CANADIAN ENVIRONMENTAL PROGRAMS IN THE PETROLEUM AND PETROCHEMICAL INDUSTRY: PROGRAMS, POLICIES AND PRIORITIES,

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ABSTRACT

This presentation provides an up-to-date summary and status report on the Canadian effluent guidelines for petroleum and petrochemical facilities affecting the design and operation of Canadian based facilities. The presentation summarizes the key aspects of federal, provincial and local regulations and guidelines that deal with emissions to the natural environment. The key emphasis of the paper is on specific examples of how the Ontario petroleum and associated petrochemical industries have coped with these new regulations, whether that be through program development, production process changes or the introduction of new treatment facilities. We have drawn on the expertise of members of the LIS (Lambton Industrial Society) *"Environmental Co-operative"* to provide case studies on their achievements. Specifically the presentation deal with the following:

- A review of applicable federal legislation such as the Petroleum Refinery Effluent Regulations under the Fisheries Act, which sets limits for effluent discharges.
- The impact of specific Ontario regulations, being the most stringent in Canada, that deal with MISA (Municipal Industrial Strategy for Abatement) as this is the most stringent of the regulations to be put in force and thus the driving force behind many of the changes.
- The overall concept of the *Responsible Care Program*, as shown by the Novacor example and the role of the Lambton Industrial Society (LIS), emphasizing where this industrial cooperative works with and assists the industries on environmental matters.

A prime example of the role of Canadian petro based industries in Canada, relative to environmental matters, is exhibited by the Lambton Industrial Society. This environmental co-operative of the Sarnia Lambton Industry area includes refinery, organic chemical, inorganic chemical and electrical generating facilities.

Four major refinery complexes are members of LIS (Imperial Oil, Shell Canada, Sunoco Inc. and Novacor Chemicals Canada Ltd.). Together they operate to keep watch on the local environment, as evidenced by some two decades of ongoing monitoring. These monitoring programs involve continuous air and water monitoring with direct computer output, state-of-the-art biological monitoring programs, and numerous solid waste programs directed at the 3 R's (recovery, recycling and reuse). The LIS has been a model for many other international associations and should be of prime interest to the Mexican industry, particularly as it is not a government controlled association.

For specifics, we have drawn on the example of a co-operating industry and how Novacor has participated in the "*Responsible Care Program*" and the impact this has had on the achievements in air emissions control, waste water treatment, spills control, and biological monitoring. Decades of technical information is available from the LIS and member companies showing how an environmental co-operative can work in the best interests of the industries and the neighbouring communities.

To close the presentation we will touch briefly on the role that the POLLUTECH has played in working with the petroleum and petrochemical industries to assist them in both meeting their environmental compliance criteria and monitoring the results. POLLUTECH's process engineering capabilities and biological research station have played an important role, however we are not alone. ORTECH INTERNATIONAL has played an important role in working with the industries on the on-line water monitoring programs and computerized air pollution (ALERT) monitoring system. The University of Waterloo's CENTRE FOR GROUNDWATER RESEARCH has similarly played an important role in designing and monitoring programs for soil and groundwater contamination.

BACKGROUND

The Canadian petroleum and petro chemical industry is a major component of Canada's thriving industrial economy. One of the principal refining areas is the *Sarnia Petrochemical Valle*y developed along the shores of the St. Clair River, flowing between the fresh water Great Lakes of Huron and Erie, in south western Ontario. This area borders directly on the United States of America, and in particular the State of Michigan.

Province of Ontario government documents report that the Ontario refining industry is dominated by seven (7) petroleum refinery complexes, of which four (4) are located in and around the Sarnia area. Two of the refineries are located near the Provincial Capital of Toronto, Ontario on the shores of Lake Ontario and the seventh is located in the Town of Nanticoke, on the shore of Lake Erie. The Ontario refineries account for employment for approximately 7,200 people, ranking these industries among the largest firms in the province.

Table 1 depicts the seven operating refinery complexes in Ontario with respect to products and effluent treatment technologies.

TABLE 1 : ONTARIO, CANADA REFINERIES (adapted from Ontario Ministry of Environment and Energy)

Refinery	Products	Treatment	Discharge
Esso Sarnia	Fuel Products Lubricating Oils Feedstocks	API Separators Biological Filtration	St. Clair River to Lake Erie
Esso Nanticoke	Gasoline Aviation Fuel	API Separators Flotation	Directly to Lake Erie

	Heating Oils Lubricating Propane, Butane Sulphur	Biological Filtration Polishing Ponds	
Novacor Coruna (Sarnia Area)	Petrochemical Feedstocks Diesel, Furnace Benzene, Toluene Xylene, Natural gas	TPI separators Flow equalization Flotation Biological Activated Carbon Holding Pond	St. Clair River to Lake Erie
PetroCan Mississauga	LPG Aviation Fuel Gasoline, Diesel Furnace Fuels Asphalt, Grease Solvents	API Separators Sand Filters Equalization Biological	Lake Ontario
PetroCan Oakville	LPG Aviation Fuel Gasoline, Diesel Residual oils Asphalt, Sulphur	API Separators Equalization Flotation Biological Filtration Holding Ponds	Lake Ontario
Shell Sarnia	Gasoline, Diesel Bunker Fuel Furnace Fuels Solvents,Sulphur BTX	API Separators Flotation Equalization Biological	Talford Creek to St. Clair River to Lake Erie

Suncor Sarnia	Gasoline Fuels Light Aromatics Sulphur	API Separators Flotation Equalization Biological Holding Ponds	St. Clair River to Lake Erie

Each of the seven plants utilize modern wastewater treatment facilities. In all cases storm water is segregated, but treatment process vary. All ballast waters receive full biological treatment. Most importantly, internal management systems have been set up to deal with the new regulations, including clear definition of environmental responsibility, extensive operator training, and key involvement of environmental personnel at the early stages of capital projects.

Capital costs for the wastewater treatment facilities at the seven major complexes, as expressed in 1989 Canadian dollars, is as illustrated by Table 2.

TABLE 2 : WASTEWATER TREATMENT CAPITAL COSTS 1970 - 1989 (SCIENCE APPLICATIONS INTERNATIONAL CORPORATION, JULY 1992)

Refinery	Capital Cost (Million Dollars)	Feedstock Production (M^3/day)
Esso Sarnia	90	17,976
Esso Nanticoke	91	18,360
Novacor Sarnia	30	11,405
PetroCan Mississauga	17.6	6,653
PetroCan Oakville	25	10,605
Shell Sarnia	47	10,400
Suncor Sarnia	10	11,076
TOTAL	310.6	86,475

Provincial statistics show that the demand for petroleum products in Ontario has declined during the past decade from a peak of 92,100 cubic meters per day in 1980 to less than 79,900 cubic meters per day in the 1990's. Actual production capacity of the seven refineries is 95,000 cubic meters per day. Declining product demand between 1980 and 1990 resulted in the closure of thirteen (13) Canadian refineries, reducing national production from 705,000 cubic meters per day to 310,000 cubic meters per day. Only two of these closures occurred in the Province of Ontario.

One of the most significant changes to the Canadian petroleum and petro chemical industry over the last decade has been the significant change in the environmental regulations that control the discharge of atmospheric wastes, liquid industrial wastes and solid wastes associated with the industry.

CANADIAN ENVIRONMENTAL REGULATIONS

In preparing this presentation for this conference our intent was to outline for our friends in Mexico the development program for the Canadian environmental regulations, specific provincial regulations that impact heavily on the operations in the province of Ontario and the means by which the industry has coped with the introduction of these regulations through the advancement of new technologies. A key component of our presentation is how the Sarnia based petroleum and petro chemical industry has grouped together to form an environmental cooperative known as the Lambton Industrial Society (LIS) which is a self regulated society responsible for monitoring air, water and solid waste discharges in the Sarnia petro chemical valley.

Numerous programs, regulations, objectives, guidelines and agreements to maintain and enhance environmental quality are in place and/or under development in many of the provinces and at the Federal government level. Such regulations (ie. Ontario Water Resources Act and Ontario Environmental Protection Act, etc.) are intended to ensure that the quality of the water, biota, air and lands are maintained. Many of the acts and regulations provided the legislative authority to control and restrict the discharge of contaminants in the air, water or onto the land. They specify numerous prohibitions that define what constitutes a contaminant and permitable discharge. The acts specify abatement mechanisms and procedures, such as Control Orders and Minister's Orders which are used to specify legally enforceable control strategies. The acts and regulations also specify permitting processes (Certificate of Approval) to ensure adequate collection, handling, treatment ann disposal of wastes, including wastewaters, atmospheric discharges and solid wastes.

Under the Canadian Constitution Act of 1867, the provinces and territories have been given authority over most natural resources and water quality except on federal property, international issues and in other specific areas of federal jurisdiction, In most instances the federal government acts in an advisory capacity on many issues by recommending guidelines to the provinces.

Canadian environmental law is based upon a number of federal regulations, coupled with numerous provincial regulations which can either directly or indirectly result in the application

of environmental controls. The federal government of Canada has created and enforces a number of acts and regulations that provide for a common minimum standard to be applied across the country. Many of the provinces, and in particular the province of Ontario have promulgated a number of very strict environmental regulations, many of which have a significant impact on the Ontario petroleum and chemical industry. In Canada the individual cities or regional municipalities also enforce environmental regulations, particularly relating to the discharge of industrial waste to sanitary or storm sewer systems.

The major piece of federal legislation relating to environmental control of industrial operations is the Federal Fisheries Act, which has a major impact on the environmental matters of the petroleum and petrochemical industry in Canada.

Fisheries Act

The Fisheries Act is the most significant Federal Statute for the protection of fish habitat from chemical pollution. The habitat protection provisions of the Act provide for the protection of fish and fish habitat from disruptive and destructive activities. The Act provides comprehensive powers to protect fish, fish habitat and human use of fish by prohibiting the discharge of deleterious substances to Canadian Fisheries waters and is legally enforceable when an impact on fish or fish habitat can be shown. A deleterious substance any substance or water that has been processed or changed which, if added to the system, would degrade the quality of the water so that it is rendered deleterious to fish or fish habitat.

Specific Fisheries Act regulations have been promulgated for six industrial groups including the petroleum refining group. Some of these regulations are currently being updated. For instance the pulp and paper sector in now required to conducted Environmental Effects Monitoring (EEM) to determine the impact of effluent discharges on fisheries resources and fish habitat. There has been some preliminary discussions with regard to the applicability of a similar regulation for the petroleum refinery sector.

The Fisheries Act impacts on the refinery operations as it:

- prohibits the deposition of *"deleterious substances"* into any waters in Canada frequented by fish;
- forms the basis of the 1974 *"Petroleum Refinery Effluent Regulations and Guidelines"* which set the minimum standards across Canada;
- calls for monthly fish toxicity tests using Rainbow Trout to ensure that the refinery wastewaters are not acutely toxic; and
- establishes loading limits (kilograms per day) for general pollutants such as oil, grease, phenols, suspended solids, sulphides, ammonia and pH.

We are concentrating our presentation on the Canadian legislation that relates to these federal acts, regulations and guidelines across Canada and how the provincial regulations impact on operations in the provinces, each of which has the jurisdictional powers to enact and enforce environmental regulations. Only four of the ten provinces, namely Ontario, Quebec, Alberta and British Columbia have enacted specific environmental regulations. Provincial legislation, if more strict than the federal legislation, takes precedence. Developing legislation, such as the federal and provincial Environmental Assessment Acts may impact significantly on the industrial operations if there is a general expansion of the regulations to

include industrial as well as government owned operations.

Whereas the federal regulations set the effluent loading from the petroleum and petro chemical facilities in total mass (kilograms per day), the provincial regulations set the effluent criteria in allowable concentrations (milligrams per litre).

The Province of Ontario established goals and policies for the management of quality and quantity of surface and groundwaters in 1978 under the Ontario Water Resources Act (OWRA). Surface water quality must be satisfactory for aquatic life, recreation and potable water supply. The Provincial Water Quality Objectives (PWQOs) are a set of numerical and narrative criteria to protect aquatic life and recreation in and on surface water. The PWQOs are the desirable level of water quality that the province of Ontario strives to maintain in surface waters of the province. They are often the starting point in deriving effluent quality criteria. The Ontario Ministry of the Environment and Energy has recently released a revised listing of PWQOs for approximately 170 parameters. The list continues to be reviewed and grow.

Municipal and industrial direct discharges to receiving water are controlled by Ontario's Municipal and Industrial Effluent Objectives established under the OWRA and the Ontario Environmental Protection Act (OEPA). In addition site specific effluent requirements protect the quality of the receiving water. Site specific requirements are based on Policy 3 of the Ontario Ministry of the Environment's Water Management Goals, Policies , Objectives and Implementation Procedures. Policy 3 dictates that effluent limits will be established based on the waste receiving capacity of a waterbody and the Provincial Water Quality Objectives. Consideration is also given to Federal or Provincial effluent regulations or guidelines. The effluent requirement will be compared to Federal effluent regulations or Provincial effluent regulations or guidelines for existing or proposed new or expanded effluent discharges. The more stringent of the effluent requirement, regulations or guidelines will be imposed. The effluent requirement derived form this procedure for proposed new or expanded discharges will be incorporated into a Certificate of Approval in both waste loadings and concentrations.

Using the Province of Ontario as an example, the major components of the individual sections of the Ontario Provincial legislation and associated regulations that affect the petroleum and petro chemical industry are summarized under the following:

Environmental Protection Act

- governs the approval for all pollution control equipment whether for air, water or solid wastes;
- provides authority for control orders, stop orders, and program orders to allow provincial enforcement of the regulations;
- provides for the "Spills Bill" regulations which mandates the reporting, remediation and compensation related to spills of industrial effluents;
- is the basis of Regulation 347, the "generator regulation" relating to the storage, handling and disposal of industrial wastes;
- provides for Regulation 346, the "air pollution regulation" setting criteria for the discharge of contaminants into the atmosphere;
- provides specific responsibilities of the officers and directors of Ontario Corporations relating to the responsibility associated with environmental emissions; and

- sets penalties for violation of the acts and regulations.

Ontario Water Resources Act

- provides clear definition as to the meaning of "contaminants" and the meaning of "adverse effect" relating to environmental discharges;
- defines the restrictions on the discharge of contaminants into the natural environment that would result in an adverse effect and the associated remedies; and
- sets out remedies for environmental infractions.

Municipal Industrial Strategy for Abatement (MISA)

In 1986 the Province of Ontario made a significant addition to the environmental laws and regulations with the introduction of the *"Municipal Industrial Strategy for Abatement (MISA)"* program. This program, which applies to nine (9) distinct industrial sectors, plus municipal waste treatment facilities, is based on the introduction of *"Best Available Technology (BAT)"* to achieve the virtual elimination of persistent toxic chemicals entering the fresh water Great Lakes. The petroleum refinery sector was the first sector chosen for intensive study and implementation. Just this past month, after an extensive period of sampling, analysis and process review, the MISA regulations were promulgated, becoming effective for the refinery sector on December 9, 1993.

The MISA program has now shifted from the monitoring to the prevention and limits phases. In anticipation of this shift many of the refineries have voluntarily initiated abatement actions, such as the banned use of chromium and zinc in cooling waters, including the principles of:

- pollution prevention;
- bans or phase-out of persistent toxic chemicals; and
- elimination of cross media transfer of pollutants (ie. air to water to solid waste).

The MISA program will favour both manufacturing and treatment processes which limit the use of persistent toxic chemicals or the transfer of these chemicals from one medium to another. It is expected that the application of MISA to the refinery sector will result in a 30 percent reduction in contaminant discharges, which includes the elimination of 300,000 kilograms of conventional pollutants (oils, solids) and 4,000 kilograms of other pollutants. The MISA regulation for the petroleum sector proposes controls for 11 substances:

- dioxins phosphorus
- furans organic carbon
- phenolics sulphides
- volatile suspended solids pH
- oil and grease ammonia
- total suspended solids

In addition, and of great importance, the effluent must be non-lethal to fish in a standard effluent toxicity test using Rainbow Trout and water fleas (Daphnia magna). An effluent discharge is considered lethal if greater than 50 percent of the fish or water fleas die in 100 percent effluent concentration, within the time period of the test.

To cope with the developing regulations the petroleum and petro chemical industry in Canada has initiated a number of control strategies or programs to deal with the emissions to the atmosphere and the receiving water bodies. To provide an outline of these, we are presenting a case study of operations from the Sarnia, Ontario, petro chemical valley. We would welcome your inquiries as to specific details of any of these programs, or specific requests for information on technologies available to combat environmental problems you may be facing here in Mexico. Technical literature on the "Lambton Industrial Society", an environmental co-operative of the Sarnia petroleum and petrochemical industries, is available at the seminar.

Technical reviews, as reported by the Province of Ontario, suggest that the Ontario refineries could achieve a 60 to 80 percent removal of contaminants without significant financial or competitive impairment to the regulated firms. Permanent price increases of between 0.127 and 0.181 cents (1/100th of a dollar) could be achieved without attracting increased imports if growth in demand were to resume.

The monitoring program for 7 Ontario refineries generated about 80 000 data points and cost approximately $300 000 per refinery. Traditional parameters such as pH, DOC, TOC, ammonia, oil and grease, phenolics, etc., as well as trace inorganics, and trace organics were monitored. A total of 143 water quality parameters were measured. Toxicity testing (using rainbow trout and Daphnia magna), flow, production rates and refinery complexity were also reviewed.

Limits were developed based upon performance and "BAT" (or Best Available Technology). BAT was defined as follows: sour water stripping, initial oil and solids removal by API separators, flow equalization, dissolved air flotation, biological treatment followed by clarification, and effluent polishing using dual media filters and/or polishing ponds. The Ministry concluded that "Ontario refineries for the most part have BAT in place".

To evaluate the performance, refineries in the US were examined. The refineries selected were those with high levels of performance. When compared, it was found that "pollutants in effluent emanating from Ontario refineries were generally found at lower levels".

CASE STUDIES

To highlight the environmental control programs put in place we have selected two (2) case studies that represent the application of unique Canadian programs to accommodate the growing level of environmental concerns, leading to the application of technologies that allow the industries to comply with the strict environmental standards. Although these represent only a small fraction of the environmental control programs in place in Canada they do highlight the advancement of the programs, policies and priorities in place at these industrial establishments. In particular we draw your attention to the achievements of Novacor Chemicals and their implementation of the *"Responsible Care Program"* and the Lambton Industrial Society, through the application of an *"Environmental Co-Operative*".

NOVACOR CHEMICALS (CANADA) LTD.

Novacor is a major petrochemicals and plastics company operating internationally from

headquarters in Calgary, Canada. Novacor produces ethylene, polyethylene, styrene, polystyrene, propylene and methanol for the Canadian market and for markets around the world. Along with NOVA's natural gas transmission company, Novacor is one of the ten largest exporters in Canada and among the top five Research and Development performers.

Novacor's petrochemical refinery complex processes up to 15 000 m3/day of crude oil, condensates, and natural gas liquids for the production of primary petrochemicals (ethylene, propylene, butadiene, benzene , toluene/xylene). The main production processes are atmospheric and vacuum distillation, olefins cracking, gasoline hydrotreating, and aromatics extraction.

Except for some ubiquitous materials, no organic priority pollutants were detected in Novacor's final effluent during the MISA monitoring stage. The effluent was non toxic to rainbow trout and Daphnia. Existing BAT technology, operated and managed properly, consistently removes conventional and priority substances.

As a result of the introduction of the MISA limits to the petroleum sector, the process effluent limits for the Novacor facility have been established, as per Table 3. It should be noted that Table 3 shows the limits that are to be met on a daily, weekly or monthly average and are not indicative of the high quality of effluent that Novacor is discharging on a regular basis.

The following codes apply to Table 3: (**D** daily **W** weekly **Q** quarterly **NM** not measurable)

TABLE 3: NOVACOR PROCESS EFFLUENT LIMITS

Chemical Group	Test Period	Not to Exceed (mg/L)	Daily Loading (kg/day)	Monthly Average (kg/day)
Ammonia plus ammonium	W		188	65
Dissolved Organic Carbon	W	110	436	256
Total Phosphorus	W	-	-	12
Total Suspended Solids	W	-	-	282
Volatile Suspended Solids	D	-	406	220

Phenolics	D	0.2	0.57	0.19
Sulphide	W		3.8	1.9
Dioxin 2,3,7,8-T4CDD	Q	NM	-	-
Furan 2,3,7,8-T4CDF	Q	NM	-	-
Oil and Grease	W	50	201	94

The wastewater from Novacor's processes are segregated from into four types: chemical or process wastewater, oily water, storm water and sanitary waste water. About 6000 m3/day of waste water is treated by the following processes:

- Process waste water is any water which has contacted hydrocarbon. It is directed to a dedicated sewer system which where it is treated by API separators, hydraulic retention ponds, dissolved air flotation, biological oxidation, clarification, activated carbon polishing (when required) and dual retention polishing ponds.
- Oily waste water is any water which lands on operating areas or tanks farms, such as rainfall and wash water, as well as recirculating cooling tower blowdown. This water leads to a dedicated sewer system which can receive all of the treatment outlined above, depending on water quality.
- Storm water is collected from non-process areas, such as parking lots and roadways and directed to a dedicated sewer system. The system terminates in a pond equipped with and oil baffle and motorized gates. This pond is normally clean, the gate and baffles are present as a contingency in the unlikely event of a spill.
- Sanitary waste is treated in pre-engineered, packaged, biological oxidation unit.

Although Novacor is certainly a leader in the technical controls related to environmental control, they also believe that attitude and commitment is something which is not frequently addressed. Innovative technologies, less regulatory pressures and community acceptance can only happen from commitment to good environmental performance. One of the most significant advances in environmental performance has to do with a program called *Responsible Care*. Almost one year ago, Novacor's President, John Fieck spoke to a meeting in Mexico City at which time he highlighted the Responsible Care program. We have extracted from this presentation Novacor's thoughts and applications for Responsible Care.

Responsible Care is a chemical Industry initiative which calls on companies to demonstrate their commitment to improve all aspects of performance which relate to protection of environment, health and safety. It is generally acknowledged that Responsible Care had its roots in Canada under the Canadian Chemical Producers Association, the CCPA. Essentially, the early history of Responsible Care is a history of the CCPA's struggle to respond to growing government and public criticism of our industry's environmental, health and safety performance and a genuine desire on our part to improve our performance. As a large Canadian based chemical company, and a key member of the CCPA, Novacor has been directly involved in the evolution of Responsible Care from the beginning.

Responsible Care is the framework within which the chemical industry will ensure we operate in a responsible manner. Novacor believes that to be a successful international company you need the support of many people; your employees, your customers, your bankers, governments and the communities surrounding your facilities. It is not possible to get that support today unless you operate in a responsible manner.

In 1983, CCPA members were ask to voluntarily sign a statement of guiding principles of industry behaviour. Theses principles stated, in part, that companies would:

- ensure their operations did not present an unacceptable level of risk to employees, customers, the public or the environment;
- provide relevant information on the hazards of chemicals to customers and the public;
- be responsive and sensitive to legitimate community concerns; and
- proactively communicate to stakeholders a commitment to continuous improvement in environment, health and safety performance.

In summary, Responsible Care is a commitment to full/honest disclosure and improved performance.

Commencing in 1986 Novacor developed a series of six codes of practice which outlined in detail how companies were required to behave at different stages of the chemical life cycle. Beginning with the research and development stage, Novacor identified manufacturing, transportation, distribution and waste management. The sixth code dealt with the responsibility to ensure the community was aware of Novacor's activity and to work with them to develop and emergency response program.

In addition to developing the codes of practise and creating the public advisory panels, Novacor also established in 1986, a chemical referral centre which anyone could phone for information on industry products without cost to them. Developing the codes of practice was Novacor's most important and most difficult undertaking. It took our industry over two years of hard work and a further four years to implement them in a meaningful way across Canada. Novacor, has fully implemented the six codes at all Canadian operations. This marks the end of the beginning phase of Responsible Care, a process that by its nature is never ending.

In order to reach this stage, Novacor assigned an overall Responsible Care coordinator and a series of managers from the line management to coordinate implementation of each of the Codes of Practice. Novacor has clearly demonstrated that you can not implement this program by establishing a Department of Responsible Care. It is the operators inside the plant that you must rely on to implement new procedures. One must rely on salespeople to work with customers on the safe use of your product. These people must be involved in developing the new policies and procedures, to be committed to a Responsible Care success.

Industrial Operations are starting to reap the rewards of the Responsible Care Program. The CCPA's President, Jean Belanger, was recognized by the United Nations' Environment Program for his work in developing Responsible Care. The government of Canada's National Environment Plan cited Responsible Care as a model for business to follow. Perhaps the best recognition has been the acceptance of Responsible Care in many countries, including Mexico. To ensure consistency around the world, Responsible Care is now being promoted by the International Council of Chemical Associations (ICCA). The world's largest chemical

companies have generally made it company policy to apply the same rules worldwide to all operations. Responsible Care provided a framework for the safe production and flow of chemicals in domestic and international trade.

Novacor has completed the implementation stage of the Responsible Care Program, however they have identified many challenges that still lie ahead:

- to measure and report on its progress in ways that are standardized and credible to the many people who are affected by our business activities;
- to ensure that the public positions we take on issues are consistent with the ethics underlying Responsible Care;
- to be willing to discipline those members of our industry who do not live up to Responsible Care in their everyday activities; and
- to promote continuous improvement in the Responsible Care effort internationally as a clear demonstration of our individual and collective commitment.

Responsible Care is an important component of overall environmental control and compliance because it clearly sets out the *programs, policies and priorities* that must be initiated to meet these goals. In Ontario, Canada the refineries and other petrochemical groups have taken this one step further, by associating as a group to monitor and control these environmental matters.

THE LAMBTON INDUSTRIAL SOCIETY - *AN ENVIRONMENTAL CO-OPERATIVE*

The Lambton Industrial Society is an association of 15 major petrochemical facilities which operate along the Canadian bank of the St. Clair River, providing for integration among a number of refinery and petrochemical operations. The area is often referred to as Canada's Chemical Valley, and is the largest concentration of petrochemical facilities in Canada.

The Lambton Industrial Society was formed in 1952 by three originating members, which has now grown to fifteen. It is a true environmental co-operative in that its only purpose is to promote and foster environmental protection through joint and individual effort. The central effort throughout the Society's 42 year history has been ambient monitoring to understand the local environment and associated industrial impacts. The Society makes all monitoring and research information available to the community, to help ensure informed environmental decisions.

The LIS is supported totally by its industrial members. Fees are determined yearly, and are distributed among the various plant sites on the basis of size of the operation. For simplicity, the fee structure is determined by the size of the workforce on each site. The range of plant sizes is such that a large operation may contribute up to five times the annual fee of a smaller operation; however, each member has one vote on the Board of Directors. Currently, the annual budget is slightly in access of $1 million dollars, 80% of which is directed to technical and monitoring programs.

All members are actively involved in directing the operation. The Board of Directors is composed of the plant managers of each of the member facilities. The small office staff reports through a General Manager to the Board. A senior advisory committee, the Technical Committee, composed of the environmental managers on each site, advises LIS staff on all

technical programs. The Technical Committee is assisted by three subcommittees of experts in air, land or water pollution control and assessment, drawn from staff of member companies. The Public Affairs Committee advises on appropriate means of providing technical program information to the community, and assists with providing appropriate comment to the community on emerging environmental issues.

The LIS technical programs are focused on long term environmental issues. A sister organization, with origins within the Lambton Industrial Society, concentrates on emergency response. This group, known as C.A.E.R. - C.V.E.C.O., for **C**ommunity **A**wareness - **E**mergency **R**esponse, and **C**hemical **V**alley **E**mergency **C**oordinating **O**rganization, co-ordinates the response capabilities of industrial, municipal, provincial and medical emergency response organizations, and educates the community on how to respond to large-scale industrial and natural emergencies.

A second related organization, the Petroleum Industry Marine Emergency Co-operative, maintains an extensive inventory of boats, booms and absorbents to respond to oil spills. Trained staff from each company respond to a spill from any member, to maximize the response capability in the shortest possible time.

Atmospheric Emission Monitoring

Monitoring to develop an improved understanding of human activity on the local environment is the primary activity of the LIS. The co-operative owns eight air monitoring stations which are operated by an independent consultant, ORTECH INTERNATIONAL. All instrumentation is frequently cross-calibrated by the Ontario Ministry of Environment and Energy, the local regulatory agency. Use of an independent, reputable consultant, and excellent co-operation with the regulatory agency provide a high level of program credibility. The existence of this monitoring network also provides a major cost benefit to members, in that the regulatory agency accepts the co-operative monitoring rather than requiring fenceline monitoring at individual facilities. Monitoring results are provided via telemetry to a central computer accessible through remote terminals by each member. In this way, all members have real-time access to current ambient conditions, and can respond quickly to changing ambient conditions.

The eight air monitoring stations are located within, as well as north and south of the industrialized area, including one in the United States. Local winds are predominantly north or south, generally aligned with the river. Not all sites are completely instrumented; however, most contaminants of concern are well represented among the stations, including:

- Sulphur dioxide, due to the many sources of heavy fuel combustion in the area;
- Ground level ozone, as it is a chronic problem in much of urbanized North America, resulting in high levels during the summer months;
- Nitrogen oxides, having been recognized as major contributors to ozone formation;
- Non-methane hydrocarbons, as they provide a simple measure of volatile organic compounds, important in a large petrochemical complex, and are also contributors to groundlevel ozone problems;
- Ethylene, which is monitored at most stations, is a major local commodity with high levels of local production and consumption;
- Total Reduced Sulphur, which provides a general measure of potential odourants,

important in such a concentration of industries;
- Particulates, measured as both Total Suspended Particulates and as Inhalable Particulates on a six day cycle corresponding to the cycle used on a national basis in Canada; and
- Wind speed and direction at 10 metres above ground level as this has proven to be valuable component in assessing the atmospheric emission data.

Trend data, such as average annual sulphur dioxide levels are available over many years. Data from the early 1960's showed sulphur dioxide routinely exceeding the acceptable annual average of 0.020 ppm. Data through the 70's and 80's demonstrated acceptable levels and recent data show continuing reductions.

Short term levels of sulphur dioxide may still rise, despite low annual averages. The area has a unique regulation, referred to as the Lambton Industrial Meteorological Alert, that relies on data from the monitoring network and meteorological predictions. If an LIS monitor exceeds a twenty-four hour rolling average trigger value of 0.07 ppm, and adverse dispersion conditions are predicted to continue for six or more hours, local industries reduce sulphur dioxide emissions to less than half the normal level by switching to lower sulphur fuels for the duration of the alert. This program has successfully avoided exceeding the 24 hour average limit of 0.1 ppm in more than 90% of the 65 episodes since its inception in 1982. The alternative to this unique regulation was a switch to low sulphur fuel all of the time, which at the time the system was implemented in 1982 would have cost local industry about $10,000 per hour.

The Society has a unique ability to undertake large data collection projects, such as routine monitoring for 23 Volatile Organic Compounds at four locations. Comparisons demonstrate that levels of four common VOCs - benzene, toluene, xylene, and ethyl benzene - are similar to or lower than levels found in other Canadian cities, despite the heavy concentration of petrochemical industries. Close examination of the local database does indicate industrial sources in addition to the expected vehicle sources. Appropriate control programs now being implemented by local industries mean that the community can look forward to even lower levels in the future.

Groundwater Hydrogeology

A second area needing a fundamental understanding is that of land use and potential effects on groundwater. Sixty percent of the area's population is rural, relying on groundwater for fresh water supply. A thick plain of grey-blue clay makes the area attractive as a site for hazardous waste landfills. The area also contains zones of crude oil and natural gas production - the world's first drilled wells were here. Liquid industrial wastes were returned under pressure to the porous zones below the hydrocarbon bearing zones, a practice discontinued in 1976. At greater depth, extensive salt deposits are found. Salt caverns are used for large volume storage of gases such as ethylene and butadiene. Such activities have the potential to result in contamination of the fresh water aquifer.

In order to understand the potential impacts of industrial activity, a thorough understanding of the movement of groundwater is essential. The LIS is developing such knowledge through the Groundwater Institute of the University of Waterloo. A number of monitoring wells, measuring both water pressures and chemistry are in place, with additional locations being added as the study continues. Three of these wells use Solinst-Waterloo devices that allow measurement at

five separate depths in a single bore-hole. Work to date has established a general pattern of groundwater flow in the region, and also that pressures in the freshwater aquifer are higher than the clay above, or the bedrock below, providing a measure of protection against contamination.

Effluent Chemical Analysis

The members of the society have publicly stated two challenging goals - the virtual elimination of persistent toxic chemicals in routine discharges, and the elimination of spills. While neither has yet been achieved, progress is evident. The Society tracks reductions in discharge of routinely monitored substances to the river. Since 1975, discharges of Total Organic Carbon, Ammonia, Phenols, Suspended solids, and Oil & Grease have been reduced by 95%.

Member companies are now tracking discharges of "priority pollutants" - about 140 persistent, toxic chemicals, with similar reductions being achieved. While such reductions - the result of huge investments - are impressive, community attention is focused on the issue of chemical spills to the river. Reporting of even minor spills is required by law, and spills receive extensive press coverage. A number of downstream communities use the river as a primary source of drinking water, which the member companies recognize the need to protect. Spill incidents are declining. Of the 36 incidents reported in 1992, over half were less than 25 litres.

Currently, spill control programs require about $20 million dollars per year. For a large older facility built initially in the 1940's, such projects may reach $40 - 100 million for a single plant site. Equally important are the intensive training programs to provide employees with the expertise to do their jobs in an environmentally safe manner.

Declines in routine discharges and spills should lead to measurable improvement in the water quality of the river. The LIS operates - again through ORTECH INTERNATIONAL- an automated, remote analyzer that provides hourly concentrations of 20 volatile organic compounds in water at a point downstream of the industrial complex. Results are returned by telemetry to the central computer, immediately available to member companies.

Only 9 compounds analyzed above detection limits in 1992. 99.6% of all analyses were below the typical detection limits of 0.2 ppb. Toluene, cyclohexane and benzene, all commodity chemicals in the area, are the most frequently detected. Except during spill incidents, concentrations are near the detection limit. Rarely do recorded concentrations reach levels of concern. In 1992, the 70 year drinking water standard - the concentration in water that can be safely consumed for 70 years at 2 litres per day - was exceeded by benzene for 11 hours and for toluene for 4 hours, during two spill events. These were the only such incidents in 1992.

The monitor also provides valuable assistance with water supply management decisions following spills. By comparing the peak value and length of time for the spill plume to pass the monitor to model predictions, the model can be calibrated. If downstream freshwater intakes must be closed, the time and length of closure can be very accurately determined.

Effluent Toxicity Analysis

Measurement of effects on the native biota is a second indicator of improvement. For several years, the LIS has carried out comparative biological monitoring at sites located upstream of

all industrial activity, and at the same downstream location as the water quality monitoring. Studies of species at three trophic levels are complete or in progress, under the direction of POLLUTECH ENVIRONMENTAL LIMITED.

Survival studies of rainbow trout eggs have been completed for the period from egg production through to the hatchling stage. Egg survival was shown to be higher at the upstream site. Differences have been attributed by the consultant to specific events, such as surface runoff from heavy rainfall, rather than to chronic contamination.

Daphnia magna have been studied for both survival and reproductive success. Daphnia are a zooplankton species that is an important food source for fish in the St. Clair River. Adult survival and young produced are tracked daily. Results compiled over a four year period demonstrate that both survival and reproduction are better downstream - below industry - than upstream, apparently due to higher nutrient levels in the downstream water.

Reproductive success of fathead minnows - also native to the St Clair River - has also been studied. Breeding pairs are maintained at the two sites, and their success at laying egg batches, the number of eggs per batch, and the health of the resultant young are being studied. Results show very clearly that breeding success is equally good at both upstream and downstream sites.

Young fish hatched during the study were sacrificed at 125 days and examined. No unusual features were identified for fish from either station. This study now includes breeding pairs of fathead minnows hatched during the previous year, to extend the study to include possible second generation effects.

Over a period of many years, beginning in 1957, studies of the benthic community, the macroinvertebrate species living in the sediment on the river bottom, have been completed. The overall numbers of animals, and the diversity of species at various locations provides an indication of both water and sediment quality. In 1957, the river bottom offshore of the industrial complex and extending about twenty kilometres downstream, was severely degraded. An additional 30 kilometres was damaged, but classed as recovering. No fully healthy benthic community was found in this survey. Subsequent surveys demonstrate continuing improvement, corresponding to reductions of contaminants in effluents. The most recent survey shows that the area immediately offshore from the industry is degraded, but that the rest of the sediment is healthy.

Public Relations

Getting the information about a recovering ecosystem out to the community - particularly children - is the final major program area of the Lambton Industrial Society, often including classroom visits. Open communication with all members of the community is vital. An annual meeting is held to provide the community with results of the year's work, and to provide a forum for important guest speakers to share their thoughts on the future. The community is introduced to topics of local environmental interest through short written discussions. The Lambton Industrial Society, in co-operation with the local school authorities, produces a series of four page "monographs" as introductions to single topics, written at the comprehension level of a mid-teenager, for which fifteen titles are now available.

In summary, regional water quality is improving, as is the quality of the local airshed. The LIS, through its intensive co-operative monitoring program, is able to demonstrate that improvement through reductions in emissions, and corresponding improvements in the ambient environment. With the programs now in place, that improvement will continue.

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