensation was meagre even by Indian standards*
- Distribution made no allowance for the fact that the worst affected groups were poor and ill-educated, and living at the margins of society.
- The standard of evidence demanded to support claims of death or injury caused by the release meant that much of the compensation money went on medical, legal and loan interest costs. Those providing such services were of variable quality and took a disproportionate amount of the money that should have gone to victims and their families.
- Distribution was slow – in 2004, twenty years after the accident, claims were still being settled.
- Interim relief was deducted from the final settlement.
- No provision was made for the clean-up of the site.
- As a condition of the settlement, all criminal charges were suspended (this was later overturned).



Emergency sign in 2014 (Julia Green www.bhopal.org)

In **2010**, over twenty five years later, eight former executives of Union Carbide India Limited (UCIL) – including one who had already died – were convicted of causing death by negligence. The seven surviving defendants were sentenced to two years in prison (the maximum allowed by law) and fined 100,000 rupees, or $2,100. They were given leave to appeal and immediately released on bail.

Worlds apart

What happened on the night of 02 December 1984 was an unspeakable, terrible tragedy, and the suffering of those who died, were physically injured or mentally traumatised cannot be overstated.

And yet it is still very difficult to write about the Bhopal accident dispassionately without offending or upsetting someone, not least because there was so much suffering and then such polarised opinion, suspicion and hatred.

There are those who believe that Union Carbide in America deliberately allowed an unsafe process to operate in a developing country and that their Chairman, Warren Anderson, personally approved this and was ultimately responsible for everything that happened.

On the other extreme there are those convinced that the process was fundamentally safe but that a single act of sabotage by a disgruntled worker caused the accident. The genuine concern shown by UCC senior executives in rushing to the

Compensation was ~100,000 rupees (US$3,000 at 30Rs/$) for each certified death and ~30,000 rupees (US$1,000) for proven injury or other loss (livestock etc.), the equivalent of about 5 years' wages for a death (assuming an average annual wage of 20,000 Rs). In the annual UCIL accounts for 1984 the lowest paid full time worker cost the company 32,000 Rs/year and the highest 80,000 Rs/year. The family of the worker Ashraf Mohammed Khan who died after an accident at the factory in 1982 was offered 72,000 Rs in compensation. The family were still contesting this when his three year old son Arshad died in the 1984 accident.

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scene of the accident was met by a lynch mob mentality and things went downhill from there.

Whatever the cause, the operating company was responsible for ensuring that design, safety systems and community emergency response contained the consequences of any accident to within the site.

There are those who believe that, after the accident, Union Carbide withheld information that could have assisted in determining the treatment of victims, that they forced the Indian government to halt programs providing effective relief because it might implicate them further and conspired with the government of India to distort the data.

On the other side, there are those who believe that most of the ongoing chronic illnesses, birth defects, disabilities and general poor health of the population is due to socioeconomic factors and no different from any other city slum population.

No one knows the exact composition of the gas released that night. There is independent evidence of different effects at different distances from the source of the release, suggesting a complex composition. There is no doubt that there was horrific physical suffering and mental trauma in the surrounding population. Help should have been and should continue to be provided unstintingly.

There are those who believe that the 2007 initiative by the Tata group to organise a "no blame" remediation of the Bhopal site was part of a conspiracy to allow foreign entities to escape any on-going responsibility** and that the only way to prevent a future Bhopal is for justice to be done, and seen to be done. However, as a result of the political and legal impasse, the old Union Carbide site in Bhopal remains rusting and leaking, thirty years on.

Multinationals

Chemical executives do not spend time stroking white cats and planning ways to poison the planet. The industry is full of intelligent, honourable people whose efforts have helped make the world a better, cleaner place for its ever increasing populations, lifting people out of poverty, providing clean water, improving communication, reducing hunger, preventing and curing disease.

Companies fund innovation and growth by promising a return to their shareholders. The requirement to maximise shareholder value puts increasing pressure on the cost of manufacturing. Together with changing demographics and growing aspirations this means manufacturing in developing countries, largely because that is where the new customers are.

The people who rise to the top of large chemical companies are those who set and meet the most challenging targets. Few are engineers and even fewer have direct experience of the realities of manufacturing. It is not enough to add lagging safety and environmental measures to the financial targets of these top executives; major accidents are thankfully too rare to be a meaningful measure. There is an increasing danger that the

The MIC Storage tanks E610, 611 and 619 in 2014 (Julia Green www.bhopal.org)

MIC Unit in 2014 (Julia Green www.bhopal.org)

Sevin Unit in 2014 (Julia Green www.bhopal.org)

MIC Unit in 2014 (Julia Green www.bhopal.org)

** *In 1986 UCC sold its pesticide division to Rhone Poulenc, acquired by Bayer in 2002. In 1994 the UCC shares in UCIL were sold to McLeod Russel (India) which merged with Eveready Industries India and the proceeds used to found the Bhopal Memorial Hospital. In 1998, Eveready Industries surrendered the lease on the Bhopal factory site to the state government of Madhya Pradesh. In 2001 Dow Chemical acquired the remains of UCC.*

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Control Room Feb 2014 (Credit BMA)

Laboratory Feb 2014 (Credit BMA)

lessons of the past will be forgotten. And accidents repeated.

Jugaad

Jugaad (pronounced "Joo-gaard") is a Hindi word for a quick fix, a creative way of solving a problem, an improvised arrangement used because of lack of resource, a cost-effective way to solve the issues of everyday life. It is commonly used when describing an innovative workaround to get through commercial, logistical, or legal issues. There are many great examples of frugal innovation where good engineering matches product design to the needs of the market: better, cheaper, faster.

Anyone who has spent time in India cannot fail to come away impressed by the ingenuity and pragmatism, the local ability to do things fast and cheap. But not always well. And not always legally. The theft of electricity by tapping into overhead cables is a prime example of Jugaad.

It is our job as engineers to ensure that risks are quantified and understood. Locally made motor vehicles, a diesel engine lashed onto a wooden cart, may provide low-cost transportation in rural India, but it comes at a price: no crumple zone, no seat belts, no child restraints, no air bags, no anti-skid or pedestrian protection. WHO Global Status Report on Road Safety reveals the staggering number of deaths due to road accidents when pedestrians are hit by unregistered vehicles.

In the Union Carbide plant in Bhopal, the pumps that were designed to transfer methyl isocyanate proved unreliable. A work-around was found that used nitrogen pressure for transfers. In order to do this the nitrogen was diverted from the vents. More than one possible contributing cause of the catastrophe is directly related to this work-around[8].

Jugaad (frugal innovation) is a concept that should never be applied to high hazard chemical plants, or bandied around in the boardrooms of the companies that run them.

A personal journey

I still remember the response of my industry. In 1984 I was working for ICI in a fertiliser factory in Leith. A few months after the accident my team was gathered in a room with a reel to reel tape recorder and made to listen to a speech by John Harvey Jones, the boss of ICI. The crux of the message was that if we, ICI, could not afford to run a process safely, then we should not run it at all.

Soon after that, in the face of competition from eastern Europe, we began to shut down the plants at the factory one by one. First the sulphuric acid plant, then the phosphoric acid, then the super and triple phosphate. Finally, in the early 1990s, the Leith fertiliser factory closed completely.

I am not suggesting that the cause of my factory closure was simply a heightened safety awareness after Bhopal, but it was made abundantly clear that in the face of huge financial losses, the answer was not to stop training or maintenance or cut costs in ways that would endanger the safety of the workers or the people of Edinburgh. The plants were run properly until the balance sheet (and a bizarre ruling by the UK monopolies commission) meant that they were shut down indefinitely.

I have changed my mind about a few things since visiting Bhopal.

Senior executives should be accountable for the safety of worldwide operations without boundary or border. Alfred Nobel made his factory managers live in the middle of explosive plants. One important way to be sure that the right decisions are taken in boardrooms is to make sure that the decision maker has a personal stake in the consequences.

The social activists are right to fight the removal of the identified toxic waste from the Bhopal site until the wider issue of land contamination is resolved. The waste is packaged and contained; once it is removed, no one will care.

The compensation that was agreed in 1989 by the Indian government on behalf of the victims was too low. Even by local Indian standards it was wholly inadequate. There was no punitive element and no provision for clean up or site remediation.

Ultimately, all individuals and groups are driven by self-interest. It is only by making the consequences of accidents punitively high that companies are forced to take serious and sustainable steps to avoid them. It hurts to realise that each seal in Alaska after the 1989 Exxon Valdez disaster had many times more money lavished on it than any survivor of Bhopal.

Conclusion

It may be little comfort to the people of Bhopal, but there is no doubt that the Union Carbide accident caused a shift in the way that the industry viewed process safety. There has been a move to safer design, reduced inventory of toxic chemicals (what you don't have, can't leak), a focus on human factors, employee engagement, emergency planning.

Some of those lessons have been institutionalised in developed countries – such as HSE's Control of Major Accident Hazards (COMAH), OSHA's Process Safety Management

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(PSM), EPA's Risk Management Program (RMP) – but 30 years on, it is timely to take a long hard look at the international chemical industry and ask some searching questions.

The interpretation, application and enforcement of environmental and process safety law varies widely from country to country. It is important to design for safety, but the tragedy of Bhopal reminds us that it is not enough. Responsibility for safe operation of high hazard manufacturing assets continues throughout their lifetime.

How do multinationals, headquartered in Western Europe or North America, ensure that their operations in developing countries are designed, commissioned, operated, maintained and closed down safely and responsibly?

The finance director who makes the decisions to cut costs, remove experienced people, take short cuts, may be long gone by the time those decisions come back to haunt the company. There will be senior executives in the chemical industry today who were still at school in 1984. Some may even view government regulation or industry led programs such as Responsible Care as red tape, bureaucracy and additional cost in countries where they are not mandatory.

If a multinational company decides that it will simply obey the local law, it runs the risk (perhaps unwittingly) of taking advantage of poorly drafted legislation full of loopholes, lax enforcement and even corruption[9].

However if a multinational company tries to apply the same European or North American head office standards worldwide, it will run into other difficulties. From engaging with the local communities[10] through cutting scaffolding boards[11] to meaningful SIL verification[12], each country presents different challenges[13]. It is impossible to run a complex project from a distant head office. Nor can key decisions be delegated to an international engineering contractor.

There is no substitute for a mix of a competent, properly trained and fully resourced local team together with on-site head office expertise. That has costs. But if a project cannot be resourced safely, then it should not be done at all. If a plant cannot be run safely, then it should be shut down: responsibly and carefully.

Remember Bhopal.

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