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HOW TO PREVENT BHOPAL TYPE INDUSTRIAL ACCIDENTS

POLICY ISSUES & ROLE OF UNIDO

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* These chapters relate specifically to the 'Terms of reference for study on Hazardous technologies' dated August 20 1986 from UNIDO.

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*Relate to the 'Terms of Reference for study on hazardous technologies' - Aug 20,1986 (UNIDO): Ch [illegible] - (a); Ch 4 - (b,c) Ch 5 - (d,e); Ch 6 - (e,f).

SUMMARY & CONCLUSIONS

This report has been prepared for UNIDO in accordance with their terms of reference dated August 20, 1986, arising from the BHOPAL disaster. The main thrust is on prevention of such accidents - with the relevant policy issues and the role of UNIDO.

Chapter 1 sets the scene with a description of the BHOPAL disaster with particular emphasis on the lessons learnt therefrom. The next two chapters deal with prevention of accidents during production, storgge and distribution of hazardous chemicals. Both the hardware as well as software aspects are covered. Chapter 4 deals with technology and its transfer in particular reference to developing countries. The right government policies can go a long way in preventing accidents/disasters - these are described in Chapter 5. The last chapter (6) emphasises that since the 'world is Bhopal', international cooperation is a must. The World Bank and UNIDO have already rendered valuble contribution, but more remains to be done. A programme of work for UNIDO is outlined in the last two pages.

The BHOPAL is a tragedy of errors, human and others. The Chernobyl mishap as also the blowup of the Challenger have both been ascribed to a series of 'human judgements.' Such statements, though correct, do not make us wiser. Man does err but he learns and errs less and less as a result. Only a fool perserveres in erring. In any case, one must go behind the sensational and simplistic headlines, to get at the root cause of an accident. Then alone we will be wiser and err less. Can man be changed so as never to make mistakes?

Perhaps, not! So, instead of trying to change people, it may be far better to try changing the situation. It is much easier too and what is more it can effectively reduce the chance of a disaster, and also reduce or minimise the tragic effects, thereof. How to change the situation?

Safety must start at the drawing board stage. The benefit of spending adequate time and money at this stage can be enormous in some cases, it may even lead to reduction of the project cost. For the Bhopal plant, for example, reducing or eliminating the MIC storage would reduce the plant cost and make it safer - since the risk at storage stage would be eliminated completely. This is precisely what has been done by some of the other manufacturers of this material.

Accidents in the chemical industry can be reduced by having properly designed safety devices This can fail, so it can be supplemented by a fail-safe device. And one can go on, there is no end. But if the devices are not maintained in proper working condition, they are no better than a single device. How does one ensure their working condition? Maintenance - proper and preventive. Far more important, however, is to have safety 'culture' - at all levels right to the top. The hardware (safety devices) one can buy and install, all one needs is money, but culture? That's the crux. It cannot be bought at any price, it has to evolve itself starting from the top. Commitment at the top level is a MUST - tp prevent and manage disasters.

This requires education/training at all levels. The company concerned is the worst sufferer in case of a disaster, hence there is a strong case for self-policing. Developing countries are confused on the type of technology (appropriate/impoverished or modern/advanced) to adopt and how to really benefit from it. These are some of the areas where UNIDO have a vital role.

Chapter 1. BHOPAL, BEFORE AND AFTER

There have been many a Bhopals before the BHOPAL, but with a difference. BHOPAL has turned out to be the worst ever industrial disaster.

ONCE IN A LIFETIME?

BHOPAL, one hopes, is a once in a lifetime disaster. But this may merely be a wishful thinking, unless we do something about it NOW. And action is required at ALL levels:

Individual

Community

Country , and last but not least

Globally

There are many a potential Bhopals around the world, but particularly in the developing world. The developed world is not immune either, witness the mini-Bhopal which happened at the Bhopal-type plant of the same company (Union Carbide) at Institue, West Virginia (USA), eight months later than the BHOPAL. And this despite the fact that the lessons learnt from BHOPAL had been translated into action at the Institute plant. As an aftermath to BHOPAL, it has been found that mini-Bhopals are lurking round the corner at many chemical plants everywhere. Of course, as we point out in the next section, a Bhopal or a mini-Bhopal can occur not only at the production plant, but also at transport and storage stages. These have happened before and one must not overlook any vulnerable area. For prevention of Bhopals, one must:

THINK GLOBALLY, BUT ACT LOCALLY

And in this light, the present study by UNIDO, as also earlier studies by World Bank and other international agencies, assumes great significance.

A LANDMARK IN CHEMICAL INDUSTRY

The world had never heard of Bhopal, a town with a population of just under one million people and the capital city of the state of Madhya Pradesh (India), until the morning of December 3, 1984. Thereafter for several days, this man-made disaster dominated the world media and everyone everywhere knew where Bhopal was and what happened there. This 'nightmare' happened at night but it was real. Total deaths were, perhaps, 4000-5000 - possibly more - and the number exceeds the deaths reported for ALL the industrial accidents worldwide in the past 40 years. The nightmare was, mercifully, a brief one for the dead but for the survivors who were exposed to the deadly methylisocyanate gas (MIC) the nightmare may be lifelong and even beyond because of the serious genetic effects. Perhaps one-third to half of the entire population of Bhopal town was affected.

No wonder that Bhopal became a familiar name everwhere. It qualified as one of the ten major events of 1984, a distinction it could well have done without. In the chemical industry, it has become a landmark and the industry will never be the same hereafter. No wonder that an international symposium (London, Nov 7-8 1985) held a year after BHOPAL was entitled:

The Chemical Industry After Bhopal

Its proceedings contain 18 papers presented at London as also the discussion thereof. All aspects, including technical, legal, insurance, public relations, safetya and risk assesment are covered (24). The International Organisation of Consumers Union (IOCU) at its World Congress in Bangkok just a few days after the Bhopal tragedy passed a resolution entitled:

Another Bhopal - Never Again!

IOCU followed this up with a comprehensive work on the subject, refreshingly entitled( ):

The Lessons of Bhopal

A well-researched report, it lists over 100 references. We have also covered the more constructive aspects (e.g., lessons) elsewhere (15-17).

BHOPAL has become as much of a landmark in the chemical industry as:

Three Mile Island (1979) - in the nuclear industry

& Challenger disaster(1986) - in the space programme

The TMI incident in Pennsylvania (US) did not, fortunately cause any casulties. Yet, it has already led to a loss of some $4 billion direct and probably much more in terms of indirect costs. And even more serious has been the loss of public confidence everywhere, but particularly in the USA. Since the TMI mishap, no fresh orders for nuclear power plants in the US have been placed and over 60 projects/orders have been cancelled. Thus, the nuclear power industry has never been the same since TMI. It is too early to know what the effect of the even worse disaster at Chernobyl (1986, USSR) will be.

It is no wonder, therefore, that chemical industry will never be the same - as a result of BHOPAL. There is, however, no suggestion that production of toxic and hazardous chemicals and gases should be given up. Instead, the thrust is on what can we learn from BHOPAL and how such a disaster can be prevented in the future. As a measure of a quantum change in the public perception of chemical industry, it is interesting to note that the Du Pont slogan:

Better Things For Better Living Through Chemistry

has been modified. The last two words have been dropped!

BEFORE BHOPAL

Tragedy and disaster are not pleasant words, but they nevertheless are a reality. Their study and analysis hold valuable lessons if only to minimise but preferably to prevent such events occurring again. Man learns by experience, and one can learn most from one's mistakes. He is a wise man indeed who can learn not only from his own mistakes but also mistakes of others as well. This is what we must seek.

Among the major industrial disasters of the twentieth century in the chemical and allied industry are (4,31)

TABLE . MAJOR DISASTERS - CHEMICAL INDUSTRY - 20TH CENTURY

Year	Site	Nature of disaster	No deaths
1921	Oppau(Ger)	Warehouse explosion. Dynamite used to pry loose caked am. nitrate.	561
1944	Cleveland (USA)	LNG storage tank. Structural weakness. Explosion.	131
1947	Texas City (USA)	Ship carrying am. nitrate exploded and nearby styrene plant exploded as a result. Fires in the city.	576
1948	Ludwigshafen(Ger)	Dimethylether railway car exploded inside factory gate.	207
1956	Cali (Columbia)	Dynamite truck explosion	1100
1974	Flixborough (UK)	Caprolactum plant. Explosion due to a pipe rupture	28
1976	Seveso (Italy)	Explosion, releasing poisonous dioxin into the atmosphere.	100's (animals)
1978	Spain	Propylene gas truck. Explosion	over 500
1984	Cubatao (Brazil)	Gasoline from leaky pipeline exploded.	over 500
1984	Mexico	LNG storage tank. Explosion.	over 500

Seven of the ten disasters listed above as also the BHOPAL have occurred while the hazardous material was stored or in transit. These are highly vulnerable areas and hence deserve special attention.

BHOPAL - A TRAGEDY OF ERRORS

There were ample warnings of the BHOPAL tragedy, but alas they went unheeded. For nearly two years (mid-1982 to mid-1984) at least four internal reports of Union Carbide noted several cases of MIC leakage and numerous safety lapses in plant design, maintenance and operation. Some remedial action was taken, but obviously not enough. These reports were released <u>after</u> the disaster in an effort to put the entire blame on the Indian subsidiary, with the observation that in the then state of the plant (Dec 1984) it should not have been operating at all!

There were ample warnings by the local media, too. A Bhopal journalist, Rajkumar Keswani, in a series of articles in his own Hindi weekly, <u>Rapat</u>, another weekly, <u>Prachand</u> , and a Hindi daily, <u>Jansatta</u>, warned of the time bomb ticking away in the heart of Bhopal. These appeared during Sep 1982 and June 1984 quoting facts and figures about accidents at the plant and noted that not a year had passed without a serious mishap. His prophetic headlines:

Sage, Please Save This City

Bhopal on the Mouth of a Volcano

If You Don't Understand, you Will Be Wiped Out

failed to make any impression on the company management and town administration. All this <u>before</u> the event.

After the disastrous event, international press and media swooped over Bhopal for investigative reporting, Keswani being picked as a collaborator by Financial Times, New York Times and Washington Post among others. Some of the headlines in these and other respectable media speak for themselves:

Safety Lapses Widespread

The Grim Wages Of Neglect

Colossal Safety Lapses

Union Carbide Flouted Own Safety Code

All The World Gasped

It Was Like Breathing Fire

What Price Progress?

A Problem That Cannot Be Buried

The various safety systems, such as Flare gas stack, vent gas scrubber and refrigeration system, were all silent witnesses to the tragedy, since for reasons of economy or otherwise none of them were functioning. An alarm was sounded and the neighbouring residents seeing smoke coming out of the factory rushed towards it, supposedly to put out the fire, to their certain death. The factory personnel are reported to have escaped to safety. Some eight hours after the event, and even after seeing dead bodies piled inheaps, the company's chief medical officer maintained that:

MIC is an acute irritant, but certainly not lethal

Across the world at their headquarters in Danbury, Conn (USA), Carbide's director of health and safety described MIC as:

nothing more than a potent tear gas

In retrospect, these statements must qualify as the understatements of the century.

Initial reaction at Danbury was that the Bhopal and the Institute plants were identical. Did it mean that a Bhopal could occur at

Institute? The earlier statement was immediately retracted and the principals completely denied any involvement in the design and engineering of the Bhopal plant. This too proved to be incorrect.

A former managing director of the Indian company, Edward Munoz stated in an affidavit in the US that he and his project team in India concerned with the Bhopal plant argued for 'only token storage' of MIC, but they were overruled by the principals. MIC is only an intermediate product and its manufacturers in Germany (Bayer) and Japan (Mitsubishi) have a closed system with no storage of MIC thus eliminating completely this hazard(17)

LESSONS OF BHOPAL

BHOPAL served as an eye opener to the chemical world who sought to draw lessons and implement them in order to prevent/minimise the chance of such disasters. Most of the leading chemical companies everywhere announced a thorough safety audit of their installations. Stricter regulations and legislation was sought to be introduced in many of the world capitals. Britain set deadlines for its chemical firms to draw up specific plans for emergencies and to inform the community about the possible risks, also what they should do in case of an unforeseen event. This was completely lacking in case of the Bhopal plant.

Regulations, no matter howsoever strict, is not the ultimate answer. There must be proper machinery to enforce these and such machinery is completely lacking particularly in the developing world. Even in the developed world enforcement of regulations is highly suspect. John Page, director of safety and occupational health of DuPont - a company which has taken safety as a mission - is quite candid( ):

There is no way that they can possibly enforce regulations if the management is not committed.

The inspectors of the regulating agencies, for example OSHA (Occupational Safety & Health Administration) agree:

We have to rely on the employer and employees.

In the ultimate analysis, despite proper plant design with the requisite safety devices, regulations and their enforcement, as also management's commitment - it is really a 'culture of safety' which can help minimise or prevent the chance of a BHOPAL type disaster. Total prevention is an ideal which probably can never be achieved except at infinite cost - as we attempt to show in the next section. But minimising the probability of a BHOPAL is certainly within human control.

Safe here is not necessarily safe there, and safety can never be taken for granted. It must be built into the total system, but even then, an expert on workers safety, Anthony Mazzocchi points out(31) shortly after BHOPAL:

It's like a giant roulette game...this time the marble came to a stop in a little place in India. But the next time it could be the U.S.

How prophetic! Just eight months after BHOPAL, a mini-Bhopal did occur at a similar plant of the same company at Institute (USA). And this despite the fact that the Institute plant had much more elaborate safety devices than the Bhopal plant and these were further augmented and supplemented as a result of the lesson learnt as a result of the BHOPAL catastrophe.

SIMPLE IS BEAUTIFUL

Despite the presence of automated and sophisticated controls on a chemical plant, the human faculties of eye, nose and ear are considered to be most valuable tools. Controls can and do fail, one can duplicate them and/or supplement them with additional fail/safe devices, but these can fail too. Man can 'see, smell and hear' trouble at a chemical plant more often than not and the controls and instrumentation may merely confirm it - IF they are in working order, in which case they can help in diagnosing and correcting the trouble. Otherwise manual controls can be brought into action to correct the trouble. At Bhopal, just about everything (that could go wrong) did go wrong - in accord with the well-known Murphy's Law.

In our various writings (e.g.,14) we constantly emphasise the maxim 'simple is beautiful.' and even have a chapter with such a heading. In the case of BHOPAL, for example, it turns out that a balloon at the Carbide factory site to show the wind direction and the simple precaution of breathing through a wet towel could have saved hundreds of lives. Such simple sechmes must form a part of emergency planning, in order to mitigate the effect of disasters.

The mishap at the the Three Mile Island nuclear power station (USA) in 1979 has already cost a few billion dollars in <u>direct</u> terms, but fortunately no life was lost. In this respect, it has been found that the plant was over instrumented with far too many controls and alarms. As a result of chain of unlikely events, several alarms sounded one after the other and the operators were totally confused as to what really had gone wrong. A post-mortem revealed that the real culprit, a critical warning light leading to a chain of unlikely and undosirable events was left covered by a sign 'under maintenance' even after it had been attended to. A simple human error! The maintenance crew just forgot to remove the sign. What's the moral?

To prevent recurrence of BHOPAL, let's listen and learn NOW!

Chapter 2. PREVENTION IS BETTER THAN CURE

Noone will disagree with the title of this chapter. But in the present context:

Is prevention of a BHOPAL feasible and practicable? Feasible? Yes, but at what cost? Here, as in most situations, we are faced with a trade-off and compromise, between cost and benefit. The cost of prevention and the extent of risk are inversely related. Risk can be reduced to zero, but the corresponding cost will be infinite - not a practical possibility. In actual situations, therefore, such as Bhopal we have to take a calculated risk so that the cost is reasonable. How to calculate risk?

RISK ASSESSMENT

The science of analysing and assessing risk is relatively new, but it is developing fast. It has been surmised in case of the disasters at Mexico and Bhopal that (23):

> if some of the field's most simple rules, to say nothing of the more sophisticated ones, had been applied, there was a chance that the blast and leak might not have occurred: and if they had occurred, far fewer people would have been killed.

But it's not quite that simple. Most of this infant science has a western focus, with capital less expensive than labour. The handling of hazardous technologies, therefore, dictates a capital-intensive solution in the west. In the reverse situation as prevailing in the developing countries, one may well opt for a labour-intensive approach (23). The cultural differences will also need to be considered in carrying out a risk assessment exercise (12). This factor has also led to a wide variation in risk management practices even within the developed world.

In a series of papers (12), the subject of assessing and controll- risks involved in handling hazardous technology has been studied in depth including issues such as:

Value judgments - risks vs benefits

Range of uncertainties in design, manufacture and use of technology

Export of advanced technologies to developing countries

Dollar value of human life

It is pointed out that risk assessment is not entirely objective and cultural variables, as mentioned earlier too, complicate the analysis. Broader philosophical issues are also tackled and the feature article in the series dealing with conceptual risks, quotes Thomas Jefferson (12):

> I know of no safe depositor of the ultimate powers of the society but the people themselves; and we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion.

The emphasis is ours. It has particular relevance to the issue of government regulations vis-a-vis self-policing by the company management and workforce, an issue which we discuss in the next chapter.

Can risk be quantified? Not exactly or at least not simply. Risk has been defined by a Royal Study Group set up in UK for this purpose as (10):

> Risk is the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge.

So, risk is expressed as a probability. It has to take into account factors, such as economic, socio-political as also the likely risk to society and the individual. What is an acceptable risk? This is somewhat subjective. Risk of one death per year in a (1):

Million is considered acceptable to general public

100,000 is acceptable to workers

10,000, perhaps, is on the border line of acceptability

As a comparison, the probability of being killed in a car accident is 1 in 7500.

A great deal of work has been done to quantify the risk in chemical and process industry by various agencies, e.g.,

Company level	- Dow Chemical	(8)
University	- UMIST, UK	(3,4)
Association	- Chemical Manufacturers Association	(6)
Federation	- ISGRA	(11)
Commission	- European	(25)
International	- World Bank	(32)

These are typical of a varietyof efforts world wide, though mainly in the developed world. There is an urgent need to collate and analyse the available data and formulate simple procedure/technique for widespread use in the developing countries. UNIDO, by virtue of its background and commitment in this regard, appears to be the right agency for this purpose. World Bank Guidelines in this respect, though designated for use by developing countries, are based on the so-called Seveso Directive of the European Communities Commission (EEC). The World Bank Manual (32) has been prepared by a London-based consultant who is offering a package programme for use on a personal computer (32).

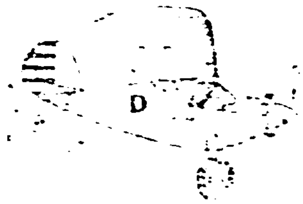
For a simple understanding of the seemingly complex subject of risk assessment and risk management, a perusal of Figs 1-5 on the next page may help. Fig 1 (29) is the conventional approach to safety through trial and error. The major system safety factors at an installation are indicated in Fig 2. Two of the main considerations in risk management are depicted in Fig 3. Fig 4 shows a typical system safety management that can prove effective. A very simple, though quantitative representation of risk analysis can be seen in Fig 5 (7).

Of course, the risk analysis and risk management of a chemical plant, like the Bhopal one, has to take in many more factors and is therefore more complex, but the figures demonstrate the basic principles.

RISK MANAGEMENT

Having accepted that in practice risk cannot be reduced to zero, and having defined the level of acceptable risk, we now examine as to how to keep within this level. The concept of risk management has been explained by reference to the figures on the next page. In the context of this report, we now aim to see how the damage resulting from a disaster like BHOPAL can be minimised. Alternatively and preferably, how could the chances of a BHOPAL recurring can be reduced. The latter, of course, is more difficult but in both cases considerable planning based on past experience is essential. After analysing a variety of disasters including an oil rig which capsizes, shipwrecks of the Titanic and the Andrea Doria, as also the gas leaks at Seveso and Bhopal, it is observed (12):

Some accidents are avoidable, others perhaps not. But in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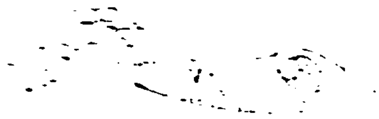

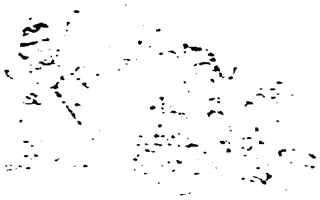


injury,
and delay

most cases a means of safe escape or treatment of injury can be provided. Such measures were lacking in the oil rig case,..., the Titanic case, and in the Seveso and Bhopal cases...why such oversights can occur...

The emphasis is ours. Society may blame the engineer for the oversight and the engineer in turn could assume that (12):

safety, risk, and all such matters are someone else's responsibility...if not the company, then government! Let the government hire safety engineers. We vote, and that takes care of our responsibility...

This doesn't help at all and we are backe to 'square one.' Man does make mistakes, but a wise man learns from his mistakes and also from those of others. Piet Hein puts it thus (29):

The road to wisdom? Well it's plain and simple to express:
Err and err, and err again, but less, and less, and less.

In case of BHOPAL and several of the other disasters listed in Table 1, storage of large quantity of the hazardous material was the main culprit. So a very simple safeguard is to avoid it wherever possible, thus not only reducing the hazard but also the cost. As explained earlier, there is no need to store the deadly MIC at all.

The various safety devices at the Bhopal plant were not in working order, but it surmised that even if they were, the run-away reaction could not have been coped with. To make matters worse, emergency planning was conspicuous by its absence. The plant workers themselves, let alone the neighbouring community, were not aware of what to do in case of emergency.

But let's now switch over to the positive side. What should a desirable risk management programme look like? For this we look at an 'inside report' of Du Pont, an acknowledged leader in the chemical industry(24). It starts with an astonishing admission that the chemical industry has not been as good at risk management as it ought to be. This was driven home to Du Pont in 1978 when the company suffered more than expected number of major incidents. A thorough investigation at that time revealed:

> weaknesses in the administration of our process hazards management program.

The program itself was found adequate but its implementation/administration/management was seen to be weak. Having identified the problem, solution followed logically. The danger signals pointing to the weakness were identified as

- Lack of adequate training of operators and maintenance crews
- Design/procedure changes without realising their impact (which can be profound even with minor changes) on safety
- Inadequate frequency of inspecting and testing critical items
- Minor incidents not investigated/identified and corrected
- Reduced maintenance in anticipation of plant sold/shutdown

Although these signals were identified by Du Pont and corrective action taken in 1978-9, Union Carbide were either unaware of them or they were completely ignored at Bhopal. ALL the signals, including dismantling the plant for sale, were there! (26)

Du Pont's conclusion of their heart-searching exercise has an important lessons which needs to be driven home (24)

> ...our process hazards management program administered... in a strong and effective manner can head off catastrophic events. It requires a lot of work and the time of many people, but the rewards are great and worth every bit of the effort.

~~And what is more, the company hasn't stoppd learning.~~

And what is more, the company hasn't stopped learning. Notwithstanding an excellent safety record since their self-policing from 1978, they sought to learn from the BHOPAL disaster. Like most other companies including Dow and Monsanto, Du Pont further reviewed their safety procedures and took appropriate corrective action.

CAN REGULATORS REALLY REGULATE?

BHOPAL immediately raised the question:

Could it happen here?

at chemical production centres everywhere, and particularly those handling hazardous materials. Governments, too, got busy in planning, drafting and enacting stricter laws and regulations. The chemical industry, itself, though already 'burdened' with over-regulations, pleaded for stricter controls.

Union Carbide's similar plant across the globe at Institute (USA) was closed, to incorporate the lessons from Bhopal, to make it safer. The safety system was upgraded, but a mini-BHOPAL did occur at the Institute plant in Aug 1985. After BHOPAL, it was reported that despite a full array of monitors, alarms, cooling systems and such, EPA (Environmental Protection Agency) observed from Carbide's own records 28 MIC leaks during 1980-4 at the Institute plant. Also six months before BHOPAL a survey by the Carbide safety team revealed the possibility of a ~~sudatory~~ runaway reaction at Institute in the MIC storage tank. This is precisely at happened at Bhopal. ~~Was~~ Did the finding from Institute lead to any action at Bhopal? ~~Was~~ Was it conveyed to the regulators in the U.S. and in India? Would they understand the implications of it - specially in India?

In general, the regulators know much less about the chemistry and the hazards thereto. The company knows far more and they are in the best position to assess and manage the risks arising from their operations. It is worth repeating the quotes of the company and a regulating agency (page 9-10):

Du Pont: There is no way that they (regulators) can possibly enforce regulations if the management is not committed.

OSHA : We have to rely on the employer and employee.

The regulator's inspection, at best, is superficial - even in the developed countries. In developing countries, as was revealed in case of Bhopal, it is practically non-existent. BHOPAL brought out another flaw as well. No regulating agency anywhere is competent to check the adequacy of the safety and emergency systems.

With this background, there is a strong move specially in U.K. towards self-regulation specially by larger companies. Trials in this respect both in U.K. and U.S.A. have proved encouraging and these have also led to valuable and much better accident statistics. The proposed legislation for self-regulation is expected to lead to(3):

- Relieving the regulators of much of the routine and superficial safety inspection work.
- Regulators can then concentrate on 'more insidious hazards'.
- Industry will draw up its own 'tight code of practice'
- Better safety organisation within the companies

This appears to be a refreshing approach.

ACCOUNTABILITY MUST REST WITH THE COMPANY

Eliminating the routine and somewhat superficial inspection by regulators may please the companies. It will eliminate much of the unnecessary work and expense to comply with regulations which may be absurd. In lighter vein, but not far from the truth, we are tempted to quote the English satirist, Swift:

> Laws are like cobwebs, which may catch small flies, but let wasps and hornets break through.

In the matter of regulations and laws, quantity seems to override quality, for; in the words of the American humorist Finley Peter Dunne:

> Laws are made to trouble people, and the more trouble they make, the longer they stay on the statute books.

And the longer they stay on the statute book, the more trouble they make!

Regulation, at first sight, may seem to absolve the company of its accountability, but it can't and it doesn't. On the contrary, it makes the company complacent on the basis that the regulators know better, which they don't and can't. After all, whatever they know is either from the books or from the company itself. And if the company knows most about its operations and their hazards, it is logical that the company alone can be accountable. The process in case of MIC, for example, was developed by Union Carbide themselves. BHOPAL has probably initiated action by Carbide and other interested firms to develop an alternative process to eliminate or minimise the hazard. A simple solution, as pointed out earlier (page 9) is to have no or nominal storage of MIC.

Some other possibilities also exist:

A substitute for MIC

A substitute for the pesticide based on MIC

These may be safer and better. But here again, the industry and not the regulators must take initiative - as they do, hence accountable too!

ALL DISASTERS DUE TO HUMAN ERROR?

Much of the research on accidents and disasters seems to point to human error as the main or only cause. Some 400 studies on this subject for over a century were used to prove this assumption. It led to the conclusion (2):

> Accidents are caused by human element and human error; changes in attitudes and changes in behaviour can reduce ...accidents. Therefore, efforts...should be directed towards mistakes and failings on the part of workers...

Blaming all the ills to human error has been a popular theme, it echoes a statement of Dr Cooke-Taylor regarding textile industry in mid-nineteenth century:

> No-one can examine a cotton mill without seeing, not only that its operations can be conducted with perfect safety, but that there must be an utter disregard of ordinary precautions - a total want of prudence, and not a little perverted ingenuity to get into danger.

A refreshing departure appeared in a 1974 report of the Factory Inspectorate (UK) which categorised the cause of accidents due to failure by:

Management

Workers

& Management & Workers jointly

About a quarter of the accidents were found to be due to failure on the part of the workers. Error/failure is an inescapable part of life, Goethe puts it thus:

> Man is liable to err as long as he strives,

A Latin Proverb goes a step further:

> It is the nature of man to err, of a fool to persevere in error.

And to cap it all, a modern poet Piet Hein puts it thus (29):

The road to wisdom? Well it's plain and simple to express:

Err and err, and err again, but less, and less, and less.

Thus blaming all accidents to human error is unproductive. In case of a catostrophe, who is in error? Worker, management, system? This has led to more meaningful questions such as (2):

Why do employers believe that safety is too costly to realise?

Why do managers give a low priority to safety?

Why do workers consider safety as management's domain?

instead of being preoccupied with the simple answer:

Human error causes all accidents.

Safety has to be designed and built into the system as a whole. It therefore starts at the design board stage but has to be persued throughout the cycle of engineering, construction, production and maintenance. An accident, if and when it occurs must be carefully analysed to determine whether it was due to:

Material failure

Design error

Production defect

Environmental stress

or Operator error

This would be the best lesson for the future.

Chapter 3. SAFE PLANTS FOR HAZARDOUS CHEMICALS

A BHOPAL has happened. We seek in this section to learn from it, and see how safer plants can be built and operated even for the manufacture and handling of hazardous chemicals. It can be done and MUST be done. Naturally we start at the beginning - what process and technology to use and how to go about selecting it, using safety as an important parameter.

PROCESS TECHNOLOGY

The main criterion for selection of technology to manufacture a designated chemical is usually techno-economic. Safety usually does not enter the scene at this stage. This is a serious lacuna and it must be corrected. Technology selection must take into account the type of hazards involved, i.e., the inherent danger and risk. Then the engineer or process selector can either use an alternative techhnology or alternatively provide the necessary measures to guard against the danger/risk. In case of an existing plant, one can only aim to make it safer through retrofit or redesign of the crucial step. Time and money spent at the initial stages for adopting preventive or defensive strategy are the best weapons against potential disaster.

The subject of selecting technology specially for developing countries is not simple and there is considerable controversy in basic terms. One school of thought - the conventional one - is in favour of appropriate or the so-called intermediate technology. A more current view, however, equates appropriate technology to underdeveloped technology. It has even been termed as 'impoverished' technology which may ultimately increase the disparity between the developed and developing world. According to this school, the advanced or capital-intensive technology is far more productive than the old or appropriate technology which is more labour-intensive. Amount of goods produced is considered far more important than the number of jobs created, since the former contributes far more to social welfare, as also to economic and political independence (9). The state of art technology (advanced/modern) provides a short cut for the Third World to 'catch up' with the rest. This would, of course, be safer too - in the context of the present subject, for sophisticated controls would supplement/complement human control. In that case Bhopal would have been as safe as Institute and perhaps the BHOPAL would not have occured or alternatively its damage would not have been as serious. Another route to safety is to take recourse to nature. As an example, instead of using the deadly pesticides (deadly to pests and man), resort to integrated pest management (IPM). This art/science is based on biological control and combines good ecology with sound economics. Cotton crop, for example, can be protected by planting alfalfa as a 'decoy' crop. Alternatively, planting can be delayed so that the bugs mature before the crop.

SAFETY STARTS ON THE DRAWING BOARD

After selecting the process technology, we proceed to design and engineer the plant, as also its layout. It is presumed that a safe location far away from populated areas has already been selected.

Design, engineering and layout of a plant is a compromise between what is technically feasible and economically justifiable, in both cases the safety parameter being included. The cost of an absolute safe plant will be prohibitive and the project may have to be abandoned. Hence the necessity to compromise.

The necessity for minimum storage of the hazardous chemicals involved in the process, whether as an intermediate product or whatever. A different process route may avoid a hazardous intermediate or replace it with a less hazardous one. Newer routes have been developed for MDI (4,4-diphenylmethane diisocyanate) and TDI (toluene diisocyanate) without the use of phosgene - a highly hazardous gas. Other simple design techniques to make chemical plants safer are (18):

Relief valves to discharge to closed systems or to a flare in case flammable material is discharged.

If flammable gases are compressed, the compressor house should have no walls. In an open system, some 100-1000 times as much material is required for an explosion to occur.

Dry chlorine can 'burn' a titanium blower. Passing the gas through a water scrubber before hand eliminates the risk.

Changes at the drawing board stage to minimise and to remove hazards are much cheaper than elaborate safety equipment which may have to be added later when the design is 'frozen' and/or plant completed. It is essential, therefore, to involve safety staff at conceptual stage of the project through to design, engineering and layout. This is also the right time for a hazard analysis, using for example an index such as the Dow Index or the Mond Index. Both these indices (8, 3/A) meet many of the requirements of an ideal hazard index, they are not difficult to use by the process design team, and yield a useful picture of the inherent process hazards. These indices have been developed by two of the major chemical companies (Dow Chemical & ICI) with considerable experience in this field and an excellent safety record.

RELIEF SYSTEMS - A REVELATION

Emergency relief system (ERS) is critical to the safety of a chemical plant, yet its design is now revealed to have been on entirely wrong premise. An industry-collaborative programme financed by 29 international chemical companies was undertaken in 1976. DIERS (Design Institute for Emergency Relief Systems) operated under the American Institute of Chemical Engineers, and its experimental and analytical work resulted in a concecnsus design by 1985. This was based on the fact that the system has to handle not only vapour, but liquid as well.- a fact which was known previously, yet a simple design method was not available. DIERS provided a simple technique for sizing the relief system in contrast to the modeling techniques available earlier. Comparison in few typical cases showed that the vent size for two-phase flow was 5-10 times that for a single-phase flow. Thus most of the relief systems, including the one at Bhopal, are grossly under designed. The findings of DIERS work have already been published (26) and a practical design manual resulting therefrom should be available shortly. But a word of caution: The new design technique must be coupled with a realistic estimate of the worst possible upset conditions. Risk management must be an essential part of the entire exercise, and each company will have to decide the level of risk they are willing to accept . This requires an estimate of the cost of a catastrophe like BHOPAL and it can only be subjective. What is the cost of a human life? There is no agreement on this, several figures have been suggested ranging from $ 1-10 million. If a median figure is taken, the total cost of BHOPAL far exceeds the total assets of Union Carbide as on Dec 1984.

DIERS work has shown, that although chemical industry is perceived to be a high-tech industry, many modern plants still use 19th century concept of plumbing in respect of relief devices. Changing them now is a complex, difficult and expensive process. But J Charles Forman, executive director of American Institute of Chemical Engineers has pointed out that changing them may be: frightfully cheap when you consider the cost of an accident (26 B ~~like BHOPAL~~) Will the industry rise to the occasion?

MAINTENANCE IS THE CRUX

The emergency relief system may be properly designed on basis of two-phase flow, but unless it is kept in sound working condition it is no better than an under-sized system. This can be assured only through meticulous maintenance and servicing, also replacement whenever necessary. Why replacement? Every component has an estimated life after which it can fail, hence replacement in good time is advisable. There is the normal wear and tear and in addition faults can appear through the occurrance of unusual events, e.g.,

- Technical faults or assembly faults
- Stresses on materials may be more than assumed at design
- Unusual corrosion, erosion or other influences
- Human fallibility during operation or maintenance

Regular servicing, maintenance and inspection specially of such components which may be critical, will help correct the situation in good time.

In case of relief systems particularly, it has been found that the relief mechanism is stuck in the closed position perhaps because the set pressure condition has never been exceeded. It is therefore essential that such faukts are detected and corrected in the course of routine and regular inspection. Perhaps a deliberate operation of the relief system and sounding of the emergency of the alarm could be practised regularly as part of a mock drill - much as fire brigades do, to ensure that their men and machines are fully alert to any emergency that may arise. Of course, none of these practices prevailed at Bhopal.

There is an urgent need to impress on workers and management, specially in developing countries, the absolute necessity of carrying out preventive maintenance as a routine operation. It will not only prevent many an accident, but it will also lead to considerable improvement in plant operations and capacity utilisation. The enormous benefits will be well worth the additional cost.

SAFETY CULTURE - THE KEY TO SAFETY

Appropriate hardware such as the emergency relief system noted above is essential for safe operation of chemical plants. But even more vital is the necessary software. It is for this reason that much of this chapter has been devoted to this aspect, e.g., technology, design,maintenance and now culture.

There is no substitute for safety culture. And the real commitment must start from the chairman down through ALL the levels to the plant floor. The chemical industry may have oversold its technical capability and in the process become so complacent as to think that science and technology could solve all its problems. It has been proved time and again that disasters lurk around many of the chemical plants in the world. The complacency at a particular plant manufacturing hazardous chemical has led to a false sense of security since no major accident has occurred for several years. This is the most undesirable scenario and, unfortunately it existed at Bhopal too.

What is the answer?

Safety culture. Discipline at ALL levels. And it must start at the top, then alone the staff and workers will be convinced that the company is totally committed to it. This has to be demonsrated by action, not mere words. Action is what carries conviction. It is not enough just to have safety manuals and strict instructions to follow the manual. There is a lot to be said for the chief executive to put on his safety helmet, boots and whatever other equipment is necessary, and just walk through his plant. This will be more effective than mere instructions.

Most of the disasters in chemical industry have been due to lack of discipline to follow procedures and not due to lack of technology. No matter how advanced the technology and how foolproof the safety equipment, operating discipline must not be overlooked. It is easy to buy and install the best of safety equipment, but to maintain it in perfect working order is much more difficult. The practice of discipline or safety culture cannot be bought, it has to be evolved and inculcated. It has to be a part of the company culture.

Dow Chemical Company, developers of Dow index (page 26) for hazard analysis), realised the importance of safety discipline in 1966 when a very serious accident in one of their plants resulted in the death of three men. The company then formulated their reactive chemicals program with the specific objective of preventing such a mishap in the future. The group comprised of members from various concerned departments, including research, to review regularly the possible hazards at each of their plant locations. These reviews covered process chemistry, reactive chemicals test data, worst case situations and lines of defense.

The review itself acted as a strong defense against a serious accident. Any shortfalls brought out as a result of the review were made good. The review group enjoyed senior status with line responsibility to the Board of Directors.

As a result of this program, the injury accident rate at Dow fell to 0.05 as compared to 0.45 for the chemical industry and 2.15 for all the industry. The total number of reactive chemical incidents fell by 50%, and the number of more significant accidents (of the 1966 type) by two-thirds. But despite such remarkable achievement, the company is not complacent. To quote a senior Dow official (28):

> Even though advances in science and technology prompted us to achieve one of the best safety records in industry, we still cannot sit back and let our flashing lights, automated valves, and computer monitors do all our work.

Why? The lights can fail, so also the valves and instruments. At Bhopal, even the temperature and pressure indicators were not in working condition and the safety devices were mere silent witnesses to the disaster.

The Dow review program revealed seven critical instrument failures on a single operation. The review group asked themselves a simple question:

> Would the addition of another safety device have prevented the incident?

And the answer?

> I doubt it. If you don't maintain one instrument, is there any better chance of maintaining two, three or four?

Conclusion? Safety culture and discipline are a MUST.

Chapter 4. TECHNOLOGY FOR DEVELOPING COUNTRIES

We have touched on this subject in an earlier chapter (page 24) noting the views of two schools of thought:

Appropriate or intermediate technology

or Advanced or modern technology

The proponents of the second term the first as underdeveloped or impoverished technology (9), perhaps even obsolete.

SELECTION OF TECHNOLOGY

There is much to be said for the two views. The word appropriate implies a 'tailored' technology for Uganda, another for Zimbabwe and yet another for India. There would, however, be a common dimension among them. A technology made to measure for a poor country would be a poor technology. In many cases, such a technology would have become obsolete in the developed world and yet there would be a 'price tag' to it. A literature search would reveal that such a process/technology is available 'off the shelf' free of charge, the relevant patents having already expired. Worse still, a second-hand plant based on the obsolete technology which would normally have a mere 'scrap' price may find ready buyers from developing countries at a 'handsome' price. There are examples of such 'white elephants' littered all over the developing world.

Why do we term them 'white elephants?' For one thing, such plants are not worth the price paid for them and for another they will be far less efficient than plants based on new and improved process and technology. The production cost will be higher and there will be no chance whatsoever for the developing country to export the surplus product in the international marketplace.

No wonder that a poor country becomes poorer as a result. The argument that use of appropriate technology provides for more jobs because of its labour-intensive nature seems self-defeating, since the amount of good produced is more important than the number of jobs created. The latter, in any case, results in unnecessary overmanning and hence low productivity.

Japan achieved a 'miracle' in a mere three decades mainly as a result of opting for advanced and modern technology in every field. The quantum jump started in the 50's, when for example the per capita steel consumption leap frogged four-fold. The mass production and the mass consumption are at the root of its miraculous development. If Japan had opted for the appropriate or intermediate technology, it is unlikely that it would ever have become developed. Japan started from a high base of the state of art in every field and then improved it so as to attain a leading position.

Selection of the best technology for developing countries can also be seen from another angle. Economic development of a country depends on three variables: Labour, Capital and Output, and the two significant ratios are:

Output/Labour i.e., labour productivity

Output/Capital i.e., capital productivity or profitability

Appropriate or intermediate technology lessen both the above productivities and are therefore uneconomical and ought to be rejected. And yet these are the very technologies being recommended for developing countries. Advanced technologies which increase both the above ratios, i.e., increased social output and increased profitability, are superior and hence desirable (9). Having selected the right technology, how to transfer it?

CAN TECHNOLOGY BE TRANSFERRED, REALLY?

Before we attempt to answer this question of transfer, let us first see what does technology comprise of? In the chemical industry context, technology includes:

Process know-how

Front end engineering

Commissioning manual

& Operating instructions

Precise documentation will vary from case to case depending on the receipient's requirements, and so also the fee comprising of a lumpsum and/or a royalty. The agreement may also provide for training of receiver's (i.e., transferee) personnel at the transferor's facilities.

Is that all?

Can the transferee now go ahead with his project?

What does he know about a possible BHOPAL type situation? How to prevent it or failing that how to deal with it?

Were the potential hazards inherent in the technology considered at the time of selecting the technology?

Was safety consideration an input at this stage?

These are vital questions and must be answered at this stage. Some answers may be available in the textbooks, but they are not good enough. Even the transferor may not know all the answers, as indeed came as a revelation in case of BHOPAL. And the answers, if known, can they really be transfered through documentation? Probably not. In case of Union Carbide, some of the key operating personnel were trained at the principal's works, but as a measure of economy they were transfered to other locations in India.

It is our feeling that technology cannot rally be transfered through any amount of ... mentation or by means of a short on-the-job training. The real 'tricks' cannot be imparted, and can be learnt through extensive experience preferably at the transferor's installation. The transfer takes place particularly on night shift, when an untoward incident happens and you have to decide quickly what to do. Presence of an expert from the transferer who has gone through such a 'drill' before can help. But sooner or later you will have to be on your own and decide the right course of action to avert an impending disaster or failing that try to minimise its damage.

Much has been written about the subject of technology transfer, but most of it is from the viewpoint of the transferor. Typical of these is a 'position paper' by CEFIC (the European Council of Chemical Manufacturer's Federations) dealing with the principles for the safe transfer of technology. The document was drafted in the light of BHOPAL and it affirmed a fundamental principla (26A):

> ...whatever the siting of the plant, its degree of safety must be the same, particualrly in the receiver's facilities as in the home ones of the technology supplier. But... the means must be adapted to local circumstances...

This is a major step forward and it is hoped that it becomes a part of the Code of Ethics in this regard - perhaps under the aegis of an international agency such as UNIDO. It is interesting to note that President Carter had sought to apply the United States laws and standards to collaborations abroad, but the Reagan administration ruled that American standards should apply only at home and American multinationals should follow the rules of the receiver's country. And the latter either do not exist or are too innocuous to be meaningful. In any case their enforcement leaves a lot to be desired(26B).

SAFETY MUST NOT BE COMPROMISED

It is accepted that human life is far too precious to be be risked, no matter where. Safety must, therefore, be a primary input in transfer of technology. Both the transferor and the transferee, but particularly the former should be vitally concerned with the safety aspect for ethical, social and economic reasons - apart from the legal liability. Safety considerations must not be clouded by political and commercial considerations. The position paper of CEFIC which we have quoted above (page 35) is quite clear in this respect (26A):

> ...the highest degree of safety reasonably practicable according to the current stage of knowledge...which offers a level of safety and health protection equivalent to that achieved in the home facilities of the technology supplier. ...the primary responsibility for transfering the 'safety package'...lies with the supplier...

The document also seeks to spell out the respective responsibilities of the technology transferor and the transferee. There is also need for the two governments concerned to reach a concensus on this issue. These and other related issues are taken up later in this chapter and also in the next chapter dealing with government policies.

HOW TO ACQUIRE TECHNOLOGY?

It is presumed that advance 'homework' by the entrepreneur has led to a short list of technology suppliers for the project in hand. A preliminary comparison, in terms of pros and cons, would also have been carried out. Proper 'homework' and evaluation at this stage can save considerable time and expense later. The necessary technology may be available either with the manufacturer of the product or a sole licensor thereof. In case of established technologies, e.g., in case of ammonia synthesis, it is available from the engineering contractors as well.

There is literally a 'supermarket' where one can 'shop' around for the requisite technology. But the main criterion should be value and not price, value to include techno-economic as well as safety aspects. Technology can be acquired in one of three broad ways depending on the level of development of the transferee's country:

1. A complete 'turnkey' plant, including technology, design and engineering, equipment supply, construction, commissioning and operation. A 'package' deal - ideal for a country in the initial stages of development. Adequate guarantees are a must.
2. Technology, front end engineering, construction supervision and commissioning - with appropriate guarantees.
3. Technology alone, i.e., process know-how and process flowsheet.

Technology is changing fast and it is advisable to have access to the advances and newer developments attained by the transferor. Perhaps a reciprocal arrangement whereby the two parties agree to exchange new information and experience - for the benefit of both. A nominal stake by the transferor in the new venture may facilitate this.

NEGOTIATE FOR A WIN-WIN APPROACH

Negotiation is a skill which is essential for success in all walks of life. It is particularly crucial and difficult in the area of negotiating for technology because of the different cultural background of the negotiators.

Negotiation is usually seen to result in Win-Lose situation. This happens particularly when the negotiators are not skilled enough in the art of negotiating. And this may be the last deal, since the loser would have become wiser and may take such an extreme position that there is no meeting ground at all. Two golden rules to a Win-Win negotiation are:

REMAIN COOL, ALWAYS: It requires considerable restraint and discipline, but it is possible and within our control. No one can irritate us without our consent. It's good to remember the wise words of Thomas Jefferson:

> Nothing gives a person so much advantage over another as to remain cool always and unruffled under all circumstances,

DON'T ATTRIBUTE MOTIVES: It is virtually impossible to read anyone's mind, so why even try? Mutual trust is at thw root of successful negotiations. With trust established, the two negotiators can then proceed to tackle the issue of technology negotiation for their mutual benefit.

The potential transferor as also the transferee have a common objective - to make the 'deal' and they can succeed only if the negotiations are carried out in that spirit. Of course, the transferee may have some choices from among the potential transferor's, but it is presumed that a preliminary round has already taken place and the present round is to 'sign and seal' the Win-Win deal.

<u>TRANSFEROR HAS OBLIGATIONS</u>

The technology transfer agreement just negotiated will spell out the obligations of both the parties. The transferee's obligations will be mainly in respect of payment and commitment to secrecy of the technology and know-how. The obligations of the transferor will vary from case to case, the contract and the clauses thereof being 'tailored' to the particular situation. The CEFIC position paper,on this subject to which reference has been earlier, states (26A):

> In principle the responsibility for safe process design, the initial technical training, the supervision of commissioning, start-up assistance and information for safe operation and handling of products used or manufactured should be part of the technology suppliers duties...

But this does not go far enough in respect of safety. The responsibility of the transferor is limited to 'safe process design' and 'information for safe operation'. As if to safeguard the interest of the transferor, the position paper which was drafted as a sequel to BHOPAL, states:

> Equity involvement is not necessarily linked with operational control...no party can be held responsible or legally liable if, for reasons beyond its control, its role in conducting and controlling matters affecting safety is limited or non-effective...even in cases of e equity involvement, contracts should be concluded between technology provider and technology receiver on an arms-length basis, i.e., as separate entities...

Such a clause is an ideal 'escape' clause for the transferor of technology. He will have 'best of both the worlds, an adequate payment for the technology but with no responsibility of its consequences in respect of safety and like considerations. The clause also implies that the technology transfer will be a 'one shot' affair. Instead a continuing relationship to cover future advances as also exchange of experiences of the two parties would be mutually beneficial.

HIGH-RISK TECHNOLOGY MUST BE 'TAMED'

Some of the chemical plants based on modern technology involve high-risk. To reduce risk, complex control systems are used but these are highly vulnerable to failure. Failure of one part or component can initiate a chain reaction and ultimately result in a catastrophe. This is exactly what happened at BHOPAL and TMI nuclear power plant. Technologists and risk assessors may assure us that a major accident is 'extremely unlikely' and yet a BHOPAL and many such have happened. The sufferers, of course, are seldom those who design, operate and control such plants. Innocent people, in hundreds and thousands suffer and lose their lives. One may well feel that (27):

> Ultimately, the issue is not risk, but power; the power to impose risks on many for the benefit of the few.

A bråad social issue which is hard to answer, but hopefully:

> better management and more operator training

can eliminate or minimise such catastrophes as BHOPAL, by 'taming' high-risk technology and learning to live with it. The high and young technologies such as nuclear power have perfect safety records until a TMI or a Chernobyl alert us of the enormous risks. The probability of the meltdown of a nuclear reactor core, considered to be the most serious disaster, was calculated as one in 20,000 years of operation. Eight years later in 1982, another risk assesment group placed the risk as 30 times greater. Such is the uncertainty in this infant science. Then too people are not impressed by the purely statistical aspect of risk.

Until risk assessment becomes a more exact science, it may be more meaningful, for the assessors to identify and asses the uncertainties and give range of likely estimates with their respective consequences. Their precise numbers give the absolutely false impression that the science is exact and one can rely on it. In layman's language it may be better to know that we are really dealing with a science whose credibility is yet to be established.

Proper management and extensive and continuing operators training, as suggested above, is our best insurance against a disaster. Adequate and proper safety equipment can help the operators in their mission to operate the plant safely. But equipment can and does fail, and operator can and does make mistakes. Equipment failure can be prevented or reduced to a minimum through regular preventive maintenance and servicing. Thanks to their learning process, operators will become more experienced and make fewer mistakes. Mock drills, as in fire fighting, will further ensure that the machines (safety equipment) and men will help prevent disasters.

Governments have an important role to play in ensuring safe operation of chemical plants - through their policies, regulations and legislation. Next chapter deals with these aspects.

Chapter 5. GOVERNMENT POLICIES CAN HELP PREVENT DISASTERS

Governments have a vital role to play in the matter of preventing BHOPAL type disasters. To be really effective, they need to go much farther than a mere statement such as:

It is forbidden to have an accident!

A wishful thinking. Or take a legal requirement in one of the states in U.S.A.:

Fire hydrants must be checked one hour before all fires.

The government policies have to be realistic and must be in tune with the state of affairs in the chemical industry.

REGULATIONS & LEGISLATION

In chapter 2 (page 19-20) we posed the question:

Can regulators really regulate?

Answer: Not really, unless the management is totally committed. After all it is the company itself who knows most about the chemistry of the process and hazards thereto. Regulators knowledge is second hand and in any case they can regulate only with the full cooperation of the employer and employee. No wonder, then, that one of the papers on this subject has the unusual and provocative title (3):

Exit The Safety Inspector?

What's the answer, then?

A refreshing alternative noted earlier (page 20) is self-policing by the manufacturing company itself. It is likely to behave in a most responsible manner knowing that the 'buck stops' here. The moral and legal responsibility for their actions lies entirely with them. With the regulations and inspection by regulators, the company may feel somewhat absolved and even complacent. But the company is aware that mere(meeting the regulations is no insurance against a disaster.

There are several non-regulatory methods for managing risk. An interesting and unusual approach emerged at a bilateral conference for comparing the American and West German practices for managing risk both through regulatory and non-regulatory methods. The methods were rated from 1 (best) to 9 (worst) and the criterion used were: Residual risk, Equity, Administrative simplicity, Transparency, Side effects and Culture. Individual ratings for each method were then combined to yield an overall rank. The final results of this exercise are (20):

Table 2. Effectiveness of regulatory and non-regulatory methods. Overall rank: 1 - best, 9 - worst

Rank	Method
7	Cultural and educational influences (behaviour modification)
2	Insurance (including self-insurance and bank loan practices)
3	Legal system (tort litigation)
4	Licensing of plant operators, professionals etc.
5	Marketplace
6	Negotiation and arbitration
7	Voluntary industry standards
5	U.S. regulation
1	West German regulation

The rating/ranking exercise was carried out by ten members of the working group at the bilateral conference based on their personal knowledge. Although somewhat subjective, it is felt that the above findings may be quite significant since the exercise posed the right questions. Two conclusions following from this novel exercise are:

1. German regulation ranked high, perhaps, because it is less politicised than U.S. regulation and and has high technical content.
2. The legal system came out better than expected, because of its high rating on equity, transparency and cultural acceptability.

One word of caution: The above exercise relates specifically to managing asbestos risks. It was repeated for a low-probability, high-consequence event (such as BHOPAL), but the results for this are not included in the paper (20). It is, however, stated that the rating/ranking is sensitive to the:

> particular risk problem being considered. In the two cases considered, it turned up quite different management methods as appearing most attractive...

It is clear that non-regulatory methods of managing risk deserve serious consideration of the governments. Perhaps international agencies such as UNIDO could take a lead in this respect.

RIGHT-TO-KNOW & OBLIGATION-TO-TELL

The citizens of Bhopal, who bore the brunt of the disaster, were ignorant of the high risk they faced from the Union Carbide operations in their town. Unfortunately, the consumer movement in India is not yet strong enough for the people to assert their right to know the extent of risk they face. Nor are there specific laws making it obligatory for the company to tell the community about the risks arising from company's operations.

BHOPAL may well change this picture. For one thing, the image of chemical industry as perceived by man has suffered a severe blow and unless the industry counters this by a strong and positive programme, the industry may lose its case by default (5). Industry needs to be much more open about its operations, in particular

relation to the type of risks for the community around its operations. Communications must be everyone's business and not just of the public relations officer of the company. It is seen as the most important function, even ahead of innovation, production and marketing. And the 'message' must be directed not only to the community outside, but also to the workforce within - for they are exposed to even greater risk - being on the spot.
Until the chemical industry puts its house in order in this respect, it is necessary for the governments particularly of the developing countries to enact the necessary legislation. The industry leaders, meanwhile, may have to educate themselves to be better communicators, instead of taking shelter behind the mysterious 'Black Box' of chemical industry.
Peter B Lederman, one time head of Environment Protection Agency's Hazardous Spill Research and Development Activity, and with a distinguished record in this field, is quite clear about this subject (21):

> The public now expects to know what is going on inside the fence, what are the plans, what are the risks and what are the benefits? We will no longer be able to hide behind 'it' is too complicated' or 'its safe and we are making something which will make your life better.'...it will be our job to prove to the public that what we are planning, building and operating is indeed safe and desirable...

In effect, the 'Black Box' will need to be opened out completely.

PUBLIC SAFETY MORE IMPORTANT THAN 'BOTTOM LINE'

'Bottom Line' is important, but at what cost? Certainly not at the cost of human lives. And what is this cost? Estimates vary considerably, but one source (12) places it at $6 million/life.

The issue is a complex one involving value judgement. In case of BHOPAL specifically and many other similar plants in general, we have pointed out (page 28) that the emergency relief system is not adequately designed. To upgrade it is a difficult and expensive process, but it may be (26B):

> frightfully cheap when you consider the cost of an accident. An informed public and operators on the job may well know about some potential hazards that the experts may have ignored, e.g., (19); An enquiry in regard to MacKenzie Valley Pipeline revealed that natives knew much more about the risks due to ice-pack movement and sea-bed scouring than the pipeline's planners and designers. In another case, a post-accident analysis revealed that machine operators were aware of hazards that the designers had missed.

Public/community have a basic right to demand that the chemical plant in their area is operated in a manner so as to ensure their safety. But to have their voice felt, the community has to understand the nature of risk and educate their members about it.

How? (1):

Form a concerned group and link up with similar-minded groups elsewhere in the country and the world.

Collect relevant data and information about the hazards.

Mobilise public support against any lapses by the plant management.

Question the need for manufacturing or using highly toxic materials on considerations of cost and benefits.

Lobby your government and other regulatory bodies to enforce strict legislation and controls.

Insist on public access to ALL health and safety data including the so-called 'trade secrets.'

Help formulate and arrange 'mock drills' for an emergency plan to cope with an unforeseen disaster.

Launch campaigns against multinationals practising double standards at home and abroad.

Strongly support action of international agencies, such as:

UN (United Nations)

UNEP (United Nations Environment Programme)

UNCTC (United Nations Commission on Transnational Corporations)

UNIDO (United Nations Industrial & Development Organisation)

ILO (International Labour Organization)

FAO (Food and Agriculture Organisation)

WHO (World Health Organization)

OECD (Organization for Economic Cooperation & Development)

& EEC (European Economic Community)

ACTION BY TRANSFEROR'S (TECHNOLOGY) GOVERNMENT

There is a dichotomy in respect of safety standards to be followed by multinationals at home and at their facilities abroad. This is most unfortunate since in the host country, regulations in respect of hazardous chemicals are either non-existent or merely on paper. There is hardly any enforcement machinery. This was sought to be corrected by President Carter, but Reagan administration put the clock backwards.

This has resulted in double standards of multinationals. BHOPAL has demonstrated that because of lower operating and maintenance standards in the developing countries, there is justification for using sophisticated and automatic controls. In matters of safety there can be no compromise and it is in the interests of multinationals themselves to follow the same standards everywhere. Failing such self-policing, there is a strong case for intervention by international agencies - as recommended in the next chapter.

The issue involved is a broad one and it has major implications. To comply with the strict standards and regulations prevailing in U.S., Japan and other developed countries, requires elaborate equipment and substantial additional cost. This has led to a major shift of hazardous and high pollution operations from the developed world to the developing countries. . Result: Developing countries have become 'pollution havens' (29). This has happened specially in case of some 'troubled industries' like asbestos which has been confirmed as the culprit for causing the lung disease, asbestosis.

Asbestos still finds large scale use in the developed world, but most of the manufacturing operations have been shifted to Brazil, Mexico, India and South Africa. And ironically these are with technical and financial collaboration with the very firms (e.g., John Manville, USA and Turner & Newall, UK.

Issues such as these call for urgent action by the governments in developed (transferor's) countries - for their own sake. This so-called exporting jobs through shifting of hazardous operations to permissive (developing) countries may well 'backfire.' (26B) For example, deadly pesticides may come 'home' in the form of coffee beans or whatever.

ACTION BY DEVELOPING (TRANSFEREE'S) COUNTRIES GOVERNMENT

In many ways, this has to reciprocate the action by the developed countries government - in the best interest of both the parties. To an extent the problem exists within the developed world as well. Witness the 'acid rain' in Britain as a result of sulphur oxides emission in Germany or vice-versa depending on the wind

~~on the wind~~ direction,or the radiation fallout in Sweden as a result of the Chernobyl disaster.

The developing countries suffer much more, witness the BHOPAL or the asbestos affair among many such, hence they must take the initiative. International agencies, particularly UNIDO would be the right forum for such bilateral North-South dialogue. They can play a catalytic role and can also view the issue dispassionately - not being directly involved in it. Their technical experts/consultants, by virtue of their expertise in hazard and disaster prevention, can make valuable contribution to negotiations and help evolve a PLAN OF ACTION by the respective governments.

The negotiations will have to be conducted on basis of mutual trust and as 'equals' - after all both will gain from implementing the agreed PLAN. Besides, they need each other! With this basis, the scene will be set for a favourable result. Another plus factor in this respect is the evolution of the single global 'monoculture' of science, engineering, technology and industry everywhere. As a result the top engineering and management talent in the developing world compares with the best in the developed world (22). This becomes quite obvious at some of the international events on a wide range of subjects. It also points out clearly that, thanks to the 'jet' age and instant communications via satellites, the world has 'shrunk!' As a result international cooperation takes on an new dimension and it becomes a compulsion. The next chapter is devoted entirely to this element.

Chapter 6. INTERNATIONAL COOPERATION IS A MUST

The world has been shrinking fast and the countries have to depend on each other. With ~~the~~ inter-dependence as the backdrop, international cooperation is a must. No wonder, one of the cover stories on BHOPAL ~~was headlined:~~ [noted that (30)]

THE WORLD IS BHOPAL

The BHOPAL tragedy was 'flashed' all over the world, almost instantly. It occurred around midnight, half the world was asleep and the other half awake. The tally of dead persons kept on m mounting fast and reached such alarming numbers for BHOPAL to qualify as the worst ever industrial disaster. World reaction to the disaster and the serious concern specially in the chemical industry showed that:(30):

> the world is Bhopal, a place where the occupational hazard is modern life. After this tragedy is out of the news...t things ought to be made considerably safer than they were before Bhopal...

A considerable amount of work/action at company, community, government and international levels has indeed followed the BHOPAL disaster, but 'things may not have been made 'considerably safer.' More action at ALL levels still remains to be taken and in any case the situation with regard to averting disasters is always dynamic. It calls for constant vigilance.

INTERNATIONAL CODES & STANDARDS

We have noted at the outset (page 1) that for prevention of Bhopal type disasters, we must:

Think globally, but act [illegible]lly.

Action, of course, has to be on [illegible]ot. But because 'the world is Bhopal', the strategy for preventing disasters has to be planned in a wider context.

Some of the international agencies are already seized with the problem and have made significant contributions towards its solution. UNIDO, for example, has been quite active in the technology transfer area but some issues (e.g., page 34-5) still need to be tackled. The World Bank has compiled an exhaustive manual (32) for hazards assesment and have also prepared practical guidelines in this regard. We discuss these later in this chapter. ILO have prepared a valuable education manual for workers and have drawn fourteen lessons for prevention of accidents. These are (13):

The problem of accidents during work

The origins of accident prevention

Accidents investigations and statistics

Some principles of accident prevention: Fire & explosion

Machine guarding

Other protections

Some practical applications of accident prevention principles

Psychological and physiological aspects-accident prevention

Propaganda, education and training

Special categories of workers

Safety activities in the undertaking

Early industrial safety activities of government, public authorities and private associations

International safety activities

Trade unions, workers and industrial safety

The fourth lesson above dealing with fire and explosion is based on lessons learnt from disasters in the chemical industry, including the one at Flixborough (UK). A common denominator of such disasters is the presence of three elements: oxygen, fuel and heat. Absence or removal of any one of these is essential to avert a disaster. This is indeed a good and simple lesson to be impressed on the workers and having understood the basics, they should be in a better position to prevent disasters. The manual should be translated into local languages of developing countries - for use as a text in formal training courses.

IMPLEMENTATION AT LOCAL LEVEL

It is obvious that ultimate action to prevent a disaster must be at the local plant level itself. Elaborate manuals and safety instructions, whether in-house or national or international levels, are of no use unless translated into practice at the chemical plant.

For this purpose, the plant organisation must include a safety task team headed by a senior executive. This team ensures proper safety engineering controls at various levels including design, construction and manufacturing. The team also carries out (29):

Periodic safety audits

Surprise 'mock' drills

Accident investigation

Safety hazard reporting through failure reports

Constant check on standards and their applicability

Regular training and refresher courses in safety

Literature scan of accidents in the industry

Draw relevant lessons from these accidents and upgrade the safety system in the light of these lessons

The relevant association at national level, e.g., chemical

Manufacturer's Association in the U.S. and their counterparts in other countries publish valuable information (e.g., 6) relating to risk management and related topics. Such material must be essential reading for members of the safety task team and translating the same at the plant level.

ILO has reported (22) that the rate of fatal industrial accidents is several times higher in developing countries than in the developed world. And even more alarming is their finding that in many of the developing countries, the rate of fatal industrial accidents was rising - probably a result of inadequate investment in safety-related hardware and software. In addition, problems of technology transfer (pages 34-5), emphasis on production at the cost of maintenance, insufficient training of operators in safety matters and non-commitment by top management to safety aspect are factors requiring urgent attention at the plant level. In effect, what is required is adoption of an all-embracing safety 'culture.'

ROLE OF WORLD BANK

The response of the World Bank to the BHOPAL tragedy has been prompt and it has already been translated into practical action. We have noted above the compilation of a manual for hazard assessment and the necessary guidelines (32). It is now being circulated widely and borrowers of bank funds are required to comply with the guidelines. The present edition is labelled 'preliminary guidelines' and it is hoped that with the experience gained in due course, a final version will be issued. The aim/goal of the guidelines is three-fold (30,32):

Identify the potential hazards

Try to prevent occurrence of accidents

If accident does occur, minimise the damage thereof

The Seveso Directive (25), evolved by the European Economic Community in response to Flixborough and Seveso disasters, forms the basis of World Bank guidelines. The bank has pooled the resources available in Europe and U.S. to produce the comprehensive manual which incorporates the guidelines as one of the appendices. To simplify the necessary calculation work, a London-based consultancy firm has developed a computer program for process plant hazard analysis. Some of the important features of the guidelines are (32):

- Minimise storage of the hazardous materials, e.g., in case of the 'culprit' MIC (Bhopal), maximum amount is 4 kgms.
- Focus attention on plant design to minimise the hazards.
- Emphasis on training and supervision aspects.
- Cost of reducing hazards is less than 1.5% of project cost.
- Bank encourages (by providing the necessary funds) for upgrading safety systems in existing plants.
- On- and off- site emergency plans in case of an accident.
- Safety zones around hazardous installations.
- Coordinate emergency plans with the relevant local bodies.

The guidelines are already being used:

to evaluate the adequacy and effectiveness of the measures to control major hazard accidents affecting people and the environment outside the plant boundary.

Although prepared primarily for appraisal of World Bank and IFC projects, the techniques and guidelines presented in the manual are expected to have wide applications in the entire chemical industry - specially such operations as are considered hazardous. The manual and guidelines should go a long way in preventing and/or in minimising the effect of a disaster, but its real implementation is voluntary since the World Bank has rather limited enforcement powers after the plant has been built and handed over. But it will be in the interest of the host government and the plant owner to follow the guidelines.

UNIDO HAVE A VITAL ROLE

Having set the scene with BHOPAL and discussing how it could have been prevented (chs 2-5), we conclude with the role of UNIDO in this regard. Having done yeomen service to the cause of development in the Third World, UNIDO can and must play a vital role in prevention of BHOPAL type disasters. In specific terms, UNIDO's role can be spelled out under four areas:

TECHNOLOGY: Two areas concern pertinent policy issues:

Appropriate or impoverished vs advanced or modern technology & How can technology be transferred, really?

Appropriate/intermediate technology is usually recommended by the 'experts' but this is seen as ensuring that the developing countries will never develop. For their real development, advanced/modern technology is essential - as has been proved by Japan. This is on the basis that amount of goods produced is far more important than the number of jobs created (page 25).

Technology cannot be transferred through documentation alone (page 35). The real 'tricks' can only be learnt by getting hands 'dirty' and working alongside the experts who 'know.' There is no shortcut or magic answer.

REGULATING OR POLICING? In dealing with hazardous operations, regulations are really ineffective (page 19) due to a combination of ignorance and difficulty of enforcement. Company knows most about the risks involved and there is a strong case for self-policing. Non-regulatory measures appear to be far more promising (page 42) and deserve more study and attention. Ultimate answer may well lie in self-policing and strong legislation against the 'culprits.'

COORDINATION: Enormous work has been done at all levels for identification of hazards and for prevention and management of disasters in the chemical industry. Also, numerous agencies are involved in this 'mission.' What is lacking is a coordination of the work by the various agencies and also collation of the results obtained by researchers and technologists all over the world. The World Bank have taken the initiative in this regard (page 53), but there are gaps in two important areas (page 12,10):

Risk assessment has a purely Western focus

& The science and particularly practice needs simplification

Any instructions at the workers level must be in plain and simple language and free of technical jargon.

TRAINING: To be really effective, training has to be at the local plant level. But the trainers themselves need to be trained in the science and art of prevention and management of disasters. At present there is no proper forum for this. There is also dearth of good training material - both for the trainers as well as for the trainees.

The training for the trainers should be both at regional as well as global levels - with a different thrust. At global level, the training will have more technical material, whereas at regional level the emphasis will be more on mechanical methods. Suitable curricula will have to be prepared, as also the necessary training material. In addition, there is need for the managements to undergo refresher/training sessions. The contents for a typical one-day seminar for this purpose are shown in an Appendix (page 60).

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APPENDIX

THE BHOPAL TRAGEDY - IT HAS VALUABLE LESSONS!

A ONE-DAY SEMINAR

SYNOPSIS:

The world had never heard of Bhopal, a town in Central India with a population of some 800,000, until the morning of 3 December 1984. The worst-ever industrial disaster that reached the headlines that morning was caused by the leakage of the deadly gas methyl isocyanate, used in the manufacture of pesticides. The result: over 3,000 dead and some 150,000 left with permanent disabilities. A major disaster.

How did it happen? Why did it happen? Who was at fault? Was it due to mechanical failure or to human error - or both? Could it have been prevented?

What are the lessons to be learnt from the Bhopal disaster? How will it affect the operations of the multi-nationals? What will be the impact on the Third World?

These are all vital questions, and their answers hold valuable lessons, if only we will both listen and learn.

PROGRAMME:

Session A — Background and history of the plant. Wh[illegible] did what? Recent performance with [illegible] reference to [illegible].

Session B — [illegible]

[illegible]

Session D — [illegible]

[illegible]

Dr. [illegible] K. Kharbanda [illegible]

[illegible] Project Cost Control in Action [illegible], Process Plant and Equipment Cost Estimation [illegible], Chem[illegible] (Sevak 19[illegible]), How to learn from Project Disasters [illegible], Total Project Management ([illegible] 198[illegible]), International Construction (Gower 198[illegible]) and Corporate Failure (McGraw[illegible]).

Dr. Kharbanda [illegible], including [illegible].