Environmental Status Report 1979-1984
Vinyl Chloride Industry

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ENVIRONMENTAL STATUS REPORT 1979-1984 VINYL CHLORIDE INDUSTRY

by

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Report EPS 1/AP/1
September 1986

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ABSTRACT

This report reviews the results of measures taken by industry to reduce vinyl chloride emissions to the atmosphere and describes other environmental protection practices relating to effluent discharges and hazardous wastes handling.

This is the first national status report that reviews compliance of the vinyl chloride and polyvinyl chloride (VC/PVC) industry with the federal Vinyl Chloride National Emission Standards Regulations which became effective on July 1, 1979. Provincial legislation specifically limiting the emissions of vinyl chloride is in place in Québec and Alberta. Ontario, the only other province in which this industry is located, does not have legislation specific to this industrial sector, but by agreement enforces the federal regulations.

The production capacity of this industrial sector has been increased by a factor of three since 1973. In the meantime, the emissions are estimated to have been reduced by 95% on a weight per weight of product basis.

RÉSUMÉ

Le présent rapport passe en revue les résultats des mesures adoptées par l'industrie dans le but de diminuer les émissions atmosphériques de chlorure de vinyle et décrit d'autres pratiques environnementales reliées aux rejets d'effluents et à la gestion des déchets dangereux.

Il s'agit du premier rapport qui évalue, au niveau du pays, le degré de conformité des usines de chlorure de vinyle et de chlorure de polyvinyle avec le *Règlement sur les normes nationales de dégagement de chlorure de vinyle*, qui est en vigueur depuis le 1er juillet 1979. Il existe une législation provinciale qui limite spécifiquement les émissions de chlorure de vinyle au Québec et en Alberta. L'Ontario, qui est la seule autre province où est établie cette industrie, ne dispose pas de législation spécifique à ce secteur industriel mais applique le règlement fédéral.

Depuis 1973, la capacité de production de ce secteur a triplé. Cependant on estime que les émissions ont été réduites de 95 p. 100 par poids de produit.

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SUMMARY AND RECOMMENDATIONS

This report reviews the results of measures taken by the vinyl chloride and polyvinyl chloride (VC/PVC) industry to reduce the vinyl chloride emissions to the atmosphere and describes other environmental protection practices related to effluent discharges and hazardous wastes handling.

This is the first national status report covering the compliance of this industry with the federal Vinyl Chloride National Emission Standards Regulations that were published in March 1979 and which became effective on July 1, 1979. Provincial legislation specifically limiting the emissions of vinyl chloride is in place in Québec and Alberta. Ontario, the only other province in which this industry is located, does not have legislation specific to this industrial sector, but by agreement enforces the federal regulations.

The production capacity of this industrial sector has been increased by a factor of three since 1973. In the meantime, the emissions are estimated to have been reduced by 95% on a weight per weight of product basis.

The following conclusions and recommendations are of a general nature. For comments related to specific plants, refer to the appropriate sections in the report.

S.1 Conclusions

1) Six plants in Canada are subject to the Vinyl Chloride Regulations: four polyvinyl chloride plants (one in Quebec, two in Ontario and one in Alberta); and two vinyl chloride plants (one each in Ontario and Alberta).
2) Monitoring on a regular basis is the only way of verifying whether or not a source of emissions is operating within the regulatory limits. It became apparent during the plant visits that two plants in Ontario had not installed adequate monitoring instrumentation. These plants have since indicated their intentions to correct this situation. The other four plants, which had installed and used adequate monitoring equipment, provided data for the past two or three years which showed a percent compliance varying between 92 and 100% with the overall average close to 100%.
3) Annual stack surveys conducted in the presence of an inspector and using specific sampling, analysis and computing methods showed 100% compliance, with a few minor exceptions. In Alberta, both Alberta Environment and the plants conduct annual stack surveys. Annual surveys were not conducted on a regular basis in Ontario and Québec during the 1979-1984 period.

4) Accidental releases of large quantities of vinyl chloride to the atmosphere were reported mainly from polyvinyl chloride plants. Although their total quantities decreased during 1983 and 1984, further decreases are warranted. The reporting of incidents (Section 5 of the Regulations) was not consistent during the five-year period.
5) Fugitive emissions are considered a significant source of vinyl chloride emissions.
6) All six plants have installed numerous ambient VC monitors in the workplace to protect the workers and help to identify sources of leaks.
7) Vinyl chloride and polyvinyl chloride plants produce wastewater containing vinyl chloride. Alberta has a standard for vinyl chloride in liquid effluents. Data from other plants are not sufficient to generate any conclusions.
8) This industrial sector generates varying quantities of hazardous materials which are disposed of in secure landfills or by incineration.
9) Since the adoption of the regulations in 1979, existing PVC plants spent approximately $15 million to reduce and monitor VC emissions. New plants (the two in Alberta) incorporated the appropriate equipment needed for compliance.

S.2 Recommendations

1) The minimum monitoring and reporting requirements for VC emissions detailed in Appendix B should be followed to enable compliance to be assessed on a uniform base. Provincial environment agencies may require more frequent monitoring and/or reporting.
2) Stack surveys conducted in presence of an inspector using Environment Canada's Standard Reference Method should be carried out annually by all plants, under normal operating conditions, for all regulated sources.
3) Appropriate procedures, technology and training programs to reduce the volume and frequency of accidental vinyl chloride releases and emissions in excess of the prescribed limits should be implemented by the industry.
4) All VC/PVC plants should adopt agressive and systematic programs to identify and abate fugitive emissions. The provincial agencies that have jurisdiction in this area should evaluate each plant's program and if not satisfied should consider further action or additional measures to ensure that an effective plan is implemented.
5) Vinyl chloride in process effluents should be controlled efficiently to prevent VC evaporation and should be monitored (concentration and loading) before exposing the wastewater to the atmosphere.

1 INTRODUCTION

1.1 Background

In January 1974, it was reported that several workers who had been exposed to an in-plant atmosphere containing measurable concentrations of vinyl chloride had died of angiosarcoma, a rare liver cancer (1). Following this disclosure, much has been done by concerned industry, government and independent research groups to generate and assess medical and scientific data pertaining to this chemical.

In September 1974, the U.S. Environmental Protection Agency announced plans to establish a national emission standard for vinyl chloride. This standard was developed under Section 112 of the U.S. Clean Air Act, which deals with hazardous air pollutants, and was promulgated in the October 21, 1976, issue of the U.S. Federal Register.

Recognizing the potential seriousness of the problem, Health and Welfare Canada recommended that vinyl chloride emissions from stationary sources in Canada be controlled and maintained at the lowest possible level, as a public health protection measure. Consequently, Environment Canada prescribed in 1979 National Emission Standards Regulations for Vinyl Chloride under Section 7 of Canada's Clean Air Act. These regulations establish the maximum quantities of vinyl chloride that may be emitted into the ambient air from stationary sources.

Control strategies outlined in Environment Canada's suggested codes of good operating practice for the vinyl chloride industry were discussed during government/industry task force meetings. A controls program that included adherence to prescribed regulations for point sources, as well as suggested codes of good operating practice for fugitive sources, was expected to reduce vinyl chloride emissions from the industry by approximately 95%.

Fugitive emissions contribute significantly to the total amount of vinyl chloride emitted to the ambient air from the vinyl chloride industry. It was estimated that of a total 4500 tonnes of vinyl chloride emitted to the ambient air in 1973, approximately 1600 tonnes were from fugitive sources.

Emissions from fugitive sources cannot be regulated under the Clean Air Act as the Act allows the specification of point source emission limits only. However, a code of good operating practice encourages industry to do what is necessary to control emissions from fugitive sources and to assist provincial authorities in the formulation of regulations to achieve this end. Alberta has set limits on some fugitive sources in the "licence to operate" it issues to plants.

The vinyl chloride (VC) and polyvinyl chloride (PVC) industry is concentrated in Ontario, Alberta and Quebec. Alberta and Quebec have enacted vinyl chloride legislation more or less equivalent to the federal regulations, while Ontario has adopted an ambient air guideline for vinyl chloride. Only the legislation adopted by Alberta has included a limit on fugitive emissions and ambient monitoring requirements. The federal and provincial vinyl chloride emissions regulations are provided in Appendix A.

During the writing of this report, Environment Canada and provincial representatives visited all VC and PVC plants and a uniform minimal monitoring and reporting system was agreed upon (Appendix B). This monitoring system should be used in provinces where no specific monitoring and reporting programs are established and is not intended to replace the current more stringent reporting requirements established by Alberta Environment. Environment Canada also met with the Vinyl Council of Canada and its member companies to explain the purpose of this report and clarify some issues related to the administration of the regulations.

1.2 Industry Description

This industry is divided into two groups: the first group manufactures vinyl chloride and the second manufactures polyvinyl chloride. For comparison purposes 1973 has been used as the base year, since this was the first year for which data were collected for the development of the regulations. In 1973, two plants manufactured vinyl chloride with a total capacity of 139×10^3 t/annum*; in 1983 two plants manufactured 405×10^3 t/a VC. In 1973, four plants manufactured 115×10^3 t/a PVC; one of them terminated operations in 1975 and a new one was built in 1979. In 1983 these four plants had a production capacity of 333×10^3 t/a PVC (Table 1).

Environment Canada published in 1978 a document entitled "Air Pollution Emissions and Control Technology: Vinyl Chloride Industry", which details the VC and PVC manufacturing processes, emissions before and after control, and the available control technology. In 1973, the total estimated vinyl chloride emissions from the polyvinyl chloride manufacturing industry were just under 4 kg/100 kg PVC produced, as shown in Table 2. According to the U.S. Environmental Protection Agency, VC emissions from American VC manufacture averaged 0.4 kg/100 kg VC.

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* t/annum = metric tonne or 1000 kg per year

TABLE 1 VINYL CHLORIDE AND POLYVINYL CHLORIDE PRODUCTION CAPACITY: 1973 and 1983

	Production Capacity 10^3 t/annum	
Vinyl Chloride	1973(1)	1983(2)
Dow Chemical, Sarnia, Ontario	85	85
Gulf Oil, Varennes, Québec*	54	-
Dow, Ft-Saskatchewan, Alberta	-	320
TOTAL	139	405
Polyvinyl Chloride		
B.F. Goodrich, Shawinigan, Québec	23	48
B.F. Goodrich, Niagara Falls, Ont.	33	95
Esso Chemical, Sarnia, Ontario	41	90
B.F. Goodrich, Ft-Saskatchewan, Alberta	-	100
Monsanto, LaSalle, Québec*	18	-
TOTAL	115	333

* Both plants terminated operations in 1975.

TABLE 2 CANADIAN AND AMERICAN VINYL CHLORIDE EMISSION FACTORS (kg of vinyl chloride/100 kg of polyvinyl chloride produced), 1973(1).

	Captive Sources	Emergency Venting	Fugitive Sources	Total
Environment Canada Survey Results	2.15	0.19	No Data	-
U.S. EPA Survey Results	2.19	0.20	1.53	3.92

Vinyl chloride is generally manufactured in Canada according to the following reactions:

$CH_2 = CH_2$	+	Cl_2	→	$ClCH_2CH_2Cl$
Ethylene		Chlorine		Ethylene dichloride

$ClCH_2CH_2Cl$	→	$CH_2 = CHCl$	+	HCl
Ethylene dichloride		Vinyl chloride		Hydrogen chloride

Ethylene is first chlorinated to ethylene dichloride (EDC). By the thermal dehydrochlorination of EDC, vinyl chloride and hydrogen chloride are produced and then separated (see Figure 1).

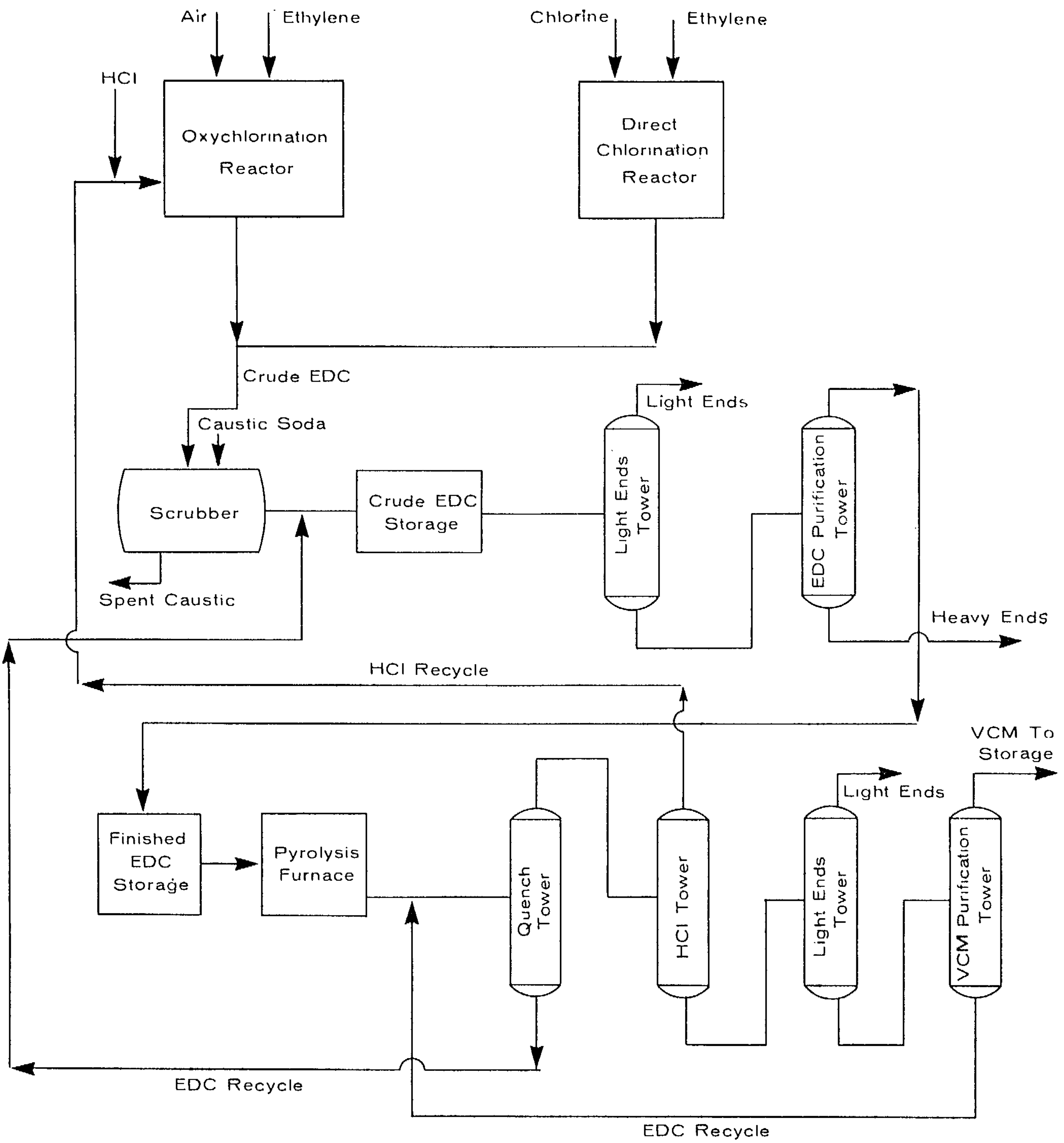
The major use of VC is the production of polyvinyl chloride (PVC), which is used in the manufacture of goods such as footwear, construction materials and furniture (see Table 3).

Figure 2 shows the suspension polymerization process which transforms the vinyl chloride to polyvinyl chloride. Approximately 70% of the PVC manufactured in Canada is produced by this process. The three main point sources of emission of VC from this process are:

a) the reactor, when it is opened (for cleaning, maintenance and inspection);

b) the VC condenser, where a discharge is made to the atmosphere after going through air pollution control equipment; and

c) equipment downstream from the stripper.



LEGEND:
EDC-ETHYLENE DICHLORIDE
VCM-VINYL CHLORIDE MONOMER

FIGURE 1 VINYL CHLORIDE MANUFACTURE - BALANCED PROCESS (1)

TABLE 3 USES OF POLYVINYL CHLORIDE (1)

Apparel

Baby Pants
Footwear
Outerwear

Building & Construction

Extruded foam mouldings
Flooring
Lighting
Panels & siding
Pipe & conduit
Pipe fittings
Rainwater systems, soffits, fascias
Swimming pool liners
Weatherstripping
Windows, other profiles

Electrical

Wire & Cable

Home Furnishings

Appliances
Furniture
Garden hose
Housewares
Wallcoverings & wood surfacing films

Packaging

Blow moulded bottles
Closure liners and gaskets
Coatings
Film
Sheet

Recreation

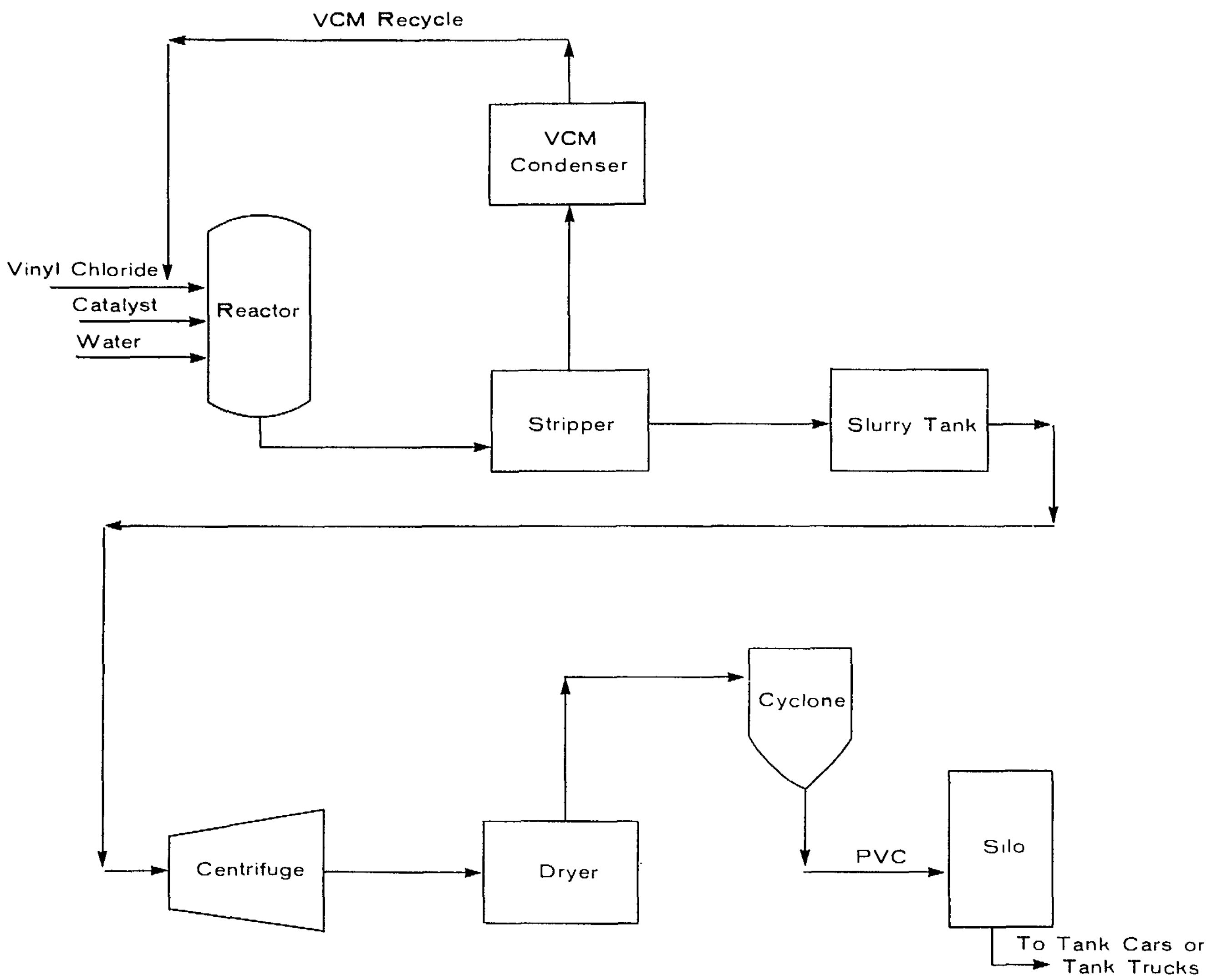
Records
Sporting goods
Toys

Transportation

Auto mats
Auto tops
Upholstery & seat covers

Miscellaneous

Agriculture (incl. pipe)
Credit cards
Laminates
Medical tubing
Novelties
Stationery supplies
Tools & hardware



LEGEND:
VCM-VINYL CHLORIDE MONOMER
PVC-POLYVINYL CHLORIDE

FIGURE 2 SUSPENSION POLYVINYL CHLORIDE PROCESS (1)

2 VINYL CHLORIDE REGULATIONS

2.1 Background

In March 1979, the federal government promulgated the "Vinyl Chloride National Emission Standards Regulations" under the Clean Air Act. These regulations were developed by a task force whose members were associated with the provincial and federal governments and industry. The three provinces affected have promulgated their own vinyl chloride regulations or guidelines (Appendix A). Table 4 summarizes the Canadian and U.S. regulations. Appendix B clarifies some items in the regulations regarding monitoring and reporting.

2.2 Federal Regulations

The federal vinyl chloride regulations mainly cover five topics:

a) the limits applicable to each type of emission source (sections 4(1), (2) and (3));
b) measurement methods (section 4(4));
c) definition of an incident and reporting (section 5(1), (2));
d) monitoring frequency for emissions (section 5(3), (4) and (5)); and
e) an annual test in the presence of an inspector (section 5(6)).

These regulations can be interpreted as applying to two broad areas: routine monitoring of emissions and reporting (a to d above), and an annual compliance test in presence of an inspector (e above).

2.3 Provincial Regulations

In 1979, Québec adopted a vinyl chloride regulation equivalent to sections 4(1) to 4(3) of the federal regulations.

Ontario has adopted a guideline on ambient air quality of 280 $\mu g/m^3$ and a guideline for point of impingement of 560 $\mu g/m^3$, but it also enforces the federal regulations.

Alberta adopted its own regulations on VC emissions in 1979. These regulations cover all the aspects of the federal regulations as well as fugitive emissions and ambient monitoring. Continuous monitoring and more frequent reports are required under these regulations. Alberta Environment enforces the more stringent regulations adopted by that province and publishes an annual report showing the results of the routine monitoring and annual stack surveys.

TABLE 4 VINYL CHLORIDE REGULATIONS

Source	Canada, 1979	Alberta, 1979	Ontario 1982, 85	Quebec, 1979	United States, 1976
	Compliance Tests (5.(6))	**Compliance Test (12.7)**			**Emission Test (61.67)**
	Annually	Annually and as specified in licence to operate.			Within 90 days of startup date
Vents	10 ppm : aver. of three 1-h samples	10 ppm	N/A	N/A	10 ppm : aver. of three 1-h samples
Reactor open	No. specified in stand. ref. method				Determined on a case by case basis
Stripping	1 sample/8 h -- aver. over 1 day	1 sample/8 h			1 sample/8 h -- Average over 1 day
Fugitive	N/A				
	Reports (5.(1))	**Reports**			**Reports**
	Within 20 days for all incidents Suggested changes 20 days : for major incidents 90 days : for minor incidents	N/A to Regulations Monthly : Licence to operate Immediate : Emergency venting (licence)	N/A	N/A	- Within 10 days for relief valve discharge (61.65(a)) - Each six months for monitoring results (61.70)
	Monitoring	**Monitoring**			**Monitoring**
Vents	Minimum: 1-h sample/8 h (5(3)) Report only excess (5(1))	Continuous for VC (licence) Report all monitoring (licence)	N/A	N/A	Continuous (61.68(a)) Report only excess: 1-h average (61.70(c)(1))
Reactor open	Monitor each opening Report excess (5.(4)	Each reactor opening (12.7(6))			Monitor and Report Each Opening (61.70(c)(3))
Stripping	Monitor 1 sample/8 h Report excess (5.(5)	1 sample/8 h			Monitor and Report 1 sample/ 8 h average for 1 day (61.70)(c)(2)(v))
Ambient atm.	N/A	1 sample/day (minimum)		N/A	
	Limits	**Limits**			**Limits**
Vents	10 ppm, 4(1)(a), 4(3)(a,b,c,d)	10 ppm	N/A	10 ppm	10 ppm
Reactor open	0.002 kg VC/100 kg PVC, 4(2)(a)	0.002 kg VC/100 kg PVC	N/A	0.002 kg/100 kg	0.002 kg VC/100 kg PVC
Stripping	0.02 - 0.04 - 0.2 kg VC/100 kg PVC, 4(2)(b,c,d)	0.02 - 0.04 - 0.2 kg VC/100 kg PVC	N/A	0.02 - 0.04 - 0.2 kg/100 kg	0.04 - 0.2 kg VC/100 kg PVC
Fugitive	N/A	Case by case (licence)	N/A	N/A	New Source Performance
Ambient atm.	N/A	N/A	0.1 ppm*	N/A	N/A

N/A Not Applicable
* Guideline

2.4 U.S. Regulations

U.S. vinyl chloride regulations are also summarized in Table 4. They correspond more or less to the Canadian regulations in the areas of limits and monitoring; the reporting and annual tests are slightly different. The measures to reduce fugitive and incidental emissions that are covered by the Canadian code of good practice are covered by the U.S. regulations in more detail.

3 VINYL CHLORIDE EMISSIONS

Over 95% of the vinyl chloride emissions in Canada are emitted from the polyvinyl chloride and vinyl chloride industries (85% and 10%, respectively). The vinyl chloride (VC) emissions data in this report commence when the VC regulations were adopted in 1979 and end with data for 1984. During these years, the administration of the regulations and monitoring and reporting of the emissions and incidents varied from one plant to another. Because monitoring frequency should be taken in consideration it is important to be cautious when comparing data on VC emissions from different plants.

The sources of VC emissions can be classified in three main categories: a) point sources regulated by the federal and provincial regulations, e.g., reactor openings, sources downstream of the stripper, and/or vents*, b) incidental releases due to malfunction of equipment or breakdown, and c) fugitive emissions (these are partly addressed in Alberta through the operating licences).

Data reviewed in this report cover emissions described in categories a) and b) for all plants. Category c) data are only available for B.F. Goodrich (Alberta).

Results of routine monitoring of point sources are obtained using a total hydrocarbon analyser in the case of reactor opening losses and an on-line gas-chromatograph for vents and sources downstream of the strippers. The residual VC in the slurry is measured by the Standard Reference Method (3).

3.1 Polyvinyl Chloride Plants

3.1.1 B.F. Goodrich Canada Inc. - Québec. This is an older plant that implemented major process changes to comply with the VC regulations limits during the last few years. B.F. Goodrich also installed equipment, monitors and implemented procedures to decrease the amount and frequency of incidental releases.

As mentioned earlier, the frequency of routine monitoring is important when comparing compliance data (when emissions are below the standards); the percent compliance for the plants that have a high monitoring frequency is, statistically, a more reliable figure. B.F. Goodrich has monitored its three regulated sources of emissions approximately 90% of the time since 1981. Except for reactor openings in 1981 and 1982 (Table 5). This is the most comprehensive monitoring data available since the company submitted records of VC emissions from the vents on a hourly basis, while other PVC plants reported these data for 8- or 12-hour periods.

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* "Vents" may include scrubbers, incinerators, absorbers, etc.

TABLE 5 PVC PLANTS: ROUTINE MONITORING AND ANNUAL TEST RESULTS (4)

19	Prepolymerization 0.002 kgVC/100 kg PVC 80	81	82	83	84	Reactor Open 0.002 kgVC/100 kg PVC 80	81	82	83	84	Stripping 80	81	82	83	84	Vent 10 ppm 80	81	82	83	84	
B.F.G. QUE.	Not Applicable						1/open	1/open	1/open	1/open		1/B,3/d	1/B,3/d	1/B,3/d	1/B,3/d		1/h	1/h	1/h	1/h	monitoring freq.
							1	29	94	96.5		98	96.6	97.4	90.7		81.4	88.2	93	93.6	% analysed
							60	95.4	98.7	99.1		98.8	99.2	96.9	98.1		98.7	92	92.4	93	% time in compliance
						-	100%	-	-	-	-	100%	-	-	-	-	100%	-	-	-	annual test (% sources in compliance)
B.F.G. ONT.	Not Applicable						1/open	1/open	1/open	1/open		1/B,3/d	1/B,3/d	1/B,3/d	1/B,3/d	1/8h	1/8h	1/8h	1/12h	1/12h	monitoring freq.
						100	100	98	100	100	94	89	97	99	100	100	100	100	100	100	% analysed
						100	77	100	100	100	82	94	94	99	99	98	91	99	98	96	% time in compliance
						-	-	100%	-	-	-	-	100%	-	-	-	-	100%	-	-	annual test (% sources in compliance)
ESSO. ONT.	Not Applicable						1/open	1/open	1/open	1/open	1/d	1/d	1/d	1/d	1/d	See text					monitoring freq.
						7	7	7	7	5	95	88	90	95	89						% analysed
						85	90	-	79	87	11	78	84	94	95						% time in compliance
						-	-	100%	64%	100%	-	-	100%	100%	75%	-	-	100%	100%	100%	annual test (% sources in compliance)
B.F.G. ALTA.	1/open	1/open	1/open	1/open	1/open	1/open	1/open	1/open	1/open	1/open	1/d	1/d	1/d	1/d	1/d	1/8h	1/8h	1/8h	1/8h	1/8h	monitoring freq.
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		92	17*	17*	100	% analysed
	100	100	100	100	100	100	100	100	100	100	100	99	99	100	100		100	100	100	99.8	% time in compliance
																	100%	100%	100%	100%	annual test (% sources in compliance)

* Incinerator not operating. Refer to text.
B = batch.

Vinyl chloride losses from reactor openings have decreased substantially from 1981 to 1984 as shown in Table 5. The reduction of reactor opening frequency has played a major role in this improvement.

Residual VC in the slurry has been well in compliance since 1981. This is due to the use of continuous stripping technology patented by B.F. Goodrich and substantial improvement to the batch stripping operation.

VC emissions from the vent gas absorber (VGA), installed downstream of the recovery unit, were within the limit more than 92% of the time during these years. The vinyl chloride absorbed in this unit is recycled.

The annual stack survey in the presence of an inspector was conducted in 1981 and showed that all the VC emitted from the three sources were within the standards. A second survey was carried out in November 1985 and its results were also within the standards. The regulations require a survey to be conducted in presence of an inspector on an annual basis.

Incidental releases of VC due to equipment malfunction or breakdown are not controlled by the regulations but must be reported within 20 days. The code of good practice describes methods and procedures that will reduce the frequency and quantities of these releases. To prevent and/or reduce incidental releases, BFG has installed the following:

a) equipment that can add a chemical inhibitor to slow the exothermal polymerization reaction, when needed;
b) improved rupture disks and safety valves on reactors;
c) a VC feed temperature control;
d) a second feed flow measuring device to double check the first one; and
e) water feed control in the control room to prevent accidental additions when the reactors are in operation.

Table 6 shows the reduction of VC incidental releases from a high of 30 tonnes in 1981 to 3 tonnes in 1984. Although incidental releases of VC are not controlled by regulations, it is important that they are dealt with in a responsible manner due to their potentially large quantities. B.F. Goodrich is commended for the efforts and steps the company has implemented to reduce these releases.

The estimated total vinyl chloride emissions from B.F. Goodrich's Québec plant were 920 tonnes in 1973 and 40 tonnes in 1983. This reduction of 95% was achieved at the cost of $3.3 million.

3.1.2 B.F. Goodrich Canada Inc. - Ontario. This is one of the older PVC plants in Canada but was expanded in 1979. The new plant uses state-of-the-art technology and is completely automated. Vinyl chloride point source emissions are routinely monitored and reported quarterly to the regional office of the Ontario Ministry of Environment.

This plant monitors VC losses from each reactor opening and measures residual VC in the PVC slurry after each batch and once every 8 hours from the continuous stripper. B.F. Goodrich continuously monitors VC from the vent of the gas absorber (VGA) and until 1984 reported compliance over a period of 8 hours; since then reporting has been for every 12 hours. This change was related to a change in shift working hours. For the purpose of uniformity and compliance with the regulations, the time period over which the 10 ppm is computed is three hours.

B.F. Goodrich has monitored its regulated sources of emissions since 1980 at a rate of approximately 98% (Table 5). Vinyl chloride losses from reactor openings have been within the limits 100% of the time since 1982. A new stripper has played a major role in reducing the residual vinyl chloride in the slurry. The contribution of older batch strippers has brought the overall percent compliance of the stripping operation to 96.5% since 1981. The VC emissions from the VGA are computed here over 8- or 12- hour periods. The VGA was operating within the limits 96.4% of the time since 1980 (the average of five years).

Major incidental releases of vinyl chloride from this plant are summarized in Table 6. During the five-year period, 30 major releases were registered, amounting to 23 tonnes of vinyl chloride emitted. During 1983 and 1984 only two incidents were reported. This improvement is mainly due to the preventive measures that were implemented, such as: use of alternative power sources (backup diesel generators), a rupture disk relief valve vent, polymerizer pressure alarms and recorders, the development of reaction shortstops, containment systems, rupture disc improvements, improved preventive maintenance and the installation of lower explosive level combustible gas alarms at storage areas.

B.F. Goodrich invested $5.5 million between 1980 and 1984 to reduce the vinyl chloride emissions from this plant by approximately 96% on a weight per weight of product basis.

The annual stack survey in the presence of an inspector was conducted in 1982 and showed that all the VC emitted from the three sources were within the standards. Such a survey, using the Standard Reference Methods(3), should be conducted annually.

TABLE 6 VINYL CHLORIDE INCIDENTAL RELEASES (4)

PVC Plants: Major Incidents

	1980		1981		1982		1983		1984		Total	
	No.	t	No.	t	No.	t	No.	t	No.	t	No.	t
BFG Qué	8	17	18	30	3	8	8	4	5	3	42	62
BFG Ont.	8	9	12	9	2	2	1	1	1	2	24	23
Esso Ont.	0	0	9	3	7	5	11	45*	6	5	33	58
BFG Alta	1	6	2	4	-	-	-	-	1	5	4	15

* 40 t due to power failure.

VC Plants

	1980			1981			1982			1983			1984		
	No.	Max. ppm	Monthly av. ppm (No. months)	No.	Max. ppm	Monthly av. ppm (No. months)	No.	Max. ppm	Monthly av. ppm (No. months)	No.	Max. ppm	Monthly av. ppm (No. months)	No.	Max. ppm	Monthly av. ppm (No. months)
Dow Alta	45	147	16 (1)	54	378	10.2 (1)	10	826	30 (2)	0	<10	<10	0	<10	<10
Dow Ont.*	1			-			-			-			2		

* See text.

3.1.3 Esso Chemical Canada - Ontario. Originally one of the largest PVC plants, this plant has been expanded and upgraded through the years. Esso has not monitored all the VC sources of emissions as extensively as the other PVC plants, but has indicated to Environment Canada and MOE representatives that it will upgrade its monitoring equipment and sampling frequency, and will implement some changes to reduce the potential for VC atmospheric releases. This plant has conducted stack surveys in the presence of an inspector since 1982.

Esso has routinely measured VC losses from 5-10% of all reactor openings and has depended on ambient air monitors in the reactor room to indicate whether the ambient VC concentration is too high. Between 1980 and 1984, the compliance of measured emissions from the reactor openings varied between 79 and 90%. In the second half of 1985, Esso was developing and validating a correlation to allow monitoring of reactor openings with a portable TLV instrument. Starting in the first quarter of 1986, Esso has measured VC losses from each reactor opening and reports the percent analysed and the percent compliance to the regulatory agencies on a quarterly basis.

The residual VC in the slurry has been monitored very extensively using the Standard Reference Method during the period under review. After commissionning a new stripping tower in July 1983, the results of the residual vinyl chloride in the slurry were the weight average results of the continuous and batch stripping. Commencing in 1986, the two types of stripping will be reported separately. For 1984, routine monitoring showed 95% compliance with the standards.

An incinerator is used to control the VC emissions from the recovery unit. This emission point was not sampled and monitored on a continuous basis. Esso depended on ambient air monitors and incinerator operating parameters to audit the incinerator performance. Spot sampling done through the period showed vinyl chloride levels to be below the 10 ppm standard. Facilities for continuous sampling of the stack are scheduled to be operational in early 1986. Vapours containing vinyl chloride will be rerouted to a gas holder when the incinerator is off-line.

Annual major releases of vinyl chloride from this plant are summarized in Table 6. During the five-year period, 33 major incidents were registered, amounting to 58 tonnes of vinyl chloride being emitted. In one instance, a power failure and consequent shut down of the operation was responsible for the release of 40 tonnes. Esso then modified its power supply to divide the reactor load between two systems and upgraded the reactor kill system to prevent the repetition of this kind of incident. A power failure after the modifications resulted in zero discharges to the atmosphere. During the five years, 215 minor incidents were also recorded, resulting in a total emission of 7 t of vinyl chloride.

Table 5 shows the results of the three annual surveys of emissions carried out by Esso since 1982. During these surveys, all the sources tested were within the standards except the reactor openings in 1983 and the stripper in 1984.

From 1979 to 1984, Esso invested a total of 5.8 million dollars in projects to reduce vinyl chloride emissions to the environment. Another $312 000 were allocated during 1985 to reduce and monitor the vinyl chloride emissions.

3.1.4 B.F. Goodrich Canada Inc. - Alberta (previously Diamond Shamrock Alberta Gas). Commissioned in 1979, this is the newest PVC plant in Canada. However, the incinerator experienced extensive downtime after start-up. Under the direction of Alberta Environment, B.F. Goodrich has replaced, repaired and modified problem areas in the system. Since January 1984, the incinerator has been on-line close to 100% of the time that the plant has been operating. During the incinerator downtime, the vent gases were directed to the flare stack for combustion to minimize vinyl chloride emissions.

This plant has monitored its emission sources since becoming operational and reports on a monthly basis the monitoring results as specified on the licence issued by Alberta Environment. Vinyl chloride losses from reactor openings are monitored; the emissions from sources downstream from the stripping operation are computed daily; and emissions from the incinerator vent are sampled continuously and computed as 8-hour averages.

B.F. Goodrich has a two-step polymerization procedure (prepolymerization and polymerization). The vinyl chloride emissions from these two steps are each subject to the same limit of 0.002 kg VC/100 kg PVC produced. The vinyl chloride losses from this source have always been within the limit (Table 5). All emissions from the combined sources downstream of the stripper have been within the limits virtually 100% of the time.

The incinerator was not operating during 9 months in 1982 and 10 months in 1983. An extensive repair program was implemented and the incinerator has been operating since January 1984 without major shutdowns and within the limits.

During the incinerator shutdown, the vent gases were flared. While the combustion efficiency of an incinerator runs usually above 99%, that of a flare can be anywhere between 80 and 99.9%, and cannot be readily measured. To be able to comment on the effects of the emissions during shutdown of the incinerator, Alberta Environment analysed and compared available data from ambient air monitors located around the plant. This comparison did not show any significant difference in the vinyl chloride concentration in ambient air when the incinerator was operating and when it was replaced by the flare (Table 7).

TABLE 7 B.F. GOODRICH, ALBERTA, AMBIENT VINYL CHLORIDE READINGS

Year	Average VC Reading* (ppm)	Number of months incinerator was operating
1980 (11 months)	0.00021	6
1981	0.00033	11
1982	0.00057	3
1983	0.00046	2
1984	0.00025	12

* Based on 24-hour average readings from five ambient VC tube stations operated by B.F. Goodrich in the vicinity of the plant.

Annual stack surveys conducted by Alberta Environment and by the company cover the incinerator vent as well as other point sources of emissions regulated by the province and limited by the company's operating licence. The reactor and autoclave openings were surveyed by B.F. Goodrich, but the Standard Reference Method (3) was not used.

Since 1982, B.F. Goodrich has spent almost $4.7 million on alterations and installations that had an overall effect of improving the air quality by reducing the VC emissions from the plant. Ninety percent of this amount was the cost of installation of a process computer to further automate the production and reduce the probability that operator error would cause a release. Other areas of improvements were the incinerator, recovery upgrading, emissions monitoring, removal of surplus equipment and installation of back-up pumps to minimize leaks.

The vinyl chloride incidental releases since 1980 are summarized in Table 6.

The licence to operate issued by Alberta Environment defined a limit for the reaction area and recovery area leak collection system vents of 6.5 kg/day. These are considered a part of the fugitive emissions. Table 8 shows the average daily emissions from this source for each year. The results show a decreasing trend in emissions.

TABLE 8 FUGITIVE EMISSIONS FROM B.F. GOODRICH, ALBERTA

Year	Average daily emissions (kg/d)	% of time limit (6.5 kg/d) exceeded
1980	3.4	9.3
1981	3.8	9.8
1982	2.1	5.3
1983	2.1	5.3
1984	1.1	0

3.2 Vinyl Chloride Plants

The two Dow plants (in Ontario and Alberta) produce vinyl chloride monomer which is used by the four plants described earlier to manufacture polyvinyl chloride. The VC emissions from these two plants are from one point source (the vents) subject to one standard listed in section 4(1) of the regulations.

3.2.1 Dow Chemical Canada Inc. - Alberta. This plant was commissioned in 1979, the same year the regulations became effective, and was equipped with the appropriate equipment and new technology necessary to meet the standards. Since 1980, Dow Chemicals has spent $59 million on environmental controls (capital and operations costs).

Routine monitoring of the emissions from the vents was generally conducted at a frequency of three hourly samples per day. When compared to the 10 ppm standard, the results of the routine monitoring were within that limit between 95 and 100% of the time.

Dow has also conducted annual stack surveys using the Standard Reference Method since 1980. The results of these tests are shown in Table 9. The emissions from the three vents were within the limits in all the tests.

Incidental releases of vinyl chloride from this plant are summarized in Table 6. Between 1980 and 1982, the total number of incidents was 109. In 1983 and 1984 no incidents were reported.

TABLE 9 VC PLANTS : ROUTINE MONITORING AND ANNUAL TEST RESULTS

	Vent No. 1					Vent No. 2					Vent No. 3					
	80	81	82	83	84	80	81	82	83	84	80	81	82	83	84	
Dow Chemicals, Alberta	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	1/8 h	Routine monit. frequency
	96	97	99	100	100	98	95	99	100	100	99	99	100.	100	100	% of time in Compliance
	-	0.8	0.07	0.35	ND	3.4	0.1	0.16	0.15	ND	ND	1.8	0.03	ND	ND	Annual test results, ppm (Limit: 10 ppm)
Dow Chemicals Ontario*																

* See text

Dow regularly monitors vinyl choride in the ambient air at four points around the plant. The 24-h average concentrations at these points are shown in Table 10. In 1984 and 1985, the ambient concentrations were below detection limits 98% of the time.

TABLE 10 AMBIENT VINYL CHLORIDE CONCENTRATIONS[a] AT THE DOW CHEMICAL, ALBERTA, PLANT PERIMETER

Concentration Range (24-h Avg. in ppm)	Percent of Time						
	1979[b]	1980	1981	1982	1983	1984	1985[c]
Not Detectable (<0.005)	89.5	86.4	96.1	90.4	95.1	98.0	98.4
0.005 - 0.009	3.0	3.3	1.4	4.9	2.6	0.3	0.3
0.01 - 0.03	6.0	6.5	1.7	3.5	0.9	0.1	0.1
>0.03	1.0	2.4	0.4	0.3	-	-	-
Not Available	0.5	1.4	0.4	1.0	0.4	1.6	1.2

a Using charcoal-tube data
b 3 month data
c 9 month data

3.2.2 **Dow Chemical Canada Inc. - Ontario.** This plant was commissioned in 1960 for the production of vinyl chloride. Emissions containing VC are normally incinerated in the thermal oxidizer (TOX) or the thermal oxidizer with heat recovery (THROX). Alternatively, they are emitted through the caustic scrubbers which remove hydrochloric acid and chlorine mist. The TOX incinerator came on line in 1973 but was not routinely used for incinerating VC emissions until 1979. The THROX came on line in 1984. The incinerators have not been subject to routine monitoring for vinyl chloride. The scrubber emissions are monitored by continuous on-line gas chromatography; however, historical records have not been retained and compliance could not be assessed. The temperature of incineration by TOX and THROX is above that required for the destruction of VC according to the company.

On-line continuous gas chromatograph monitoring will be implemented on the TOX and the THROX, in addition to the scrubbers T9/T12 vent stacks, in the second quarter of 1986. Results will be validated against the Standard Reference Method (3). Dow is evaluating the feasibility of having the THROX provide complete backup to the TOX. This will eliminate having to direct vents to T9/T12.

Between 1979 and 1984, the TOX incinerator was not operating 6 to 20% of the time. During some of this time the VC plant was also down for annual maintenance, and the VC-containing streams were emitted through the scrubber between 1 and 15% of the time. According to the U.S. Environmental Protection Agency (5) the uncontrolled emissions of VC from vinyl chloride production by direct chlorination are 0.18 kg/100 kg VC produced (EDC finishing column 0.07 kg/100 kg; VC finishing column 0.11 kg/100 kg). On this basis, at a production rate of 85 000 t/annum, the emissions of VC from Dow Chemical, Sarnia, would be in the range of 1.53 to 22.95 t/annum. Determinations of total flow for the scrubbers in future will help to ascertain the true rate of emission.

The annual stack test in the presence of an inspector was performed twice in 1985 on the TOX and the THROX; no vinyl chloride was detected during these two tests.

4 OTHER ENVIRONMENTAL ISSUES

To provide a comprehensive report on this industrial sector, it is essential to present, discuss and comment on environmental effects other than the atmospheric emissions.

4.1 Vinyl Chloride in Effluent (5)

Wastewater from PVC/VC plants can contain vinyl chloride up to 1320 mg/L. In a polyvinyl chloride plant the sources of the effluent are the reactors, centrifuges, compressors, and the floor and sewer drains. The average effluent flow rate from a PVC plant is about 15.3 litres/kg of product. From VC plants, the average flow rate is 2.08 L/kg of product with an average concentration of 1400 mg/L before treatment.

Based on solubility data, it is estimated that essentially all the vinyl chloride in the effluent would be released to the atmosphere. In the presence of a large amount of pure air, the partial pressure of vinyl chloride would be extremely small causing the solubility of vinyl chloride in the water to be essentially zero. It appears from reported data that the retention time of an effluent treatment system is sufficient to allow all the vinyl chloride to be released to the atmosphere prior to discharge.

This emission source can be controlled by stripping out the vinyl chloride in a stripping column prior to the treatment ponds. The vent gases from the stripper containing the stripped vinyl chloride can be returned to the process or treated in the plant vinyl chloride control system. The two principal ways of stripping are air stripping and steam stripping. In both cases the high temperature of the effluent will facilitate stripping. At high temperatures air stripping will be more effective since the volatiles will have a higher vapour pressure and steam stripping will require less steam for heating the water to the boiling point. Stripping can be performed in a multistage (multiple trays) column with a large countercurrent flow of air or steam, or in batch tanks. In either case, mixing is essential for good stripping.

Based on solubility data, it is estimated that the potential concentration of vinyl chloride in the water from a polyvinyl chloride plant can be reduced by stripping to 2.8 mg/L which is 99.77% reduction. This is based on a stripping operation temperature of 90°C, pressure of 760 mm Hg and an air flow rate of 0.075 m^3/L water. Under the same conditions, it is estimated that the potential maximum concentration of vinyl chloride in water from a vinyl chloride plant can be reduced by stripping to less than

2.8 mg/L, which is about a 99.8% reduction. These levels should be reached rather quickly after the temperature is raised and continuous agitation provided.

Based on the above, the U.S. EPA has regulated the content of process effluents from PVC/VC processes to 10 ppm (mg/L) before mixing with other effluents or discharging into surface waters.

In Canada, only Alberta requires by its Clean Air Act, section 12.6 (4)(g), that "the concentration of vinyl chloride in process wastewater is reduced to less than 10 milligrams per litre, before exposing the wastewater to the atmosphere".

Table 11 shows that most PVC plants in Canada treat their process water in a stripper to reduce its vinyl chloride content. Not all plants monitor this stream on a regular basis before mixing it with other effluents or before exposing it to the atmosphere. It is important that vinyl chloride monitoring in liquid effluents be carried out just after the stripping of the process effluent to ensure that the stripping operation is adequate. For those plants that do not have a specific provincial monitoring requirement for this process water, it is recommended that a monthly sample be taken and analyzed for vinyl chloride; the results of this analysis should be attached to the quarterly report.

TABLE 11 VINYL CHLORIDE IN EFFLUENT DATA (4)

	Effluent Monitored		VC Concentration (mg/L)		
Company	Process	Final	Before Treatment	After Treatment	Treatment Technology Used
B.F. Goodrich, Quebec		X		ND	Stripping
B.F. Goodrich, Ontario		X		0.25	Stripping
ESSO, Ontario		X		0.24	Stripping
B.F. Goodrich, Alberta		X		0.9	Stripping

ND: not detected.

References (6) and (7) provide analytical procedures for vinyl chloride in aqueous effluents.

4.2 Hazardous Waste

The quantities of hazardous waste and disposal methods utilized by the vinyl chloride industry are summarized in Table 12. A detailed review of the adequacy of these disposal methods was not undertaken. As a general recommendation, it is suggested that provincial agencies ensure that this industrial sector deal with hazardous waste in a responsible manner and ensure that, while in storage or handling, maximum care be observed to prevent accidental spills, atmospheric releases and groundwater contamination.

TABLE 12 HAZARDOUS WASTE GENERATION AND DISPOSAL

		Disposal			
Plant	Quantity Generated	On-Site Secure Landfill	Off-site Secure Landfill	Off-site General Landfill	Incineration
B.F. Goodrich, Quebec					
B.F. Goodrich, Ontario	3864 L solvents				X
ESSO, Ontario*	1000 m^3		X		
B.F. Goodrich, Alberta**	Only non-hazardous waste			X	
DOW Chemicals, Alberta**	331 m^3 (1983) 490 m^3 (1984)	X			29 000 t (1985)
Dow Chemicals, Ontario	2800 t (1985)				X

* Includes non-hazardous stripped resin waste.
** Telephone conversation with Joe Kostler, Waste Management, Alberta Environment, October 16, 1985.

4.3 Safety and Accident Prevention

Since vinyl chloride is a flammable substance, all PVC plants are monitoring its concentration in the workplace with special equipment that would sound an alarm if

VC concentration exceeded a preset limit. To prevent the potential of explosion due to a high concentration of VC, some plants have their equipment on platforms (without enclosing walls), while others have very efficient ventilation systems that can be adjusted depending on circumstances.

The above-mentioned systems are also effective in protecting the health and safety of the workers. Some of the new PVC plants or those that have been partially modernized have opted for complete automation which can be operated from a remote control room, reducing the need for the workers to be in direct contact with the process equipment and vinyl chloride fugitive emissions.

For further protection, employees are monitored closely and must undergo a physical check-up annually.

4.4 Fugitive Emissions (8)

Fugitive emissions are diverse emissions of vinyl chloride to the atmosphere that, with few exceptions, originate from sources other than a vent, stack, flue or other openings designed specifically for the purpose of emitting vinyl chloride. Fugitive emissions occur due to leaking valves, flanges and seals, open-ended lines, drains, vessel opening losses (other than reactors), building ventilators, open ponds, and the like. Each occurrence may be small, but they can add up to large amounts when emissions from all possible plant equipment are included.

Fugitive emissions can be controlled and minimized. The federal regulation does not address these emissions; only the provinces have a mandate in this area and provincial regulations could be promulgated if necessary.

The U.S. EPA regulations specify performance and reporting standards for fugitive emissions from the so-called petroleum refineries and synthetic organic chemical manufacturing industry sector. Periodic measurement of process equipment for leaks is required using a portable organic monitor, and equipment found to be leaking must be tagged and fixed within a specified period.

Plant programs to specifically look for and abate fugitive emission sources are recommended. Each operator should attempt to design a program that best fills his needs, but the program should address the following:

a) a periodic check of equipment to identify sources of fugitive emissions (in some cases area monitors may be placed to provide assistance),
b) a maximum time between identification and correction, and
c) a method to determine performance of the program.

If diligently followed, such a flexible approach may produce results superior to those of a rigid, regulated requirement.

4.5 Emergency Venting

In 1973, the U.S. EPA had estimated that the vinyl chloride emitted through emergency venting from PVC plants amounted to 5% of total vinyl chloride emissions (1). If the emissions from regulated captive sources are reduced, the emissions from emergency venting represent a higher percentage of the total. For this reason it is important to review the causes of a runaway reactor and the measures that can be taken to prevent releases from emergency venting.

The principal causes of a runaway reactor temperature condition and, in turn, emergency venting of vinyl chloride are:

- control instrument malfunction,
- interruption of cooling water supply (e.g. pump failure),
- interruption of electrical power supply, and
- operator error or negligence.

Depending on the stage of the reaction cycle at which the upset is triggered, the operator has about 10-15 minutes to take corrective action before conditions within the reactor are out of control and safety devices must be actuated. During this period, several procedures can be followed to virtually eliminate the release of vinyl chloride to the atmosphere through emergency venting.

In the case of a single reactor upset, all or part of the reactor contents may be vented to a 'gasholder' or an equivalent containment device. Since the gasholder may be used to temporarily contain vinyl chloride laden gas streams from other plant sources, this vessel should be sized to hold more than the equivalent of one reactor charge. Under this control scheme, vinyl chloride contained in the vessel may be recovered for reuse or destroyed by incineration. However, if several or all of the reactors are simultaneously affected by a single emergency (such as an area wide power failure) the only course of action to avoid emergency venting to atmosphere would be to stop the reaction by injecting a chemical inhibitor into each reactor.

Other measures used to reduce the vinyl chloride released to the atmosphere through emergency venting include:

- installation of a twin power line from the main electric supply grid;
- an emergency power generator;

- computerized control of the reaction process to achieve a greater degree of surveillance and control of operating conditions.

4.6 Vinyl Chloride Spill Prevention

This section covers the potential for VC spills during transportation and the measures taken to prevent such spills. Vinyl chloride produced by Dow Chemical's plants in Ontario and Alberta is shipped by pipeline to neighbouring polyvinyl chloride plants and by railroad to other plants and to the U.S. and Mexico. The use of tank trucks was discontinued in 1975 because the potential risk of highway accidents was deemed unacceptable.

In Fort Saskatchewan, vinyl chloride is shipped between the Dow Chemical plant and the B.F. Goodrich plant by pipeline. The VC pipeline is inspected regularly to detect any leaks.

Vinyl chloride is shipped to B.F. Goodrich's plants in Ontario and Québec by railroad. The Esso plant in Sarnia would also receive railroad shipments if the Dow Sarnia plant were shut down for any long period.

Railway tank cars used to transport vinyl chloride are subject to certain specifications to reduce the potential for release of VC during transport, loading and unloading. Some of these specifications are described in the Enviro TIPS manual for vinyl chloride (9). This manual also contains pertinent information on vinyl chloride, health effects, spill countermeasures and analytical methods.

In 1980, a train derailment resulted in a spill of 49.7 tonnes of vinyl chloride in MacGregor, Manitoba. In view of the potentially large amount of vinyl chloride that can be released in a derailment, railroad employees and first responders should be informed of the response and protection procedures that should be taken. Appendix C (10) shows some vinyl chloride characteristics.

REFERENCES

1) Environment Canada, Air Pollution Emissions and Control Technology: Vinyl Chloride industry, Report EPS 3-AP-77-4, 1978.

2) Petrochemical Census, Canadian Petroleum, April 1984.

3) Environment Canada, Standard Reference Methods for Source Testing: Measurement of Emissions of Vinyl Chloride from Vinyl Chloride and Polyvinyl Chloride Manufacturing, EPS 1-AP-77-1, 1978.

4) Data submitted by companies directly or through the province.

5) U.S. Environmental Protection Agency, Standard Support - Environmental Impact Document : An Investigation of Health Effects and Emission Reduction of Vinyl Chloride in the vinyl chloride monomer and Polyvinyl Chloride Industries - Vol. II, March 1975.

6) United States. National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals. Federal Register, Vol. 50, No. 219 Wednesday, Nov. 13, 1985, Proposed Rules.

7) U.S. Environmental Protection Agency. Master Scheme For the Analysis of Organic Compounds in Water Interim Protocols, Athens, Georgia October 1980.

8) F. Witthoeft, Air Quality Branch, Alberta Environment.

9) Environment Canada, Environmental and Technical Information for Problem Spills (EnviroTIPS), Vinyl Chloride, March 1985.

10) Environment Canada, Manual for Spills of Hazardous Materials, Ottawa, March 1984.

APPENDIX A
FEDERAL AND PROVINCIAL REGULATIONS

FEDERAL REGULATIONS

11/4/79 *Canada Gazette Part II, Vol. 113, No. 7*

Registration
SOR/79-299 30 March, 1979

CLEAN AIR ACT

Vinyl Chloride National Emission Standards Regulations

P.C. 1979-1025 28 March, 1979

His Excellency the Governor General in Council, on the recommendation of the Minister of State (Environment), pursuant to sections 6 and 7 of the Clean Air Act, is pleased hereby to make the annexed Regulations prescribing National Emission Standards for Vinyl Chloride emitted by Vinyl Chloride and Polyvinyl Chloride Plants.

REGULATIONS PRESCRIBING NATIONAL EMISSION STANDARDS FOR VINYL CHLORIDE EMITTED BY VINYL CHLORIDE AND POLYVINYL CHLORIDE PLANTS

Short Title

1. These Regulations may be cited as the *Vinyl Chloride National Emission Standards Regulations.*

Interpretation

2. In these Regulations,

"Act" means the *Clean Air Act*; (*loi*)

"bulk resin" means a resin manufactured by a polymerization process in which no diluent is used; (*résine polymérisée en masse*)

"copolymer resin" means a high molecular weight resin comprised of repeating molecular units of two or more compounds; (*copolymère*)

"dispersion resin" means a resin manufactured by a polymerization process in which monomer molecules react in an aqueous medium to yield an emulsion of very small particles in water; (*résine polymérisée en dispersion*)

"homopolymer" means a high molecular weight compound comprised of repeating molecular units of a single compound; (*homopolymère*)

"manual venting" means an operating practice involving controlled release of a quantity of gaseous material from a polymerization reactor to counteract an abnormally rapid increase in temperature and pressure within the reactor; (*ventilation manuelle*)

"Minister" means the Minister of the Environment; (*ministre*)

"monomer recovery system" means a system used in a polyvinyl chloride plant to collect and recover unreacted vinyl chloride and to control emissions of vinyl chloride associated with the collection and recovery thereof; (*dispositif de récupération du monomère*)

"polymerization reactor" means a vessel in which vinyl chloride is partially or totally polymerized into polyvinyl chloride; (*réacteur de polymérisation*)

"polyvinyl chloride plant" means any facility used to polymerize vinyl chloride alone or in combination with other materials; (*fabrique de chlorure de polyvinyle*)

"process vent" means any vent emitting a gas stream directly or indirectly into the ambient air, whether continuously or intermittently, excluding building ventilation exhaust streams; (*évent de poste de fabrication*)

"reactor opening loss" means the emission of vinyl chloride into the ambient air when a polymerization reactor is opened; (*dégagements à l'ouverture du réacteur*)

"resin stripper" means a vessel in which unreacted vinyl chloride is removed from resin under controlled operating conditions; (*dévolatiliseur de la résine*)

"slurry stripper" means a vessel in which unreacted vinyl chloride is removed from slurry under controlled operating conditions; (*dévolatiliseur de la suspension*)

"suspension resin" means a resin manufactured by a polymerization process in which droplets of monomer are dispersed in water in the presence of a suspension agent; (*résine polymérisée en suspension*)

"undiluted" means a condition that does not include air or other gases in excess of the quantity necessary for normal processing requirements at a vinyl chloride plant or polyvinyl chloride plant; (*non dilué*)

"vinyl chloride plant" means any facility used in the manufacture of ethylene dichloride, vinyl chloride or 1,1,1 trichloroethane. (*fabrique de chlorure de vinyle*)

Application

3. Nothing in these Regulations shall be construed so as to permit a vinyl chloride plant or a polyvinyl chloride plant to emit vinyl chloride in a quantity or concentration that exceeds the quantity or concentration that is permitted to be emitted or discharged by the plant by or under any law of a province.

Emission Standards

4. (1) Commencing July 1, 1979, the vinyl chloride emitted into the ambient air by a vinyl chloride plant from any process vent shall not exceed

(*a*) a concentration of ten parts per million by volume, measured dry and undiluted, or

(*b*) a total of two kilograms per day,

whichever is greater.

(2) Commencing July 1, 1979, the quantity of vinyl chloride emitted into the ambient air by a polyvinyl chloride plant shall not exceed

(*a*) in the case of a reactor opening loss, 0.002 kilograms per 100 kilograms of polyvinyl chloride produced by the reactor since it was last opened;

(*b*) 0.02 kilograms per 100 kilograms of polyvinyl chloride produced in the manufacture of homopolymer suspension resins, from all sources downstream of the slurry stripper;

(*c*) 0.04 kilograms per 100 kilograms of polyvinyl chloride produced in the manufacture of bulk resins, from all sources downstream of the resin stripper; and

(*d*) 0.2 kilograms per 100 kilograms of polyvinyl chloride produced in the manufacture of dispersion resins or for the manufacture of copolymer resins, from all sources downstream of the slurry stripper.

(3) Commencing July 1, 1979, the concentration of vinyl chloride in gases emitted into the ambient air by a polyvinyl chloride plant from a process vent shall not exceed ten parts per million by volume, measured dry and undiluted, where the gases are emitted as a result of

(*a*) the monomer recovery system;

(*b*) the reactor or stripper exhausting and purging procedures;

(*c*) the slurry or resin stripping procedures; or

(*d*) the depressuring of the reactor, including depressuring procedures used as a routine means of controlling operating conditions.

(4) The quantity or concentration of vinyl chloride emitted into the ambient air as described in subsections (1) to (3) shall be determined under normal operating conditions and by the appropriate method described in Department of the Environment Report EPS-1-AP-77-1 entitled "Standard Reference Methods for Source Testing: Measurement of Emissions of Vinyl Chloride from Vinyl Chloride and Polyvinyl Chloride Manufacturing".

Incident Report

5. (1) Subject to subsections (2) to (6), where pursuant to section 6 of the Act, the Minister requests information relating to the operation of a vinyl chloride plant or a polyvinyl chloride plant, the operator of the plant shall submit to the Minister the information required by the incident report in Form 1 of the schedule

(*a*) in respect of emissions of vinyl chloride into the ambient air in excess of the emission standards prescribed in subsection 4(1), (2) or (3), and

(*b*) in respect of malfunction or breakdown resulting in

(i) controlled (manual venting) or uncontrolled (safety valve or rupture disc) emissions of vinyl chloride from a polymerization reactor,

(ii) emissions of vinyl chloride from process equipment in operation for polyvinyl chloride manufacture, other than from a polymerization reactor, or

(iii) emissions of vinyl chloride from process equipment in operation for vinyl chloride manufacture,

within twenty days of the emission of the vinyl chloride.

(2) The incident report shall contain information that is based on emission measurements conducted in accordance with the measurement method described in the report referred to in subsection 4(4) or in accordance with any other method the results of which can be confirmed by that method.

(3) Where the incident report relates to an emission from a process vent referred to in subsection 4(1) or (3), the report shall be based on the determination of the concentration of vinyl chloride conducted on the stream at least once every eight hours, but where a stream does not occur every eight hours the determination shall be made as soon thereafter as the stream does occur.

(4) Where the incident report relates to an emission from a reactor referred to in paragraph 4(2)(*a*), the report shall be based on the determination of residual vinyl chloride in the reactor at the time of its opening for inspection or cleaning.

(5) Where an incident report relates to an emission from the sources specified in paragraph 4(2)(*b*), (*c*) or (*d*), the report shall be based on the determination of vinyl chloride concentration and stream flow rate conducted on the stream

(*a*) at least once every eight hours, for continuous stripping operations; and

(*b*) at the end of each stripping cycle, for intermittent or batch stripping operations.

(6) The determinations referred to in subsections (3), (4) and (5) shall, at least once per year, be conducted in the presence of an inspector.

Report on Emission Measurement Methods

6. Where, pursuant to section 6 of the Act, the Minister requests information on the methods employed to monitor vinyl chloride emissions at a vinyl chloride plant or a polyvinyl chloride plant, the operator of the plant shall submit the information required by the report on emission measurement methods in Form 2 of the schedule within two months after the request is sent by the Minister, and at such times thereafter as changes occur in the information provided.

Control Equipment/Procedure Report

7. Where, pursuant to section 6 of the Act, the Minister requests information on the establishment of control measures at a vinyl chloride plant or polyvinyl chloride plant, the operator of the plant shall submit to the Minister, for each source, the information required by the report on control equipment and procedure in Form 3 of the schedule within two months after the request is sent by the Minister and at such times thereafter as changes occur in the information provided.

Signing of Reports

8. When a report under section 5, 6 or 7 is made by a corporation it shall be signed by the person designated by the appropriate officers of the corporation to sign the report on its behalf.

Samples and Related Information

9. Where, pursuant to section 6 of the Act, the Minister requests samples from a plant and such related information as will enable the Minister to cause an analysis to be made of the quantity or concentration of vinyl chloride emitted into the ambient air from a plant, the operator of the plant shall obtain the samples at regular three month intervals in the presence of an inspector in accordance with the appropriate method described in the report referred to in subsection 4(4) and shall forthwith submit the samples and related information to the Minister.

SCHEDULE

FORM 1

Incident Report

Company Name ____________________
Plant Address ____________________
Telephone Number ____________________
Unit or Process ____________________
Emission Source ____________________
Production Rate at Time of Incident ____________________
Date and Time of Incident ____________________
Nature of Incident ____________________
Duration of Incident ____________________
Emissions of Vinyl Chloride during Incident (quantity or concentration)

____

as determined by (method)____________________
Cause ____________________
Corrective Measures ____________________

I certify that the above statements are correct to the best of my knowledge and belief.

____________________ (Signed)
____________________ (Title)
____________________ (Date)

FORM 2

Report on Emission Measurement Methods

Company Name ____________________
Plant Address ____________________
Telephone Number ____________________
Unit or Process ____________________
Emission Source ____________________

1. Measurement equipment and procedures are as prescribed in the Department of the Environment Report EPS-1-AP-77-1, "Standard Reference Methods for Source Testing: Measurement of Emissions of Vinyl Chloride from Vinyl Chloride and Polyvinyl Chloride Manufacturing. (YES) or (NO). If "NO", complete 2.

2. (*a*) Measurement Equipment ______________________
   (*b*) Measurement Procedure ______________________

I certify that the above statements are correct to the best of my knowledge and belief.

______________________ (Signed)
______________________ (Title)
______________________ (Date)

FORM 3

Control Equipment/Procedure Report

Company Name ______________________
Plant Address ______________________
Telephone Number ______________________
Unit or Process ______________________
Emission Source ______________________
Type of Control Equipment/Procedure ______________________
Supplier of Control Equipment ______________________
Schedule of Installation
  Engineering Design Initiated (date) ______________________
  Control Equipment Ordered (date) ______________________
  Installation of Control Equipment Initiated (date) ______________________
  Installation of Control Equipment Completed (date) ______________________
  Start-up of Control Equipment or Procedure Initiated (date) ______________________

(Attach a copy of control equipment specification and purchase order when order is placed or amended, or a copy of control procedures when completed or amended, as appropriate).

I certify that the above statements are correct to the best of my knowledge and belief.

______________________ (Signed)
______________________ (Title)
______________________ (Date)

QUEEN'S PRINTER FOR CANADA, OTTAWA, 1979

QUEBEC REGULATIONS
Part 2 GAZETTE OFFICIELLE DU QUÉBEC,
January 14, 1981, Vol. 113, No. 2 67

Division XVI

VINYL AND POLYVINYL CHLORIDE PLANTS

54. Vinyl chloride plants: When a vinyl chloride plant emits more than 2 kilograms of vinyl chloride into the atmosphere per day, it cannot emit that contaminant into the atmosphere in a concentration of more than 10 ppm by volume, on a dry and undiluted in the effluent gas.

55. Permitted emission level: A polyvinyl chloride plant cannot emit into the atmosphere more vinyl chloride than is permitted in the following table:

source	*standard in kg/100 kg of polyvinyl chloride produced*
opening loss	0,002
downstream of the slurry stripper for the manufacture of homo-polymer suspension resins	0,02
downstrean of the resin stripper for the manufacture of bulk resins	0,04
downstream of the slurry stripper for the manufacture of dispersion resins or copolymer resins	~~0,02~~ 0.2

56. Allowed concentration: A polyvinyl chloride plant cannot emit vinyl chloride in a concentration higher than 10 parts per million by volume measured dry and undiluted where the gases are emitted as a result of the monomers recovery system reactor or stripper exhausting and purging procedures slurry or resin stripping procedures and the depressuring of the reactor in the case where it is a standard means of controling operating conditions.

57. Date of application: This division applies from December 1, 1979 to existing polyvinyl plant.

PART 3.1

Gaseous Emissions

Vinyl Chloride and Polyvinyl Chloride Plants

12.5 In this Part

(a) "bulk resin" means a resin manufactured by a polymerization process in which no diluent is used;

(b) "copolymer" means a high molecular weight resin comprised of repeating molecular units of 2 or more compounds;

(c) "dispersion resin" means resin manufactured by a polymerization process in which monomer molecules react in an aqueous medium to yield a product that is an emulsion of small particles in water;

(d) "fugitive emission" means the presence of vinyl chloride in an effluent stream from any plant source including loading and unloading lines, pumps, compressor and agitator seals, pipe joints, open vessels, process wastewater, laboratory fume hood vents and building ventilation but excluding flues, stacks, vent pipes, reactors and strippers;

(e) "homopolymer" means a high molecular weight compound comprised of repeating molecular units of a single compound;

(f) "monomer recovery system" means a system used in a polyvinyl chloride plant to collect and recover unreacted vinyl chloride and to control emissions of vinyl chloride associated with the collection and recovery therof;

(g) "polyvinyl chloride plant" means a building, structure, reactor, vessel, operating and storage facility and land used in and for the polymerization of vinyl chloride alone or in combination with other materials;

(h) "process wastewater" means any water that is contaminated with vinyl chloride;

(i) "reactor" means any container in which vinyl chloride is partially or totally polymerized into polyvinyl chloride;

(j) "reactor opening loss" means the quantity of vinyl chloride that escapes into the atmosphere when a reactor is opened by means other than a valve;

(k) "stripper" means any vessel or reactor in which vinyl chloride is removed from slurry, resin or process wastewater;

(l) "suspension resin" means a resin manufactured by a polymerization process in which droplets of monomer are dispersed in water in the presence of a suspension agent;

(m) "undiluted" means a condition that does not include air or other gases in excess of the quantity necessary for the normal processsing requirements;

(n) "vessel" means any mixing, weighing, blending, holding, or storage container including pipes, tubes, centrifuges, slurry strainers, pumps, compressors, agitators, valves or other process equipment containing vinyl chloride in excess of 10% by volume, but does not include a reactor;

(o) "vinyl chloride" means vinyl chloride monomer in the liquid or vapour state;

(p) "vinyl chloride plant" means a building, structure, reactor, vessel, operating and storage facility and land used in and for the manufacture of ethylene dichloride, vinyl chloride and 1, 1, 1 trichloroethane, or any combination thereof.

AR 319/79

12.6(1) Subject to subsection (4), the vinyl chloride in an effluent stream to the atmosphere from a vinyl chloride plant shall not exceed a concentration of 10 parts per million by volume, measured on a dry and undiluted basis.

(2) Subject to subsection (4), the quantity of vinyl chloride in an effluent stream to the atmosphere from a polyvinyl chloride plant, per 100 kilograms of polyvinyl chloride produced, shall not exceed,

(a) in the case of a reactor opening loss, 0.002 kilograms in respect of the reactor based on all polyvinyl chloride produced by the reactor since the previous reactor opening loss;

(b) in the manufacture of suspension homopolymer resins, a total of 0.02 kilograms from all sources

(i) downstream of the stripper, or

(ii) if stripping is not used, downstream of the reactor;

(c) in the manufacture of bulk resins, a total of 0.04 kilograms from all sources

(i) downstream of the stripper, or

(ii) if stripping is not used, downstream of the reactor;

(d) in the manufacture of dispersion resins or in the manufacture of copolymer resins, a total of 0.2 kilograms from all sources

(i) downstream of the stripper, or

(ii) if stripping is not used, downstream of the reactor.

(3) Subject to the provisions of subsection (4), the concentration of vinyl chloride in any effluent stream to the atmosphere from a polyvinyl chloride plant shall not exceed 10 parts per million by volume, measured on a dry and undiluted basis, in respect of

(a) the monomer recovery system;

(b) the reactor or stripper depressuring, venting and purging procedures;

(c) vessel depressuring, venting and purging procedures; and

(d) the slurry or resin stripping procedures.

(4) Fugitive emission into the atmosphere from vinyl chloride plants and polyvinyl chloride plants are permitted if

(a) vinyl chloride remaining in loading and unloading lines prior to opening the lines to the atmosphere is reduced to less than 0.0038 cubic metres at standard conditions;

(b) vinyl chloride remaining in vessels prior to opening the vessels to the atmosphere is reduced to less than 2% by volume or 0.0950 cubic metres, whichever is greater, at standared conditions;

(c) vinyl chloride leaks from pump, compressor and agitator seals are reduced to a minimum

(i) by the installation of double seals, and

(ii) by maintaining the pressure between the seals above the pump, compressor or agitator pressure or by ducting the vinyl chloride between the seals to a control system from which the concentration of vinyl chloride in the exhaust gases does not exceed 10 parts per million, measured on a dry and undiluted basis,

or by equally effective equipment and procedures;

(d) ball type or at least equally effective valves are used;

(e) a rupture disc is installed upstream of each pressure relief valve or the pressure relief valve is connected to a control system from which the concentration of vinyl chloride in the exhaust gases does not exceed 10 parts per million by volume;

(f) pipe joints are of the ring sealed or at least equally effective type;

(g) the concentration of vinyl chloride in process wastewater is reduced to less than 10 milograms per litre before exposing the wastewater to the atmosphere;

(h) the concentration of vinyl chloride in an effluent stream to the atmosphere from building ventilation procedures does not exceed 5 parts per million by volume.

(i) the quantity of vinyl chloride emissions from all laboratory fume hood vents does not exceed a total of 2 kilograms per day.

(5) No person shall emit or permit the emission of vinyl chloride from liquid level guages and sampling equipment to the atmosphere.

AR 319/79

12.7(1) The owner or operator of a vinyl chloride plant or polyvinyl chloride plant shall cause each effluent stream or other source in or about a vinyl chloride or polyvinyl chloride plant from which vinyl chloride is emitted to the atmosphere, except fugitive emissions and laboratory emissions from fume hood vents, unless advised otherwise by the Director of Standards and Approvals, to be surveyed

(a) once within the first 30 minutes of the commencement of an effluent stream and once every 8 consecutive hours thereafter with respect to those sources specified in section 12.6(1) and (3);

(b) once after each opening of a reactor with respect to the source specified in section 12.6(2)(a); and

(c) once every 8 consecutive hours, or as often as the Director of Standards and Approvals may require, in the case of continuous stripping operations or at the end of each stripping cycle for intermittent or batch stripping operations with respect to the sources specified in sections 12.6(2)(b), (c) and (d).

(2) A survey under subsection (1) shall be conducted by a method satisfactory to the Director of Standards and Approvals and shall include but not be limited to

(a) determinations for vinyl chloride quantity chloride quantity or concentration, as the case may be, and

(b) determination of the corresponding operating unit production rate or plant production rate, as the case may be.

(3) A survey under subsection (1) shall be carried out at least once in each consecutive 12 month period

(a) in the presence of an authorized employee of the Department of the Environment, and

(b) after not less than 2 weeks prior written notice of the proposed survey has been given to the Director of Pollution Control.

AR 319/79

12.8(1) The owner or operator of a vinyl chloride or polyvinyl chloride plant shall monitor or cause to be monitored the atmosphere in the vicinity of a vinyl chloride or polyvinyl chloride plant for the presence of vinyl chloride

(a) during a period and in a manner satisfactory to the Director of Standards and Approvals, but

(b) consisting of at least one 24-hour average vinyl chloride concentration determinations in every consecutive 24-hour period.

(2) Notwithstanding subsection (1)(b), averaging times may be reduced and the frequency of determination and the number of monitoring stations may be increased in a permit or licence if considered appropriate by the Director of Standards and Approvals.

AR 319/79

PART 4

Miscellaneous

13 *The Clean Air (Maximum Levels) Regulations being Alberta Regulation 10/73 as amended are hereby rescinded.*

AR 218/75

APPENDIX B
MINIMUM MONITORING AND REPORTING REQUIREMENTS

CANADIAN POLYVINYL CHLORIDE PLANTS
VINYL CHLORIDE EMISSIONS
MINIMUM MONITORING AND REPORTING

1. Reactor Opening

The VC emission limit for reactor opening is, set in section 4(2)a of the federal regulations on VC as, 0.002 kg VC/100 kg PVC produced since the reactor was last opened.

Regular monitoring: A total hydrocarbon analyser can be used for each reactor opening at the three levels indicated (top-middle and bottom of the reactor). This procedure should be correlated to the standard reference method prior to the routine use of the analyser and at the time of the annual test in presence of an inspector.

Reporting for auditing purposes and incident reporting. Incidents can be classified into two categories:

a) Major incidents: reactor upsets resulting in the release of the total reactor contents or some portion thereof to the ambient atmosphere or the release of 100 kg or more of VC. These major incidents should be reported to the provincial inistry of Environment and copies to the EPS regional office on form 1 within the time frame requested by the province and no later than 20 days from the date of the incident.

b) inor incidents: those are defined as exceedances of the standard that will emit VC in quantities smaller than those listed in major incidents. Minor incidents should only be reported on part 1b) of table 1, on a quarterly basis, to the provincial ministry of Environment and copies to the EPS regional office.

Part 1a) of table 1 shows % openings analysed and % compliance, for auditing purposes. This also be submitted on a quarterly basis.

2. Slurry Stripping

The residual VC in the PVC after stripping is set in section 4(2)b, c, d of the federal regulations on VC and varies between 0.02 to 0.2 kg VC/100 kg PVC produced, depending on type of resin produced.

Regular monitoring: the standard reference method is to be used in sampling and analysis of each sample taken: (section 5(5) of regulations)

a) once each eight hours from continuous strippers.

b) after each batch, for batch strippers.

After proving compliance with a) and b) above separately, for each type of resin, special averaging procedures can be accepted to decrease the laboratory load.

Reporting: For auditing purposes and incident reporting. Incidents can be classified into two categories.

a) Major incidents: when the weekly average of VC monomer in the slurry has exceeded the standard. These are reported as described in major incidents (re: reactor opening).
b) Minor incidents: each individual sample that has exceeded the limit is to be reported on part 2b) of table 2, on a quarterly basis.

Part 2a) of table 2 shows % samples analysed and % compliance, for auditing purposes. This also should be submitted on a quarterly basis.

3. Process Vent

The VC emission limit from process vents is set in section 4(3) of the federal regulations on VC, as 10 ppm.

Regular monitoring. The standard reference method (4(4)) is indicated to be used to sample and analyse VC from process vent:

a) once every eight hours, for continuous venting.
b) as soon thereafter as the stream does occur, in case of non-continuous venting.

The standard reference method ask for three 1-h samples to be averaged. To simplify this analysis procedure an in-stack continuous monitoring (total hydrocarbon analyser) for VC can be acceptable.

Reporting for auditing purposes and incidents reporting. Incidents can be classified into two categories:

a) Major incidents: when emissions of VC exceed 100 kg. These are reported as above major incidents.
b) Minor incidents: when a malfunction or breakdown or emission standard is exceeded (for an average of three hours), but <100 kg. These are reported on part 3b) of table 3, on a quarterly basis.

Part 3a) of table 3 shows the number of hours of operation of the control equipment (incinerator or absorber), the number of 3-h averages over the 10 ppm limit and % compliance, for auditing purposes. This also is submitted on a quarterly basis.

APPENDIX C

VINYL CHLORIDE: CHARACTERISTICS AND EMERGENCY MEASURES

VINYL CHLORIDE $H_2C{:}CHCl$

IDENTIFICATION

UN No. 1086

Common Synonyms

VINYL CHLORIDE MONOMER
VCM
CHLOROETHYLENE
CHLOROETHENE

Observable Characteristics

Colourless, gas or liquid. Sweet odour.

Manufacturers

Dow Chemical Canada Inc.,
Sarnia, Ont., Fort Saskatchewan, Alta.

Transportation and Storage Information

Shipping State: Liquid (compressed gas).
Classification: Flammable.
Inert Atmosphere: No requirement.
Venting: Safety-relief (under pressure); pressure-vacuum (atmospheric pressure).
Pump Type: Steel or stainless steel; positive displacement or gas, explosion-proof.

Label(s): Red label - FLAMMABLE GAS; Class 2.1.
Storage Temperature: Ambient.
Hose Type: Teflon, Viton A; flexible stainless steel.

Grades or Purity: Commercial or technical, 99+% (inhibiter, phenol 40 to 100 ppm may be added).
Containers and Materials: Cylinders, tank cars (steel or stainless steel).

Physical and Chemical Characteristics

Physical State (20°C, 1 atm): Gas.
Solubility (Water): 0.006 g/100 mL (10°C); 0.003 g/100 mL (25°C).
Molecular Weight: 62.5
Vapour Pressure: 240 mm Hg (-40°C); 580 mm Hg (-20°C); 2 660 mm Hg (25°C).
Boiling Point: -13.4 to -13.9°C.

Floatability (Water): Liquid, floats.
Odour: Sweet odour (260 to 4 000 ppm, odour threshold).
Flash Point: -78°C (o.c.).
Vapour Density: 2.2
Specific Gravity: 0.97 (-20°C); 0.91 (15°C).

Colour: Colourless.
Explosive Limits: 3.6 to 33%.
Melting Point: -153 to -160°C.

HAZARD DATA

Human Health

Symptoms: Inhalation: irritation to respiratory tract, dizziness, anaesthesia, difficulty breathing, lung irritation, headache, paralysis. Contact: skin - drying, freezing, inflammation; eyes - irritation, watering, inflammation. Ingestion: nausea, vomiting, drowsiness, loss of consciousness, narcosis, shock.
Toxicology: High toxicity upon inhalation and contact.

TLV®- (inhalation) 5 ppm; 10 mg/m^3.
Short-term Inhalation Limits - No information.

LC_{50} - No information.
LC_{Lo} - Inhalation: rat = 6 000 ppm/4 h
TD_{Lo} - Inhalation: rat = 250 ppm/39 weeks
Delayed Toxicity - Recognized carcinogen.

LD_{50} - Oral: rat = 0.5 g/kg
TD_{Lo} - Oral: rat = 34 g/kg

Fire

Fire Extinguishing Agents: Do not put out fire until leak has been shutoff. Water may be used to cool fire-exposed containers.
Behaviour in Fire: Fire may cause violent rupture of tank. Burning releases hydrogen chloride gas. Flashback may occur along vapour trail. Under high temperatures or in contact with certain catalytic impurities, may violently polymerize.
Ignition Temperature: 472°C.
Burning Rate: 4.3 mm/min.

Reactivity

With Water: No reaction.
With Common Materials: Can react vigorously with oxidizing materials.
Stability: Stable.

Environment

Water: Prevent entry into water intakes and waterways. Aquatic toxicity rating: >1 000 ppm/96 h/TLm/freshwater; **BOD:** No information.
Land-Air: No information.
Food Chain Concentration Potential: None.

EMERGENCY MEASURES

Special Hazards

FLAMMABLE.

Immediate Responses

Keep non-involved people away from spill site. Issue warning: "FLAMMABLE". CALL FIRE DEPARTMENT. Eliminate all ignition sources. Contact manufacturer for guidance. Stay upwind and use water spray to control vapour. Dike runoff. Stop or reduce discharge if this can be done without risk. Notify environmental authorities.

Protective Clothing and Equipment

Respiratory protection - self-contained breathing apparatus. Boots - high, rubber (pants worn outside boots). Acid suit - (jacket and pants), "slicker suit" - neoprene, or coveralls. Gloves - rubber.

Fire and Explosion

Do not put out fire until leak has been shut off. Use water to cool fire-exposed containers. Fire may cause violent rupture of tank. Flash back may occur along vapour trail. Under high temperatures or in contact with certain catalytic impurities, may violently polymerize.

First Aid

Move victim from spill site to fresh air. Call for medical assistance, but start first aid at once. Inhalation: give artificial respiration if breathing has stopped. Give oxygen if breathing is laboured. Contact: remove contaminated clothing and wash eyes and skin with plenty of warm water for at least 15 minutes. Ingestion: unlikely with vinyl chloride but should this happen, give warm water. Keep victim warm and quiet. If medical assistance is not immediately available, transport victim to hospital, doctor or clinic.

ENVIRONMENTAL PROTECTION MEASURES

Response

Water

1. Stop or reduce discharge if safe to do so.
2. Contact manufacturer or supplier for advice.
3. If possible, contain discharge by damming or water diversion.
4. Notify environmental authorities to discuss disposal and cleanup of contaminated materials.

Land-Air

1. Stop or reduce discharge if safe to do so.
2. Contact manufacturer or supplier for advice.
3. Dike to prevent runoff from rainwater or water application.
4. Remove material with pumps or vacuum equipment and place in appropriate containers.
5. Recover undamaged containers.
6. Notify environmental authorities to discuss disposal and cleanup of contaminated materials.

Disposal

1. Contact manufacturer or supplier for advice on disposal.
2. Contact environmental authorities for advice on disposal.

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Environment status report, 1979-1984: vinyl chloride industry/ by Raouf Morcos

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