

4 ACCIDENT PREVENTION MEASURES

This section deals with the specific safety and loss control programs of industry in the areas of design, construction, operation of plant, storage and distribution facilities as well as government programs related to transportation and workplace safety.

4.1 Industry

4.1.1 Engineering Design and Construction. In the design of chemical and related industrial plants, standard chemical, mechanical, civil and electrical engineering concepts are employed by registered professionals which ensures that an acceptable standard of safety is "built in". This approach to design is complex in nature and over the years has become technically very sophisticated. In recent years the field has been expanded to include specialization fields such as environmental sciences, toxicology, occupational medicine, industrial hygiene and safety.

The design of new facilities and major modifications to existing plants are subject to Environmental, Health and Safety reviews at all stages of the project, including pre-project environmental impact assessments and pre-start-up safety reviews. A list of topics covered during the project review stages is shown in Table 1. Typical examples of this review process are presented in Appendix II-5.

A recent publication by The Chemical Manufacturers' Association (May 1985) entitled "Process Safety Management" presents a systematic approach to evaluating and controlling hazards during the design and pre-operating phases of a project. Such hazard and operability (HAZOP) studies are applied to new designs to assess the hazard potential for "mal-operation" of individual pieces of equipment and the consequences of such mal-operation on the total facility. These studies not only assist in selecting optimal equipment systems, but also lead to minimizing hazards by reviewing alternative feedstock and process options.

More rigorous systematic approaches to hazard identification include techniques such as: fault tree analysis; cause-consequence diagrams; and event tree analysis. A schematic diagram showing the integration of hazard identification, assessment and control is shown in Figure 1.

4.1.2 Operations. Each plant facility, operating location or major function has as a minimum a written set of standard operating procedures to be followed. In addition, formal procedures for maintenance and control, inspection and testing, control of plant modification, security and emergency response plans are part of operations safety and loss

TABLE 1 CHECKLIST OF SUBJECTS COVERED DURING PROJECT REVIEW

Process Design

1. Alarm/Interlocks
2. Control System Reaction Time
3. Flow
4. Pressure
5. Temperature
6. Corrosion
7. Chemical Reaction
8. Electrical Classification
9. Emergency Conditions and Emergency Shutdown
10. Control System Sequence
11. Safety Relief Devices Capacity
12. Valve and Piping Specifications
13. Critical Instrument Control
14. Fire and Emergency Protection Systems

Maintenance/Operability

15. Physical Arrangement
16. Accessibility (platforms-ladders)
17. Required Safety Equipment
18. Piping Supports
19. Safety Valve Discharge Routing
20. Insulation
21. Handrails and Guards
22. Provisions for Isolation
23. Provisions for Cleanup
24. Pipe Stress
25. Vibration
26. Equipment and Line Labelling
27. Effects of Unchanged Facilities
28. Reliability
29. Spare Parts Availability

Personnel Safety

30. Gas Detection
31. Excessive Noise
32. Excessive Heat
33. Proper Ventilation
34. Lighting
35. Radiation Exposure
36. TLV Exposure
37. Protective Equipment and Procedures for Handling Chemicals

Environmental Concerns

38. Air Emissions
 39. Water Effluent
 40. Solid Waste Disposal
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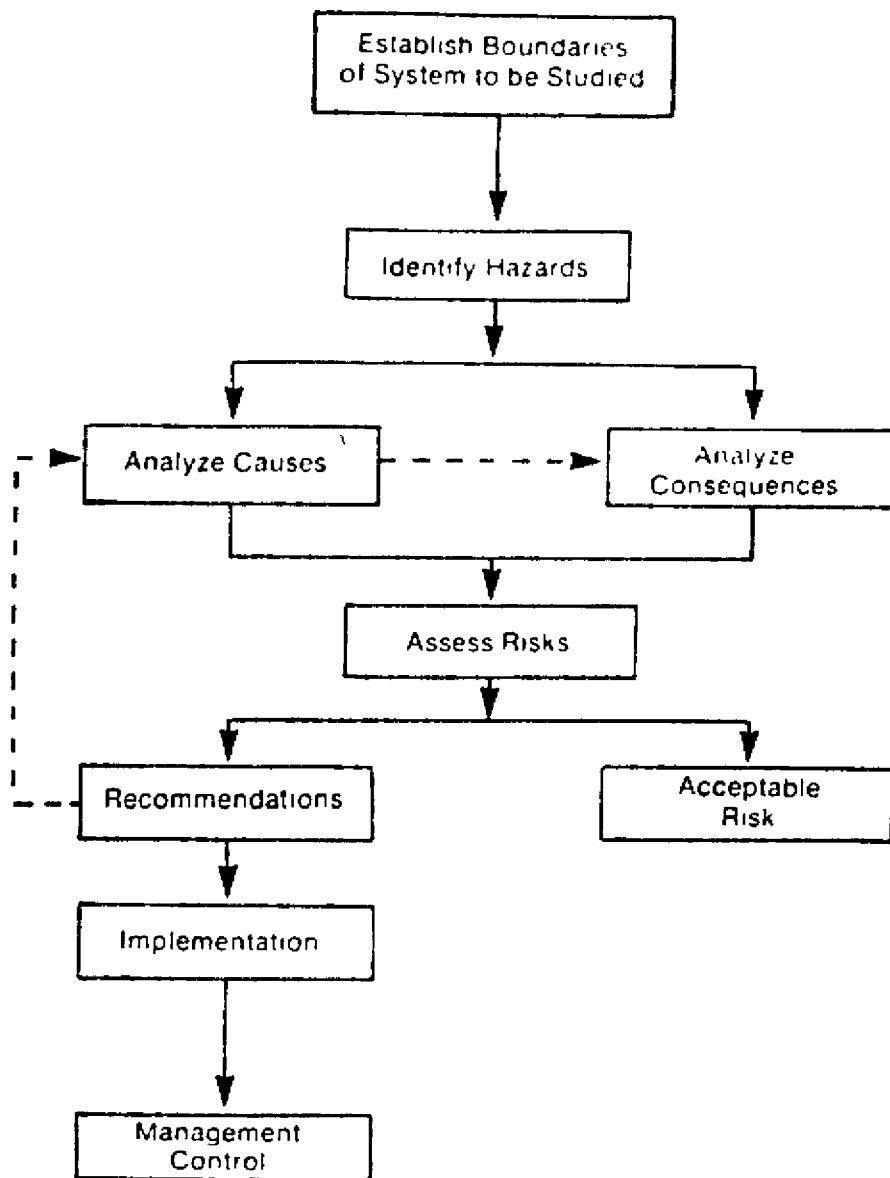


FIGURE 1 INTEGRATION OF HAZARD IDENTIFICATION, ASSESSMENT AND CONTROL (CMA, 1985)

control programs. In addition, operator training and periodic audits of process safety practices and operator and maintenance staff training are carried out by personnel external to the site.

Accidents or near misses are being investigated, analyzed and reported on a factual basis. The reports should be communicated widely and a system for learning from other plant's experiences should be in place.

For a more detailed description of safety practices during the operating phase of the product cycle the reader is referred to the "Process Safety Management" publication (CMA, 1985).

4.1.3 Storage and Distribution. Storage and distribution facilities for chemical or petroleum products undergo the same scrutiny as petroleum refineries and chemical plants. Safety practices during design and operation follow the systematic reviews and audits.

Special emphasis in storage should be placed on minimizing quantities of hazardous materials stored not only as raw materials and finished products, but as chemical intermediates as well. Secondary containment facilities and techniques are employed in order to minimize potential atmospheric releases or accidental spills.

In terms of product distribution and transport, companies shipping hazardous commodities, in recent years, carry out inspections of tank trucks and railway tank cars to reduce the risk of accidental losses.

In the case of rail transport, undercarriage as well as tank vessel inspections are carried out both by the major chemical companies and the railway companies. Inspection for mechanical integrity are a requirement under the Canadian Transport Commission regulations.

Routing of hazardous chemical carriers is usually designed to minimize public exposure to hazards. In the transportation industry, traffic controls and communication systems have been modernized and in many cases computerized, to increase safety in areas of high population density and traffic.

4.1.4 Effectiveness of Industry Practices. As an indication of the effectiveness of industry's safety programs, Working Group 2 found a lack of good statistical data on hazardous chemical accidents. However, Statistics Canada has provided information on worker injuries by different industry sectors. The data listed in Table 2 show that the petroleum and chemical sectors had 25 to 50% fewer reported time loss injuries in 1982, than the industry average. This demonstrates that the safety practices in the industry are relatively effective in comparison to other major sectors.

TABLE 2 WORK RELATED INJURY FACTS - 1982 (all Provinces)

Industry Sector	Reported Time-Loss Injuries and Illnesses per 100 Workers
Manufacturing:	9.4
Primary Metal	8.7
Paper and Allied Products	7.1
Electrical Products	5.7
Petroleum and Coal Products	2.4
Chemical and Chemical Products	4.5
Construction	12.1
Transportation, Communications and Other Utilities	5.4

Note: These results are based on data provided by all provincial Workers' Compensation Boards and by Statistics Canada for the year 1982. Reported work related time-loss injuries and illnesses, and national employment statistics were used. Industry sectors shown are from the Standard Industrial Classification Code.

These incident rates (injuries and illness per 100 workers) reflect to some considerable extent the results of efforts by employers and employees to control the causes of industrial accidents. They are based on data collected from the Workers' Compensation Boards in each provincial jurisdiction, for the purpose of developing national work injury statistics covering all industries in Canada. The accuracy of the data available for the industry sectors shown was deemed to be sufficient to illustrate in a relative way, how average rates of accidental injuries in two potentially high risk industries compare to some other industries in Canada for the year 1982.

A time-loss injury or illness is reported when a worker is absent one or more days because of injury or illness due to work related causes such as on-the-job accidents and work hazards. It is generally accepted that such accidents are prevented and hazards controlled when employers and employees co-operate in effective accident prevention programs.

Safety statistics can be interpreted as an indication of the approach taken by a sector towards safety but not as a reflection of the programs in place to prevent a major incident.

4.2 Government

4.2.1 Workplace Hazardous Materials Information System (WHMIS). The importance of information about potential workplace safety and health hazards related to the production and use of chemicals and chemical products has been well recognized by industry, organized labour and federal-provincial occupational safety and health regulatory agencies. In 1982 a federal-provincial government task force proposed that hazardous materials should be required to be labelled for the workplace, that material safety data sheets (MSDS) should be provided for such materials, and that workers should be trained to work safely when using such materials.

The Workplace Hazardous Materials Information System (WHMIS) was then developed in consultation with industry and labour. In June 1985 the recommendations of the WHMIS Project Steering Committee were presented for consideration of senior authorities in all jurisdictions. As of November 1, 1985 approval in principle has been given by most and is expected from all jurisdictions. The task of drafting appropriate legislation and regulations which will allow WHMIS to function on a national basis and satisfy all parties concerned, remains to be done.

When WHMIS is implemented, domestic producers and importers of hazardous industrial materials will be required to evaluate and classify their products, and provide all pertinent available information by labelling containers and providing an MSDS for each product. Also, employers who are users of hazardous materials will be required to inform and train their workers, on the basis of the information provided, to work safely and be protected from possible harmful effects of exposure to these materials. Workers will be responsible for participating in these education programs and for using information gained on the job to protect themselves and their fellow workers.

Many petroleum and chemical companies have already developed material safety data sheets and are well advanced in employee training programs.

4.2.2 Transportation and Routing. The Canadian Transport Commission (CTC) has had on-going programs for many years in regard to rail safety. However, the Mississauga accident caused the Canadian Transport Commission and the transport industry to reevaluate certain measures particularly in regard to the recommendations of the Grange Commission (incl). A few of these modifications are:

- double-walled bulkheads on cars carrying hazardous liquids;
- improved insulation on bulk cars for certain commodities;

- spacing of cars carrying certain chemicals to reduce the opportunity of accidental mixtures in the event of a spill;
- speed reductions for trains carrying special commodities through populated areas;
- improved "hot-box" detection techniques; and
- increased inspection requirements.

The report lists many more areas where improvements could be made. The Canadian Transport Commission is continuing to work with the railway industry to upgrade its rolling stock, the road beds and routing of dangerous chemicals to minimize the risks.

The enactment at the Transportation and Dangerous Good Regulations, effective July 1, 1985, while affecting all transport modes, will probably have the most impact in road and rail transport sectors. While it is perhaps too early yet to identify specific programs which have resulted from the legislation, there is no question that all of the major shippers of petroleum and chemical products have increased their training and safety programs in order to comply.

4.3 Information Programs

4.3.1 Safety Associations. While the role of safety associations is important to society as a whole, the Working Group does not consider that there is a significant impact of these particular programs vis-à-vis Bhopal-type incidents. Nevertheless, we would be remiss if these programs were not mentioned.

We are fortunate, in Canada, to have a comprehensive listing of associations (Land et al., 1985). The sixth edition brings together, in one compact document, listings for over 12 000 associations. International and foreign associations, with offices and branches in Canada, national, inter-provincial associations are included. Thirty-eight associations, listed in Table 3, are given in this Directory under the entry for 'Safety'. Another eighteen are listed under 'Industrial Safety' and these are given in Table 4.

4.3.2 Canada Centre for Occupational Health and Safety (CCOHS). CCOHS was established in October 1978 "to promote the fundamental rights of Canadians to a healthy and safe working environment". It is a Crown corporation, reporting through the federal Minister of Labour but governed by a Council representing federal, provincial and territorial governments, labour and employers. The Centre has a specific charter as laid out in the Act which established it. Programs centre mainly on information exchange through a computerized retrieval system.

TABLE 3 SAFETY ORGANIZATIONS

Academie de sauvetage du Quebec inc.
Alberta Safety Council
Association de securité des exploitations forestières du Québec inc.
Association de securité des pâtes et papiers du Québec inc.
Association for Canadian Registered Safety Professionals
Association of Canadian Security Services
Association paritaire de prevention pour la santé et la securité du travail
British Columbia Safety Council
Burnaby Safety Council
Canada Safety Council
Canadian Alarm and Security Association
Canadian Lifeboat Institution
Canadian Society of Air Safety Investigators
Canadian Society of Safety Engineering
Capital Region Safety Council
Chemical Industries Accident Prevention Association
Chilliwack and District Safety Council
Coquitlam and District Safety Council
Farm Safety Association Inc.
Grain, Feed and Fertilizer Accident Prevention Association
Industrial Accident Victims Group of Ontario
Kelowna and District Safety Council
Langley and District Safety Council
La Ligue de sécurité du Québec
Manitoba Safety Council
Metal Trades Accident Prevention Association
Motor Vehicle Safety Association
New Brunswick Safety Council Inc.
North Shore Safety Council
Nova Scotia Lifeguard Service
Nova Scotia Safety Council
Ontario Retail Accident Prevention Association
Ontario Safety League
Ottawa-Carleton Safety Council
The Royal Life Saving Society Canada
Saskatchewan Safety Council
Service national des sauveteurs inc.
Traffic Injury Research Foundation of Canada
Vancouver Safety Council

The Centre provides its services to industry, governments and the public. Much of the information relates to chemical characteristics and properties affecting health. For example, virtually all CCPA member companies provide their safety data sheets to the Centre and these are available to the public at no charge.

TABLE 4 INDUSTRIAL SAFETY ORGANIZATIONS

Accident Prevention Association of Manitoba
Association de sécurité des exploitations forestières du Québec inc.
Association de sécurité des industriels forestiers du Québec inc.
Association des sécurité des pâtes et papiers du Québec inc.
Association for Canadian Registered Safety Professionals
Association paritaire de prévention pour la santé et la sécurité du travail
Ceramics and Stone Accident Prevention Association
Chemical Industries Accident Prevention Association
Construction Safety Association of Ontario
Electrical Utilities Safety Association of Ontario
Food Products Accident Prevention Association
Forest Products Accident Prevention Association
Industrial Accident Prevention Association of Ontario
Industrial First Aid Attendants Association of British Columbia
Leather, Rubber and Tanners Accident Prevention Association
Mines Accident Prevention Association of Ontario
Occupational Health and Safety Council of Prince Edward Island
Ontario Pulp and Paper Makers Safety Association

The Working Group feels that the Centre should play a much more important role in information exchange and suggests that a more positive relationship be established by all parties having need for data on occupational health and safety including health departments, labour agencies, Workmen's Compensation Boards, Statistics Canada and industry associations.

4.3.3 Other Sources. A relevant collection of information is available from a publication of Corpus Information Services (Trimarco, 1982). This document lists over 200 pieces of legislation, over 100 government departments, agencies, boards and commissions and over 100 national and provincial associations, societies, labour organizations and educational institutions. Publications from these societies, including those from other countries, are numerous. Of special interest are those from the International Labour Office (1972), Van Nostrand - Reinhold Publishing Co. (Sax, 1984), National Safety Council (1981), Her Majesty's Stationery Office (1978), and the American Conference of Government and Industrial Hygienists (1980).

Various provincial and federal government departments have produced documents to cover special areas of industrial hazard. In the case of laboratory safety, a recent publication (Environmental Health Directorate, 1985) provides a 'Code of Conduct' for managers and personnel associated with laboratories and a previous review

(Withey, 1982) surveyed the literature on the health and safety of laboratory works in Canada.

Numerous publications cover the aspects of organization and implementation of laboratory safety practices (National Academy of Sciences, 1980; National Safety Council, 1981; Fawcett, 1972; Her Majesty's Stationery Office, 1978; National Chemical Laboratory, 1964; Steere, 1971;).

An example of a provincial government program is the handbook on the symptoms and treatment of pesticide poisoning, produced by the department of the Alberta Environment (Kelly, 1985). Pamphlets similar to those entitled 'Chlorine at the Worksite' and 'Ammonia at the Worksite' are also published by the Alberta Occupational Hygiene Branch (1985). The College, University and School Safety Council of Ontario (CUSSCO), assisted by the Safety Education Division of the Worker's Compensation Board holds an annual conference and publishes a newsletter every two months (CUSSCO, 1985). The Advisory Council on Occupational Health and Occupational Safety of the Ontario Ministry of Labour publishes an annual report every March.

5 REACTION TO BHOPAL-TYPE INCIDENTS

As was stated earlier the shock waves caused by the Bhopal incident reverberated throughout the world. Canada was no exception and Working Group 2 undertook an assessment of the reaction of the Canadian Chemical and Petroleum Industries to this event. The following is a summary of the findings.

5.1 Chemical Industry

Prior to the Bhopal incident the Canadian Chemical Producers' Association developed a policy of "Responsible Care". Under this policy the association encourages its members to exercise responsible care for ensuring that their products do not present an unacceptable level of risk to its employees, customers, the public and the environment. Acceptance of the guiding principles contained in the policy is now a condition of membership.

Two programs may be developed which deal with safety assessment and responsible care practices. The safety assessment program has already been developed and is shown in Appendix II-3.

On December 17, 1984, at a special meeting, the CCPA Board of Directors recommended that each member company of the Association carry out an immediate safety audit of its operations and report to CCPA. When this was accomplished, 64 of the 65 member companies provided a prompt response to the audit. Four of the respondents did not feel a need to carry out a formal audit for the following reasons:

- one company uses two substances that could be considered dangerous but the company is thoroughly audited by the suppliers of those two substances and its insurers on a regular basis;
- one company uses no dangerous substances other than corrosive liquids. This company did a form of audit sufficient to satisfy itself, that any spill or leak would be confined to the plant site and existing procedures would be satisfactory to respond to it; and
- two other companies use limited numbers of dangerous chemicals in such small quantities that in the event of a mishap they would not escape from plant site.

Twenty companies specifically mentioned their use of international or North American audits or the Five Star International Rating System (see Appendix II-4). This is important, since many of these companies are the smaller or medium sized CCPA

members that might not be expected to have the resources necessary to develop sophisticated audit systems themselves. These companies have, however, access to comprehensive audits developed by parent companies or affiliates, or they have recognized the advantages of using an existing system like Five Star.

Eight member companies reported that there is no likelihood of their becoming involved in a Bhopal-like incident. The companies reached this conclusion based upon the types of dangerous substances (if any) they use or handle, the types of operations they carry out and the shipment sizes for their products.

A common outcome of the audit process was upgrading precautions for a specific material produced or used by the company. A number of companies are also improving training and procedures for fire fighting and liaison with local fire departments. One company reviewed all the potentially dangerous chemicals it handles. It found that additional precautions were necessary to further enhance safety factors for one potentially hazardous raw material. Following an audit one company removed products from a warehouse with floor drains connected to the city's sanitary sewers and placed them in a warehouse with an adequate containment system. Visits by local fire officials and representatives of the provincial environment ministry were arranged.

In general, CCPA member companies underwent an audit that showed most of their existing safety programs could be improved. These improvements usually represented fine tuning and the follow-up to Bhopal was viewed as an opportunity to improve existing safety and loss control programs.

5.2 Petroleum Refining Industry

With a few exceptions many of the petroleum refineries are linked to large international corporations. As is the case in the chemical manufacturing sector, these petroleum companies are regularly exposed to internal and external safety audits conducted by the companies themselves and others such as insurance companies.

As a direct result of Bhopal, the Petroleum Association for Conservation of the Canadian Environment (PACE), who for the past 15 years have concentrated on spill prevention, control and emergency response, expanded their activity to include community participation in emergency planning.

5.3 Oil and Gas Production Sector

The oil and gas production sector suffered a Bhopal-like incident in the fall of 1982 when an Amoco gas well being drilled at Lodgepole, Alberta went out of control.

For two months, the blowout continued, the lives of two workers were lost and at times people residing near the blowout, feared for their health and safety. A public enquiry was held, 39 recommendations were made and the industry and government agencies are implementing these recommendations.

A summary of the recommendations and actions as prepared by the Alberta Energy Resources Conservation Board for the two most important areas follows:

(i) Reduce Blowouts

While blowouts cannot be totally eliminated, they can be significantly reduced. The Panel has recommended that:

- new strict rules apply to drilling critical sour wells, to ensure careful planning, superior equipment and well trained crews;
- the design, capacity and operating problems of key components of drilling rigs be carefully examined to determine whether changes are necessary;
- drilling operations in the critical zone be conducted in a cautious manner;
- ERCB increase both the number and completeness of its inspections of drilling operations; and
- the training of drilling personnel be improved.

Each of these recommendations has been implemented or is under active consideration.

(ii) Reduce Effects of a Blowout

If a blowout were to occur the Panel believes that its effect can be reduced by:

- requiring a site-specific emergency response plan for critical sour wells;
- ensuring effective coordination of government response to the blowout;
- ensuring effective communication with the public and particularly with the people residing in the immediate area;
- ensuring that H₂S exposure limits are appropriate - especially for sensitive people; and
- ensuring that H₂S concentrations are carefully monitored and the information made available to the public.

Most of these recommendations have been at least partially implemented.

The industry has also worked with government agencies to develop a policy on the ignition of a critical sour gas well in the event of an accident. This policy was announced by Alberta Public Safety Services in October, 1985.

Safety audits of gas plants are now a routine activity of this industry sector which has already responded to its own "Bhopal". While no fatalities were incurred in the general public at Lodgipole, the significant human health threat ranks this incident as a potential "Bhopal" in the same vein as Mississauga mentioned earlier. The Working Group therefore concludes that the ERCB and other regulatory agencies as well as the industry itself have learned from Lodgipole and steps are being taken to prevent future accidents.

5.4 Other Industry Sectors

Although the Working Group did not formally review the accident prevention programs of other major industry sectors such as pulp and paper and mining, plants in these sectors can be major users of the types of chemicals discussed.

(1) Pulp and Paper. The pulp and paper sector is essentially a chemical process industry using one of the major hazard chemicals, chlorine. For several years now the industry has been substituting chlorine with less-toxic bleaching chemicals, such as oxygen, in some processes. While economics and productivity are important considerations here, the safe handling of chemicals factor also enters in. The same idea can be extended to the pulping processes where again less-toxic chemicals processes are being investigated. While no specific details were provided the Working Group understands many companies reviewed their procedures for handling and storage of chemicals especially after the chlorine release at Fort Frances in November 1984. This has involved reductions of inventories where possible.

(2) The Mining Industry. While the Working Group did not undertake a thorough review of the programs of this industry sector, there is a record of some particular industry measures. The Noranda group, for example, have conducted safety audits at all of their plants where deficiencies have been identified, actions have and are being undertaken to correct them. Another company is undertaking a review of its inventory requirements for dangerous chemicals. In one case it has been estimated that SO₂ quantities can be reduced by over 80% through simply ordering by tank truck load rather than train car lots. Audit programs are underway at one facility in light of its proximity to a major transportation corridor.

There are probably more examples which could be found; however, the Working Group concludes that there probably is a need for increased effort in this major user industry.

6 WORKER AND COMMUNITY AWARENESS

One of the key issues to surface as a result of the Bhopal accident, is the "community right to know" issue. Following that tragedy, people living in the vicinity of chemical facilities asked the question: "What is going on behind that plant fence that could affect me?" This is a legitimate question and one that requires an answer.

Today people living in surrounding communities adjacent to chemical or petroleum complexes want to know the hazards to which they are potentially exposed. Working Group 2 is of the opinion that companies have a responsibility to inform the public as to what chemicals are being handled and their hazardous properties.

Companies have an obligation to inform not only their workers about the hazards of the chemicals they are exposed to on the job, but also local officials and residents should have access to the same health and safety information that is available to employees.

Many companies have urged their managers to be good neighbours, open their plants to visit from the public and to participate in local meetings to achieve a better understanding of the role of the industry and the community. Many plants have brought in local police, fire and emergency measures officials into the plants to discuss the hazards of the chemicals at the site, to explain the company's safety practices and to coordinate any emergency efforts to a community response plan. In some situations companies have been able to participate in cooperation with other industries on a mutual aid basis (Part 3).

The Canadian Chemical Producers' Association together with their U.S. counterpart, the Chemical Manufacturers Association, supports the principle of community awareness. In principle, they endorse the attitude that member companies have a responsibility to provide information on hazardous chemicals to the public. This information should be adequate to meet the needs of special groups such as municipal councils, police, local fire departments, physicians, hospitals and the general public.

Plant managers are encouraged by these trade associations to work closely with local officials on emergency planning activities; these associations are prepared to assist the companies and the local communities by providing guidance on how to proceed in developing emergency response plans.

In the U.S., the Chemical Manufacturers Association has developed a community outreach program. The "Community Awareness and Emergency Response", (CAER) handbook is an excellent source of information regarding the initiation and

development of a contingency plan. Two other equally valuable sources of information include "Evaluation of Public Health Hazards Associated with Chemical Accidents" (Silvano, 1985) and the U.S. Environmental Protection Agency's recent publication, "Chemical Emergency Preparedness Program" (EPA, November, 1985).

Working Group 2 supports the initiatives taken by industry and would promote its universal application across Canada, in strengthening the communication programs between local industries and local communities.